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Entertainment Computing – ICEC 2011

10th International Conference, ICEC 2011
Vancouver, Canada, October 2011
Proceedings

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Preface

We are pleased to present the proceedings of the 10th International Conference on Entertainment Computing (ICEC) held in beautiful Vancouver, BC, Canada, October 5–8, 2011. This gathering of scientists, engineers, artists, game developers, educators, and many flavors of academics and practitioners assembled to discuss the increasing role that information and computing technology plays in entertainment. The diversity and strength of the submissions this year continued to demonstrate that entertainment drives computing advances as much as computing advances drive entertainment. As well, the range of entertainment types keeps expanding as computing technologies are exploited by talented, creative researchers and practitioners. ICEC is at the forefront, looking at this exciting field from an academic and scientific perspective, providing novel directions and theoretical foundations for emerging advances. We are pleased with the published efforts of our growing community and the way these feed the growth and development for the future of entertainment computing.

This year we received 65 full paper submissions and 29 submissions to the other tracks, giving a total of 94 submissions. We accepted 20 long papers, 18 short papers, 24 posters, three demos, two workshops and one tutorial. All the submissions were peer-reviewed by three or more reviewers. We are proud of the current selection of papers presented in these proceedings. They represent the top research in the field. We are grateful for all the efforts of the reviewers to make the proceedings so stimulating. Without their commitment and support we would not have had such excellent proceedings.

We were very happy to have our three exemplary keynote speakers, invited specifically to represent critical components of this ever-growing field. Glenn Entis's pioneering work in the film and game industry and his current position looking to identify the next big opportunity provided insights that help to promote and direct entertainment technology researchers. Chris Klug brought his experience of theatre and opera as it influenced his leadership in the gaming industry and the role it plays in academia, specifically with regard to research in entertainment. This combination is rare and motivates practitioners and researchers to see that diversity, culture, and adventure are keys to deeper understanding of entertainment computing. Regan Mandryk brought her fresh perspective on the academic side of entertainment computing with her award-winning research in evaluating computer games. This topic is critical for our field since it is necessary for providing evidence that research and development efforts are improving and leading to pathways of discovery and refinement. We expect the dialogue from their participation at ICEC 2011 to be relevant for the future of entertainment computing.

We ran the conference program as a single track as we believe that each paper has an important contribution to make within the field. By having a single track, everyone was able to see each other's work, while the breaks provided opportunities for discussions. Demos and posters were integrated to provide as many opportunities as possible to engage with authors. Additionally, the workshop and tutorial program balanced the tracks with special topic areas within entertainment computing.

We were grateful to our sponsors, the Networked Centres of Excellence on Graphics, Animation and NewMedia (GRAND), the Media and Graphics Interdisciplinary Centre (MAGIC) at the University of British Columbia (UBC), Simon Fraser University (SFU), and the IFIP TC14 committee, with special thanks to Drs. Ryohei Nakatsu, Matthias Rauterberg, and Hyun Yang for their help and support of ICEC 2011. We offer our gratitude to Terry Lavender who created and maintained the ICEC 2011 website. The efforts of the student volunteers and Lavana Lea, our administrative assistant, were critical in making ICEC a successful event.

August 2011

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Magy Seif El-Nasr
Nick Graham
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Draw Your Own Story: Paper and Pencil Interactive Storytelling

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Abstract. In this paper, we present a storytelling system able to dramatize interactive narratives in augmented reality over a conventional sheet of paper. The system allows users to freely interact with virtual characters by sketching objects on the paper. Users interacting with the system can indirectly affect the characters' decisions, even to the point of radically subverting the storyline.

Keywords: Interactive Storytelling, Augmented Reality, Sketch-Based Interface.

1 Introduction

Since from times immemorial, humans have been using hand drawings, sometimes rather crude but good enough to convey a personal touch, as a visual complement to oral storytelling. Currently, stories are told through several types of media (books, movies, games) and, with the advent of new technologies, digital storytelling is becoming increasingly interactive. How to combine visualization and interaction while a story is being created is even today an active field of research. Though it seems convenient to equip storytelling systems with user interfaces inspired on video game interfaces, there is a risk that such interfaces may restrict user immersion and creativity.

HCI researchers have been focusing on immersive interfaces over the last fifteen years, from different viewpoints: multimodal interfaces [19][20], virtual reality [19], and augmented reality (AR) [17][18]. However, few immersive systems are devoted to interactive storytelling. Moreover, these few works require special devices, such as CAVE-like immersive displays [22] and see-through head-worn displays [21]. Complex devices installations make the immersion experience less natural and creative. An interesting way of exploring the user's creativity and natural engagement in interactive storytelling is the use of sketch-based interfaces.

Sketch-based interaction has been used in engineering, education and 3D modeling (see the special issue on this subject elsewhere [23]), and it is a permanent research topic since Ivan Sutherland proposed his famous SketchPad system [24] in the sixties. Those systems use special input devices (such as tablets) or the projection display.

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Augmented reality systems using sketch-based interaction and simple paper and pencil have also been proposed [25][1]. However, the development of AR systems for interactive storytelling is still an open research topic.

In this paper, we explore the use of an augmented reality visualization interface combined with a sketch-based interaction interface. We present a storytelling system able to dramatize interactive narratives in augmented reality over a conventional sheet of paper. The system allows users to freely interact with virtual characters by sketching objects on the paper. The system recognizes the hand-drawn sketches and converts the drawings into virtual objects in the 3D story world.

The paper is organized as follows. Section 2 describes related works. Section 3 presents the architecture and implementation of the paper and pencil interactive storytelling system. Section 4 describes a simple application, together with a preliminary user evaluation. Section 5 contains the concluding remarks.

2 Related Work

The use of hand-drawn sketches in an interactive narrative environment is discussed by Vogelsang and Signer [2]. Their system is dependent upon a special pen, known as the Anoto Digital Pen[1] which, when used on a special paper, is capable of recording the user strokes and sending the drawing information to a computer. The idea of transferring paper drawings to a virtual world was explored by Kuka *et al.* [3]. Their system is also based on the Anoto Digital Pen technology. A combination of mixed reality and collaborative environment is found in Bayon *et al.* [4]. The authors present a storytelling environment where a variety of devices (PDAs, scanners, bar codes and a large screen display) are used by children to tell stories.

The use of mixed reality environments in the context of interactive narratives has also been the focus of some research projects. Dow *et al.* [5] present an augmented reality version of the desktop-based interactive drama Façade [6]. With a similar approach, Cavazza *et al.* [7] present an interactive storytelling application that captures the user's video image and inserts him/her in a world populated by virtual actors. Users are able to interact with the virtual actors using body gestures and natural language speech. While Dow *et al.* [5] bring the virtual characters to the real world, Cavazza *et al.* [7] place the user inside the virtual world. Zhou *et al.* [16] explore the use of tangible cubes as interaction interface for mixed reality interactive storytelling.

In the gaming context, Hagbi *et al.* [1] explore the use of hand-drawn sketches as a content-authoring tool for augmented reality games. A similar approach is used by Huynh *et al.* [8]. Leitner *et al.* [9] explore the interaction between real world objects and virtual objects in board games.

None of the above-mentioned works appears to combine all the characteristics of the system proposed in the present work, that is: a paper and pencil interactive storytelling tool with a sketch-based AR interface that allows an easy and more natural way of interfering in the ongoing story.

---

[1] `http://www.anoto.com`

3 Paper and Pencil Interactive Storytelling

The proposed system (Figure 1) is composed of a computer equipped with a conventional webcam, an ordinary sheet of paper with a fiducial marker printed on it, and a common pencil.

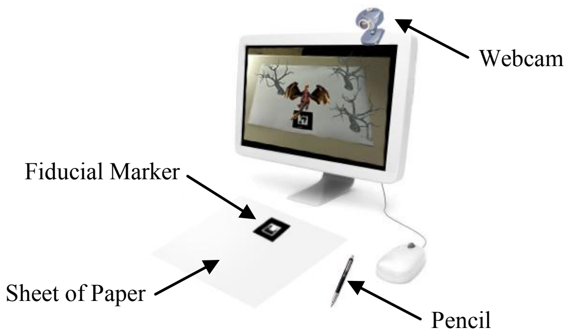


Fig. 1. The simple environment of the proposed system

In the system, stories are graphically represented in augmented reality over the paper, which creates the illusion that the sheet of paper is a virtual world populated by virtual characters. The entire world may comprise several sheets of paper, each one representing a different location in the virtual world. Users can switch between places by changing the paper shown to the camera or by pointing the camera to other sheets of paper. They can distinguish the places represented by the various pages based on their respective fiducial markers.

Users act as gods of the virtual world, in a way reminiscent of the *deus ex machina* of classical theater. For example, a hero may not have enough strength to slay the villain with his bare hands, but if the user draws a sword close to the hero's position in the paper, the sword will be transferred to the virtual world and taken by the hero, who will now be able to defeat the villain.

The paper and pencil interactive storytelling system is composed of three main modules: the story planner, the sketch recognition interface and the augmented reality dramatization system (Figure 2). The story planner handles the actions of several virtual autonomous characters, each one introduced with predefined goals, whose behavior may however be redirected via user interactions. The sketch recognition system consists of a support vector machine classifier trained to recognize a set of hand-drawn sketches produced by the users on the sheet of paper, which were captured by the camera. The augmented reality dramatization system controls and renders the virtual world superimposed over the real world objects, creating a mixed reality environment. If a fiducial marker is found on the image, the system renders the virtual world objects and characters according to the virtual location identified by the marker.

The parallel architecture of the system is important to guarantee that there will be no noticeable delays in the rendering process – which is currently limited to 30 frames per second, due to the camera capture speed. Since the recognition of user sketches is the most expensive process in the system, it must be executed in a separate thread, so that the system is able to render the output images effectively in real-time.

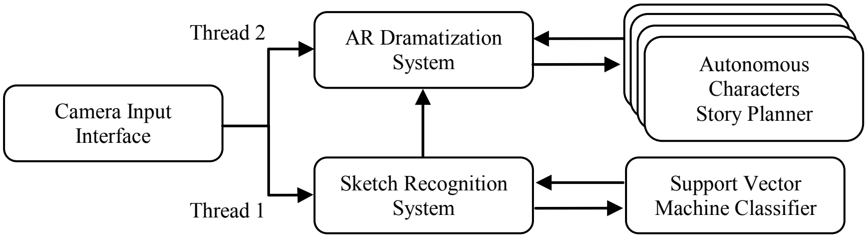


Fig. 2. Parallel system architecture

3.1 Story Planner

Interactive storytelling systems can follow three basic approaches: plot-based [27], character-based [30], or hybrid approach [26]. In this paper, we add a layer on top of a nondeterministic hybrid approach to interactive storytelling found in some of our previous works [27][28][29]. In this approach, a nondeterministic planning algorithm generates a plan in which events allow characters to try achieving goals without necessarily succeeding [29]. Furthermore, events can be specified by nondeterministic automata [28], in which the arcs represent short episodes that we call “actions”. In the present paper, we propose an interactive layer that can represent an action in those automata. As the actions are nondeterministic, the interactions that occur via this layer can influence the rest of the story.

In the presented layer, the story evolves towards surprising outcomes depending on emotional and physical states that characters can attain as a result of the user interventions over a sheet of paper. The example implemented in the prototype corresponds to a short story within a swords and dragons genre. In this story, a villain (dragon) kidnaps a narcissistic princess, who can easily get depressed, and a brave knight tries to rescue her.

The emotional, physical, and social attributes of the characters are modeled as a multi-character network (Figure 3), where nodes represent characters and bidirectional arcs define affection relationships in the social environment of the story. Each node has the name of the character and the values of the emotional/physical attributes. Affections are not reciprocal, that is *affection*(i, j) is not necessarily equal to *affection*(j,i), except when there is a self-affection situation. Affection values vary within the interval [-10,10].

The emotional model adopted by our planner uses the six emotions proposed by Ekman and Friesen [10], but we consider them lying on six emotion axis with negative and positive sides that represent opposite emotions: [calmness, anger], [liking, disgust], [confidence, fear], [joy, sadness], [cheeriness, sorrow], and [anticipation, surprise]. The values in each axis are numbers within the interval [-10, 10]. In this model, sorrow is not a synonym of sadness, but a sense of loss or a sense of guilt and remorse. For the sake of simplicity, we refer to an axis by the name of its positive side. The sign (− or +) does not mean destructive or constructive emotions, but a connotation of drama impact and opposite states.

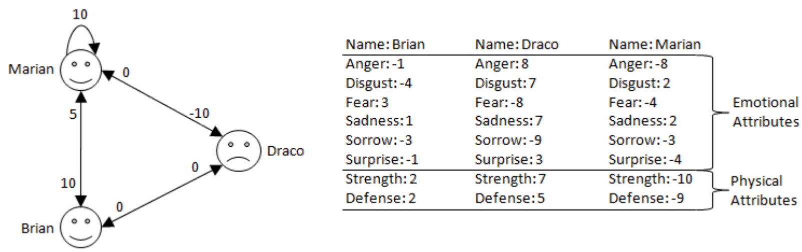


Fig. 3. The proposed multi-character network

In the proposed model, emotions can be combined to form a new emotion, for instance: love = joy + liking + confidence. Also, we can refer to extreme values on an axis as being special emotions, *e.g.*: grief = very high levels of sadness and ecstasy = very high levels of joy (that is, very low levels of sadness).

The story planner used by the paper-and-pencil interactive layer is defined by general rules and production rules. General rules express general knowledge about the genre, such as "if a person is not at home he/she will be unprotected". For example: $\forall X\ currentPlace(X) \neq home(X) \rightarrow {\sim}protected(X)$, where ~ denotes negation.

Production rules concern actions and have the following form:

CONDITIONS → actions(CONCRETE_ACTIONS, ATTRIBUTE_CHANGES)

where CONDITIONS is a conjunction of observed facts; CONCRETE_ACTIONS is a list of concrete actions, such as go, take, hit, and kidnap; and ATTRIBUTE_CHANGES is a list of increments and decrements to the indicated characters' attributes using the operators *add(X,Attribute,Increment)* or *addr(X,Y,Attribute,Increment)*, *e.g. add(marian,sadness,9)* increments Marian's current value of sadness by 9 and *addr(marian,brian,affection,5)* increments Marian's affection to Brian by 5. In the proposed model, we work with attribute operators that return the current level of a specific attribute for a specific character *X*. These operators use the same terminology of the multi-character network, *e.g. sadness(X)* and *affection(X,Y)*. Also the model has an important operator that confirms if a specific *Object* drawn by the user can be seen by a character *X*: *cansee*(*X*,*Object*). For example, if the user draws a mirror on the paper close to princess Marian, *cansee*(*marian*,*mirror*) will be true. Users interacting with the system can indirectly affect the characters' decisions, even to the point of radically subverting the storyline. The following sentences are examples of production rules used in the prototype:

(a) Bored princesses always become sad:
$\forall X\ princess(X) \wedge protected(X)\ \wedge\ surprise(X) < -2\ \rightarrow\ actions([\,], [add(X, sadness, 9)])$

(b) Drawing objects on paper (detected by *cansee*) causes changes in attribute levels:
$\forall X\ princess(X)\ \wedge free(X) \wedge cansee(X, mirror)$
$\rightarrow actions([go(X, mirror), take(X, mirror)], [add(X, surprise, 3), add(X, sadness, -3)])$

(c) Actions can be more complex than simple movements, such as the one that defines the act of kidnapping:

$$\forall X \forall Y\ villain(X) \wedge affection(X,Y) < -8 \wedge \sim protected(Y) \wedge free(Y)$$
$$\rightarrow actions([go(X, currentPlace(Y)), hit(X,Y), kidnap(X,Y), go(X, home(X))], [\,])$$

Our previous works [27][28][29] use Constraint Logic Programming to specify rules used in plot generation and dramatization control at a higher level. In this work, however, actions occur at a lower level and we decided to use a C++ forward chaining procedure here, due to performance reasons. In the present work, we implement a story loop with a fixed time step (15 seconds) to update the characters' states. In every story loop all the rules are executed again. When the user interferes in the story, the states are updated as soon as a new object is created on the sheet of paper.

3.2 Hand-Drawn Sketches Recognition

The process of recognizing hand-drawn sketches can be divided into a pre-processing phase and a recognition phase.

3.2.1 Pre-Processing Phase

The objective of the pre-processing phase is to eliminate the background of the input image and highlight the drawing forms. The approach used in this work to segment the image and remove the background is based on the application of five increasing threshold levels and a canny edge detector over the input image. This process generates six new images containing the candidate drawings. The use of several threshold levels is important to ensure that the drawings may be identified by the system even with different illumination conditions.

The threshold levels and the canny edge detector reduce the number of objects on the image, but are still not enough to clear all the background. To completely clear the background, the system uses the paper rectangular border as a boundary to ignore all the objects that are outside it. The sheet of paper is recognized as the largest rectangle on the image. The augmented reality marker, located inside of the paper, is also removed at the pre-processing phase to avoid being classified as a user drawing. The segmentation process is illustrated in Figure 4.

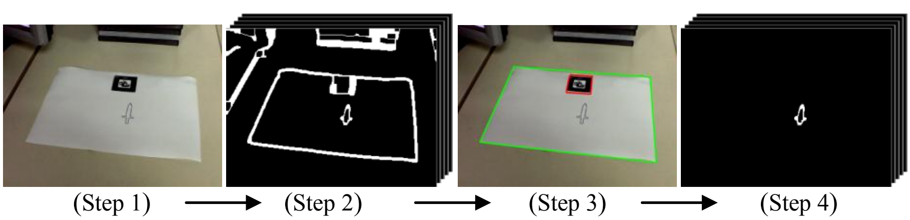


Fig. 4. Segmentation process. (Step 1) input frame captured by the camera; (Step 2) segmented images; (Step 3) detection of the paper rectangle and the marker; (Step 4) set of candidate drawings.

3.2.2 Recognition Phase

In the recognition phase, the sketches (previously segmented during the pre-processing phase) are classified according to a predefined set of drawings. To perform this classification, the system uses a support vector machine (SVM) classifier trained with structural features to classify hand-drawn sketches. SVM [11] has proved effective in many real-world applications, such as in systems for detecting microcalcifications in medical images [12], automatic hierarchical document categorization [13], and 3D camera control [14].

The SVM structure is composed of the output classes (the vocabulary of hand-drawn sketches understood by the classifier) and the features vector (numerical features characterizing the hand-drawn sketches). The classifier uses the features (in a training phase) to create a pattern that classifies unknown input features vectors in one of the output classes (prediction process).

The features vector adopted in the implementation of our classifier is composed of seven moment invariants, which are extracted from the candidate drawings found on the segmented images. The Hu descriptors, proposed by Hu [15], are based on non-orthogonalised central moments that are invariant to image rotation, translation, and scale. This invariance requirement is essential for allowing the classifier to recognize the drawings from different camera positions and angles. The combination of those seven Hu descriptors uniquely characterizes a specific pattern or shape.

Before using the SVM to recognize hand-drawn sketches, the classifier must be trained. The training process consists of capturing (from different angles) several images of hand-drawn sketches, and then processing these images to segment the background and extract the drawing features used by the SVM.

The recognition process can be summarized as follows: (1) Extraction of the contours from each candidate drawing found in pre-processed images; (2) Extraction of the features used by the SVM classifier from each candidate drawing; (3) Filtration of the candidate drawings that have too small areas or a number of vertices outside the range defined for the known drawings; (4) Classification of the candidate drawings using the SVM classifier; (5) Analysis of the SVM output to identify the drawing recognized by the classifier.

For each image frame captured by the camera, the system classifies the hand-drawn sketches found at all segmentation levels resulting from the pre-processing phase. In this way, the system has the classification of the same drawing in different segmentation conditions. Based on these results, the algorithm can search for the best-fitting class. A voting approach is adopted to choose the final classification of the drawing.

3.3 Augmented Reality Dramatization

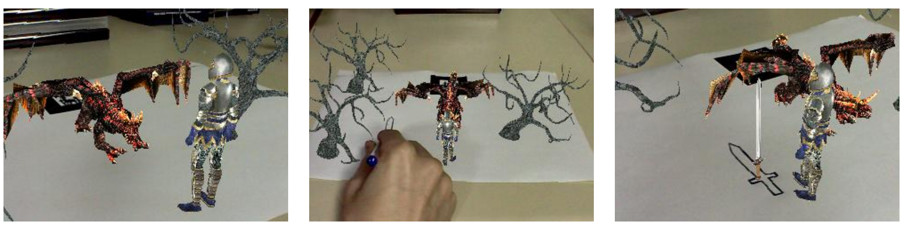
The augmented reality dramatization system uses the ARToolKit Library[2], which encapsulates functions to calculate the position of the real camera based on the size and orientation of physical fiducial markers. Each marker has a distinctive pattern and is associated with a specific location of the virtual world (Figure 5).

---

[2] `http://www.hitl.washington.edu/artoolkit/`

Fig. 5. Fiducial markers used by the system to compute the position of the virtual camera according to the real camera. The maker image is also used to identify the virtual places.

The dramatization system represents the characters of the stories through animated 3D models that can walk freely across the scenarios displayed over the sheets of paper. The virtual characters who are in the location where an object was created are informed about the presence of the new object. The planning system then chooses the appropriate actions for the characters according to the observed situation. The user interaction process is illustrated in Figure 6.



(*a*) (*b*) (*c*)

Fig. 6. User Interaction. Image (*a*) shows a scene being dramatized in a virtual place; image (*b*) shows the user sketching an object; and finally, image (*c*) shows the sketched object (sword, in this case) coming to life in the augmented reality environment.

4 Application and Evaluation

The prototype application developed to test our system is based on an overly simplified “Swords and Dragons” genre. The virtual world is populated by three main characters: the charming, narcissistic, and lonely princess Marian, who lives under strict protection at a palace; a brave young knight, sir Brian, in love with the princess; and the evil dragon, Draco, constantly waiting for a chance to kidnap the princess. The virtual world is composed of four places: the princess's palace, the dragon forest, a church and the forest where the wandering hero dwells. Users are able to interact with the virtual characters by sketching on a paper. For the prototype application, the following six items are recognizable, whose presence can somehow affect the storyline: a “hand mirror”, which may divert the princess's eyes while increasing her level of joy; a “sword”, which Brian would gladly wield to supplement his bodily strength; a “shield”, adequate for the hero's defense; a “magic stone”, that can dangerously increase Draco's strength; a “rat”, which can serve either to distract the dragon's attention, or to scare princess Marian; and a “poison bottle”, a possible inducement to Marian or Brian to commit suicide in desperate situations. The recognizable sketches used in the prototype are illustrated in Figure 7.

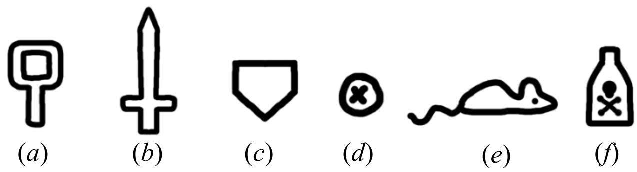


Fig. 7. Recognizable sketches. (*a*) hand mirror; (*b*) sword; (*c*) shield; (*d*) magic stone; (*e*) rat; (*f*) poison bottle.

The prototype application is able to generate a considerable number of diversified stories under the stimulus of the user interactions. For example: in more conventional stories, the princess is kidnapped by the dragon and then saved by the hero who kills the dragon; in stories with a not so happy ending, the hero is defeated by the dragon; and in others with a darker outcome, the dragon kills the princess, or she commits suicide. But the dragon's participation is not really indispensable to cause misfortune. One story was generated wherein the princess, frightened by the rat, broke her mirror, whereupon she became so distraught that she drank the proffered poison.

To evaluate our system, we performed two tests: a technical test to check the performance and accuracy of the system, and then a user evaluation test to check the system's usability from a Human-Computer Interaction (HCI) perspective. The following sections describe these tests.

4.1 Technical Evaluation

The technical evaluation concerns the accuracy and the real-time performance of the system. The tests were mainly focused on sketch recognition, which constitutes the most expensive process and includes a machine-learning method that is not guaranteed to provide correct answers at all times.

The evaluation of the sketch recognition system was based on two experiments: (1) the recognition rate test, to check the accuracy of the predicted sketches; and (2) the performance test, to check the time needed to process the input frames and recognize the hand-drawn sketches.

For the recognition rate test, we utilized a collection of 250 pictures (captured by a conventional webcam from different angles), using training datasets ranging from 100 to 300 samples. In this test, the classifier was trained to recognize 6 classes of sketches. The computed average recognition rate is shown in Table 1.

To evaluate the performance of the sketch recognition system, we again utilized a collection of 250 pictures, and calculated the average time necessary to perform the pre-processing and the classification of the sketches. The computer used to run the experiments was an Intel Core i7 2.66 GHZ CPU, 8 GB of RAM using a single core to process the algorithms. Table 1 shows the result of the performance test, with training datasets ranging from 100 to 300 samples.

Table 1. Recognition rate and performance test with training datasets ranging from 100 to 300 samples

Training Samples	100	150	200	250	300
Recognition Rate	92.1%	92.8%	93.4%	93.4%	93.8%
Recognition Time (*ms*)	83.6	81.2	84.4	84.7	85.1

Analyzing the test results, it seems fair to conclude that the classifier ensures high recognition rates without sacrificing the system's performance.

4.2 User Evaluation

We have conducted a preliminary evaluation with six participants, four male and two female, all between 20 and 26 years old, with diverse backgrounds: a cinema professional, an undergraduate student in Media Studies, a graduate student and two undergraduate students in Computer Science, and an undergraduate student in Fine Arts with some experience in Computer Science.

We asked participants to interact with the story using our system, including objects and changing scenes to influence the story unfolding as they wished. They were asked to interact both with our system (S) and with a modified version of it (M) that used menus to include objects in the scene instead of sketching. In order to reduce learning effects, half of the participants used S first, and the other half used M first.

After using each version, the participants filled out a questionnaire with 21 questions about their motivation to change the story, their understanding of how to do so, the effort to do so, and how immersed they were in the story creation, as reflected in their awareness of their surroundings during their interaction with the system. After having interacted with both systems, the participants were interviewed about their preferences and what they would like to see improved in the sketching version.

Figure 8 summarizes the results of the questionnaire. As for the interviews, all participants stated they preferred to interact with the sketch-based version, because it was more interesting, attractive, exciting, innovative, caught their attention more, and allowed them to explore their creativity, despite the slightly increased effort, mostly due to some limitations of the recognition algorithm. They thought the menu-based version was too simplified, easier, but less motivating.

Fig. 8. Averages and standard deviation of questionnaire topics in both versions of the system

Although the quantitative results are inconclusive, the increased motivation and interest in influencing the story, especially expressed in the interviews, indicate that this is a promising direction of research.

5 Conclusion

In this paper, we presented a mixed reality interactive storytelling system that allows users to visualize stories in augmented reality and to interact with virtual characters by sketching objects on a sheet of paper. As far as we are aware, this is the first time a pencil-and-paper interactive storytelling system is implemented and tested.

The storytelling approach presented in this paper opens up many possibilities to explore the user creativity, especially when we consider the use of our system as an education tool for children. As a future work, we intend to improve our system by including facilities to allow users, as much as possible, to extend the repertoire of recognizable sketches, and by designing an authoring tool to simplify and unify the authoring process in a single framework. We also intend to conduct more user studies with a larger number of participants to effectively validate our system.

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The Experience of Interactive Storytelling: Comparing "Fahrenheit" with "Façade"

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Abstract. At the intersection of multimedia, artificial intelligence, and gaming technology, new visions of future entertainment media arise that approximate the "Holodeck" ® idea of interactive storytelling. We report exploratory experiments on the user experience in a 'classic', foundational application of interactive storytelling, "Façade" (Mateas & Stern, 2002), and compare results with an identical experiment carried out with users of the adventure game "Fahrenheit". A total of N = 148 participants used one of the systems interactively or watched a pre-recorded video sequence of the application without interactive involvement. Using a broad range of entertainment-related measures, the experience of Interactive Storytelling was found to depend strongly on interactivity (mostly in "Façade") and to differ substantially across the systems, with "Façade" achieving a stronger connection between interactive use and the resulting profile of entertainment experiences.

Keywords: Interactive storytelling, user experience, "Façade", enjoyment, adventure games.

1 Introduction

Research and development on Interactive Storytelling (IS) is about to bring out systems and media that provide novel modes of entertainment, learning, and other experiences [1]. Departing from existing media, such as adventure video games, and synthesizing diverse streams of technology, including as artificial intelligence, 3D real-time imaging and/or speech recognition, the vision of Interactive Storytelling is to facilitate user experiences that combine immersion in fictional stories with perceptions of agency and the situation dynamics of improvisation theatre. Conceptually, IS emerges as one pathway towards next generation entertainment computing [2]. So far, various demonstrators have been developed that illustrate how this vision of new entertainment media could be implemented technically in the future (e.g., the "Façade" system [3] or the "Madam Bovary" system [1]).

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But audiences are going to perceive, use, and adopt such (radically) new media remains an open question [4]. How using such media will 'feel like', which qualities of enjoyment Interactive Storytelling can facilitate is not well understood, which is due to both a lack of theoretical-psychological reasoning and of empirical exploration. In addition to fundamental scientific knowledge gaps, not much is known from an applied and commercial perspective either. The acceptance of future IS systems by lay audiences and their market success will certainly depend on whether they achieve the satisfaction of target audience expectations and meet user capabilities as well as emotional preferences. It is therefore important to consider psychological perspectives on how users respond to current IS systems in order advance basic research in media entertainment and entertainment computing and at the same time to ground design decisions and future technology developments for user acceptance and economic success. Moreover, social research and user responses to IS prototypes can build bridges between technology-driven research on new media systems and social science perspectives on media entertainment, learning, and other domains. The present paper thus addresses the question which kind of entertainment experiences users find – and do not find – in Interactive Storytelling.

2 Conceptual Background: Mixing Interactivity and Narrative

Modelling user experiences in IS exposure turns out to be a theoretical challenge [4]. Because IS systems share similarities with a wide array of conventional and new media entertainment [5], the list of construals from media psychology that could emerge as relevant dimensions of the IS user experience is remarkably long. In general, existing approaches to media entertainment offer (A) well-established psychological accounts of emotional responses to non-interactive stories, such as novels or movies [6] and (B) more recent propositions of interactive media enjoyment, mostly related to the video game experience [7]. Similarly, in the game studies community, theoretical propositions have been advanced that root in 'narratology' and consider what interactivity might 'do' to conventional story experiences, or are based in 'ludology' and consider what mediated narratives might 'do' to conventional play experiences [8].

The key conclusion from this diverse literature base is that there is probably not 'the one' kind of (radically new) user experience one should expect from IS usage. Rather, quite different types of user experience, such as suspense or exhilaration, may emerge from specific characteristics of given applications [9]. So a theoretical forecast of what the user experience of IS might be is inevitably vague and in need of elaboration.

Roth et al. [10] and Klimmt et al. [11] conducted a theoretical analysis and expert interviews with creators of IS applications to come up with a dimensional framework of the most important and most likely dimensions of the user experience in IS. According to their findings, multimedia Interactive Storytelling will be capable to foster the following psychological processes and states that are linked to enjoyment. First, this conceptual work identified five important preconditions of meaningful user experiences:

- System usability, (i.e., the experience that the interaction with the story is fluent, smooth, and error-free)
- Correspondence of system capabilities with user expectations (i.e., the experience that the system makes realistic offers about how users can influence the story and then keeps its promise so that frustration is avoided)
- Presence, (users establish a sense of 'being in the story world')
- Character believability (virtual agents in the story world contribute to a coherent story experience and do not damage users' illusion, e.g., through 'intelligent' behavior and predictable response to user input), and
- Effectance [12] (i.e., users can easily recognize when and how they have causally affected the story or story world).

Next, the conceptual framework includes five types of key user responses that reflect 'typical', common patterns which are likely to occur across different IS systems):

- Curiosity, (users maintain interest in what will happen next and how they could affect the story)
- Suspense (users develop hopes and expectations about the story progress, but also face uncertainty about that progress)
- Flow (users become absorbed in ongoing, continuous interaction with the story world)
- Aesthetic Pleasantness, (positive experiences of beauty or artistic impressiveness)
- Enjoyment (an overall sense of positively valenced experiential quality)

Finally, the model of the IS user experience includes elements that emphasize the unique characteristics of each IS application, such as the specific story content that may facilitate very diverse emotional experiences or the virtual characters that may evoke very specific user responses. Therefore, users overall emotional condition (as reflected in a specific affect model [13] and the degree of identification with the story's protagonist were proposed as system-specific user reactions.

Overall, the theoretical model comprises 12 dimensions of user responses that the authors identified as meaningful and important across 'any' type of interactive story. They reflect the commonalities of IS applications with conventional (and interactive) entertainment media. With this theoretical framework, a foundation was created that allows exploring actual user experiences to interactive stories empirically. Exploratory experiments were conducted to find out which of the theorized facets of the user experience may turn out as important so that conceptual and design-related conclusions can be drawn.

3 Research Design

In order to explore user responses to IS applications, the concepts identified by Roth et al. and Klimmt et al. were transformed into self-report measures that could be administered immediately after exposure to an IS system [14]. With this user experience questionnaire, we examined audience reactions to two applications of IS: One was a commercial adventure video game that featured some elements of interactive storytelling, "Façade" (Atari, 2005), the other was the 'classic' prototype demonstrator of dialogue-based, ‘true’ IS that is widely cited in the IS research and development community, “Façade” [3]. “Fahrenheit” is an audiovisually advanced type of story with pre-scripted narrative and relatively few degrees of freedom for users decisions. Its setting borrows from classic crime and mystery thriller plots and puts the player into the role of an amnesic murder suspect. “Façade” is audiovisually less impressive, but employs a dialogue-based interface and thus opens considerable more levels of user impact on the progress of story events (see figure 1). Its setting is more similar to TV series contexts that focus on interpersonal relationships and personalities of individual characters.

The comparison of user experiences to both systems was intended to reveal system-bound profiles of users’ entertainment experiences. Moreover, an experimental approach was implemented so that participants either used the system interactively (and thus shaped the progress of the story by themselves) or merely watched a pre-recorded video of what happened in the story when somebody else had interacted with the system (non-interactive control condition). This way, the impact of adding interactivity to the story on users responses was examined across two different IS applications.

Fig. 1. Screenshots from “Fahrenheit” (Atari, 2005) and “Façade”

In the “Fahrenheit” experiment, $N = 80$ university students (22 males, 58 females; average age M = 20.08 years, SD=1.91 years) with a relatively low degree of computer game literacy (M=1.60, SD=.84 on a scale from 1-3) were recruited. Exposure time in the interactive and the non-interactive conditions was about 30 minutes. The recruited students were randomly assigned to the interactive or the non-interactive group. After exposure to “Fahrenheit”, participants were kindly requested to fill in a computer-based questionnaire that included the 12 scales on user reactions to IS systems, as well as some demographics items. Some participants received credits for a course they were attending, others received 10 Euros for their participation in the experiment (see [14] for more details).

A total of N = 68 university students (22 males, 44 females; average age M = 20.74 years, SD=5.33 years) with a relatively low degree of computer game literacy (M=1.54, SD=.74 on a scale from 1-3) participated in the “Façade” experiment. They were randomly assigned to either the interactive (normal play) condition, or to the non-interactive (pre-recorded sequence) condition. After 30 minutes of exposure, they filled out the computer-based questionnaire. Like in the “Fahrenheit” study, some participants received credits for a course they were attending, others received 10 Euros for their participation in the experiment. The overall procedure typically lasted for about 50 minutes. Therefore, the experimental set-up and procedures were virtually identical for the "Fahrenheit" game and the "Façade" prototype, which maximized the comparability of user experiences. In both parts of the study, self-report scales reached satisfying reliabilities (with very few exceptions Cronbach's Alphas > .80).

4 Results

Data analysis was conducted separately for users of the different systems in order to follow experimental procedures (interactivity had been manipulated, whereas the comparison of two quite different games/systems is not strictly experimental). Tables 1 and 2 display the group means for "Fahrenheit" and "Façade" users in the interactive and non-interactive conditions, as well as significance tests for differences between interactive system use and the non-interactive 'watching' condition.

Interestingly, for "Fahrenheit" the addition of interactivity did not shift user reactions on very many dimensions of experience. Curiosity, suspense, aesthetic pleasantness and even the flow experience (which is commonly theorized to be bound to interactivity) were not observed to differ between interactive users and 'passive watchers'. Overall enjoyment did also not differ significantly between the groups. However, the manipulation of interactivity caused reduced perceptions of usability, a higher correspondence with expectations, lower levels of perceived character believability, and substantially higher levels of efficacy (effectance). So users who interacted with the "Fahrenheit" story perceived their causal influence on the game world more clearly when they interacted with the system, but at the same time found more usability problems compared to 'passive watchers' who did of course not face any usability issues at all. Results are thus interpretable, but the key finding is that the entertainment experience of the "Fahrenheit" story did not shift drastically – that is, across many theorized dimensions – if interactivity was added or removed.

Table 1. Results from the study on "Fahrenheit". Scale means (*M*) were obtained by averaging participant responses to five-point rating items.

	Interactive condition		Non-interactive condition		
User experiences	*M*	*SD*	*M*	*SD*	*p*
System usability	3.11	.94	3.69	.75	.004*
Correspondence /w user expectations	3.63	.56	3.38	.62	.06†
Presence	2.68	.98	2.62	.95	.77
Character believability	2.98	.90	3.48	.59	.004*
Effectance	3.23	.69	2.40	.97	.000*
Curiosity	3.58	.73	3.43	.64	.35
Suspense	3.33	.72	3.44	.77	.51
Flow	2.95	.71	3.00	.49	.70
Aesthetic pleasantness	2.00	.65	2.24	.62	.10
Enjoyment	2.94	.82	2.80	.66	.41
Emotional state: positive	4.60	1.66	4.51	1.50	.79
Emotional state: negative	2.59	1.51	2.91	1.43	.33
Role adoption	2.71	1.04	2.67	1.05	.86

Table 2. Results from the study on "Façade". Scale means (*M*) were obtained by averaging participant responses to five-point rating items.

User experiences	Interactive Condition *M*	*SD*	Non-interactive condition *M*	*SD*	*P*
System usability	3.93	.81	3.81	.68	.53
Correspondence /w user expectations	3.46	.61	3.10	.66	.025*
Presence	3.27	.84	2.77	1.00	.033*
Character believability	3.84	.63	3.64	.93	.32
Effectance	3.18	.92	2.47	.80	.001*
Curiosity	3.49	.62	3.33	.78	.33
Suspense	3.50	.68	3.33	.71	.32
Flow	3.00	.59	2.98	.61	.89
Aesthetic pleasantness	2.45	.80	2.54	.78	.67
Enjoyment	2.86	.73	2.54	.73	.07†
Emotional state: positive	5.07	1.31	4.31	1.53	.034*
negative	3.05	1.29	4.06	1.79	.011*
Role adoption	3.24	.80	2.88	1.02	.11

In contrast to "Fahrenheit", the manipulation of interactivity changed users' experience fundamentally in "Façade" users (table 2). While no difference in usability emerged (which suggests excellent technical usability in the Façade system), group differences were observed for satisfaction with expectations, Presence, effectance, enjoyment, and emotional states. In general, participants reported more favourable experiences in the interactive condition. Again, a strong impact of interactivity on effectance was observed. Thus, the variation of interactivity caused somewhat differing patterns in users' experiences across the two examined systems.

5 Discussion

The exploratory experiment with the "Fahrenheit" adventure game and the "Façade" IS demonstrator revealed interesting findings. "Façade" was rated as substantially higher in usability in the interactive conditions than "Fahrenheit". This mirrors important design differences between the applications, because "Fahrenheit" as an interactive movie or adventure game comes with much more complicated affordances for users when to interact and how to interact in given game/story situations than "Facade". For users who are unfamiliar with the system, "Fahrenheit" thus causes inevitably greater difficulties to translate one's intention into actual game events. "Façade", in contrast, seems to provide a rather smooth, irritation-free way of interacting with the system and its characters.

Character believability ratings were also much higher in interactive "Facade" users than in interactive "Fahrenheit" users. This difference can be explained by the fact that "Facade" is much more focused on dialogue with characters within a limited plot (a relationship argument between the protagonists Trip and Grace). In contrast, "Fahrenheit" contains a crime drama story with exceptional events (such as the protagonist finding a dead body under his hands) but less user-character dialogue, which may make the "Fahrenheit" personnel appear much less authentic. Presence was also higher among interactive "Facade" users than among interactive "Fahrenheit" players; interestingly, this finding occurred although "Fahrenheit" presents more elaborate graphics and sound. However, "Facade" puts the user in the midst of a dense interpersonal conflict, and the intensive story of "Facade" seems to afford higher levels of (social) Presence than the richer sensory experience of "Fahrenheit". Finally, it is noteworthy that "Facade" created both more positive and more negative affect than "Fahrenheit". This observation again reflects design differences of the two interactive stories examined, as "Façade" has been explicitly constructed to trigger uneasy feelings in users, but is on the other hand fun to use. In contrast, playing "Fahrenheit" does not trigger such a broad range of emotional responses.

While the comparison of the interactive users of the two different systems supports the argument that Interactive Storytelling is likely to facilitate various elements of enjoyment, depending on specific system properties, the examination of experimental interactivity effects across the two systems can help to derive further conceptual conclusions.

First, the most general impact of interactivity in Interactive Storytelling appears to address users' perceptions of *efficacy* (effectance, [12]). In line with various conceptual approaches, the results indicate that in addition to 'classic' types of entertainment experiences, users of interactive stories recognize their causal agency within the environment, which adds an important element to the overall entertainment experience. The increased level of effectance as a consequence of added interactivity was observed across the two examined systems. However, further consequences of interactivity in interactive stories strongly differed between the systems, which suggests that the implementation of interactivity is closely bound to individual attributes, plot elements, and other design decisions of given applications.

The second observation that is constant across systems is that several enjoyment-related experiential components (such as curiosity, surprise, suspense) as well as enjoyment itself did *not* display substantial differences in interactive and non-interactive users. This finding calls for theoretical explanations that may also have an effect on how to envision user experiences with full-scale interactive stories of the future. Concerning the fact that the experimental manipulation of interactivity did not affect suspense, curiosity, and flow, one interpretation is that these types of enjoyment can be fueled by different assets of media content and form (such as audiovisual effects, appealing characters, or surprises in the plot [6]). So even if interactive user participation would influence suspense, curiosity, and flow, alternative factors could compensate so that, for example, suspense could be maintained high through affective bonds with believable characters also if interactivity 'is removed'. Some modes of enjoyment could therefore be construed as 'robust' in the sense that if some of their causal determinants are unavailable, other determinants can still provide a satisfying level of fun.

Concerning the fact that curiosity, suspense, and flow did not differ across the two examined systems, one could argue that these experiential qualities of IS use do not depart from what is well-known in conventional entertainment. This would mean that curiosity, suspense, and flow emerge as those components of enjoyment that systems of Interactive Storytelling will have in common with existing mainstream entertainment such as current video games or movies. In turn, these commonalities could mark an important link that helps users feel comfortable and have fun with the upcoming new types of entertainment media in the IS paradigm, as parts of the new experience will feel somewhat familiar. Clearly, further research on these ‘classic’ ingredients of entertainment experiences in the IS context is warranted.

Finally, an important result of comparing two quite different systems of Interactive Storytelling is that ‘switching interactivity on versus off’ caused a broader range of experiential changes in “Façade” users than in “Fahrenheit” users. Interactivity thus seems to play specific roles in the two systems, which suggests that more advanced types of IS (for which “Façade” is an example) can achieve a tighter integration of interactivity and storytelling so that more profound perceptual (Presence) and emotional effects result. If interactivity is closely connected to other elements of the experience, particularly those elements related to the narrative, an artificial switch-off of interactivity is likely to have profound impact on the user experience, as can be seen in table 2. In contrast, “Fahrenheit” has obviously achieved a less tight connection of interactivity with the remaining system elements, so that removing interactivity had only limited effects for the user experience. For “Façade” users, then, the interactive experience was ‘more different’ from the non-interactive version than for “Fahrenheit” users. This is proposed as empirical evidence for IS researchers’ understanding that advanced integration of user agency and narrative generation can indeed lead to innovative modes of entertainment experience [1] [4]. The present data suggest that this innovative experience is best characterized by strong immersion and affective dynamics (both positive and negative emotions), which may lead to very inspiring and long-lasting personal impressions.

Replications with even more sophisticated prototypes of interactive stories will show whether the integration of interactivity can make an even greater difference for the user experience than what we found with “Fahrenheit” versus “Façade”. The present studies have already shed some light on the theoretical challenges of understanding the user experience in Interactive Storytelling. They also demonstrate the importance of reflecting about the intended and actual qualities of enjoyment a given media application will facilitate in users. Because the profile of enjoyment will vary greatly among systems, there is not “the one” type of fun involved, nor is there one universal argument to convince users of the fun value of IS-based media experiences.

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Emotion-Driven Interactive Digital Storytelling

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Abstract. Interactive digital storytelling has attracted a great deal of research interest in recent years. However, most interactive stories are told following a goal-oriented and task-based mode, which motivates the player to interact with stories by achieving the goals rather than empathizing with the characters and experience the enriched emotions. Given this fact, we propose an emotion-driven interactive digital storytelling approach based on Smith and Lazarus' cognitive theory of emotion. In this approach, the player's emotions, as a driving force, motivate the story forward and contribute to their experience directly and explicitly. To evaluate this approach, an interactive video was made by re-editing existing footage of the TV comedy *Ugly Betty* and ten players were interviewed afterwards. The results reveal that the interviewees' experience is largely influenced by their gender and favorite media entertainment.

Keywords: interactive digital storytelling, emotion-driven, cognitive theory of emotion, user experience.

1 Introduction

Interactive digital storytelling, as a promising entertainment industry, has attracted a great deal of research interest in recent years. Most interactive digital storytelling systems to date employ a goal-oriented and task-based approach. That is to say, the way that a story evolves is driven by the goals. In order to achieve a goal, a set of tasks are structured by generating a sequence of actions [1]. Therefore, the motivation of interacting with stories primarily comes from competing with others to achieve these goals rather than empathizing with the characters' experience to enrich emotions and guide story development accordingly. Interactive digital storytelling therefore ignores the capacity of empathized emotions in creating an engaging story to contribute to users' experience. It does not satisfy potential players who are oriented to movies [2] and demographic groups who are interested in attractive and challenging stories [3] [4]. Given this consideration, we propose a new design approach–emotion-driven interactive digital storytelling – in which players experience a series of emotions by empathizing with the characters, more importantly, the players' emotions act as the

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explicit driving force to motivate the story forward. The aim of the emotion-driven interactive digital storytelling approach is to allow players to adapt narrative storylines *in accordance with their experienced emotions.*

2 Emotion-Driven Interactive Digital Storytelling

2.1 Cognitive-Motivational-Emotive Theory

Emotions play a significant role in a wide range of human cognitive processes. A number of cognitive theories of emotion have emerged accordingly. Appraisal theories which argue that emotions arise from two basic processes: appraisal and coping are widely applied into several computational models of emotion, for example, EMA [5], FLAME [6], WILL [7]. In particular, our work is inspired by Smith and Lazarus' [8] cognitive-motivational-emotive theory.

In a classic paper, Smith and Lazarus examined how emotions arise in particular situations through an *appraisal process* and how individuals are likely to respond given their current needs and goals as well as their longer term attitudes and beliefs. Depending on their personality, two individuals can *react* with quite similar or entirely different emotions towards the same situation through different appraisal processes. The emotions individuals experience lead to an *action tendency* which is an urge to respond to the situation in a particular way. The nature of the emotions determines the nature of action tendency which leads to different coping strategies, for example, to attack in anger, flee or avoid in anxiety. Influenced by these coping strategies, action tendencies are translated to a wide array of behavioral responses or actions. Smith and Lazarus argued that our experience of emotions and our responses to them changed dynamically with the situation we found ourselves in. Furthermore, they argued behavioral responses would not stop the emotional experience, but continuously influence the subsequent appraisals and emotions leading to new actions.

2.2 Emotion-Driven Interactive Digital Storytelling

When Smith and Lazarus' theory is applied to interactive digital storytelling, emotions can act as the driving force to motivate narrative evolution. As an important mechanism of emotional involvement with narrative, empathy helps the player build emotional bond with the character [9]. By thinking and feeling from the character's perspective, the player experiences the character's emotions vicariously. Due to the influence of personality on the *appraisal process*, each player might feel different emotions. Therefore, in emotion-driven interactive digital storytelling, the players are given the opportunity to make a series of choices as they move through the narrative about how they feel from the character's perspective in a variety of emotional conflict moments. The choices they make determine the character's emotions and then result in different *action tendencies* as well as behavioral responses in the character. In addition, the character's actions with respect to a narrative can also serve as stimuli to evoke new emotions in the player and then trigger new actions. Therefore, the choices players make which reflect their *emotional reactions* towards the storyline can result in a particular series of events being shown which, in turn, evoke new emotions and trigger new actions in interactive digital storytelling. The series of emotional responses of the player direct the narrative and determine the final ‘story’ they experience. In this sense, different players would experience different stories based on their different emotions evoked by empathizing with the characters. Emotions, thus, become a powerful driving force for narrative configuration in interactive digital storytelling [10].

3 Evaluating Emotion-Driven Interactive Digital Storytelling

3.1 Method

Semi-structured interviews were used to elicit information about the player’s experience, especially with respect to their emotional engagement and enjoyment. Questions were designed to prompt the interviewee’s experience regarding their narrative understanding, emotional involvement, emotion-driven interaction and overall enjoyment based on the theory of narrative engagement [11].

3.2 Materials

To focus on the narrative aspect and reduce the influence of gameplay as well as other technical issues, an interactive video was made to evaluate user experience by re-editing existing footage from the TV comedy *Ugly Betty* creating a series of storyline segments which could be pieced together in different ways rather than shooting each segment from scratch. The method used to capture players’ emotions was similar to that employed by Roberts et al. [12], namely, players were asked questions about their emotions after each video segment. Their responses at these points determined the main character Betty’s actions. Therefore, the video segment which contained these actions would be chosen from a series of options and shown to the player next.

3.3 Participants and Procedure

Ten students and staff (5 male and 5 female) participated in this study. All of them were English speakers. Every interviewee was required to watch the interactive video individually. The video was shown online. Before they started to watch the video, an introductory text on the homepage was shown to explain the procedure of this study and how to interact with the video. After watching the video, a demographic questionnaire was required to fill out which aimed to get their background information, such as their favorite entertainment, whether they have watched *Ugly Betty* before. Following the demographic questionnaire, the interviews were conducted. All interviews were recorded and transcribed.

3.4 Results

We found interviewees’ experiences were largely influenced by gender and their favorite media entertainment. In general, females felt more engaged than males with the emotional involvement and emotion-driven interaction. All females felt empathy for, and built the emotional bond with, the character. They perceived the emotions from the character’s standpoint while at the same time combining this with their own experience and concerns. They made the choices based on the blend of these two emotions.

> “Sometimes it was my own emotional sort of connection to the story, sometimes sort of putting (myself) in her issues….”

In contrast, male interviewees found it relatively difficult to empathize with Betty. Although they enjoyed this interactive experience, their motivations in making choices were made more on the basis of their own feelings or self-set goals rather than emotional empathy with the character.

> “I have a goal of bringing this guy down … I invented this goal and gave it to myself. My personal emotion was affected both by what I was looking at and by whether I’ve achieved my goal or not.”

Two other factors determined the interviewees’ user experience: their previous interactive digital storytelling experience and their favorite media entertainment. Interviewees, who had interactive digital storytelling experience before, especially those who prefer digital games, felt the interaction in this video was “slow”. They expected more choices and shorter video segments. Influenced by the mode of interaction with digital games, one interviewee said:

> “I was expecting like in games that I would have choices very earlier on and much more often.”

For other interviewees who liked watching TV or film, the number of choices was not a problem. They enjoyed watching the interactive video in the same way as watching a TV program or film while also enjoying the feeling of influencing how the story evolved.

> “I think it (the length of the video segments) is alright, because you tell a story. For me, it is like a movie story.”

Because existing TV footage was used, the player’s experience is also affected by the original storyline of *Ugly Betty*. The interactive video creates multiple choices and storylines. To do this the temporal and spatial structure of original linear TV footage is broken and recomposed. Visual and sound discontinuities which make the story difficult to understand may therefore result. Fortunately, this was not reflected in interviewees’ reports. Only one interviewee pointed out that one transition between two video segments was not smooth, but it did not affect his understanding of the whole story. Almost all interviewees expressed their interest in watching other storylines even those who had watched the original *Ugly Betty* before.

4 Discussion and Future Work

The interviews reveal that the user experience of this emotion-driven interactive video is impacted by the different player types (i.e. male vs female) and their preferences for different media (digital games vs traditional narrative media). In general, females feel more emotional involvement and empathy than males and those who like traditional media entertainment, such as TV and film, get more pleasure from interaction than those who like playing digital games: importantly, these findings have since been confirmed in convergent quantitative research carried out in our laboratory. These two factors are inter-related. Usually traditional media entertainment tends to create other-directed emotions, *i.e.* emotions directed towards others through empathy. In contrast, digital games are more likely to evoke self-directed emotions which concern the player's success and desires to fulfill their goals or tasks [13]. Psychological research [14][15][16] has shown that women are more likely to feel and express other-directed emotions than men who are more likely to experience self-directed emotions. This may be the reason why women tend to be the predominant audience of TV dramas since they focus on the emotional relations between the main protagonists [17], while males are dominant in the world of digital games [18]. Females therefore appear to be the potential target audience for this emotion-driven interactive digital storytelling.

This study also indicates that re-editing television footage can provide an effective way of making interactive stories, it is clear that the choice of footage is critical. The TV comedy *Ugly Betty* appears to cater more to women's taste, so it may be possible to choose material which might engage men better. For example, one player said he would be more interested if "there was Arnold Schwarzenegger". In addition to making characters more relevant, other footage could alter the pace and narrative style of the original material to make it faster moving. However, it is important to note that it takes time to create emotional conflicts and evoke emotions. This leads to a conflict between the length of video and the frequency of the player's interactions: further research is required to determine how long a video segment should be to evoke sufficient emotions while maintaining the player's interest in interaction.

In future, we will examine in more detail how different types of players and their previous experience determines their emotional response to storytelling to provide information which will make it possible to predict which target groups are likely to enjoy emotion-driven interactive digital storytelling. Two main concerns became apparent from this work: the need to find appropriate narrative genres for different groups of individuals and solving the conflict between the length of the video segment and the frequency of the player's interactions. Nevertheless, the results suggest that this emotion-driven interactive digital storytelling can create a variety of different emotional user experiences and has the potential to develop as a new approach for interactive digital storytelling design.

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Verification of Temporal Constraints in Continuous Time on Nondeterministic Stories*

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Abstract. This paper proposes a language based on temporal logics to specify constraints on nondeterministic stories, generated by interactive storytelling systems, taking into account that time is continuous and branched. These constraints are checked, in real time, during story generation. Constraints to be checked are described by temporal formulas over the properties of the story. To make possible the verification in real time, it is assumed that these properties are piecewise-linear functions. A prototype, using Constraint Logic Programming for the verification of properties, is operational.

Keywords: Continuous Change, Interactive Storytelling, Constraint Programming, Branching Time.

1 Introduction

Interactive storytelling systems are applications in which stories are generated and told in accordance with the user interference. They have been developed for different purposes, such as helping the authoring of stories, education and training and, of course, in the context of games and entertainment in general. In most of the cases, there are relevant continuous properties that vary over time. The level of tension, the intensity of emotions and soundtrack features are examples of such properties, which we might want to control. We can understand stories as a finite set of events that are logically connected so that goals are achieved. These events should generate peaks in the intensity of emotions, in order to keep the audience's interest in the story. The sequence of events should also generate an overall tension during the narrative, which typically reaches a climax that leads to the end of the story [1].

The author of a story should then be concerned with the variation of these properties. When the story is linear and closed, it is possible to predict, at least intuitively, their values and the degree of involvement of the reader at every moment. In interactive storytelling systems, the task is more complicated because there are different alternatives, generated automatically, to be considered. In particular, if the events of the stories are considered to be nondeterministic, the outcome of each event might lead to different continuations, providing then a greater degree of diversity in plots and more opportunities for user interaction. In this case, interactive stories (or parts of them generated at a given time) are trees of events, in which each path from the root to a leaf is an alternative plot.

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A nondeterministic model for the events within an interactive storytelling context is adopted in [2], where an extension of the system Logtell [3-5] is proposed to deal with nondeterminism and weak goals (representing attempts to reach a certain situation, which could either succeed or fail). Nondeterministic planning is used to generate a tree of events for every chapter of a story. The path followed during the 3D dramatization depends on the selection of branches, which occurs either at random or in accordance with (direct or indirect) user intervention. As continuous properties might vary in accordance with the followed path, it is interesting to provide a mechanism to check whether a tree of events satisfies a certain temporal constraint. In this paper, we propose an approach for verifying constraints on continuous properties in chapters generated by the new version of Logtell. The verification of continuous properties occurs just after the generation of each chapter. When constraints are not satisfied, the chapter should be discarded and another alternative chapter (another tree) generated.

As plot generation occurs in real time, in parallel with a continuous 3D plot dramatization, special care is taken to guarantee that the verification process does not hinder the overall storytelling process. Properties vary continuously over time and the evaluation of continuous changes tends to be very time consuming. Furthermore, as an interactive story corresponds to various paths resulting of the branches after each event, we should also be able to talk about these paths. It is therefore a problem to be approached by temporal logics such as CTL (Computation Tree Logic) [6], with the additional requirement of treating an infinite and continuous set of states. In order to be able to verify constraints in real time, we assume that the continuous properties are piecewise linear functions, the variation of the properties being specified by a sequence of constant values for their derivatives assigned to each event. By doing this, we are able to use *constraint logic programming* [7] to verify the satisfaction of constraints. As the height of the trees generated for each chapter is limited and the number of branches after each event is usually a number between one and three, we are able to avoid a combinatorial explosion on the number of different paths to be tested.

2 A Logic for Nondeterministic Continuous Events

As stories are created by means of an automatic process, formal models for the variation of the properties during the events have to be specified, so that an automatic verification procedure can be applied. A story, for example, may have a chapter in which a villain tries to kidnap a victim, with different possible outcomes. The villain might succeed, but the victim might also escape or die. If the desired level of suspense is reached, the chapter can be considered valid. If it is not reached, the chapter can be discarded. When time is considered to be continuous, the set of space states becomes infinite. Verifying the satisfaction of temporal formulas over an infinite space of states is extremely difficult, because there is no possibility of enumerating all possible states. We have then to resort to symbolic methods, which demand some kind of simplification in the way properties are represented.

In order to be able to verify constraints, we created a model for the specification of continuous properties as functions of the execution time. Each event has a function that specifies the derivative of the property. The derivative can vary during the event, but only as a sequence of constant values. Each constant value is assigned to a percentage of the execution time of the event. To calculate the level of a property at a certain moment, we can integrate the derivative from the beginning of the story until that moment, considering the specification of the derivative for each event. If we assume that the initial value of the continuous property varies linearly, we are able to use CLP in the verification process, because constraints to be imposed on the values are always linear. Most of the times, properties of stories that vary over time can be nonlinear functions of the time, but it is straightforward to approximate them by means of pieces in which the variation is considered to be linear. This approach simplifies the verification, as each piece is represented by a linear function and the transition from one piece to another occurs instantaneously. In this way, the satisfaction of constraints on the values can be verified by examining the ends of each linear piece.

The logic to be used in the specification of constraints has to be expressive enough to describe relevant constraints that should be satisfied by a (chapter of a) story with continuous and branching time. In this way, our logic uses the CTL path quantifiers **A** (meaning along **all** paths) and **E** (meaning that there **exists** at least one path) to speak about the satisfaction of a formula over the paths. To speak about the satisfaction of a formula over the states of a path, the following quantifiers are used: **U** (meaning that a formula holds **until** another formula holds), **G** (meaning **globally**, ie. in all states of the path), and **F** (meaning **finally**, i.e. at some state in the path). As time is continuous, the number of states is infinite and we cannot speak about the next state of a certain state, then the CTL operator X is not used in our logic. In contrast, we might want to impose constraints on the end of the (chapter of the) story. We added then a new state operator "**end**" which speaks about the satisfaction of formulas at this specific moment. A well-formed temporal modal formula is recursively defined by means of the following grammar (in which *a* and *b* represent linear combinations of continuous properties, which have specific values at each moment of the story, α and β represent temporal modal formulas, and the semantics for the satisfaction of basic constraints and formulas with the logical connectives (∧,∨,¬, and ⇒) is defined as usual):

$$\alpha, \beta \rightarrow basic\_constr \mid AF\ \alpha \mid AG\ \alpha \mid EF\ \alpha \mid EG\ \alpha \mid A\ \alpha\ U\ \beta \mid E\ \alpha\ U\ \beta \mid A\ end\ \alpha \mid E\ end\ \alpha \mid \alpha \wedge \beta \mid \alpha \vee \beta \mid \alpha \Rightarrow \beta \mid \neg\alpha \tag{1}$$

$$basic\_constr \rightarrow a = b \mid a \neq b \mid a > b \mid a < b \mid a \leq b \mid a \geq b \tag{2}$$

3 Verification of Properties

In our prototype, constraints are specified by means of the temporal logic described in the previous section. To implement a verification procedure, we chose to use a constraint logic programming package, corresponding to a version of Prolog, enhanced with constraint solving. We implemented verification modules that can run either on SICStus Prolog [8] or on SWI Prolog [9]. As explained earlier, nondeterministic stories (or their chapters) are modeled in the form of trees of events. The final dramatization is always one of the paths from the root to a leaf and depends on the user interaction and selections that occur at random. Figure 1 shows two alternative stories, note that in Story 2 the event after EV3 is EV7, instead of EV6.

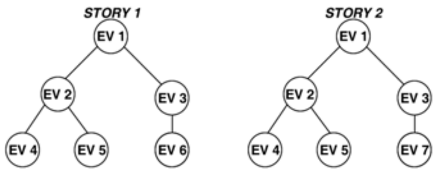

Fig. 1. Trees of events that represent two different stories

Suppose that we want to know if, in least one path, there is a time in the future in which the level of *Fear* is higher than the level of *Joy* and, from this time on, in all future paths, the final level of *Joy* is higher than the final level of *Fear*. We could use then the following formula:

$$(\boldsymbol{EF}\ (\ \boldsymbol{Fear} > \boldsymbol{Joy} \wedge (\boldsymbol{A\ end\ Joy} > \boldsymbol{Fear}))) \tag{3}$$

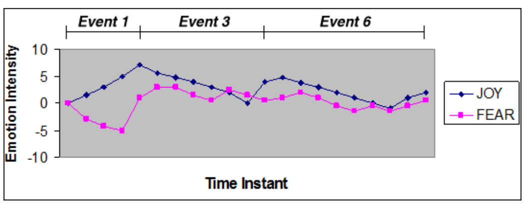

Fig. 2. Values of the properties in path EV1→EV3→EV6 in Story 1

Figure 2 shows that Story 1, because of the path EV1→EV3→EV6, satisfies this constraint as the condition (***Fear* > *Joy***) is true at a certain moment during EV3 and, in its only continuation, after EV6, the final values satisfy the condition (***Joy* > *Fear***).

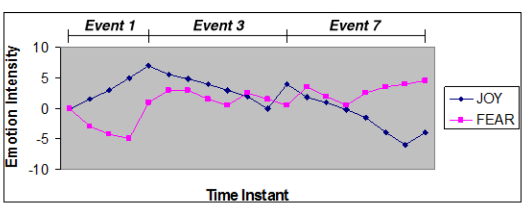

Fig. 3. Values of the properties in path EV1→EV3→EV7 in Story 2

Figure 3 shows, on the contrary, that the sequence EV1→EV3→EV7 in Story 2 does not satisfy the constraint. In order to satisfy the formula, Story 2 should have another path where the condition (***Fear* > *Joy***) could be observed at some state.

In our verification procedure, the events are broken into small parts, in which the derivative of all continuous properties is constant and we transform formulas in order to eliminate negations and conditionals. This is easily done using De Morgan's law and the fact that the negation of a basic constraint is also a basic constraint (e.g. the negation of A>B is A ≤ B).

As we consider the execution of a sequence of events, we impose constraints on the values of each property at various points during the event, and we establish the relation between them in accordance with the corresponding derivatives, here the verification process can be broken in two parts: (i) path verification and (ii) verification of the states of a path. In the first case whenever we have a formula with quantifier **A**, we test all alternative paths to be followed and, whenever we have a formula with quantifier **E**, we test the possible subsequent paths using chronological backtracking and stop the verification when the formula is satisfied. In the second case, whenever we have a formula with quantifier **G**, we impose constraints on all ends of each part of the event. Whenever we have a formula with quantifier **F**, we check, for each part of the event, two possibilities: the formula either holds at a specific point in the interval or it holds after that interval. In the first case, formulas to checked after that part might be identified and the process might have to go on by checking these formulas. The same occurs if we identify that formulas have to be checked in the subsequent events. Whenever we have a formula α **U** β to be verified, we need to verify if α holds in all states until β holds. In order to do that, we mix the strategies used for the verification of formulas with quantifiers **G** and **F**. Constraints are imposed at the ends of intervals to force the satisfaction of α, but we also consider (by imposing constraints) that β might hold at a specific point of the interval, which makes the satisfaction of α unnecessary in the rest of the path.

Formulas with operator "**end**" are verified only after considering the execution of the last event of a path. In order to speed up the verification process, we simplify formulas whenever it is possible. The verification of a formula *(EF EG p)*, for instance, can be transformed into an equivalent formula *(E end p)*, which is easier to test.

As the trees of events corresponding to the chapters have a limited number of branches and a limited height, the implemented procedure has shown to be effective to verify constraints in real time, without hindering the overall storytelling process. The verification of the satisfaction of a formula like (***EF*** (***Fear > Joy ∧ (A end Joy > Fear)***)) by stories with around 58 events and 18 different paths lasts no longer than 141 milliseconds in a PC running a Windows version of SWI Prolog on a Core 2 Duo processor.

4 Concluding Remarks

The real-time verification of continuous events is a difficult task that did not receive much attention in the early ages of Artificial Intelligence, because of the difficulty in modeling the events and technological limitations [10]. This type of verification, however, is extremely important. In many real world situations, there are properties that continuously vary over time. Technological advances in the area of verification of real-time systems led to the appearance of different computational tools.

Hytech [11, 12] is a system that works with the satisfaction of temporal formulas in continuous time on hybrid timed automata. The specification of the properties is done using a logic derived from CTL, which treats continuous time with the aid of delay and clocks variables. Hytech also works with derivatives of continuous variables, but it uses Model Checking procedures [13] and approximations based on exact arithmetic to perform verifications. In our approach, as the numbers of events and branches to be considered are limited, we did not have to resort either to the discretization of time or to approximations, which could occasionally cause errors. We chose to perform symbolic executions using constraint logic programming. In addition, we worked with nondeterministic events and proposed a temporal logic that tries to take into account the needs of constraining nondeterministic stories. The prototype is able to verify temporal constraints in continuous time on nondeterministic stories. Our preliminary tests show that such a verification can occur in real time. This is important because the procedure can be applied to: (i) force the occurrence of patterns that are either typical of the genre or can be more appealing to the audience in general and (ii) adapt stories in accordance with the preferences of a specific intended audience.

In spite of being proposed to be incorporated to Logtell, our approach can be used to verify continuous properties of other interactive stories, including eletronic RPGs (role playing games). Techniques can be used, for instance, to search for stories in a library of stories, using our logic to specify users' preferences. Moreover, the formalism proposed here may be useful in other systems that require the verification of properties that continuously vary over time.

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GrabApple: The Design of a Casual Exergame

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Abstract. Many people do not get the recommended 30 minutes of exercise per day, which can result in health problems such as obesity, muscle atrophy and chronic disease. Based on the principles of casual games and exergames, we propose and define casual exergames for motivating people to exercise in multiple small chunks of time throughout the day. We designed, implemented, and tested a casual exergame called GrabApple. Our preliminary results show that users enjoyed playing the casual exergame and that in just 10 minutes of play, their heart rate was elevated to an average of 72% of maximum heart rate, and that they burned an average of 91.8 Calories. If played three times per day, our casual exergame produced sufficient physical activity to meet current fitness guidelines. We discuss the potential health benefits of casual exergames.

Keywords: Exercise, casual game, exergame, exercise efficacy.

1 Introduction

People should do at least 30 minutes of moderate-intensity exercise a day; however, most people do not perform this suggested amount of daily exercise despite the benefits [1]. First, regular exercise can reduce the risks of developing coronary heart disease, hypertension, high blood pressure, colon cancer, obesity, and diabetes [1]. Second, physical activity can relieve symptoms of depression and anxiety, and improve mood [1]. Third, aerobic exercise has been linked to cognitive benefits, improving many aspects of cognition and brain function [2]. Finally, a healthy society produces less strain on an overburdened health care system.

One strategy to encourage people to get their recommended amount of daily activity is to break the 30 minutes of exercise into smaller chunks so it is more manageable. People might then be able to better manage this time commitment, and there would also be a lower overhead to exercising, including reducing the need to change into exercise clothes or shower after exercising. Research supports that breaking exercise into small chunks is a good approach because the physical benefits of three moderate-intensity short bouts of physical activity (lasting about 10 minutes) are similar to one continuous 30-minute bout [3, 4]. Still, given a 10-minute break in their day, many people do not choose to use this time to exercise because typical short bursts of activity, such as climbing stairs or jogging for 10 minutes are not very enjoyable. Many people say they do not exercise so they can do other activities, such as watching television (47% of respondents selected this), sleeping in (43%), doing household chores (59%) or working (43%) [5].

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One approach to making exercise more fun is through the use of exergames, which are games that use exercise as part of the activity required to play a video game [6, 7]. Exergames have been shown to be more fun to play than a corresponding level of standard exercise [7]. Although exergames can promote physical activity, these games are often tedious to set up, use specialized hardware, and need a committed chunk of time to play. To motivate people to do 10-minute bouts of exercise in a fun way, we take the novel approach of applying the principles of casual games—which have been described as games that are "fun, quick to access, easy to learn and require no previous special video game skills, expertise or regular time commitment to play" ([8], p.3)—to exergames [7], creating the new genre of casual exergames. We define casual exergames as *games that players can learn easily and access quickly, using simple rules and special game mechanics, to motivate them to exercise at a moderate intensity for short periods of play*. The advantages of casual exergames are two-fold. First, casual games appeal to people of all ages, genders and nationalities [8], are fun, and are easy to start and stop playing. Second, exergames have game mechanics promoting exercise so it makes exercise seem less difficult and more enjoyable [7]. Therefore, casual exergames should motivate physical play in small manageable chunks of time, and help people to exercise for the recommended 30 minutes per day.

We designed and implemented a casual exergame based on the principles of casual games and exergames. To make the game simple to play we use the player's body as the game controller, where movement is sensed through the use of inexpensive and accessible hardware (Microsoft Kinect sensor). Through a four-month development process, we iteratively playtested our game, generating a short, fun, and easy-to-learn play experience that caused players to elevate their heart rate and burn Calories.

We then conducted a preliminary study to investigate how much fun our game is and how much exercise it produces in players. We compared our casual exergame to a mouse-based version of the game using eight study participants. Initial results showed that the casual exergame is fun to play and can elevate players' heart rates to target levels for moderate-intensity aerobic exercise. We discuss the potential health benefits of casual exergames and present future research opportunities in this space.

2 Defining Casual Exergames

2.1 Casual Games

In 2006, the casual games industry was a $2.25 billion/year industry and was growing by 20%/year [8]. This was prior to the smartphone and tablet revolution, which has catapulted casual games into an entirely new level of popularity. There are many definitions for casual games and the community has yet to converge on a final definition [9]. The Casual Games SIG of the International Game Developer's Association (IGDA) defines casual games as "games with a low barrier to entry that can be enjoyed in short increments" ([10], p.9). The casual games community has generally agreed on the following criteria for a game to be considered casual:

Easy to learn. Casual games should have limited instructions, provide rules that are easy to learn, and guide players with a clear and consistent user interface [10].

Simple controls. Casual games should take advantage of assumed knowledge, such as drag, drop and click [10].

Play in a relatively short play period. Casual games should be able to be enjoyed in a series of short time increments, though sometimes people play one level after another for many hours [8]. Most casual games' play intervals are between 5 and 15 minutes to complete a level [8].

Reduced complexity and non-punishing game play. Casual games allow depth and complexity to emerge from the player's basic actions instead of making the player master a large and complex set of actions [10].

Family friendly. The IGDA Casual Games SIG deems that casual games should not contain objectionable content, such as overt violence, or sexuality [10]. The CGA agrees that casual games should appeal to people of all ages, genders and nationalities [8]. In recent years, casual games have been developed (e.g., games rated 17+ for Apple's iPad) that do not adhere to this criterion.

2.2 Exergames

Exergames can motivate players to be more physically active by combining games and exercise together. Some commercial games can be considered exergames. For example, in Dance-Dance Revolution, players step on colored sections on a platform to musical and visual cues [11]. Wii Fit works directly with the Wii console to bring players a fun and exciting way to experience fitness [12].

Researchers have designed and tested a variety of exergames. Some games use custom sensors such as in Ping Pong Plus [13], Breakout for Two [6] and Kick-Ass Kung Fu [14]. Others have integrated standard exercise equipment, such as the stationary bikes used in Heart Burn [15] and Life is a Village [16]. Exergames have also been developed that do not prescribe the type of exercise, but are based on the player's heart rate, such as Triple Beat [17] and Nenonen et al.'s biathlon game [18].

Because our game is intended to be a casual game, the overhead to play needs to be minimal and we cannot use expensive hardware, such as resistance bikes or custom sensor floors. We chose to use the movement of the body as input to the game, requiring no game controller or exercise equipment.

Efficacy of Exergames. The goal of exergames is to create play experiences that are both fun and that elevate heart rate. In general, researchers have shown that their exergames are fun to play, but do they have the same benefits as regular exercise? Research shows that many exergames can be utilized as part of an overall aerobic exercise program because in a 30-minute exercise session, a player's heart rate and caloric expenditure are both within the American College of Sports Medicine recommendation for daily physical activity [19]. However, in another study that investigated the relative efficacy of Wii games and their real life sports counterparts, it was shown that the energy that players used to play active Wii Sports games was not of high enough intensity to reach the recommended daily amount of exercise in children [20]. It is important for exergame researchers to demonstrate the efficacy of the exercise generated by their game to ensure that the players of these games are getting the health benefits of exercise. An alternative viewpoint is that playing exergames (as opposed to traditional games) means that players are at least unable to simultaneously play and work their way through an unhealthy snack such as a bag of potato chips. Although perhaps not a direct benefit, replacing traditional games with exergames will at the very least prevent this type of unhealthy behavior.

2.3 Casual Exergames

Because we are proposing a new genre of game, there is not a previous framework to understand the casual and exergame aspects of casual exergames. We propose that casual exergames are games that require exertion to play and adhere to the criteria of casual game design. More specifically we define casual games as *games that players can learn easily and access quickly, using simple rules and special game mechanics, to motivate them to exercise at a moderate intensity for short periods of play.*

Some people argue that exergames developed for recent commercial gaming platforms, such as Wii Sports, can be considered as casual games [8, 10] because they are easy to learn, are family friendly and use simple controls. However, many commercial exergames do not provide enough exercise intensity to be considered a casual exergame by our standards. For example, previous work shows that the energy used playing active Wii Sports games is not intense enough to reach the recommended daily amount of exercise for children [20]. In addition, these commercial games do not necessarily meet the criteria for casual games defined previously; i.e. casual games must be able to be played in a relatively short play period. If casual games are to be played in short play periods, they should also be quickly accessible games with little-to-no setup time [10]. If setting up a console game requires even 5 minutes to boot the system, navigate the menus, and calibrate the controllers, then it is not in line with the duration of play expected of a casual game. Finally, the accessibility of gaming consoles, which are generally kept in domestic environments, limits their use as systems on which to play exergames during breaks in the work day.

3 GrabApple: A Casual Exergame

We designed GrabApple—a casual exergame that uses the player's body as the game controller and the player's own body weight as resistance to elevate heart rate. In this section, we describe the design and implementation of GrabApple and show how it conforms to the principles of casual game design and efficacious exergame design.

3.1 Game Concept

In GrabApple (Figure 1), the goal is for players to try to pick up falling red and green apples and avoid touching the falling bombs. Apples and bombs are picked and touched using a virtual hand whose position on the screen is controlled through the movement of the player's body. Each apple picked adds one point to the total player score, while each bomb touched subtracts five points.

Fig. 1. GrabApple. Players move the hand to grab falling apples while avoiding falling bombs

Designing for Casual Interaction. We designed the game to conform to the principles of casual game design in the following ways:

1) *Easy to learn.* The concept of GrabApple is easy to learn – a player should touch the apples and avoid the bombs. There are only two additional mechanics: players can only hold five apples at a time and thus need to empty the virtual hand into a collection bag; and there is a mushroom bonus that appears and players have to press a key on the keyboard to get extra points. Also, we clearly provide feedback to players on their performance through floating scores and an energy bar that displays total points (Figure 1).
2) *Simple controls.* GrabApple uses the player's body as the game controller. The virtual hand is mapped to the player's movements so players jump, duck and move to control the virtual hand movement.
3) *Play in a relatively short play period.* GrabApple takes an average of three minutes to complete a game level. The setup time is also in line with short play periods. After plugging the Microsoft Kinect sensor into the computer's USB port, the player launches the application in a similar manner to most casual games. With the short setup time and the use of standard computers, players can quickly access and play our casual exergame.

4) *Reduced complexity and non-punishing game play.* The game mechanics and controls of GrabApple are simple. In addition, it is difficult to lose the game, but players are rewarded after completing a level with an unlocked higher level and can compete for the high score.
5) *Family friendly.* GrabApple has no objectionable, violent, or sexual content.

Designing for Efficacious Exercise. We motivate people to get the recommended aerobic exercise intensity level through the game design and game mechanics.

1) *We encourage players to move around.* We give score multipliers for picking consecutive apple of the same color and give a penalty for touching any bombs. This encourages the players to move the virtual hand around the screen instead of standing and waiting for the apples to fall.
2) *We elevate players' heart rates by using their own weight as resistance.* The virtual hand on the screen can only hold five apples. Players have to empty the virtual hand by putting it into the collection bag on the right side of the screen. They can only reach this bag by running to the side and jumping, thus using their body as resistance and increasing their heart rate. Also, in order to pick up the maximum number of apples, players need to jump up and bend down.
3) *We elevate players' heart rates by adding extra exercise.* Once in a while, a mushroom appears on the screen and players can get a five-point bonus by picking up the mushroom. In order to receive the bonus points, players have to run to the keyboard and press any key. Players have to hurry, as the mushroom is only available for two seconds, so they need to reach the keyboard as fast as they can. Because players stand approximately 1.5 meters from the keyboard when playing the game, quickly running to the keyboard increases overall activity.
4) *We raise exercise intensity by increasing game difficulty through game levels.* In higher game levels, we increase the speed and the number of falling apples and bombs. These game levels become accessible when players get sufficient points as shown by the energy bar on the left of Figure 1.

We designed our game for casual play and for exercise, but also designed the game to be fun to play through the use of reward animations and player achievements [21].

3.2 Game Implementation

We implemented two versions of our game: the exergame and the mouse version. Both games were programmed in Processing. For the casual exergame, we use the Microsoft Kinect sensor to detect users' body movements. The Kinect is essentially comprised of one camera that detects x and y position and another infrared receiver camera that detects depth through the dispersion of dots displayed via an infrared transmitter. In our game, we can track the player's body movement by the average location of a given number of points that meet a specific depth threshold. We use Daniel Shiffman's Kinect library for Processing [22]. For the mouse-based version, we use the mouse cursor location to control the position of the hand on the screen and players left clicked the mouse to empty the hand into the collection bag.

Fig. 2. Playing the Kinect (left) and mouse version (right)

4 Preliminary Study

We investigated the enjoyment of our game and the intensity of exercise during play.

4.1 Participants

We recruited 8 university students (7 male), aged 22 to 44 (mean of 29). Six of the participants played video games at least weekly; the other two played only a few times a year. Our players reported that they play different types of video games, including role-playing games, first-person shooters and puzzle games. None of our participants play games using the Kinect on a regular basis.

When asked about their daily exercise, only 3 out of 8 participants got 30 minutes of sustained physical activity per day. Four participants exercised for 15-30 minutes per day, while one exercised for 0-15 minutes per day. Most players (five) said that they do not have time to complete the daily-recommended amount of exercise, and three said that their lack of exercise was due to laziness. When asked if they take regular breaks during the workday, six of our players said that they take a break every hour or two. The other two reported that they seldom took breaks.

4.2 Apparatus

The game was played on Mac OS X 10.6.6 with a 20-inch monitor. A low resolution (800×600) was used as players stood about 1.5 meters from the display to play the casual exergame. During the play of the casual exergame, players wore a Garmin Forerunner 110 heart rate monitor with a strap around the chest so we could log their heart activity and the Calories burned.

4.3 Procedure

A within-subjects design was used where participants played both the casual exergame and the mouse-based version. To reduce crossover effects between conditions, players visited the laboratory on two consecutive days to participate. To reduce differences between conditions, we had participants play at approximately the same time each day and asked them to try to keep their patterns the same prior to each experimental session in terms of the amount and time of food and caffeine consumption, and the amount of sleep. To reduce order effects, half of the participants played the casual exergame on the first day, while the other half played the mouse-based version first.

Participants began by filling out an informed consent form and learning the rules and procedures of the game through an initial training session. Then participants played the game for 10 minutes. After playing the game, participants rated their exertion level according to the Borg Rating of Perceived Exertion Scale, where people subjectively rate how hard they feel they are working on a 15-point scale ranging from 6 (no exertion) to 20 (maximal exertion) [23].

After completing the second experimental session, participants filled out a questionnaire asking about their demographic information and for a comparison of the two game versions.

5 Results

We first present the results for the efficacy of exercise, followed by the results related to the enjoyment of the game.

5.1 Efficacy of Exercise of GrabApple

The American College of Sports Medicine recommendations for moderate-intensity exercise is 64–76% of maximum heart rate (220-age) [24]. After our participants played the casual exergame for 10 minutes, their average heart rate was 72% (SD=12%) of their maximum heart rate, which is in the range of moderate-intensity exercise. The average Calories burned in those 10 minutes was 91.8 (SD=31.86). If we assume that participants play our game for three 10-minute bursts per day, the average Calorie expenditure will be 275, which exceeds the recommended Calories per day that adults should burn through aerobic exercise (200 Calories)[25]. The average Borg Rating of Perceived Exertion after playing the casual exergames was 12.38 (SD=0.85), which is within the recommended intensity for improving aerobic capacity of 12-13 (somewhat hard) to 15-16 (hard) [23]. The exercise efficacy of GrabApple as indicated by our measures is shown in Figure 3.

5.2 Exergame vs. Mouse-Based Game

We asked participants to rate five aspects of the game (fun, exciting, challenging, frustrating, and easy to learn) on a 5-point Likert scale (1=strongly disagree, 5=strongly agree) after playing each version. Given the non-parametric nature of our ratings data, we transformed these ratings into ranks – for each question, participants chose the mouse version, the Kinect version, or neither. Figure 4 shows the rankings. A chi-squared test for each aspect reveals that more participants thought that the Kinect version was more fun ($\chi2=6.3$, $p=.044$), more exciting ($\chi2=7.0$, $p=.030$), and more challenging ($\chi2=16$, $p\approx.000$). They were equally easy to learn as evidenced by a majority of participants choosing neither the mouse nor the Kinect version ($\chi2=7.0$, $p=.030$). There was no difference in the choice of game for frustration ($\chi2=4.75$, $p=.093$).

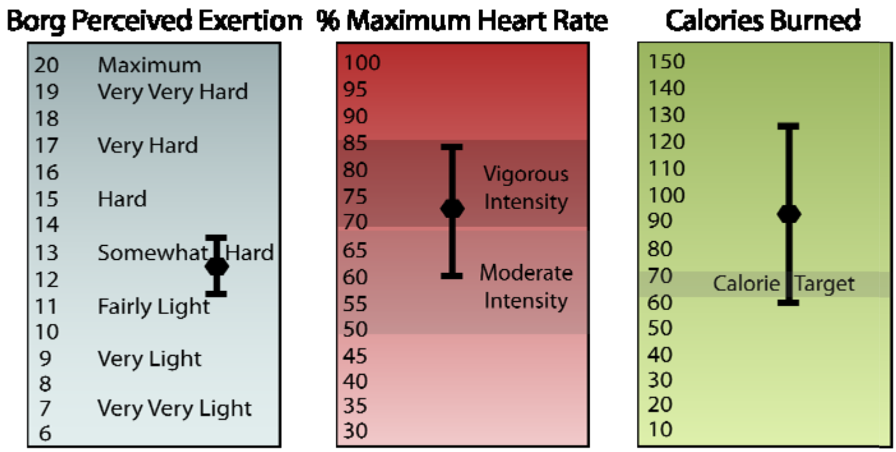

Fig. 3. Our three measures of exercise efficacy. Dots represent the mean of that measurement over all players and error bars represent one standard deviation in player measurements. The average perceived exertion is somewhat hard, the average heart rate is within recommended targets for aerobic activity, and the number of Calories burned exceeds the recommended Calories that adults should burn through physical activity three times daily.

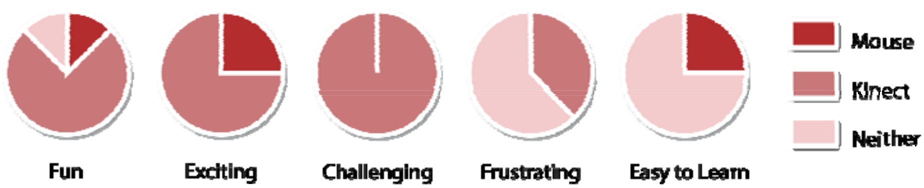

Fig. 4. Participant rankings for the two versions of the game. The size of the pie wedge for the mouse and Kinect version shows the number of participants who ranked that condition higher. The 'neither' wedge shows the number of participants who ranked both versions equally.

We asked whether participants would consider playing the casual exergame when they had a ten-minute break during their day. Five participants agreed or strongly agreed, with one participant answering each of neutral, disagree or strongly disagree. The participants who disagreed were also two of the bottom three participants in terms of exercise intensity as measured by both target heart rate and Calories burned. It could be that these players were not sufficiently motivated by the game to try hard and would not choose to play it again. It could also be that these players were quite fit and the game did not promote enough activity for them (in which case they don't need a casual exergame to get the recommended daily activity levels). For one of the players, this was the case as s/he already gets over 30 minutes of exercise every day.

6 Discussion

Our results showed that GrabApple is fun and that most of our participants would consider playing the casual exergame during breaks in their day. Our results also showed that the level of exercise produced by our casual exergame is sufficient to provide health benefits when played a few times per day in 10-minute increments. After playing the Kinect version of GrabApple for ten minutes, participants' average heart rate, Calorie expenditure and Borg exertion rate were all within the recommended exercise intensity [23-25].

In summary, our casual exergame was fun to play and produced a level of exercise consistent with targets for moderate-intensity aerobic activity.

6.1 Future Work

Although our initial results are very encouraging, there are three main research directions that we plan to pursue to establish casual exergames as a method for improving health. First, we need to design and implement a suite of casual exergames. To encourage play for the recommended 30 minutes of activity per day, we need to provide players with a selection of games so that repeating the play of a single game during each exercise break does not bore them. As part of this process, we will use the feedback provided by our participants to adjust the gameplay of GrabApple. For example, one player recommended giving score multipliers for consecutive apples grabbed using duck then jump movements. These changes could increase the amount of exercise achieved during play. Second, we need to establish that people are sufficiently motivated by the casual exergames to play them when not participating in an experiment. To find out whether people will partake in short bursts of physical activity by playing casual exergames, we will supply our suite of casual exergames to participants for a longer-term study. Through a combination of data logging and exit interviews, we can establish how well our games motivate people to exercise in small bursts throughout their day. Third, we need to conduct larger studies to establish the health benefits of casual exergames. We plan to consider both physical health and cognitive health as physical activity can relieve symptoms of depression and anxiety [1], and improve mood [1] and cognitive function [2]. Finally, as new forms of activity sensors become available on personal computers, laptops and smartphones, we will consider how to develop casual games for emerging sensing hardware to continue to improve the accessibility of casual games for players.

7 Conclusion

To encourage increased physical activity through short bouts of fun activity, we applied the principles of casual game design to exergames in our design and implementation of GrabApple – a casual exergame. Initial tests of GrabApple are encouraging. First most of our participants enjoyed playing the casual exergame and would consider playing the game during breaks in their day. Second, participants' heart rates were elevated to aerobic levels and sufficient Calories were burned during game play. In general, we are encouraged by our preliminary investigation and plan to continue this line of research with further development and formal studies of casual exergames. Casual exergames are an interesting new genre of games that can add physical activity into people's daily routines in an enjoyable way.

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Motion-Based Games for Parkinson's Disease Patients

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Abstract. Games for rehabilitation are developing rapidly in recent years. It has been shown that utilization of therapy and gaming technology affects positively on the patients' physical and mental condition. However, to this day there are only few playable games for Parkinson's disease patients. This paper presents the development process of WuppDi! – a collection of five motion-based games for Parkinson's disease patients, aimed at supporting their exercises routines in various playful environments. We describe the game design challenges for Parkinson's disease patients and our solutions used in the games. Finally, we present the results of a conducted field test showing a very positive motivational effect among the majority of the patients but also highlighting remaining issues and technical difficulties, which can be beneficial for the future development in this field.

Keywords: serious games for health, parkinson's disease, motion-based game controls, physiotherapy.

1 Introduction

Parkinson's disease (PD) is a non-reversible, progressive neurodegenerative condition. The main physical symptoms of PD are slowness of movement, loss of ability of movement, rigidity of the arms, legs or trunk, resting tremor, and problems with balance and falling [15, 14]. Besides the medication, physiotherapy plays the most important role in treating PD [6]. However, it is only effective when the exercises are done on an intensive daily basis [9, 17]. Daily training, supervised by a therapist, poses great economical problems for most patients [5, 12] and patients often get mentally bored and physically tired [20] thus losing their motivation. WuppDi!, our collection of motion-based games, addresses these problems by offering a low-cost game system to complement physiotherapy. Previous research has shown that games can be effective because exercising through games is perceived as play rather than therapy by the user [4]. Games offer the possibility of unlimited repetitions facilitated by a continuous feedback loop, immersion, and a state of winning [9]. While mainstream commercial training games and game devices like the Nintendo Wii could be useful for physical therapy purposes for PD patients, e.g., to help to decrease rigidity of patients with PD [10] or for lowering akinesia [9], improve coordination, spatial

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perception, reflexes, and balance [19], off-the-shelf games are not designed with the special requirements of PD patients in mind and thus are too difficult, especially for severe cases [9, 12, 17]. Furthermore, commercial games, e.g. for the Playstation EyeToy, usually include negative feedback when the performance of the player is not sufficient [4] and lack meaningful tasks in terms of therapy [8]. In contrast to these systems, WuppDi! is particularly designed for and with PD patients to aid them in exercising at home. Besides presenting our games, we also want to examine whether it is possible to let PD patients enjoy the exercises provided by our system.

2 Related Work

In the field of virtual systems for rehabilitation, the Interactive Rehabilitation EXercise (IREX) system is commonly referred to as the state of the art example [5, 12]. Unlike WuppDi!, this system requires an elaborate setup. In some cases, it also requires the users to wear gloves. Finally, due to its cost, the system is not applicable to home use. Based on studies of Kizony et al. the Playstation EyeToy, which shares a similar motion-based approach as WuppDi!, is able to induce the same level of felt presence as the more complex IREX system [12, 17].

A system similar to WuppDi! in terms of overall cost and input paradigms was developed by Burke et al. [5]. However, their system is designed to be used in the field of stroke rehabilitation. Their system and WuppDi! both rely on a webcam interface tracking colored markers. However, our system additionally offers games that can be played with free motion input where no colored markers are required.

A system in the area of PD therapy described recently by Yu et al. [20] makes use of a sophisticated motion capture system. While trying to catch falling objects, the player is shown an avatar mirroring his movements. Movements promoted by this system are of similar, repetitive nature as in our system. In contrast to WuppDi!, this system requires the user to wear motion tracking sensors placed on several positions on her body. To our knowledge there are only a few games specifically aimed at patients with PD sold commercially, none using full body motion input. One example produced in 2004 by Roche Pharma AG, called “Welt der Spiele”[1], is a collection of mini-games using standard mouse and keyboard controls.

An early approach towards a taxonomy for games for rehabilitation considers features like application area, interaction technology, game interface, number of players, competitiveness, collaboration, genre, adaptability, progress monitoring, performance feedback and portability [18]. With regard to this taxonomy WuppDi! trains both cognitive and motor skills. The interaction with the interface is through motion tracking using 2D and 3D. Only one player is able to use the system at a time, but a turn-based competitive multiplayer mode is included. WuppDi! fits in the game genre “assorted”. Currently, no dynamic adaptability is available but there are levels with various difficulties. Both visual and auditory feedback guides the player. However, there is no progress tracking. The game can be setup up at home as well as in clinics.

[1] http://www.slvideo.at/de/portfolio_interaktiv01.htm (accessed: April 18th, 2011)

3 WuppDi!

3.1 Development Method

In order to develop games specifically tailored to PD patients, we followed a participatory design approach. We established a cooperation with the Bremen regional group of the "Deutsche Parkinson Vereinigung e.V."[2] (German Parkinson Association), an association for self-help of PD patients, which provided us with contacts to patients and physiotherapists. With their help and by participating in physiotherapeutic sessions we gained further insights into patients' motion disabilities and training requirements. With respect to games and game technology, we started testing commercial off-the-shelf motion games (Wii Sports and Playstation Eye Toy Play) with patients to identify advantages and problems of game mechanics and input devices. The outcome was that participants in general enjoyed this new way of physical activity. However, these games turned out to be too demanding for this target group, especially in terms of handling the input device, visual overload and concerning speed and complexity of game play. The development of WuppDi! was initialized by creating throw-away prototypes for testing basic input mechanics. Afterwards, the final games were implemented in an iterative process over a period of 6 months, involving monthly field tests with small groups of PD patients for identifying problems and gaining feedback for constant enhancements. The final state was evaluated in a more extensive field study.

3.2 Design Principles

Through research and experiences during the development of the WuppDi! games the following principles were identified which should be taken into account when designing games for this target group.

Appropriateness of Movements – In order to design game mechanics that are beneficial for training, the movements encouraged by the game should be adapted to the abilities of the patients and ideally adopted from tailored gymnastic exercises. Especially the amplitude of movements is a crucial factor. Early prototypes showed that slow accurate movements of the arms are difficult and even induce or intensify tremors which cause frustration. Besides, PD patients tend to do very reduced movements and rather need to train continuous large amplitude movements ideally involving their whole body as also highlighted in the "Training BIG" approach [7]. The games should therefore foster wide fluent movements.

Positive Feedback – Visual and auditory feedback is an effective mechanism to support players' perception of their progress and the effect of their actions on game elements [5]. In the case of games for therapy and rehabilitation, especially positive feedback is of importance and should be emphasized [5, 8]. We experienced that patients felt frustrated when they could not achieve the goals relatively straight away. Some of them felt that the failure was a result of their own poor abilities and even

[2] http://www.parkinson-vereinigung.de

excused for their performance. Therefore, it is important to reward players for their engagement, give them a feeling of success and encourage them to continue playing [5, 8] more so than in mainstream games. Besides encouraging sounds, nice visual effects, and rewarding feedback texts, we designed our games in a way that there is no failure in terms of loosing progress regardless of the player's performance.

Simplicity and Support – Many PD patients have, like elderly in general, little experience with computers and only few of them have played video games. Therefore, simplicity is an important principle to avoid excessive demand and frustration of players. Regarding gaming devices, our tests with the Wii revealed that patients are hardly able to coordinate moving a controller and pressing buttons at the same time. Even with no button input required, they seem confused by the presence of the buttons. We designed our input in a way that it only requires simple non-technical equipment or no equipment at all, respectively. For the game design it is important to avoid visual overload and respect the slower response times of the target group in terms of reaction and movement [8, 1]. To help novel players overcome the barrier of first time use, it is beneficial to provide built-in instructions [1]. We created video tutorials for each mini-game, introducing story, goal, and controls of the game.

Adaptability – The cognitive abilities and motor skills of PD patients vary largely depending on their specific symptoms, the state of their disease, or even their daily condition. This poses challenges in designing a game play that is accomplishable but yet demanding and interesting enough, even for practiced players. Our collection of mini-games cover different degrees of complexity. While some games are rather simple and mainly focusing on movement, others require an advanced level of coordination or concentration. For alternating the difficulty within games, mechanisms from commercial games, such as levels, can be adopted [5]. Alternatively, approaches for dynamic adaptation of difficulty according to the player's performance and difficulty calibrations through physiotherapists have been proposed [2, 5]. Each of our games features several levels or game modes of increasing difficulty which can be chosen by the player or an instructor.

Music and Rhythm – As described in the literature [13, 20, 16] and also observed in gymnastic sessions, music plays an important role in the training of PD patients for initializing and facilitating movements and overall enhancing the effectiveness of the therapy. Regarding these positive effects, music and rhythm should be considered important elements in game design. We suggest including background music with a clear beat that is aligned to the speed of game play. Beyond that, game mechanics can base upon rhythmic movements related to dancing. Here, the player scores higher when staying in the rhythm.

Appeal and Familiarity – One of the most challenging aspects in designing computer games for the elderly is to create appealing game scenarios. Understanding fields of interests, avoiding negative and violent contents can make the games more appealing for elderly to play [1]. Furthermore, Aison et al. [1] emphasize the importance of familiarity as the main motivation for game selection. Based on these elements, we chose fairytale as our main theme. Five well-known fairytales provide the background theme for each of our mini-games. The fairytale theme also offers the potential for cross-generational play of PD patients with their younger family members (e.g. grandchildren) which could increase their motivation to play.

3.3 Implementation

We aimed at a system that is deployable in physiotherapy groups or at homes of patients, i.e., that can be installed on prevalently existing hardware without the need of purchasing expensive or special equipment. Games are implemented using Microsoft XNA Game Studio 4.0 and can be run on any DirectX 9 compatible Windows PC. For the input, a webcam is required. While any webcam works in principle, we used the Sony PlayStation Eye camera due to its wide lens and good performance in low light conditions. For input processing, two alternative methods (with and without colored markers) were implemented using the OpenCV[3] computer vision library Marker input is based on a simple color tracking approach that is able to distinguish yellow and red markers. The markers are graphically represented in the game, in the form of hands or tools, and can thus be used to interact with virtual game objects. As marker, we use self-made colored Styrofoam balls fixed on a wooden stick. Alternatively, colored gloves have been tested during development which turned out to be unpleasant for some of the patients. Due to a lack of fine motor skills they had problems putting the gloves on by themselves and had to be helped by the instructors. Marker-based games require the use of either one or two markers, one to hold in each hand. Markerless input is based on detecting movements of the player by computing the difference between subsequent frames of the webcam capture. Actions in the game are triggered if motion is detected within certain predefined areas. These are either invisible or displayed on screen, e.g. in the form of buttons or collectible items. In order to give the player spatial feedback, the webcam image or the binarized image difference is shown in the background during play.

3.4 Games

Following the design principles mentioned above, we created five mini-games that are depicted in figure 1. Each game is based on a well-known fairy tale. The games are accompanied by an interactive game menu (cf. figure 1, top left). The main game menu for selecting a mini-game contains six buttons arranged in an arch shape around a human silhouette. Seeing the webcam image in the background, the player can arrange herself to stand within the displayed outlines indicating the optimal position to reach all buttons. Using markerless input, buttons are triggered by reaching for them and waving the hand for three seconds. Once a game is chosen, a submenu displays a tutorial video and instructions. Subsequent menus, similarly structured as the main menu, let players select level, difficulty and (if applicable) number of players.

Cinderella is a markerless game that can be played by up to three players. The game encourages movements according to music rhythm. The player has to mirror the

[3] http://sourceforge.net/projects/opencvlibrary/

movements of a prince avatar in the given rhythm and will thereby hit musical notes. Movements are based on gymnastic exercises and include: stretching both arms sideward and moving them up and down simultaneously, moving both arms diagonally up and down, and marching with swinging arms.

Ali-Baba is a single player memory game, played with two markers. The player has to get a secret treasure hidden behind a cave's door by memorizing and repeating motion sequences in the right order which are demonstrated by a thieve character. Stretching the arms towards buttons placed around the door triggers them and opens part of the door until the treasure is revealed. Town Musicians is a single player game, played with two markers representing a needle and a net, respectively. The player has to release captured town musicians' voices from flying bubbles by first freezing them with the net and afterwards bursting them with the needle. The game trains coordination between both arms and requires large continuous movements to reach bubbles across the screen.

Frog Prince is an explorative single player game based on markerless input in which the player has to steer a frog avatar through a pond, collect items and finally find a golden ball. The game requires wide circular arm movements, similar to breaststroke swimming. Synchronous movements of both arms make the frog swim forward; isolated single arm movements make it turn right or left.

Star Money is a single or multi player game that can be played with one or two markers. The game aims at training wide hand motion in a variety of ways depending on the selected game mode. In one, the player has to control a girl character by performing horizontal arm movements and collecting as many falling star coins as possible. In the other mode, she has to follow a star trail by performing fluent wide circular single arm movements in order to let stars fall from the sky. In multiplayer mode, both modes are combined, each played by one player.

4 Field Study

We conducted a field study to see how PD patients use the games in terms of game content, game play, and motion. The field study included a questionnaire, a reaction speed measurement tool, and an open interview part. Our field study was conducted in collaboration with local physiotherapy groups for PD patients with a total participant number of thirteen. Participants were between 54 and 86 years old with an average age of 70 and an average affection of PD of about 9 years. Both female (38%) and male (62%) participants participated. 70% of the participants reported to own a computer but none of them owned a webcam. 38% of all participants reported to play games that are included in operating systems, e.g., “Minesweeper” or “Solitaire”. 15% had already played games on the Wii console. 46% of the participants had already been involved in the development process and were familiar with one of the previous versions of WuppDi! and familiar with the input paradigms. Eleven of 13 participants confirmed they do training at home where seven of them stated to do this on a daily basis. Only two of 13 participants negated to do any physical training at home.

Fig. 1. Top left: Game Menu; Top right: Cinderella; Center left: Ali-Baba; Center right: Town Musicians; Bottom left: Frog Prince; Bottom right: Star Money

4.1 Setup and Procedure

We used a projector as a display device. Participants stood in front of the projection wall with enough space to perform the physical activities. We recorded the evaluation sessions on video from two different perspectives (front and back view of the participant). Each evaluation session began with the instructor reading a short introduction to the participant introducing the functionality of the reaction speed measurement tool (cf. figure 2). A short survey about demographical data followed and then the participants completed the reaction speed measuring tool. Each participant played two games covering both input methods used in WuppDi!. Each game was introduced by the instructor in terms of game play and game goal. Then the open interview was conducted. Afterwards, each participant left the evaluation room and completed the questionnaire part in private.

The participants were asked to complete a speed measuring test using our testing tool to assess their limits with regard to our chosen input method (cf. figure 2). The tool was designed to measure the reaction speed of a visual stimulus for activation of an in-game object. In the open interview directly after playing, participants were asked which game they liked and what specifically they had fun with. Then the participants were asked to fill out the questionnaire. With respect to the target group the overall number of questions we could ask in the questionnaire was severely limited. Therefore, we decided to aim for a broad feedback on game experience as well as usability considerations. Thus our questionnaire was composed of different parts of existing tools, sacrificing comparability to some extend for potential insights on a broader scale. The questionnaire was composed of parts of the Game Experience Questionnaire (GEQ) [11] and the System Usability Scale (SUS) [3]. We added some specific questions about physical motion, game theme, and aesthetics and asked the participants if they would play WuppDi! Together with their grandchildren. All questionnaire parts used a five point Likert scale. As the evaluation took place in a physiotherapist practical, experts on physical therapy were present during the evaluation sessions to monitor the participants while taking part in the sessions.

4.2 Results and Discussion

The results of the speed measurement tool showed that all participants performed equally and well in completing this task. The open interview showed the “Star Money” game was liked the most by the participants. Five of 13 participants mentioned that having success in the game was the main reason for having fun while playing. Three of 13 participants criticized they did not see a clear goal in the game. Overall our system scored 63 of 100 in the SUS part. The general outcomes of the categories “Positive Affect” and “Negative Affect” indicate that the majority of the participants had little or no negative affection (avg. 0.4; on a scale from 0 = no affection to 4 = big affection) while playing. Indeed, with the exception of one participant the results show an overall very positive affection (avg. 2.5; on a scale from 0 = no affection to 4 = big affection). Video footage recorded during the evaluation suggests that this particular participant was in general very unconfident about game tasks and how to play the games. The GEQ average score was not significantly influenced by the score of this specific participant. The participants liked the game theme “fairy tales”. Most of the participants considered to play WuppDi! together with their children or grandchildren. The aesthetics of the game were described as to be appealing. Positive influence on participants’ motivation for exercising was also directly observed by attending physiotherapy staff. A participant was observed to do a stretching motion “even better and more dedicated” than in regular therapy to reach a specific goal in the “Star Money” game.

Game Menu – The navigation of the menu was observed to be intuitive as all participants understood how to navigate through it quickly and straightforward. However, usability problems could be observed in terms of the input paradigm as there were participants that accidentally executed menu items by tremor or unaware motion of their upper limbs.

Frog Prince – While the goal of "Frog Prince" was clear immediately, there were several usability and abstraction problems during game play. The participants had problems hitting the defined motion triggering areas in a synchronous way or keeping their whole body still to steer the frog left or right. The wider the participants were moving their arms the better did the input method work for the game. The unpredictable swim directions of the frog due to triggering motion areas unintentionally led to minor frustration experiences and detained the participants from completing the game goals in some cases. In contrast we had participants who understood the input method at once, hence reached all game goals and had fun playing the game.

Cinderella – The instruction to imitate a motion from a virtual game character was conversed also by people that never played a computer game before. Though, the exact imitation was observed to be difficult, especially in terms of timing to collect the items that appeared according to the rhythmical background music. Body motion of the participants was delayed frequently due to the observation process to imitate the motion of the game character which led to inferior performance in the game. Most participants could be observed to fulfill excessive upper limb stretching in order to collect game items that are in the upper screen area.

Star Money – The usage of markers on a wooden stick to control this game was easily adapted by most of the players. On the other hand side this caused some participants to do small and stiff arm motor activity. The auditory and visual feedback as well as the rhythmical music of the game was mentioned positively by almost all participants. In combination with the easy game mechanics and the easy to understand goal (collect the stars to gain points) most players considered "Star Money" as being the most fun game of WuppDi!.

Ali-Baba – The game goal of this game was unclear for most of the participants. The alternation of observing, memorizing and moving was considered as being difficult by most of them. The possibility to let the game character repeat the sequence of shown items was rarely used by the participants, therefore the activation button of this functionality was triggered unintentionally sometimes which led to confusion of the player. Confusion about the shown sequences and unintentional triggering of sequence repetitions were frustration factors for some participants.

Town Musicians – Observation of participants playing this game revealed a design issue: Marker symbols used in this game are not adequately salient as some of the participants were not able to recognize them instantaneously. Most of the participants could be observed to have a clear enhancement of ambition while exploring the game mechanics. Also the enhancement of reaction speed in terms of two hand coordination could be observed. Participants that did not show explorative behavior lost focus on the game goal which led to inferior performance of playing the game.

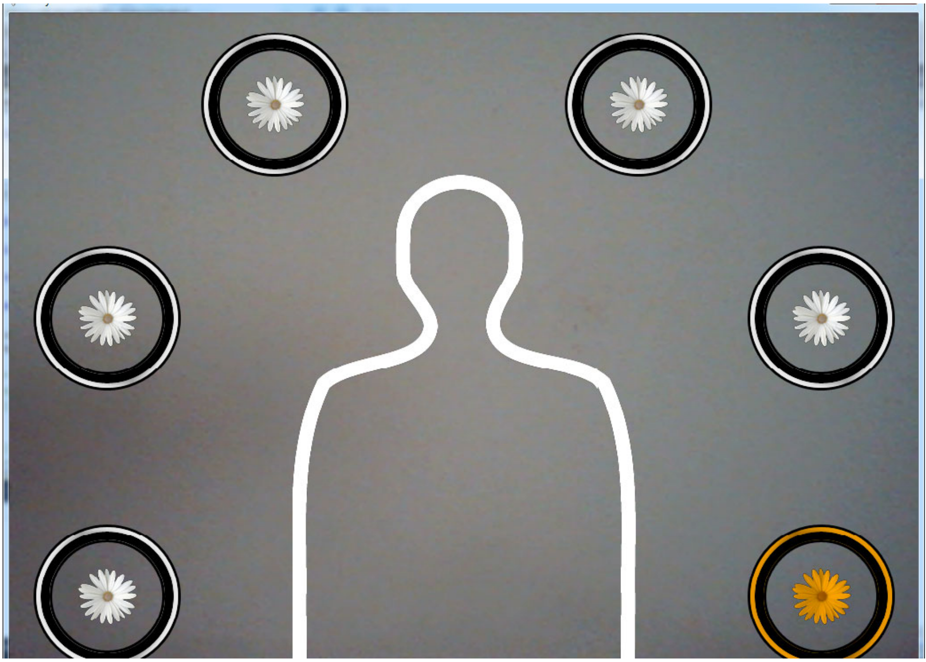

Fig. 2. Reaction time measurement tool

5 Conclusion and Future Work

The goal of our work was to examine how to develop a gaming system specifically for PD patients. For this, we used a participatory design approach and worked closely together with PD patients and physiotherapists. The intensive cooperation and the feedback of concerned persons proves the high interest of the target group in such a system and user tests during development as well as the final field study show that it is possible to let PD patients enjoy exercises in form of an Exergame. With WuppDi!, we developed a proof of concept games system consisting of five mini-games of different difficulty and focus. The overall usability of our system was rated positive according to the results of the SUS. Furthermore, results show that most of the patients enjoyed playing as indicated by the GEQ. We showed that it is possible to reach this level of enjoyment with the use of low cost technology like the Playstation Eye Camera.

The field study also confirms the design principles that were identified during the development process. Especially, the role of positive feedback and constant success for enjoyment were highlighted since participants liked those game most that they could all play successfully. Although following these principles throughout the development, the observations during the field study revealed that some of them are not sufficiently implemented. Here, we revealed a lot of potential for future work. In order to guarantee a satisfying game play for different patients, difficulty needs to be decreased in some of the games and a more dynamic method of adaption would be needed. Features like an initial calibration determining the maximum reach ability or a dynamic adaption of difficulty would also help to respect the player's physical abilities and help to achieve better results in therapy. Additionally more emphasis needs to be invested towards the fusion of game mechanics, music, and rhythm.

While initially aiming at a game system for home use, our results and observations show, that WuppDi! was not adequate for being used by single patients entirely on their own. On the one hand, still being in a prototype state, the system requires a setup that is rather complicated for the target group which is mostly not proficient in the use of computers. This minimally includes starting the software as well as attaching and positioning the webcam in an adequate way for playing. On the other hand, assistance of a healthy person is recommended for severe cases to assure balance and stability of the player. Rather, the system can be used in groups of patients supplementing gymnastics or physiotherapy. This also adds a positive social component to game play and allows for multiplayer playing.

Our field study is limited in expressiveness in terms of long term use and medical impact. In order to determine if the build in mechanics can help patients to reduce their physical symptoms, WuppDi! needs to be tested in a long term evaluation study. Additionally, doctors and physiotherapists need to use the tool and examine the outcomes in the terms of physical therapy usefulness. Lastly, adding the possibility to record a play session and sending the data to a therapist would greatly increase WuppDi!'s potential of being one day an engaging Serious Game for physiotherapy usable at home.

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Universal Game Based on Traditional Children's Outdoor Games

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Abstract. A universal game, *Daruma*, has been developed that can be played by both healthy people and people with physical limitations. It is based on the Japanese variation of the traditional outdoor children's game Red Light, Green Light. We devised two ways to play the game: one is by swinging an arm; the other is by tapping a desk with two fingers. Players can select either of these choices, enabling people with physical limitations to enjoy the game. We conducted experiments to verify their ease of play and to evaluate their degrees of enjoyment and utility. We found that both ways of playing were appropriate for the visually impaired and that healthy people also enjoyed playing *Daruma*.

Keywords: universal game, traditional children's plays, physical limitations, devises, "Red light, green light".

1 Introduction

Every generation of children enjoys playing games that require physical activity. The games rules or roles decide how each player should act. For example, the rules of "tag" state that the tagger, "it", runs after other players in order to touch one of them, who then becomes "it". Thus, there is an obvious relationship between roles and actions. Needless to say, this game is very basic, but it is this simplicity that makes it enjoyable. However, people who have physical limitations cannot enjoy playing it. However, if the rules are changed for their sake, it is difficult for all of the other players to enjoy it.

Recent years have seen changes in how we move our bodies to play games. For example, Wii Remote [1] or Kinect [2] are controlled by the whole of the player's body and do not require running. They use an instinctive interface and are new additions to the long list of games that require physical activity. However, if a player has physical limitations, it is not easy for him or her to enjoy these games fully. Therefore, if a game has roles that require certain physical actions these players

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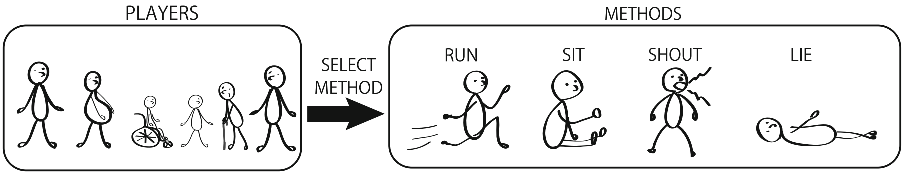

Fig. 1. Players can select methods for playing

cannot do, it is not easy for them to enjoy playing it. Thus, we believe that, in some games, players can overcome physical limitations if they can select a different method of playing, as shown in Figure 1.

This study aims to construct a system that can be played by anybody anywhere regardless of physical limitations. (We call it a "universal game.") Therefore, we emphasized a simpler game design and researched a number of methods of playing. We propose a game without visual information in order to make it simple. It is based on traditional children's outdoor games because they have rules that are easy for children to understand and can be played by a lot of children. Therefore, we believe that they have many elements that can be utilized in the universal game. We chose to base the content on Red Light, Green Light because this game requires physical activity and is played the in similar ways all over the world. Moreover, we verified that this system could overcome physical limitations and was enjoyable for healthy people.

2 Related Research

Wii Sports (Nintendo Co.,Ltd.) is a video games system that requires players to move a lot. Wii Sports games need players to move as if they were playing real sports, such as tennis or bowling, while holding the Wii Remote. Therefore, it is simple to understand and easy to play. However, if a player's arm or hand cannot move due to some sort of limitation, it is difficult for him or her to play it enjoyably.

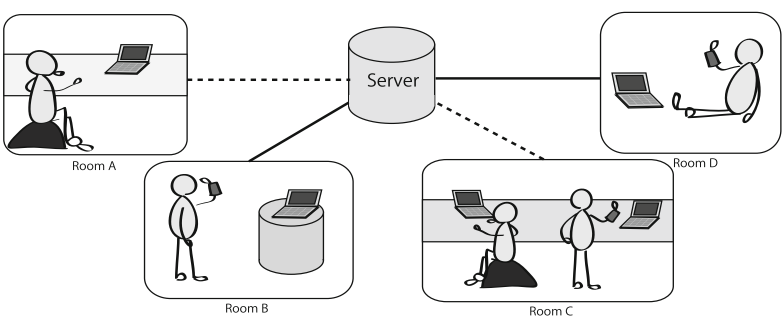

Fig. 2. Playing on-line versus mode

Japan Software Company for the Handicapped released ``Space Invaders for the Blind [3]." This was made for the visually impaired to play, but it was not easy for them to enjoy playing because they had difficulty recognizing the situations of the game by only sounds.

Team Kanai proposed games that can be played by using only the sense of touch. In their study, they supposed an interface and contents that both visually impaired and sighted people could play together [4].

3 System Configuration

3.1 How to Play

In this study, we developed a game named *Daruma* (based on the Japanese variation of Red Light, Green Light are called *Darumasan ga koronda*) in which a system plays the role of *Oni* (the tagger) and the players wear sensors. A lot of voices that were recorded in advance and have different playing speeds (Darumasan ga: ten patterns, koronda: ten patterns, total: 100 patterns) are played at random. A player can move when he or she hears voices. If a player moves when he/she should not, a voice ("You moved!") is played and the player losses. At first, the player and *Oni* are 100 meters apart. The player can approach *Oni* by running when he or she hears the voices. The change in value gotten by sensors and the times over the set threshold were given as the variable number for the judgment of approaching. The goal of this game is for a player to arrive at *Oni* and release a captive. Therefore, if a player arrives at *Oni*, he or she wins. The closer the player gets towards *Oni*, the louder the voices becomes in order to let the player know the distance between he/she and *Oni*. Moreover, we had the players wear eye-masks so they could not to obtain any visual information and wear head-phones or ear-phones so to block any outside noise. These could give the players the voice exactly, making it easier for them to imagine where they were.

We provided two game modes. In the single mode, one player plays against the system. Single mode can be played offline. In the online versus mode, two players play together. The first person to arrive at *Oni* was the winner. In the on-line versus mode, we can play *Daruma* by using network. Figure 2 shows people playing the on-line versus mode of *Daruma*. Each room is connected to a server computer. The server sorts opponents. The players in Rooms 1 and 3 are playing against each other, as are players in Rooms 2 and 4. Moreover, each player chose either way of playing.

3.2 Devises

We devised two methods of playing the game: one swinging an arm, which are detected by an acceleration sensor; the other is tapping a forefinger and a middle finger on a desk, which are detected by a microphone. We define the former as "arm-swing *Daruma*" and the latter as "finger-tap *Daruma*." Players can select either, enabling people with physical limitations to enjoy the game.

In arm-swing *Daruma*, the system converts analog data obtained by the tri-accelerator (AE-KXP84) into digital data by using a microprocessor (PIC12F675), which is connected to a PC through a USB conversion module (AE-UM232R) and USB mini cable. Each player wore a wristband with the sensor. The number of arm

Fig. 3. Arm-swing and finger-tap *Daruma*

swings was measured, and the distance between the player and *Oni* was calculated on the basis of the measured value and the number of arm swings in the same space of time.

In finger-tap *Daruma*, the sounds made by fingers on a desk with a microphone on it were judged. The distance between the player and *Oni* was calculated on the basis of the number of taps by sound gain and frequency analysis. The sounds could be made on wooden, metallic, or glass desks. Although the player needed to wear a sensor on his or her arms in arm-swing *Daruma*, he or she does not in finger-tap. Moreover the player does not need a special sensor to input because many laptop PCs have a built-in microphone.

4 Experiment I

4.1 Verification Experiment and Result I-1

We experimentally evaluated each method of operation. At first, the participants had the game explained to them by an announcement recoded in advance. Then, we answered the questions about things that they did not understand. They experienced the single mode of *Daruma* by playing arm-swing and finger-tap three times each. The participants were five healthy people (21-22 years old). After they finished playing both forms of the game, we interviewed them. The results showed that participants found finger-tap *Daruma* was easier than armswing *Daruma*. However, there was no difference in the average of clear times.

4.2 Verification Experiment and Result I-2

We experimentally verified which physical limitations each method overcame. In arm-swing *Daruma*, we found no difference between playing while standing and sitting. In addition, we found that we could play even while lying down. In finger-tap *Daruma*, the players' posture did not affect their ability to make sounds.

5 Experiment II

Objective and methods: The purpose of the assessment experiment was to investigate whether *Daruma* is enjoyable for healthy people. Because the game contents do not depend on visual information and so tend to be extremely enjoyable for healthy people, we thought this game needed to be investigated to see if it was enjoyable enough for them to play.

First, the game was explained to participants by a recoded announcement. They played both arm-swing and finger-tap *Daruma*. The participants were ten healthy people (21-24 years old: six men and four women). We divided them into two groups (A and B) of three men and two women. People in Group A firstly played arm-swing *Daruma*, and then they played finger-tap *Daruma* while people in Group B did the opposite. We had the participants wear eye-masks so they could not to obtain visual information. After the participants finished both games, we gave them a questionnaire.

Results: The result for **Q1** are an average on a ten-point scale and those for **Q2** to **Q6** are the proportion of participants who answered "Yes". **Q1.**"*How much did you enjoy this game? (10-point scale)*" was Group A(*M*= 7.20, *SD*= 1.94), Group B (*M*= 7.60, *SD*= 1.50), **Q2.**"*Did you easily understand the rules?*" was Group A= .60, Group B= .80, **Q3.**"*Did you feel difficult about the judgment for playing*" was Group A= 1.00, Group B= .80, **Q4.**"*Were you aware of how close you were to Oni at any given point?*" was Group A= .80, Group B= .60, **Q5.**"*Did you enjoy this game even though your eyes were closed?*" was Group A= 1.00, Group B= 1.00 and **Q6.**"*Do you want to play this game again?*" was Group A= 1.00, Group B= 1.00. As a result, Groups A and B did not significantly differ. When asked for reasons they answered "No" to **Q2**, one participant said "I wanted you to explain the rules by video because it was not easy for me to understand them by only an announcement." Eighty percent of the participants asked questions to clarify rules.

6 Discussion

First, *Daruma* can be played in different ways; players who have difficulty playing the original game can take part in the same game with running children by using the arm-swing or finger-tap techniques. Secondly, the results of the verification experiment showed that players could play the game with either method of operation even if their postures or environments were different. Therefore, these things suggest that *Daruma* is a universal game. What suggests this game could be enjoyed by visually impaired players was all experiment participants answering "Yes" to "Could you enjoy this game even though your eyes were closed?" despite this game being simple and them having no visual information at all. In addition, Group A and Group B barely differed in their answers, suggesting that either method works just as well. Therefore, we found both methods were equally understandable and usable. In this experiment, we made healthy people pose in ways that assumed physical limitations. Therefore, as a future task, we need level adjustment by doing the same experiment with the people who actually have physical limitations.

In the future, we will consider how to produce the distance perspective and realistic sensations with stereophonic sound by using binaural recording technology. We must improve this because the sense of tension towards the climax is important in the original *Darumasan ga koronda*.

7 Conclusion

In this study, we aimed to develop a universal game that overcomes players' physical limitations. Specifically, we suggested and developed a system by which players who have physical limitations can choose alternative ways of playing so that they can play with players who do not. Moreover, we suggested that players who have visual limitations could participate in this game because it has no visual information in order to keep the game design simple. However, the universal game that overcomes all limitations players may have has not been achieved because this system has no provisions for players who are hard of hearing. We believe we have succeeded in developing a narrow universal game.

As a future task, we will find ways in which players who have oral and aural limitations can participate. This will need a system can that explain rules without using either aural or visual information. Therefore, we aim to develop the perfect universal game that can overcome all physical limitations and that anybody can play.

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Gemini: A Pervasive Accumulated Context Exergame

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Abstract. Exergames encourage physical activity, but generally require specialized hardware and prescribed activities; whereas pervasive accumulated context exergames (PACEs) allow players to choose their type of exercise, but have limited depth of play. For mass commercialization of PACEs, facilitating long-term behavioural change, we propose two requirements: that PACEs support large-scale and flexible deployment; and that the design of PACEs support staying power through long-term playability. From these requirements, we motivate six PACE design principles and use these principles to develop a multiplayer roleplaying PACE. Results from a week-long study of our game showed that by satisfying the six design principles, we can create a PACE with scalability and staying power. Our results are the first step toward creating PACEs that promotes long-term game engagement, which is needed for activity-related behaviour change.

Keywords: exergame, pervasive game, activity sensing, accumulated context.

1 Introduction

Obesity rates are on the rise, due in part to recent decreases in physical activity [1]. This decreasing trend of physical activity is particularly salient for college-aged adults in the 18-24 year-old age range, who spend significant amounts of time engaged in sedentary leisure activities such as watching television and playing video games [1] and have the sharpest increase in subscriptions to massively multiplayer online (MMO) games like World of Warcraft [2].

Given that 68% of American households play video or computer games [3], the negative potential impact of digital play on physical activity is clear. To address the lack of physical activity, game designers and researchers have created exergames – video games that use exertion as part of the activity required to play [4]. Exergames have been shown to be effective in getting players to exercise, and to be more fun than a corresponding level of standard exercise [5]. Although exergames can promote physical activity, these games often use specialized hardware, prescribe that users engage in a specific type of exercise, and require a dedicated time and space for play [6,7,8,9,10,11]. While these systems can provide immediate exercise benefits, the associated games are often simple systems that may not hold a player's interest long enough to create positive activity-related behavioural changes.

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To address these shortcomings, researchers have proposed exergames that continually accumulate player activity levels through pervasive sensing, and incorporate these levels into subsequent game play. Although these previous systems have successfully dealt with the issues of specialized hardware, specificity of exercise, and particular play time, they are linked to simple games that do not have the potential to engage players in the same way as popular commercial titles such as World of Warcraft. Without sufficient engagement with the game, players will not commit to playing for long enough to support effectual changes to physical activity.

In a pervasive accumulated-context exergame (PACEs) the collection of activity occurs continuously in the background, and play occurs in a traditional digital game. Activity impacts the game at the beginning of each play session, instead of altering the game during play. While researchers have investigated preliminary properties and effects of PACEs [12,13,14], they did not consider commercially viability. To create PACEs that will be appropriate for mass commercialization, engendering long-term behavioural change, we propose two primary requirements: 1) that PACEs support large-scale and flexible deployment; and 2) that the design of PACEs support staying power through long-term playability.

Because the digital portion of a PACE must function as a stand-alone game, standard game design principles apply. We describe additional design principles here to highlight those game design components most tightly coupled with accumulated activity. Based on the two requirements above, and drawing from well-known design principles [15], we identified six design principles for commercial-grade PACEs:

1.1 Unobtrusive pervasive activity monitoring
1.2 No expensive or specialized hardware
1.3 Flexibility in choice and time of exercise so that exercise is integrated with life
2.1 Integration of exercise with dramatic elements of the game
2.2 Limited imposition on preferred play style
2.3 Replayability through complexity of the objectives and sources of conflict

Using these six design principles, we created a multiplayer role-playing PACE called Gemini. Our game measures activity levels pervasively via sensor motes (as stand-ins for sensor-enabled smartphones) to conform to requirement one, and has a sophisticated game design to support requirement two. Through analysis of a week-long series of play sessions with a single group of players, we evaluated the design of Gemini, the resulting engagement of players, and the process of accumulating activity levels pervasively. We found that Gemini was compelling, contained enough strategic depth to maintain player interest, and that our approach to pervasive activity sensing was effective. We also find that while players see the collection of activity as part of the overall game experience, they cannot articulate the ludological role it has within the game. Our results are the first step toward creating PACEs that promote long-term game engagement, which is necessary for eventual activity-related behaviour change.

2 Related Work

Many initial exergame systems use specialized sensors to promote physical activity. The exergame research community grew in earnest after the publication of

Mueller et al.'s Breakout for Two – a breakout-based distributed and competitive game using a soccer ball and a custom-built sensor wall [4]. Mueller's group continued to produce exergames using custom sensors including the mat in Remote Impact [6], the table in Table Tennis for Three [7], and the force input device in Push and Pull [4]. Custom sensors were also used in Nautilus – a large-screen projection game played on pressure-sensitive floor [8] and Kick Ass Kung Fu – a large-screen projection martial arts game played using free body movement sensed using cameras [9]. Alternatively, stationary bikes were used as input in Life is a Village [10] and Virku [11].

Although these games all promote physical activity, they require specialized hardware. In addition, they specify what type of activity is to be performed. We argue that for large-scale commercial deployment of exergames, the hardware must be inexpensive and the type of exercise performed needs to be flexible. One solution is to create a middleware layer that allows for many types of input to be used in the exergame, which was demonstrated by Brehmer et al., in their GAIM toolkit [16]. An alternative to specialized hardware is to use cheap and available sensing devices, such as heart-rate monitors, as the measurement of exercise in a game.

Heart-rate has been used as an exergame input to directly control player characters and indirectly control game elements. In TripleBeat, joggers are rewarded during a run with high scores for maintaining an appropriate target heart rate [17]. In Nenonen et al.'s biathlon game, heart rate was used to control the speed of the skier during the race portion and the steadiness of the aim during the shooting portion [18]. Indirect use of heart rate in a game includes Masuko and Hoshino's boxing game, where content is adjusted to keep the player in their target heart rate zone [19], and Buttussi et al.'s use of heart rate to adjust game difficulty in two sample games [20]. To deal with heart rate control issues including lag and age-related differences, Stach et al., created a formula to differentially map heart rate to in-game speed in a racing game called Heart Burn [21]. Although these heart-rate-based games may not require specialized hardware or specify activity, they do require that users exercise during a dedicated play time. Activity sensing and play occur simultaneously, so although users get fit through play, they do not learn to integrate exercise into their lives. To encourage people to exercise, but reward them using exergame design, some researchers have instrumented users with sensors and used the sensed activity levels as input to a game.

The closest analogues to PACEs in the literature and industry are pervasive fitness games. Neat-o-games used accumulated activity to change the base speed of the player's avatar in a simple racing game [12]. Because of the simplicity of the game Neat-o is closer to a visualization tool like Ubifit Garden [22] than a PACE. Neverball uses cumulative activity to modify the speed of an avatar and the duration of a game [14]; however, the accumulation of activity only takes place while playing the game. Persuasive RTChess used accumulated activity gathered via sensing mote to change the speed and power (attack and defense) of chess pieces in a real-time networked multiplayer chess game [13]; however, the game suffered from poor activity-game mappings, and lacked the needed strategic depth to maintain player interest.

Two commercial games have started to explore the PACE space: Pokewalker and 4square. Pokewalker allows players to accumulate a virtual currency within the Pokemon games. The core mechanic of game play does not change from previous versions, but the superior Pokewalkers have an advantage over their peers. In 4square, players report their positions to a central server to earn badges. While not designed as an exergame, 4square could potentially encourage people to get out more.

The two commercial games have demonstrated the requirements for a broadly deployed PACE. Pokewalker uses an inexpensive pedometer to monitor players' activity and 4square is entirely a software entity that runs on players' smartphones, echoing our contention for the use of simple hardware platforms (design principles 1.1-1.3). No existing PACE games utilize game design to leverage scaffolding, likely contributing to their poor adoption compared to MMOs or popular social media sites.

3 Experimental Setup

To explore the design of RPG-based PACEs (RP-PACE), we designed, implemented, and tested a game that collects and accumulates players' activity levels pervasively and incorporates them into a multiplayer RPG.

3.1 Pervasive Activity and Context Sensing

Activity was measured in both studies using a MicaZ wireless base (commonly called a mote) with an MTS310 sensor board containing accelerometers, light, and temperature sensors. The motes communicated wirelessly (using the Zigbee protocol) with base stations placed strategically throughout the work areas of the participants. Data was logged and either opportunistically or manually downloaded through a base station to a central server. Our mote approximates the capabilities of a modern smartphone with built in accelerometers, camera and Bluetooth. Although we implemented the study on more specialized hardware based on availability, our implementation is directly portable to increasingly-common consumer devices, thus satisfying design principle 1.2. Players wore the motes anywhere on their person by attaching the motes with a Velcro strap. In this way, our technology was designed to be unobtrusive, supporting design principle 1.1.

While any contextual measurement such as position, social situation, or even local weather conditions could be used as input to a PACE, our game uses accumulated activity level as the primary player context because it is an obvious component of an accumulated context exergame designed to promote physical fitness. We adopted a broad definition of activity. Participants were considered active if the variance of their acceleration over a given time window was higher than a pre-defined threshold. We used additional sensors to characterize the players' activity for integration into the RPG. Light and temperature data was used to determine whether people were indoors or outdoors. Wireless packets passing between two motes were used to determine whether other players were nearby (within 10 m).

Because activity and context are continuously monitored in the background, players can schedule activity whenever they desire, explicitly satisfying design guideline 1.3, and providing compliance with the requirement that PACEs support large-scale deployments. To ensure that this monitoring results in long-term behavior change we must also account for the playability of the digital game portion.

3.2 Game Description

We implemented a multiplayer online roleplaying game (RPG) using the Neverwinter Nights 2 (NWN2) Aurora toolset. Leveraging the Electron toolset and NWN2 graphics and game systems provided us with a compelling experience based on the canonical and well-balanced Dungeons and Dragons rule set. We felt that integrating activity into gameplay using an RPG would allow us to create believable mappings that integrated with the formal and dramatic elements of the game, thus supporting design principle 2.1. Additionally, our design allowed us to leverage the compelling social and competitive elements of commercial MMOs, which provided a different platform from the toy examples in section 2, and supported design principle 2.3.

In the game, players were told that they have been condemned to a kind of purgatory, where their soul has been split into two. The primary soul portion, vested in the player-created PC avatar, is anchored to the purgatory in which they currently find themselves. A smaller portion of their subconscious remains linked to their physical form and manifests as an animal companion. Their opponents from the war that led to their condemnation are also in purgatory, but only one faction can escape.

In keeping with design principle 2.2, we designed the game to cater to all of the major MMO player types as described by Bartle [23], and further by Yee [2]. The game play is focused on team-based PvP combat, providing desirable experiences for Socializers and Killers. The game scope and size is significantly larger than the exergames described in section 2 and provide a suitable outlet for Explorers. The mix of play and capacity to build the primary character, animal companion and compete in the PvP portion provides a mechanism for Achievers to interact with the game. The playable zones in our implementation are shown in Fig. 1.

Base Zones and PVE Zones. Players spawned into the base zones when they joined a game, when they were killed and when they were removed from the temple at the end of a temple round. The base zones contained an NPC vendor and a second NPC who provided teleportation service to a point near a tower in the center zone, if the tower was under faction control (dashed lines in Fig. 1). While all zones permitted player versus player (PvP) play, the green zones (1-4) were designed for simple player versus environment (PvE) play. Monsters respawned every few seconds within these zones, providing an opportunity for players to level their primary characters through combat. Zones 3 and 4 provided low-level monsters, while zones 1 and 2 provided more challenging opponents. The intention of providing both PvP and PvE areas was to support multiple play styles and satisfy design guideline 2.2.

Player Versus Player (PVP) Zones. PvP play was added to the game for two reasons: first to provide competitive incentive for players who prefer team competition; and second, to provide a source of immediate conflict to make the game more compelling. However, simply adding PvP mechanics is not enough to satisfy our two requirements. Support for individual playstyles and long-term replayability is needed. Finally, a mechanism that allows activity to affect the game, while not creating a dominant strategy [15] or dictating playstyle [15] is required. We achieved these multiple design objectives by subdividing the PvP into zones. The center zone (beige) was the primary PvP zone. While the zone itself did not have any intrinsic value, it contained the access to both tower zones and the temple zone, which were crucial to the PvP game.

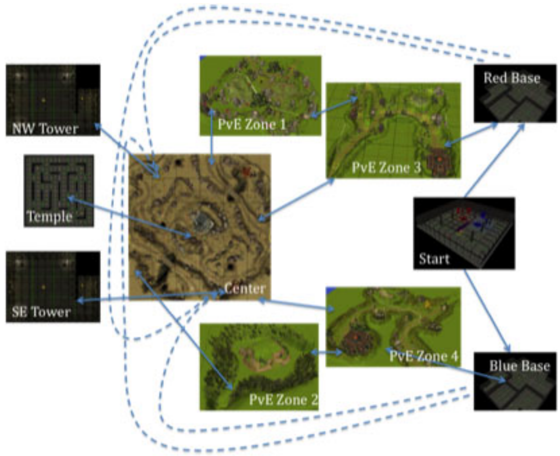

Fig. 1. Zone Configuration. Arrows denote persistent (*solid*) or contingent (*dashed*) transitions

Each tower zone contained four switches and a vendor. A team that had all three perimeter switches simultaneously thrown to their team's colors (either red or blue) controlled the tower. The center switch caused all opponents in the zone to be paralyzed for six seconds, with a one-minute cooldown. Controlling a tower provided a bonus to the score in the temple domination minigame, provided access to more powerful items, and allowed for teleportation from the base zone to the central zone.

Battles within the temple generated team points. Players did not control their character avatar within the temple; instead, they controlled their animal companion. Player-controlled animal companions competed in a team Bomberman-style minigame. Animal companions were given three different bomb types that damaged, slowed down, or decreased the resistance of their enemies. Points were scored by hitting or killing an enemy, possessing a tower, and for being in the temple; points were lost by hitting yourself or a teammate. The first team to reach 700 points, or the team with the highest score when time elapsed won the game. Winning the most rounds of the temple game ensured your team's escape from purgatory, making contesting the temple the primary PvP activity.

The Animal Companion/Daemon. The animal companion (or daemon) did not gain levels through traditional RPG in-game activities; instead, it leveled through the measured real-world activities of the players, mapped onto the existing NWN2 class system. All daemons were triple-classed characters with levels in the Barbarian, Monk, and Bard classes. Different types of activity leveled the daemon classes as shown in Table 1, as well as the damage from and resistance to different bomb types in the temple minigame. Daemon leveling was artificially linearized because, in traditional D&D rules, geometrically more experience points are required to achieve the next level. While additional effort should be required to gain each daemon's level, players cannot be expected to maintain geometric growth in their physical activity.

Table 1. Activity context to daemon ability mappings

Activity	Class	Bomb/Effect	Bomb Resisted
Outside	Barbarian	Fire/Damage	Magic
Inside	Monk	Frost/Slow	Fire
With Other Player	Bard	Magic/Decreased Resistance	Frost

The daemon is meant to aid the player without dictating their play style. In PvE play, the daemon is a versatile computer-controlled companion who can provide either direct combat enhancement through barbarian and monk classes or support through the bard class. In tower PvP play, the daemon is primarily a target to be defended and a combat assistant. Finally, daemons are an integral part of the temple minigame where they are directly controlled by the players. The design of the daemon-activity interaction satisfies all the design guidelines for both primary requirements for PACEs. Activity is monitored cumulatively and continuously in the background using mobile sensors (1.1, 1.2, 1.3), and is mapped to a secondary character that plays a central but optional role tied directly to the game narrative and strategy (2.1) in multiple ways (2.3), while still allowing players to determine the playstyle for their primary character (2.2).

3.3 Game Evaluation and Player Demographics

The study lasted five days and involved eight participants (male, aged 19 to 24). On each day of the study, participants met at 4:00pm for an hour to play our game. Players were divided into two teams of four for the duration of the experiment. The temple domination game was only active during scheduled sessions, but players could log into the computers at any time to level their characters in the PvE zones. The first day was primarily tutorial on the game and background on the activity mappings.

After each session, the players were interviewed as a group. On the last day of the study, we carried out an extended group interview, and users completed an online survey. All participants used computers for more than two hours per day, played video games at least weekly, and had little or no experience with NWN2.

4 Results

The proof-of-concept system described above was used to evaluate the efficacy of our design principles (DP). The principles we derived were meant to satisfy the two additional requirements we identified for PACEs: that they be mass-market friendly, and that they support long-term play to facilitate scaffolding. This section presents initial evidence that the design principles can be leveraged to create a viable PACE.

4.1 Mass Market Capacity

To determine whether the game concept has mass-market potential, we asked players to rate how much fun the game was and how much fun having the daemon was on a 5-point scale (strongly agree to strongly disagree). Players generally responded positively (1-Srongly Agree (SA), 7-Agree (A)) in response to the questions “The game was fun to play" and "Having both the daemon and my character in the game was fun" (1-SA, 6-A, 1-Neutral(N)). In player interviews it was revealed that a player's role was determined by their skill as a player (e.g., combat expertise guarded the tower) and by the skill of their animal companion (e.g., most active player fighting in the temple). We also wanted to determine whether players entered a flow state, indicating an optimal balance between skill of the participant and challenge of the activity [24]. Using the flow state scale [25], we determined that users were significantly above the flow threshold (one-sample t_7=4.7, p=.001).

To determine the potential of the mote as a proxy for a smartphone-based activity sensor, we asked players if they were "comfortable wearing the mote" (1-SA, 4-A, 3-N), and if the "mote interfered with their daily activities" (1-A, 3-N, 4-disagree (D)). These findings indicate that players were comfortable wearing the mote and having it record their activity. This is encouraging because the mote constitutes a more invasive activity and context collection device than a player's own phone, which is where we believe activity-monitoring technology is headed. Furthermore, when asked if they "thought about NWN strategy while wearing the mote", 6 of the 8 players answered "No", indicating that the mote did not cognitively interfere with the player. Taken together, our measures indicate that the activity collection was sufficiently in the background, the game was fun enough to support a large user base, and the game design supported players entering a state of flow.

4.2 Replayability for Scaffolding

Our second requirement was that the game provide extended playability or replayability to facilitate long-term changes in activity. By leveraging an existing game and building a larger, more sophisticated game than the previous PACE examples, we created a game with more extended play. There are several methods of extending play, one of which is providing a richer set of strategic balance and gameplay options over prior PACEs. We evaluated the strategic depth through both survey responses and gameplay analysis. Players tried to use strategies (3-SA, 4-A, 1-N), and "tried to use collaborative strategies" (1-SA, 6-A, 1-N) in the game, which included "trying to interpret what [the other team's] strategy was and do the opposite, "trying to capture both the towers with two people and have two people in the temple," "[trying] to spread false intelligence to the enemy players," and considering "individual abilities and character strengths." This strategic diversity over the experiment session was apparent in heatmaps of activity in the PvP zones. The central zone and one tower for the final three days are shown Fig. 2, where green dots represent player locations, and red x's represent the location of a PvP battle.

It is apparent in Fig. 2 that players had not settled on a single strategy by the end of the experiment. On day 3, the central zone and southern tower (shown) were contested. On day 4 the temple and southern tower were contested and on day 5 the center zone, northern tower and temple were contested, clearly indicating that players were experimenting with different PvP strategies even after a week of regular play. Player comments supported these observations: "the multiplayer aspect was very fun, and required a decent amount of strategy"; "…there was strategy…I find that only one week was not enough time to really investigate the strategy of the game." Together, these results indicate that there was sufficient complexity in the design of the objectives and conflict to promote extended and continued play.

Fig. 2. PvP Combat in center and tower zones on day 3 (right), day 4 (center) and day 5 (right). Dots represent locations, X's represent battles.

The purpose of the second requirement was to provide a sufficient duration of play to facilitate behavior change through scaffolding. While a single week is too short to actually observe scaffold-induced changes, we asked players if the mote and game changed their perception of activity. When asked if "wearing the mote caused me to think about my daily activities more than usual," players answered in the affirmative (6-A, 2-N). When asked if "having my daily activities impact the daemon settings caused me to think about my daily activities more than usual," players also answered positively (6-A, 1-N, 1-D). Player comments also indicate that having activity level the animal companion caused them to reflect on their activity, "The daemons provided immediate feedback for actions which I knew were, in the long run, good for me"; "When I was doing exercise, I did think it was cool that my daemon was leveling up". Overall, our PACE encouraged people to think about their activity levels and make small changes to their behaviours: "given the choice I would opt to (say) walk to the store rather than drive"; "…most lunch hours I'm stationary; with the mote, I decided to use the time to go on walks. On one occasion I didn't bother taking my bus home because of the mote. The resulting walk took nearly two hours."; "I was more inclined to take stairs instead of an elevator, walk somewhere nearby instead of driving, or to go somewhere a little farther than I usually go to for lunch."

4.3 The Role of Activity in the Game

As an additional research question, players were asked to identify the role of the activity mapping in the game. When asked "If you chose to exercise when wearing the mote…were you playing NWN or training for NWN?", four players chose "I don't know", 3 players chose "neither" and 1 player chose "training". The player who chose training left a comment that indicated he was also somewhat neutral: "If I had to chose between the two motivations, I would say a little of both, but leaning towards the 'training' - it was more indirect than the competitive sessions, and so I felt it more of an extension to the game than a core element of the game itself." This apparent ambiguity is interesting as it indicates that accumulated context, unlike the direct activity sensing employed in other exergames, has a new ludological role.

5 Discussion

We have demonstrated important concepts in this paper: first, that PACEs designed using our requirements and design principles can result in compelling gameplay experiences where the accumulation of activity complements rather than dominates the experience; and secondly, that while players enjoyed having the activity-linked companions, they were unsure as to the exact ludological role of the activity mapping.

Because the digital experience in PACEs must function as a stand-alone game, good game design principles apply. The six design principles provided here are meant to highlight the aspects of game design that are most tightly coupled with the addition of activity measurement. Setting aside the possibility of gaming the activity collection itself, the addition of activity should not generate trivial winning conditions and not compromise players' ability to adopt a play style of their choice. These constraints were met by the separation of the accumulation of activity from the progression of the player's primary character. Additionally, by providing myriad game-play opportunities, we have allowed the player flexibility in how the exercise affects the advantages provided by the animal companion.

Perhaps the most fascinating results we have obtained relate to the unknown ludological role of the animal companion and its associated activity mappings. This confusion is important for the design of PACEs as players explicitly rejected characterizing the activity recording as play, making it, by definition, outside of the magic circle [26], and therefore not subject to the same privileged social space as the game itself. Players also rejected the notion that activity accumulation was training, like the exercise regimens employed by athletes. This further implies that designers must be especially careful with the perceived impact of the activity mappings. If players perceive that activity mappings provide a significant or dominant advantage, they may object, or even perceive high activity levels as a form of cheating because, as neither play nor training, it has no place in the game. However, players enjoyed the activity mapping, and felt it added to the game, so it is also obviously not an unwelcome component. The exact role of activity sensing in PACEs and players' understanding of it is an interesting future research topic.

Synthesizing our design criteria and the finding of ludical ambiguity, it should be possible to create PACEs in a number of genres. In many ways a single player experience would be easier to balance, as the players would be less concerned about relative differences in activity-ability mapped parameters (because parameter mismatches between players would not affect other players' games). However, multiplayer games, and MMOs in particular tend to have larger staying power and the added incentive of social dynamics for behavior change, making persistent multi-player experiences a more compelling match to the PACE requirements described here. This concept could be mapped to multiplayer shooters through access to better equipment, common to many games in the genre, or to online communities like Second Life through avatar appearance, almost like an ambient life blogging exercise. We feel that PACEs have a great deal of potential to both enhance physical activity and provide compelling game-play experiences.

6 Conclusions

Traditional exergames are limited by the requirements for specialized hardware and dedicated play times. To alleviate these, we proposed PACEs, games that accumulate activity for digital rewards inside a game. We motivated two requirements for PACE design: that they have mass-market potential and that they support long-term play. Based on these two requirements, we identified six design principles that were used to design a multiplayer RP-PACE. We conducted a week-long evaluation of our game based on game logs, player surveys, and player interviews. Our results showed that a game designed using our six principles is scalable and of sufficient strategic depth to support long-term play, which are necessary requirements to engender behaviour change on a large scale. In the future we intend to perform longitudinal studies to evaluate the persuasiveness of a PACE to increase physical activity, to further investigate the ludological role of activity monitoring, and to deploy this system on smartphones to provide interactive feedback.

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Evaluating User Experience in a Selection Based Brain-Computer Interface Game

A Comparative Study

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Abstract. In human-computer interaction, it is important to offer the users correct modalities for particular tasks and situations. Unless the user has the suitable modality for a task, neither task performance nor user experience can be optimised. The aim of this study is to assess the appropriateness of using a steady-state visually evoked potential based brain-computer interface (BCI) for selection tasks in a computer game. In an experiment participants evaluated a BCI control and a comparable automatic speech recogniser (ASR) control in terms of workload, usability and engagement. The results showed that although BCI was a satisfactory modality in completing selection tasks, its use in our game was not engaging for the player. In our particular setup, ASR control appeared to be a better alternative to BCI control.

Keywords: Brain-computer interface, steady-state visually evoked potential, games, user experience, engagement, usability, workload.

1 Introduction

Traditional human-computer interaction (HCI) modalities, mouse and keyboard, have long served as a reliable means of input. Despite their reliability, they restrict users expressive capabilities and therefore the information transferred from the user to the computer. As a response to this problem, modern HCI uses natural human input such as speech and gestures. Moreover, through brain-computer interfaces (BCIs), even brain activity can be provided as input to computers.

In HCI, it is important to offer the correct modalities for specific tasks and situations. BCIs, for example, have long been in use for selection tasks in assistive [14] and also recreational [15] applications. However, in all these applications, the primary concern has been to optimise the recognition performance so the appropriateness and consequences of using BCIs for selection tasks has never been considered. In entertainment computing, the primary goal of the user is not to optimise task performance. While playing a game, the user (i.e. player) might still have tasks to complete but their actual purpose in playing the game is enjoyment. They may attempt to fulfil the tasks in the game or may simply wander in the virtual environment (VE). They may get bored using the mouse and the keyboard, which offer no challenge to them, but enjoy tackling the shortcomings of a non-traditional

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modality, such as BCI [12]. Especially for BCIs, which provide relatively low throughput [17], factors such as usability and workload should carefully be taken into account. Unless the user has the suitable modality for a task, neither task performance nor user experience can be optimised.

The aim of this study is to assess the appropriateness of using a steady-state visually evoked potential (SSVEP) based BCI for selection tasks in a computer game. We evaluate BCI control subjectively in terms of user experience related factors, which are workload, usability and engagement, using questionnaires. We contrast the evaluation results for BCI control with control with a comparable input modality, an automatic speech recogniser (ASR), in the same game. BCI and ASR are both imperfect but natural input modalities. Moreover, they are suitable candidates for multimodal control in gaming applications, considering the assumption that the majority of the primary game controllers already occupy the players' hands. In this study, ASR control is a reference for assessing BCI control.

2 Background

2.1 Evaluation of User Experience in BCIs

In evaluating BCI applications, the traditional concern is improving the recognition performance. Nevertheless, user experience has recently been considered in BCI system evaluations. The most commonly evaluated aspect is the workload imposed by the BCI. Frequently the NASA Task Load Index (NASA-TLX) [5] is used in evaluating BCI systems based on selection tasks. Example studies include the evaluation of spellers [13] and other assistive communication applications [16, 19]. In one of these examples [13] the usability of a speller was also evaluated using the System Usability Scale (SUS) [3]. In another one [16] overall user satisfaction was measured in a communication application by using a 10-point visual analogue scale. Subjective assessment of presence in a VE controlled by BCI has also been demonstrated [4].

As the aforementioned studies indicate, subjective evaluation is a commonly practised and suitable technique for evaluating BCI systems. The questionnaires are especially easy and comfortable to apply, suitable for extracting statistical analyses quickly, strong and reliable once validated, and applicable to the majority of BCI users [9]. Note that all the studies mentioned so far in this subsection involve assistive BCI systems, targeting disabled people. Studies evaluating user experience in BCI entertainment applications are extremely rare. An example study [10] suggested a user experience questionnaire for BCI games although the game used in the study was a simple, controlled game. To our knowledge, no work has been done on systematic evaluation of user experience in realistic BCI games. Hence the time has come to set up user experience evaluation tools for these games.

2.2 BCI, SSVEP and BCI Games

BCIs can infer a user's mental/emotional state or intention by interpreting brain activity and use this information to control computer applications. First, brain activity is acquired and quantified as a signal, which is mostly done through the use of an electroencephalograph (EEG). EEG measures electrical brain activity via electrodes in contact with the scalp. Then, the signal is processed and analysed using neuromechanisms. Neuromechanisms signify certain changes in the signal with respect to an event. The event can be a voluntary action such as moving a hand or looking at something as well as an involuntary reaction to a stimulus or an error. Finally, according to the result of signal analysis, a control signal is sent to an application.

SSVEP is a stimulus dependent, widely used neuromechanism. When a person attends to a visual stimulus repeating with a certain frequency, the amplitude of the signal measured from the visual brain area is enhanced at the frequency of the stimulation. This enhancement is known as the SSVEP [8]. SSVEP is frequently used for selection tasks. By presenting multiple stimuli with distinct repetition frequencies, it is possible to detect which of the stimuli a person was paying attention to. So if each of these stimuli is associated with a choice, then it is possible to detect the person's selection. The strength of the SSVEP is dependent on the stimulation properties. These include, but are not limited to, flicker frequency, size, colour and shape of the stimulus [1].

We can identify two genres of BCI games: active and passive BCI games. In the former, the player intentionally tries to regulate their brain activity while in the latter the game captures naturally-occurring brain activity. So, a game in which the player concentrates on a flickering image to produce an SSVEP would be an active BCI game while a game which changes the speed of an avatar according to player's state of relaxedness would be a passive BCI game. The principles of active and passive BCI games are analogous to directly and indirectly controlled physiological games. Recent research has shown that direct physiological control affords a better user experience due to its visible responsiveness [11]. We also opted for direct control, in other words for an active BCI game, while developing the game used in this study.

3 Method

3.1 Rationale

With BCIs, especially with the stimulus-dependent ones such as the SSVEP-based BCI which we also used in our study, many factors deserve attention while evaluating gaming experience. The flow provided by the game, the workload imposed by the stimulation, player's comfort and safety in relation to the stimulation, usability and intuitiveness of the interaction need separate assessment. At the moment, there is no standard questionnaire or method to evaluate BCIs collectively for user experience factors. This is why, as we mentioned in section 2.1, multiple questionnaires are used together for evaluating BCIs.

To understand whether SSVEP based BCI is a suitable modality for selection tasks, we assessed user experience during BCI control in a computer game with respect to three concepts, namely workload, engagement and usability. We use standard questionnaires for assessing these concepts. We also compare the results against ASR control in the same game, as a reference condition. So, the analysis results can shed light on the appropriateness of using BCI as well as ASR for selection tasks. To support the interpretation of subjective findings, we analyse the objective data corresponding to player performance and effort, both of which may have a role in user experience.

3.2 The Game: Mind the Sheep!

Mind the Sheep! (see Fig. 1) is a multimodal computer game where the player needs to herd a flock of sheep across a field by commanding a group of dogs. The game world contains three dogs, ten sheep, a pen and some obstacles. The aim is to pen all the sheep as quickly as possible. For the purpose of this work, we used the BCI and ASR controlled versions of the game.

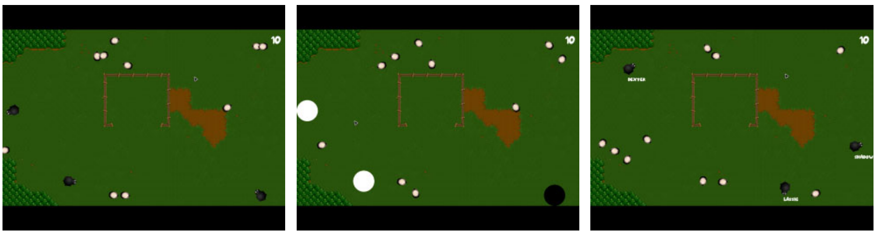

Fig. 1. Screenshots from the game. From left to right: BCI game with stimulation off, BCI game with stimulation on, and ASR game.

To command a dog, the player positions the cursor at the point to which the dog is supposed to move. The player holds the mouse button pressed to provide the command to select the dog. Meanwhile, the game displays cues specific to the active modality (ASR or BCI). When ASR is the active modality, names appear under the dog images and the player pronounces the name of the dog they want to select. When BCI is the active modality, dog images are replaced by circles flickering at different frequencies and the player concentrates on the circle replacing the dog they want to select (so as to obtain an SSVEP). The stimulation persists and, depending on the active modality, EEG or acoustic data is accumulated as long as the mouse button is held. When the player releases the mouse button, the signal is analysed and a dog is selected based on this analysis. The selected dog immediately moves to the location where the cursor was located at the time of mouse button release.

3.3 Questionnaires

We use the NASA-TLX [5] for workload evaluation as it is a brief, yet powerful questionnaire used frequently in BCI research. The NASA-TLX measures subjective workload for a task using six items which assess mental demand, physical demand, temporal demand, performance, effort and frustration. Each item is rated using a 20-step bipolar scale resulting in a score between 0 and 100. The low and high ends of each scale are anchored with a word pair indicating the two extremes for the item (e.g. word pair perfect-failure for performance). An average or a weighted average of item scores provide the overall workload score. A higher score implies a higher subjective workload associated with a task. In our study we used an unweighted version of the NASA-TLX.

For engagement assessment we used the Game Engagement Questionnaire (GEQ) [2] because, to our knowledge, it is the only well-defined and validated questionnaire designed specifically for games. The GEQ is a questionnaire measuring subjective level of game engagement in four dimensions which are absorption, flow, presence and immersion. Nineteen items, each formed as a statement, are marked on a 5-point bipolar scale with respect to the level of agreement. Columns corresponding to the low end, middle and high end points of the scale were anchored with words No, Maybe and Yes respectively. The points are averaged over the items to reach the overall engagement score. A higher score indicates a higher level of engagement in the game.

Our choice of questionnaire for assessing usability is based on a previous comparative study [18]. In that study, AttrakDiff2 [6] was suggested as the most suitable usability evaluation method for a broad range of multimodal applications. AttrakDiff2 has a reduced version as well [7], which we also use in this study, making it more convenient to fill in and analyse. The AttrakDiff2 evaluates product quality in three dimensions which are pragmatic quality, hedonic quality and attractiveness. Pragmatic attributes are those relating to a product's functionality (i.e. utility) and ways to access functionality (i.e. usability). Hedonic attributes, on the other hand, are those that provide stimulation and communicate user identity. The questionnaire contains twenty-one items rated using a 7-point semantic differential scale. For each item, the scale is anchored at extremes by opposite word pairs (e.g. simple-complicated). Ratings averaged over the items imply an overall product quality score. The higher the score, the better the subjective quality of the product. Although our aim is to evaluate the usability (i.e. pragmatic quality) of the interface, we kept the items for the other two dimensions in as well.

4 Experiment

4.1 Participants

Twenty people (3 female) participated in the experiment. They had an average age of 24.9 ($\sigma = 2.87$), ranging from 19 to 29 years, and normal or corrected vision. None of them were native English speakers. Eight of them had previous experience with BCIs and fourteen of them with ASRs. Six of them indicated that they played games more than five hours per week. Informed consent was obtained from all participants and they were paid according to the regulations of our institution.

4.2 Game Parameters

Ensuring the equivalence of the ASR and the BCI in terms of recognition performance was a concern, as this could highly affect the game experience. We did not want to artificially deteriorate the performance of modalities by introducing noise or random errors but we did try to equalise the performances by tuning game parameters.

We conducted two pilot studies to standardise the recognition performances of the ASR and the BCI. For the ASR, we tested for different sets of dog names; and for the BCI, we tested for different sets of frequencies and sizes for the flickering circles. We decided to use Dexter, Lassie and Shadow as dog names, 7.5 Hz, 10 Hz and 12 Hz as flicker frequencies and 3 cm as the flicker diameter length. Literature also confirms that flicker frequencies between 5-12 Hz can evoke strong SSVEP and size of 3 cm can provide an optimal comfort-performance combination [1].

4.3 Procedure

Participants sat on a comfortable chair approximately 60 cm away from a 20″ screen with a resolution of 1280 × 960. They played Mind the Sheep! two times in total; once with BCI and once with ASR in counterbalanced order. They played each game until all the sheep were penned or the play time reached 10 minutes. After each game, they filled in the three questionnaires, NASA-TLX, GEQ and AttrakDiff2, in the given order. In the NASA-TLX, the "task" was defined as "selecting a dog". For the AttrakDiff2, the "product" was replaced with "the interface for commanding the dogs" and participants were instructed to complete the questionnaire with respect to the devices they would need to use and tasks they would need to perform to select a dog.

In the ASR game, BCI control was not available and brain signals were not analysed. Sound was acquired by the microphone located to the right, behind of the participants. This particular location was chosen in order to match the ASR recognition performance with that of the BCI, as described in the previous subsection. In the BCI game, ASR was not available and speech was not recognised. Brain signals were acquired by five EEG electrodes placed on participant's head. During all games, each key press and mouse click was logged along with a timestamp. The game world layout was different in each game but comparable in difficulty.

4.4 Analysis

For workload and engagement analysis, we computed the means of NASA-TLX and GEQ scores respectively over all participants. For usability analysis, we did the same only with the pragmatic quality scores of the AttrakDiff2. In NASA-TLX we also computed the mean score per item and in GEQ the mean score per dimension. Furthermore, we analysed log data to support our interpretation of the questionnaire results. We computed average selection durations as an indicator of effort and total number of selections (i.e. number of times the mouse button was released) and total game durations as indicators of performance.

Although we computed and report the means in analysis results, we opted for non-parametric statistical testing for assessing the significance of all differences since we neither can assume nor could prove normally distributed samples. Thus, the significant differences mentioned throughout the next subsection were assessed by the Wilcoxon signed-rank test ($p < 0.05$). Unless otherwise stated, reader should assume non-significant difference.

4.5 Results

Fig. 2 displays the box plots summarising the three questionnaire scores for both games. NASA-TLX (i.e. workload) scores were higher for the BCI game ($\mu = 45.21$, $\sigma = 15.12$) than those for the ASR game ($\mu = 40.08$, $\sigma = 14.85$) and AttrakDiff2 pragmatic quality (i.e. usability) scores were higher for the ASR game ($\mu = 5.08$, $\sigma = 1.27$) than those for the BCI game ($\mu = 4.25$, $\sigma = 0.85$). GEQ (i.e. engagement) scores were comparable for BCI ($\mu = 2.31$, $\sigma = 0.62$) and ASR ($\mu = 2.35$, $\sigma = 0.53$) games. The difference in AttrakDiff2 pragmatic quality scores was significant.

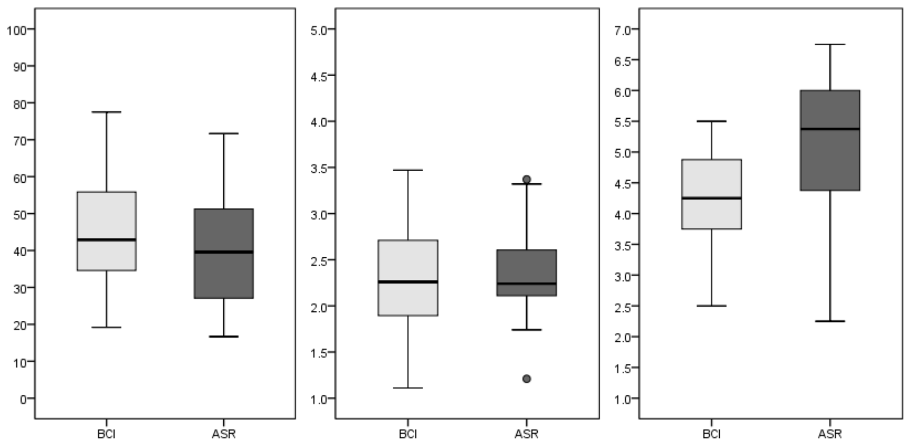

Fig. 2. Box plots of questionnaire scores for both games. From left to right: NASA-TLX, GEQ and AttrakDiff2 pragmatic quality scores corresponding to workload, engagement and usability levels respectively. The difference in AttrakDiff2 scores is significant.

There was no significant difference between the two games in any GEQ engagement dimension score (see Table 1). A deeper analysis, at item level, did not yield any significant difference either.

Table 1. Mean and standard deviation (in parentheses) values of scores for the GEQ engagement dimensions

Dimension	BCI	ASR
Presence	2.51 (0.70)	2.45 (0.67)
Absorption	1.88 (0.77)	1.79 (0.57)
Flow	2.38 (0.69)	2.51 (0.65)
Immersion	3.10 (1.25)	3.25 (1.25)

Item level analysis of the NASA-TLX workload questionnaire revealed that the mental demand item was significantly different between the two games (see Table 2). There was also a trend for significant difference in the effort item ($p = 0.076$).

Table 2. Mean and standard deviation (in parentheses) values of scores for the NASA-TLX workload items. (* significant difference, † trend toward significant difference with $p = 0.076$).

Item	BCI	ASR
Mental Demand*	52.00 (21.67)	39.50 (24.06)
Physical Demand	30.50 (21.39)	33.50 (21.40)
Temporal Demand	49.25 (25.56)	46.50 (19.13)
Performance	31.50 (17.93)	32.00 (22.68)
Effort†	58.78 (20.64)	49.25 (20.28)
Frustration	49.25 (27.40)	39.75 (24.79)

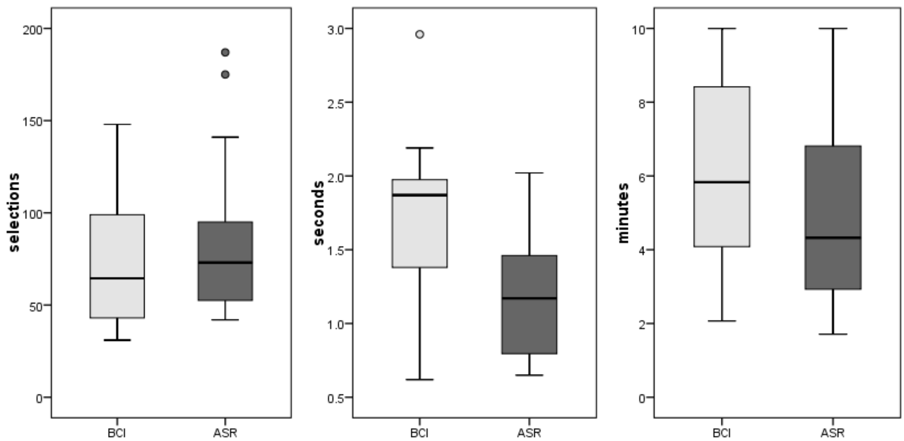

Fig. 3. Box plots for log analysis results. From left to right: number of selections, average selection duration, and game duration. The differences in the latter two are significant.

Fig. 3 displays the results of the log analysis in box plots. The number of selections was less during the BCI ($\mu = 72.35$, $\sigma = 33.05$) game than that during the ASR ($\mu = 84.25$, $\sigma = 41.28$) game. Average selection duration (in seconds) was significantly longer in the BCI game ($\mu = 1.71$, $\sigma = 0.53$) than that in the ASR game ($\mu = 1.17$, $\sigma = 0.37$). Furthermore, total game duration (in minutes) was also significantly longer for the BCI game ($\mu = 6.29$, $\sigma = 2.47$) than that for the ASR game ($\mu = 4.98$, $\sigma = 2.63$).

5 Discussion

5.1 Workload and Performance

The results of the NASA-TLX workload analysis showed that participants experienced slightly higher workload during the BCI game in comparison to the ASR game. But neither of the games imposed high workload, as the mean scores for both were below the median value (50/100). Lower level analysis revealed that the difference in the performance item was negligible between the two games. Since in the NASA-TLX we asked the questions for the task of selecting dogs (thus not for the game as a whole), this way, our pilot study to equalise the recognition performances of the two modalities was validated subjectively. Also objectively, the log analysis showed that the number of selection attempts were comparable in both games. This suggests that participants achieved similar performances for selecting dogs in both games. On the other hand, it took significantly more time for the participants to complete the BCI game than the ASR game. This might suggest that ASR performed better than BCI. However we note that the game completion time is not dependent only on the recognition performance of the modalities but also on modality specific strategies. For example, as the log analysis showed, the average duration of selections was significantly higher in the BCI game than that in the ASR game. In this case, while making a selection in the BCI game, the game state would change more than it would in the ASR game. This might necessitate recreating a strategy after some selections in the BCI game thus increase the game completion time.

Mental workload was the item which differed the most significantly between the two games. It was followed, though non-significantly, by effort and frustration. Altogether, these imply that although the participants could achieve comparable performance during both games, the task of selecting dogs was more mentally demanding in the BCI game so that they had to put more effort in. Achieving the same end result by putting in more effort might have introduced more frustration during the BCI game.

With respect to temporal and physical demand, there were no significant differences. There was no deadline for completing a task in both games so the temporal demand, which is the pace of the task, was independent of the control modality. Therefore the absence of difference in temporal demand is in line with the game logic. We understand that looking at the stimulation in the BCI game and speaking in the ASR game were equally demanding. Here we note that during the ASR game some participants needed to speak louder than they would do in real life since the microphone was located behind them for the sake of equalising modality recognition performances.

5.2 Engagement

There was no difference in the overall GEQ engagement scores for the BCI and ASR games. There was also no difference in any questionnaire dimension or item. This implies that modality was not a factor in engagement during the game. The total engagement scores for both games were lower than the median (2.5/5.0) so we understand that the game itself might not be engaging enough. Participants did not confirm that the game was not engaging but some of them indicated that the GEQ seemed more suitable for more immersive games.

5.3 Usability

AttrakDiff2 pragmatic quality scores for both modalities were above the median (3.5/7.0) so both inputs were satisfactory in terms of usability. Nevertheless, the scores were significantly higher for the ASR. Thus, speech input was rated higher than thought input for the usability aspects covered in the questionnaire such as simplicity, predictability and practicality. Note that, our instructions for AttrakDiff2 instructed participants to consider the devices they used for selections. In the ASR game, participants had no contact with the microphone. In the BCI game we placed a cap on participants' head, applied some electrolyte gel in their hair, and connected the electrodes placed on their head to an immobile EEG. Consequently, the additional setup time and lack of freedom to move might have decreased the usability of BCI.

5.4 Assessment and Limitations of the Study

Although we used validated questionnaires in this study, their effectiveness is highly influenced by the appropriateness of the context they are used in. NASA-TLX is a brief questionnaire, used regularly in BCI studies as we also said in our survey in section 2.1. In our study we also obtained invaluable insight into workload using this questionnaire. AttrakDiff2 is often used for evaluating the usability of commercial products. The role of usability in gameplay might seem to be negligible but, as we have also showed in this study, it can make a difference when comparing modalities in a game environment. Despite the fact that GEQ was developed for measuring engagement in computer games, in our study it did not prove to be effective. Participants had problems especially in answering the negated questionnaire items and understanding some terms. Thus, it is doubtful whether the information we obtained out of GEQ is reliable.

This work is not a conclusive study on the use of BCI in computer games. We used a particular neuromechanism, SSVEP, which is very frequently used in BCI applications, especially for selection tasks. Further research is necessary with other neuromechanisms, tasks and types of games. Perhaps a neuromechanism independent of stimulation can impose much less workload. For example imagining movements or trying to relax are commonly used actions in BCI applications and do not require any stimulation [15]. Maybe a more intuitive way of commanding dogs can provide better usability. We usually look at things when we want to interact with them but they do not flicker in real life. Whereas calling a dog by its name is quite intuitive. This is a possible reason that might explain the higher usability during the ASR game in our study. The game we used had a restricted 2D environment with few agents. Therefore it might not be the best platform to do an engagement study. A more complex game, perhaps modification of a popular casual game so as to include BCI, might be more suitable to conduct engagement research. The EEG we used to acquire brain activity was an immobile device restricting bodily movements to some extent and requiring application of electrolyte gel in the hair. Using a portable EEG device with dry electrodes might improve the usability during the BCI game.

6 Conclusions

The purpose of this work was to evaluate user experience during SSVEP based BCI control in order to assess whether it is a suitable modality for selection tasks in HCI. We considered subjective evaluation of three factors related to user experience, which are workload, engagement and usability, while playing a BCI computer game. The evaluations are compared against ASR control in the very same game which can be considered as a reference condition.

BCI control imposed a workload below the median and provided usability above the median of the questionnaire scales we used. On the other hand, it yielded a level of engagement that is less than the median of the used scale. These suggest that although BCI might be a satisfactory modality in completing selection tasks, its use in games for selections might not be entertaining for the player. ASR control gave a similar overall impression except that it was significantly easier to use. BCI scored above the average with respect to mental demand and effort while ASR scored below the average. But the perceived performances of the modalities were not different. Achieving the same end result by putting in more effort might have introduced the higher frustration found for the BCI game. All these findings suggest that although BCI is a suitable modality for selection tasks, there is at least one better alternative, ASR.

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Influencing Experience: The Effects of Reading Game Reviews on Player Experience

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Abstract. Game reviews are used by game developers for making business decisions and measuring the success of a title, and have been shown to affect player perception of game quality. We conducted a study where players read positive or negative reviews of a game before playing, and show that the valence of review text affected game ratings and that these differences could not be explained by mediating changes in mood. Although we show predictable changes in player experience over the course of the study (measured objectively through physiological sensors), there were no objective differences in experience depending on review valence. Our results suggest that reading reviews does not directly affect play experience, but rather is a post-play cognitive rationalization of the experience with the content of the review. Our results are important for understanding player experience and to the game industry where reviews and user forums affect a game's commercial success.

Keywords: Biasing effects, game reviews, critics, player experience, games, physiology, GSR, EMG, affect.

1 Introduction

Game reviews play a major role in the video game industry and in video game culture. They shape our understanding of games, sway business decisions and consumer choice, and impact player experience. The combination of these and other factors has made video game reviews a large and influential business. Players form opinions about a game before ever playing them due, in part, to the influence game reviews wield over other aspects of the business such as marketing, and also directly over players' purchase intent.

In our previous work [10] we demonstrated that biasing effects from reading negative game reviews cause players to rate the quality of a game significantly lower than after reading positive reviews, or reading no reviews at all. Our results showed that the changes in perceived game quality were not mediated by subjective changes in the players' overall moods. However, what remained unclear was whether the effect of game reviews caused a change in the player experience, or if we observed a

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post-play cognitive rationalization of player experience with the content of the review text. In the former situation, a player who read a negative review would enjoy the play experience less than a player who read a positive review. In the latter, both players would have a similar experience; however, the one who read a negative review would interpret their experience as having been more negative. This distinction is important as it helps us to understand the impact of reading game reviews on subsequent player experience in a time when it is common for players to read about a game prior to making a purchasing decision or before even playing a demo version of the game.

To determine whether player experience is directly affected by review text or whether the biasing effects are a cognitive rationalization of player experience with the content of the review, we designed an experiment that measures a player's subjective rating of a game, their subjective mood throughout the experiment, and their objective play experience throughout the experiment. To provide an objective measure of play experience, we collected a player's physiological data during game play. It has previously been shown that the body's physiological reaction changes when presented with a stimuli – such as a video game – and correlates strongly with the user's emotional experience [13] and in-game events [6]. We operationalize objective player experience through the measurement of two orthogonal signals – galvanic skin response (GSR) to measure arousal (degree of activation), and facial electromyography (EMG) to measure valence (positive or negative). Differences in the physiological measures would reveal that players reading negative reviews experience the game differently from players reading positive reviews, while similar measures would reveal that the play experiences themselves are not different.

Similar to our previous research, our results show that players' ratings of a game are systematically affected by reading positive or negative review text of a game prior to playing it. We also show that these differences are not fully explained by subjective changes in the players' moods as a result of reading emotionally-charged text. As predicted by previous work, we found significant physiological differences for the different tasks in the experiment (i.e., reading reviews, playing game). Finally, we did not find objective differences in players' physiological responses to the game depending on the valence of the review text for either the valence or the arousal signals. These findings suggest that the variations in player ratings of the game's quality can be attributed to a cognitive rationalization of players' experiences with previously read review text, and not to differences in the play experiences themselves. Important for our understanding of the impact of reading game reviews on subsequent player experience, we have shown that despite rating the games differently, players' experience of the game was essentially the same.

2 Related Work

Previous work has shown that negative stimuli have a significantly greater effect on an individual than positive stimuli, an effect that has been observed in almost every area of psychology [1]. For example, it has been shown that negative information is more attention grabbing [1][4], influences impression more [4], is remembered better [16], and is cognitively processed more carefully than positive information [1], resulting in a greater biasing effect of negative stimuli.

Persuasive power has been explored in the domains of movies [18], e-commerce [20], advertising [23], and news [19]; however, there has been little investigation into the effect on player experience. Jenkins et al. [8] studied the effects of showing a high, low, or no game score to players. The authors found when players were exposed to a high review score (e.g., 90%) they were more likely to rate a game higher than if they were exposed to a low review score (e.g., 61%), and attributed their results to "anchoring" [22]. *Anchoring* is a biasing effect where an individual's ability to estimate is biased toward a previously known value. In our previous work [10] we found that the biasing effect remained when anchoring effects were removed. We presented participants with various affective text stimuli including game reviews, user comments, movie reviews, and no text at all. We found that the valence of the reviews significantly affected player ratings, that the authority of the text did not matter (both user comments and critic reviews showed effects), and that the relevance of the text did matter (no differences were observed after reading positive and negative movie reviews). We also found that the biasing effect was strongest in the negative text conditions – consistent with similar work in psychology [1] – and likely primarily a cognitive effect caused by the more careful processing of the negative affective text. Finally, we showed that the ratings differences could not be explained by changes in subjectively-measured mood. This work raised the question of whether the ratings differences were a result of a change in player experience or a reflection of the player's cognitive rationalization of their experience with the review text. The present study answers this question by evaluating the effect of game reviews on objective player experience measured using physiological signals.

The study of players' physiological responses to video game stimuli has seen a significant amount of research. Mandryk et al.'s work [10,11] has explored the psychophysiological effects of games on an individual, and showed that the physiological measures were related to the subjective responses of players [13], and that the physiological measures could be used to build a mathematical model of player emotional state [12]. Drachen et al. [3] also found a significant correlation between psychophysiological arousal and self-reported player experience. Hazlett showed a relationship between players' physiological measures and in-game events. He found positive facial EMG activity to be higher during positive events, while negative facial EMG activity was greater during negative events [5,6]. Ravaja et al. [17] also showed a relationship between in-game events and phasic responses in GSR, EMG and heart rate acceleration, and Nacke et al. [14] showed that challenging game situations evoke positive affect and high arousal in players as measured by GSR and EMG. Finally, although there are significant individual differences in physiological responses, researchers have demonstrated success in the normalization of GSR [11] and EMG [6] data for between-participant comparisons. These works demonstrate the relationship between physiological responses with both self-report and in-game events. However, these studies focus on the effects of the game condition or the game itself on physiological measures. In our study, we extend these works by examining the effect of systematically-processed [2] information read prior to play on a player's physiological response.

3 Experiment

3.1 Design, Apparatus, Participants, and Procedure

We used a single-factor between-subjects design manipulating two levels of valence (positive, negative). In our previous study we found the biasing effect manifests when the text is relevant to the task being performed [10], so we used game review text. We created the review text by modifying real reviews to ensure that the text stimuli were comparable across conditions and as authentic as possible. To create the positive and negative versions, we used affectively-charged antonyms. To control heuristic cue effects [2] the content and subject matter between conditions was maintained as much as possible. To increase participant buy-in, they were informed that the text had been taken from a professional review website. In all cases, the review text was about 1000 words. To ensure that the affective tone (positive or negative) of our text was comparable across conditions, we used the Linguistic Inquiry Word Count (LIWC) text analysis tool [15] to measure the valence of review text for each game (see [10]).

For our experiment we used a little-known game. Tag: The Power of Paint is a 3D puzzle shooter, and winner of IGF's 2009 Best Student Game. The primary factor in choosing a game was obscurity – the game had to be of professional quality, but be unknown so that users did not have prior first or second hand experience with it. All participants were unfamiliar with Tag prior to participating in the experiment.

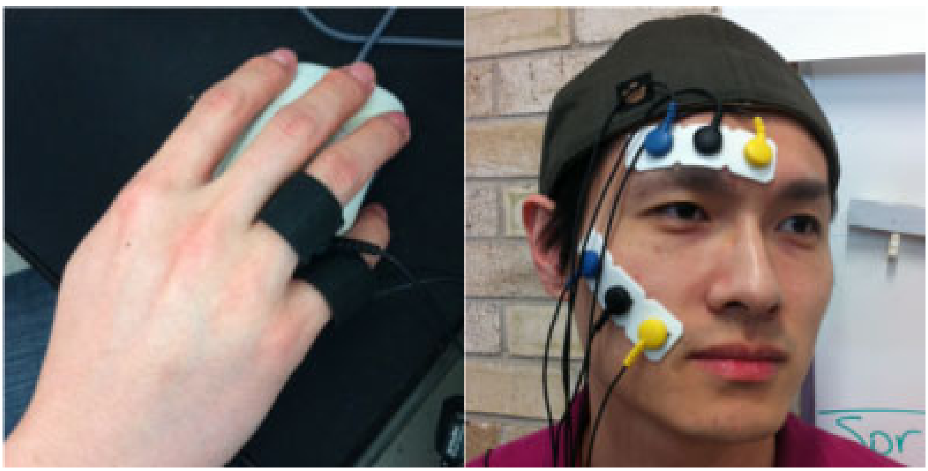

Fig. 1. Physiological sensors. GSR (left), Zygomatic and Corrugator EMG (right)

To measure physiological responses, we used Thought Technology sensors (EMG, GSR) connected to the FlexComp Infiniti encoder. The EMG band sensors were attached to the right corrugator and zygomatic muscles of the face (Figure. 1). To ensure strong EMG signals, players were screened prior to participation for excessive facial hair. The GSR sensors were attached to the ring and pinky fingers of the right hand (Figure. 1). The right hand was chosen because players moved the fingers less using the mouse with the right hand than using the keyboard with the left.

Twenty participants (8 female), aged 18-25 (M=21.8 years) began by completing a consent form, and were then randomly assigned to one of the two experimental groups, balancing for sex. Players completed the experiment using a custom system developed to deploy the game and gather the survey responses using an online form.

Players were first connected to the physiological sensors and the setup was tested (for about 1 minute) to ensure strong signals from each sensor. Players then provided their demographic information. Physiological data was collected at four times during the experiment: during the baseline, during the reading of textual stimulus, while answering stimulus questions, and during gameplay. The baseline and gameplay sessions were timed to record precisely four and fifteen minutes respectively. Players were not time-limited during the reading or answering phases, rather markers were added to the data when the player started reading, stopped reading, started answering, and stopped answering. During the baseline phase, players were shown a gray screen with a cross displayed slightly off center. The player then performed a pre-text valence and arousal rating via the self-assessment mannequin (SAM) [9]. Next, participants read the text stimulus corresponding to their test condition and answered the required questions that followed. The SAM valence and arousal was measured again, and then the game was played for 15 minutes. Afterwards, the SAM valence and arousal ratings were collected a final time.

To evaluate their perception of game quality, players wrote a short game review and provided a game rating. Players were never shown numerical scores to ensure that no biasing anchoring effects were present. To help players choose scores, and to aim for consistency across players in their interpretation of the ratings scale, a guideline was provided (0-19: I hated it; 20-49: I didn’t like this; 50-74: It was ok, but I’m rather indifferent; 75-89: It was good, but room for improvement; 90-100: I loved it).

3.2 Data Processing and Analysis

Physiological data were exported from BioGraph as raw CSV files and imported into MATLAB for processing and analysis. Data were divided based on the action being performed. Subsequent analyses were conducted during reading of the stimulus text and playing the game, although the baseline phase was used for signal normalization. EMG and GSR require different signal processing, so custom scripts were developed for each physiological sensor.

Electromyography (EMG). The raw data collected from both EMG sensors was the RMS of the signal. Consistent with normal EMG signal analysis [21] the raw data was first filtered, and then smoothed. All EMG data was subjected to a 3rd order Butterworth low-pass filter at 500Hz, then smoothed using a moving average window of 0.5s (1024Hz). The remaining data points were normalized by subtracting the baseline or reading values (whichever were lower) from each sample and representing each sample as a percentage using the min and max values found across all filtered and smoothed samples for a specific participant. Normalizing was required to allow for meaningful between-participant comparisons.

An EMG ratio was also calculated using a similar approach to the one described by Hazlett [6]. We calculated the total time spent in activation higher than one standard deviation above the mean for both the corrugator and zygomatic muscles. The ratio of zygomatic to corrugator activation was expressed as a decimal value. These ratios could safely be compared between participants.

Galvanic skin response (GSR). Similar to the EMG data processing, GSR values need to be normalized to allow for meaningful statistical comparisons between participants. GSR was normalized by calculating each sample as a percentage of the entire span of GSR, using the min and max values over all samples for one participant. This practice is consistent with GSR analysis of gameplay experience [11]. The mean and standard deviation for each GSR sample was calculated and recorded as a percentage.

Data Analysis and Dependent Measures. Our subjective dependent measures are SAM arousal, SAM valence, and game ratings. Our objective dependent measures are normalized GSR, normalized zygomatic and corrugator EMG, and Hazlett EMG emotion ratio. The subjective dependent measures do not meet the assumptions of normality and equal variance, which is typical with ratings data. We used the Mann-Whitney Test for all between-groups tests, and the Wilcoxon Signed Ranks Test for within-player comparisons [7]. The objective physiological measures were analyzed using the appropriate parametric statistical tests.

Table 1. Means and SDs of dependent measures for each phase, split by group. Arousal and valence were measured after the phase on a 9-pt scale, while the physiological measures were averaged over the phase and normalized between 0-1.

	Positive Review			Negative Review		
	Baseline	Reading	Playing	Baseline	Reading	Playing
Ratings			80.9(8.61)			44.3(22.94)
Arousal	2.9(0.88)	3.3(1.77)	6.1(1.66)	2.6(0.70)	2.7(1.06)	3.9(1.85)
Valence	6.2(1.55)	6.2(1.62)	7.1(1.45)	7.0(0.94)	5.8(1.32)	6.1(2.33)
EMG Cheek		0.05(0.06)	0.09 (0.09)		0.02(0.04)	0.11(0.07)
EMG Brow		0.04(0.03)	0.01 (0.03)		0.02(0.03)	0.02 (0.02)
GSR		0.23(0.13)	0.65(0.08)		0.23(0.20)	0.67(0.07)
EMG Ratio		1.36(0.86)	1.67(0.93)		1.03(0.53)	2.10(1.47)

3.3 Results

Does the text's valence affect perception of game quality? Consistent with our findings from our previous study, players who read positive text rated the game significantly higher than players who read negative review text ($Z = 3.6$ $p \approx .000$).

Can the ratings differences be explained by changes in mood? Consistent with our previous work, we were interested in whether the game ratings differences could be explained by mediating changes in a player's mood. Perhaps the players reading positive text were put into a more positive mood and then enjoyed the game more than players reading negative text (thus rating it higher). We asked players to rate their valence and arousal three times: prior to reading the game review, after reading the game review, and after playing the game. Means and variances are in Table 1.

There were no differences between the two groups for any of the three valence ratings (Z(p) - Pre-read: 1.07(.315); Post-read: .70(.529); Post-play: .97(.353)). There were also no differences in arousal between the groups prior to or after reading the game reviews (Z(p) - Pre-read: .80(.481); Post-read: .82(.481)). However, there was a difference in the arousal rating after playing the game, where the positive review group rated their post-game arousal significantly higher than the negative review group (Z(p) – Post-play: 12.45(.015)). To determine what this difference means, we looked into arousal changes over the experiment for each group. There were two arousal differences that we considered – the difference between before and after reading the review text and the difference between after reading review text and after play. For the negative group, there was no difference in arousal after reading the review text (Z=.58, p=.564) or after play (Z=1.78, p=.076). For the positive group, arousal did not increase after reading the review (Z=.96, p=.336), but did increase after playing the game (Z=2.68, p=.007). Thus it appears that reading the review text did not increase players' arousal for either group; however, playing the game significantly increased the positive group's arousal, but only marginally increased the negative group's arousal, resulting in a net difference between the groups.

Are the ratings differences reflected in objectively-measured player experience? The main goal of the present study was to determine whether the game ratings differences are reflected in differences in player experience during play, or whether the differences are a cognitive rationalization of similar play experiences with differing review texts. We conducted a RM-MANOVA with one between-subjects factor (valence of review – positive or negative) and one within-subjects factor (phase of experiment – reading review or playing game) on four dependent measures (GSR, EMG cheek, EMG brow, EMG ratio). Means and variances are shown in Table 1.

As expected, there was a significant main effect of phase on GSR ($F_{1,18}$=143.6, p≈.000, η^2=.89), EMG cheek ($F_{1,18}$=15.0, p=.001, η^2=.46), and EMG ratio ($F_{1,18}$=6.2, p=.023, η^2=.26), which showed that players were more aroused and experienced higher valence during game play than during reading. There was no effect of phase on EMG brow ($F_{1,18}$=1.0, p=.329, η^2=.05). These results confirm our expectations that gameplay is more exciting than reading review text, and also demonstrate the capability of the physiological signals to differentiate player experience objectively.

There was no main effect of valence of review text on any of the dependent measures (GSR: $F_{1,18}$=.03, p=.879, η^2≈.00; EMG cheek: $F_{1,18}$=.08, p=.780, η^2≈.00; EMG brow: $F_{1,18}$=.75, p=.399, η^2=.04; EMG ratio: $F_{1,18}$=.02, p=.885, η^2≈.00). These results show that there were no overall objective differences between the two groups.

There were also no interaction effects between valence group and phase on any of the dependent measures (GSR: $F_{1,18}$=.021, p=.886, η^2≈.00; EMG cheek: $F_{1,18}$=2.0, p=.175, η^2=.10; EMG brow: $F_{1,18}$=1.9, p=.184, η^2=.10; EMG ratio: $F_{1,18}$=1.9, p=.187, η^2=.10). These results show that the two groups did not respond differently during the two phases. We may have expected similar levels of objective experience during reading, and that the positive group might demonstrate more enjoyment during play than the negative group. However, this is not the case as our results suggest that there are no differences in the responses of the two groups to the experiment.

4 Discussion

There are four main results to take away from our findings:

1. Reading positive or negative game reviews influences subsequent player ratings of game quality.
2. The ratings differences cannot be explained by changes in the self-reported player valence, but may have been mediated by player arousal. Increases in self-reported arousal after playing were significant for players who read positive reviews, and marginal for players who read negative reviews, resulting in a between-group difference in self-reported arousal post play.
3. There were significant increases in GSR, EMG of the cheek, and the Hazlett EMG ratio when playing the game over reading the review text, demonstrating the sensitivity of these signals to measure player experience.
4. There were no differences in any of the physiological measures between those who read positive or negative reviews, suggesting that player experience did not change as a result of reading review text, but that ratings differences were a post-play rationalization of experience with the previously-read reviews.

The first three results are consistent with previous work, while the fourth resolves a question left unanswered by previous work. We focus our discussion on the contributions of game-related pre-play and play experiences on resulting opinion about a game, the potential impact of our results on industry practices, and the research opportunities in this space.

4.1 Effects of Review Text on Player Experience

We conducted this work to shed light on an unanswered question – does reading positive or negative game reviews affect player experience? Previous work had shown that reading positive or negative game reviews affected player perception of game quality provided by a game rating, and showed that these differences were not mediated by changes in a player's mood [10]. Our work replicated these results, but also showed that reading positive or negative game reviews did not affect player experience during play of the game itself. So if players who read positive text did not experience the game differently than those who read negative text, why did they rate the game significantly higher?

We feel that the game ratings are not indicative solely of the player's experience, but are actually a cognitive rationalization of the experience in the context of the previously-read review text. This does not mean that players are under a false impression of their experience, or that review text wins when there is a discrepancy between the review content and their experience. It is possible, and quite likely, that players who read negative text would subjectively characterize their experience as worse than players who read positive text, indicating that the rationalization of experience with the influencing reviews affected not only the perception of game quality, but also the perception of the play experience. That measured player experience did not differ does not make the reflective difference in experience any less real to a player or any less true. It does mean that players who read negative reviews decided that they liked the game less than those who read positive reviews, not because of differences in play experience, but in spite of no differences in play experience. This lack of difference in play experience after reading game reviews has important impact for the game industry.

4.2 Impact on Industry

Current review methods used in the game industry include game reviews from both professional and amateur critics, and discussion forums where players can discuss their opinions and experiences. These textual channels offer players a freely available source of influential reports, which then influence player perception of game quality. The game industry is known for releasing games to critics prior to release. As our results show that reading reviews (especially negative reviews) biases the player's perception of the game, game studios should be careful of critical receptions prior to game release. It is tempting to believe that a good play experience will outweigh negative buzz surrounding a game, but we show that this may not be the case. Even though experience of the game was not different, players who read negative reviews were still more critical in their perception of the game's quality.

Our findings can also be extended to other marketplaces where the exposure of reviews and ratings is becoming more prominent. For example, the Apple app store prominently displays user ratings and comments right on the main app page for each app. Our results suggest that these ratings may adversely affect the perception of quality of those products for users who read the reviews prior to using the app. Although these ratings often come from users of the apps and not professional critics, our previous work revealed that the authority of the review source did not matter; players were influenced both by game reviews and by user comments. Developers need to be aware of the impact these reviews and comments have, not only directly on their sales, but also on the experience users have with their products.

In an online community this negative effect can snowball as users who are influenced by critic reviews may in turn post negative comments online, influencing an even larger user population. As this cycle continues with new users reading and being influenced by the negative press, the bottom line of a game or an app in terms of commercial success could be negatively affected.

4.3 Alternate Explanations of the Results

There are cognitive biases that can influence a user's perception of a game quality. We controlled for related biases in our study in order to attribute the results to the reading of review text and not other cognitive biases. For example, affective priming uses a stimulus, unrelated to the task or object to be viewed, to change a participant's affective state or mood [23]. Because our review text was related to the game, we can assume that our results are not due to affective priming. Anchoring is a biasing effect where an individual's ability to estimate is biased toward a previously-known value. In previous work, players exposed to a negative rating of a game rated that game lower themselves [8]. The authors identify this as an effect of anchoring. In our study, we did not present the players with any numerical ratings, so the content and tone of the review text was causing the difference in perception of game quality. Thus, our results cannot be attributed to the biasing effects of anchoring or affective priming.

Although players rated the game differently depending on the valence of previously-read review text, we observed no physiological differences between the groups. One might suggest that there were in fact differences in player experience, but that physiological measures are not sensitive enough to show differences. Because our results showed significant and predictable physiological differences between reading the review text and playing the game, we feel that the signals are a good measure of player experience and are sensitive enough to reveal differences.

4.4 Limitations and Future Work

We examined average physiological responses over a play session, and did not test phasic responses to specific game events. Our results confirm that player experience was not different overall, but cannot confirm whether player responses within a play session were similar. It is possible that the two valence groups responded differently to specific game events (especially those that were targeted in the game reviews), but that these differences were not large enough in magnitude or frequency to affect average experience. Future work examining phasic responses to in-game events would help to shed light on the player reactions that make up overall experience.

We gathered subjective reactions through game quality ratings. It is possible that although we saw no objective differences in play experience, the interpretation of similar play experiences in the context of different review text might cause players to subjectively characterize their play experience differently. Although outside the scope of this work, it would be interesting to know whether the cognitive rationalization of play experience with review text resulting in differing game ratings would also be reflected in differing subjective characterization of play experience.

Our study is the first use of physiological measures to evaluate experience prior to the playing of a game, which is important when considering biasing effects that can influence experience. The importance of pre-play events should not be dismissed, as we show that the experience begins before engaging in actual play. This introduces a variety of interesting research questions as events prior to play deserve consideration, and more study is required to determine their impact on player experience. Our study only looks at biasing effects of game review text, but our methods could prove useful in the evaluation of any number of pre-play activities, such as the effects of any pre-game menu traversal, loading times, or profile creation.

5 Conclusion

In this paper we have demonstrated the biasing effect that reading video game reviews has on player perceptions of a game. We show that these effects cannot be entirely explained by mediating changes in mood, and that the effects do not influence player experience as measured objectively through physiological sensors. Our major contribution is showing that the differences in perception of game quality that result from playing a game after reading a review are not stemming from differences in the play experience, but are a cognitive rationalization of the experience with the content and tone of the review. Our results are important for understanding player experience and for the game industry where reviews and commenting forums affect sales.

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Quality of Service and Quality of Experience Correlations in a Location-Based Mobile Multiplayer Role-Playing Game

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Abstract. The well-established Quality of Service and the relatively recently emerged Quality of Experience research topics are unquestionably linked, yet to date little effort has been invested in the study of their precise correlation and mutual reciprocity. This paper examines the impact of three representative QoS-related parameters on user QoE in the particular context of location-based multiplayer games played on mobile devices. The choice for this research context is motivated by the rapidly expanding popularity of this application domain. Analysis of the quantitative and qualitative results from an empirical study involving 32 participants confirms that modifications in the performance of the investigated technical parameters does indeed hold implications for the quality of the users' experiences; at the same time, the results clarify the magnitude of these implications. Our findings are valuable as they provide practical insight in the QoS/QoE relationship and can hence aid software developers in delivering high-quality usage experiences to their customers.

Keywords: QoS, QoE, quantitative and qualitative user study, location-based mobile gaming, multiplayer, user experience.

1 Introduction and Background

Quality of Service (QoS) is a notion that has been around for quite some time and that has become a well-established concept in software and system engineering. It acts as a measure of technological performance and excellence which, in general, denotes the quality of systems, networks or applications. QoS is especially frequently used in the domain of computer networking, where it refers to the ability of the transportation network to guarantee a certain performance level, for instance in terms of throughput, maximal delay, average delay variation, bit error rate, and so on. In summary, although being a relatively extensive construct, QoS focuses exclusively on technical dimensions. As a direct consequence, it is objectively measurable.

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In contrast, Quality of Experience (QoE) has only fairly recently become an active research topic. Attention for QoE has emerged in the late 1990s but has since then increased exponentially. QoE can be considered the semantic variant of QoS since, broadly speaking, it denotes the overall experience that is witnessed by an end-user. Stated differently, it refers to a consumer's satisfaction when using a particular product or service. As such, it is clear that it is a humane and highly subjective metric that is hard or even impossible to quantify objectively. Compared to QoS, it is also much more multi-disciplinary since it might involve aspects from several non-technological domains, including sociology, cognitive sciences, psychology, usability research, user interface design, context-aware computing, expectation modeling and market studies.

Given its broad scope, QoE definitions abound in the literature. Probably one of the most elaborate and versatile definitions is provided by Wu et al. in [10]. In this article, the term QoE will be wielded loosely to denote the experience or the satisfaction of the user, in this case while playing a multiplayer location-based mobile game that requires data communication via a transportation network.

The QoS and QoE concepts are irrefutably related. This is for instance manifested in the fact that, somewhat paradoxically perhaps, the majority of initial studies on user experience optimization was concentrated primarily on technical performance and QoS achievements. Even to date, a strong attention for technological factors remains explicit in user research. For example, Eberle et al. have developed a cross-layer methodology for trading off performance versus energy consumption in wireless communication environments, but they largely neglect actual user satisfaction in the process [1]. Soldani has investigated QoE in a telecommunications setting (i.e., for cellular phone users) and claims that QoE performance is defined by service accessibility, retainability, availability and integrity [8], which are all purely technical elements. As a final example, Vanhaverbeke et al. quantify user experience in HDTV video streaming setups exclusively as the number of Visible Distortions in Twelve hours (VDTs) and propose Forward Error Correction (FEC) and retransmission schemes as means to improve video quality and hence user satisfaction [9].

Unfortunately, the exact relationship between QoS and QoE to date remains largely uninvestigated and therefore unclear. Such information nonetheless seems very valuable for developers of (distributed) applications. For example, a decent understanding of the mutual impact of QoS and QoE dimensions as well as their interaction with each other is likely to allow software developers to optimize the experience of their users. This in turn might prove an important asset in Customer Relationship Management (CRM) in general, and in achieving customer loyalty in particular. The main contribution of this paper is that it unveils some of the correlations that exist between QoS and QoE by means of a user research methodology comprising both quantitative and qualitative components.

The field of mobile gaming was selected as context to conduct our research. This decision is motivated by the steadily expanding popularity of this application domain, which is for instance exemplified by the widespread penetration of handheld game consoles such as the Nintendo DS in the mainstream consumer market. Two remarks regarding the adopted research field are in place. It is first of all stressed that we focus our attention exclusively on *distributed multiplayer* games. Such games allow multiple individuals to share a single game environment and to interact with each other in this environment, be it in the form of partnership, competition or rivalry. To enable the interaction, multiplayer games typically rely on a transportation network to disseminate information among involved players. As a result, the operation and performance of the networking substrate might substantially influence user experience. Secondly, the scope of our research was further narrowed down to games which revolve around *location determination*. In such games, the position of players and/or objects in the physical world is tracked and plays a prominent role in the gameplay. Modern hardware that can be used for mobile gaming purposes (e.g., handheld consoles, smartphones) typically comes equipped with a number of peripherals (like a GPS module and/or a digital compass) that can be exploited to implement localization in outdoor environments. Alternatively, location determination can be achieved via triangulation of the device's wireless signal. Example location-based games include Tourality (`http://www.tourality.com/`), an outdoor GPS-based multiplayer scavenger hunt game, and Pac-Manhattan, a large-scale urban game that recreates the 1980s video game sensation Pac-Man in the streets of New York City (`http://www.pacmanhattan.com/`).

In the just delineated gaming context, the effect of three concrete technology-related parameters on user experience was studied by means of hybrid quantitative and qualitative user research. This yielded a number of significant findings regarding the QoS/QoE relationship. These findings can function as high-level directives for developers of mobile location-based games (and potentially also other types of distributed mobile applications): if they are taken into account during design and implementation, the expected outcome is an improved QoE for the end-user. A secondary contribution of this article is hence that it transfers valuable knowledge concerning QoS and QoE interactions to developers of distributed mobile software.

The outline for the remainder of this article is as follows. Section 2 describes the location-based multiplayer game that was used to conduct our research. Next, section 3 overviews the technical parameters that were studied for their potential impact on player QoE. All facets of the performed user research, including practical considerations, employed methodology and result analysis, are grouped in section 4. Finally, section 5 presents our conclusions.

2 Research Context: Location-Based Role-Playing Game

The investigation of QoS and QoE correlations occurred by means of an in-house developed mobile location-based multiplayer game. The game stages a World War I (WW I) setting and was originally intended to promote WW I musea (and tourism in general) in Belgium. The game is played outdoors between two rivaling teams that respectively represent the Allied forces and the German army. It is a location-based game in the sense that the gameplay involves players walking around in the physical world while carrying a handheld device (currently a small Gigabyte T1000 netbook; in the future potentially a PDA or smartphone). Players' physical movement is tracked via a GPS receiver that is attached to the portable device and is distributed among the other participants, after which it is visualized on a satellite view of the outdoor environment [3].

Players can interact with both other participants and with the environment through QR tags, an ISO/IEC standardized 2D barcode specification [5]. In particular, each player carries such a (unique) QR code and there are also a number of codes scattered around the playing area, which each represent a virtual item. By photographing a QR code with the built-in camera of their portable device, players respectively start an interaction with the corresponding user or pick up the associated virtual item. This mode of interacting with virtual objects via QR tags can be considered a form of Augmented Reality (AR).

The game can be designated a Role-Playing Game (RPG) in that it enables players to take on different profiles. The selected role determines which actions the player can undertake in the game, what his/her objectives are and which virtual items he/she can gather in the real world via QR code scanning. The supported roles are the following:

`Commander` Does not enter the playing field but instead remains at a fixed indoor location (i.e., a stationary PC). The `Commander` has a global overview of the actions of his entire team. He also permanently sees the objects that are discovered by his outdoor team members and can instruct the players on the field (e.g., about the position of these objects).

`Soldier` Needs to search for weapons in the playing field and can use these weapons to engage players from the opposing team.

`Spy` Is responsible for acquiring intelligence items and is able to scan his surroundings to uncover the location of enemy players.

`Medic` Needs to collect medical supplies and can use these to heal injured teammates (by scanning their QR code); can also revive killed players.

Figure 1 shows a screenshot of the game. Each player and discovered virtual object is represented by means of a marker on a top-down map of the real-life environment in which the game is played. As players relocate in the physical world, their marker is relocated accordingly. In contrast, item markers will never relocate in the course of a single gaming session. There are some restrictions on marker visualization: (i) only teammates are permanently visible on the map; (ii) members of the rivaling team become visible for a short period of time when they attack you (only applicable for an enemy `Soldier`) and when a `Spy` scans for their presence in his immediate vicinity; (iii) items only become visible on the map once they are discovered in the physical environment by a teammate; in addition, items are only displayed for a short amount of time on the virtual map for outdoor players, but remain permanently visible for the team's `Commander` and for the player that discovered the item.

The game includes inter-player communication facilities in the form of voice chat between teammates. This is implemented via a push-to-talk mechanism (see figure 1). Speech data (like all game-related data) is disseminated among participants via the 3G connection of the mobile device.

A gaming session lasts a predefined amount of time. The objective of the game is to accumulate as much points as possible during this time interval; the team with the highest aggregate score at the end of the session is the winner of the match. Players receive points for picking up virtual items and for the actions which they perform (e.g., a healing effort by a `Medic`). Different items and actions yield different revenue.

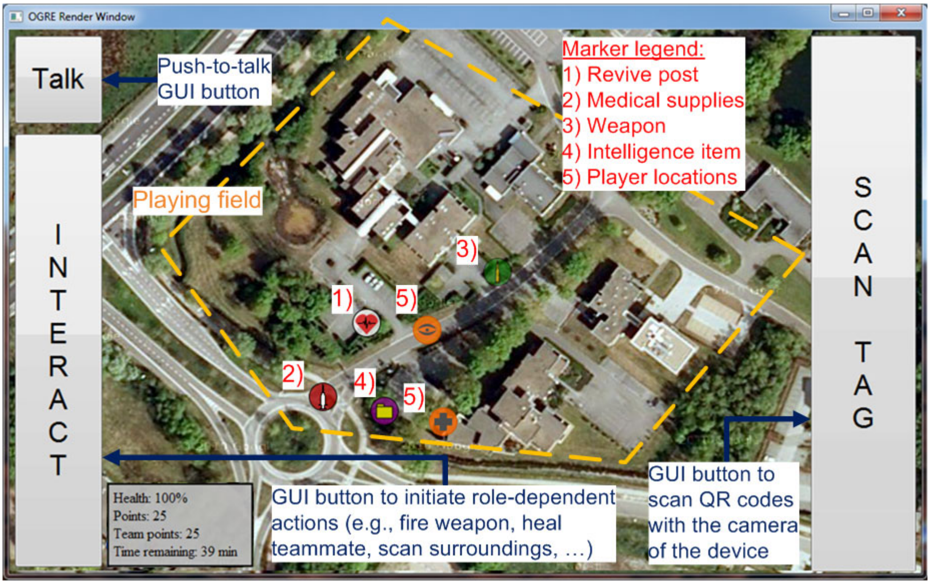

Fig. 1. The main screen of the game displays a satellite view of the real-life environment

3 Investigated Technological Factors

In the context of the just described mobile game, the influence of three QoS-related parameters on the QoE perceived by players was studied. Each parameter acted as a separate test condition and was hence investigated in isolation. It is hereby important to note that the test conditions themselves are representative (i.e., the simulated situations might very well occur in a real system), whereas the magnitudes used in each condition might somewhat be exaggerated. The choice for unrealistically high values is motivated by the fact that these were expected to elicit pronounced and unambiguous reactions from test subjects.

3.1 Precision of Player Location Determination

Localization techniques might not always be completely reliable. As an example, the accuracy of GPS-based solutions is affected by a number of factors, including atmospheric conditions (e.g., clouds) and natural barriers (e.g., buildings in an urban environment). It seemed interesting to determine the impact of such imprecisions on player QoE. We therefore developed a test condition in which the position of players on their team members' map was artificially and randomly varied in a 10 meter radius around the actual location. In practice, this resulted in a rapid bouncing motion, in a circular area, of the position of the player.

3.2 Player Location Refresh Rate

The rate at which player positions are disseminated forms an important design parameter for location-based games. A higher refresh rate yields more accurate positioning, but at the same time injects additional traffic in the transportation network. Stated differently, the location update pace allows for the trade-off between network load and data staleness to be controlled.

Under normal operation, player positions were updated multiple times per second in the game. A test condition was however implemented in which locations were only refreshed every 6 seconds. The outcome was a situation in which player visualizations discretely jumped from one position to the next at 6-second intervals (instead of producing smooth motion).

3.3 Voice Communication Delay

Communication and interaction in distributed applications is affected by the delay that is induced by the transportation network. Multiple factors can attribute to delay buildup, including congestion, failing links and bandwidth constraints. Regardless of the type of application, the International Telecommunication Union (ITU) recommends not to exceed a one-way latency of 400 milliseconds [6]. In this test condition, an additional voice delay of 2 seconds was artificially enforced on top of the latency that was implicitly introduced by the 3G network. As a result, fluid interpersonal communication was radically impeded because only 2 seconds after a sentence was uttered by a player, it was received by his team members.

4 User Research

4.1 Pilot Testing

Prior to the actual user studies, an iterative phase of pilot testing was organized in order to optimize the test procedure, to verify the robustness and stability of the game and to evaluate the implemented technical simulations. The pilot tests revealed that several users experienced problems with the QR tag scanning. Given the fact that it forms a cornerstone of the gameplay and is hence vital for making progress in the game, a tutorial application was developed to allow participants to master this operation. The pilot studies also resulted in a refinement of the user instructions and surveys in terms of clarity and layout.

4.2 Practical Approach and Participant Demography

Four separate user studies were organized with 8 test subjects each. In every study, the participants were evenly divided in 2 teams and each participant assumed a different role in his/her team (i.e., there was consistently one `Commander`, `Soldier`, `Spy` and `Medic` per team). The assignment of roles to players was randomized. The test subjects were beforehand deliberately not informed about the QoS manipulation and its resulting test conditions.

12.5 % of the test population were female. The average age of the participants was 29 years (Standard Deviation 9.04); the youngest was 16 years old, the oldest 57. More than 80 % had played a video game during the past month. In terms of professional occupation, a great deal of the sample consisted of students (just over 40 %) and employees (almost 50 %).

The gaming sessions took place at a 7 hectare research and science park in Diepenbeek, Belgium (see figure 1). A total of 25 virtual objects (in the form of QR codes) were strategically dispersed in this area. These consisted of 3 revive posts, 6 medical supply items, 4 intelligence items and 12 weapons.

4.3 Test Procedure and QoE Data Collection Methodology

Every test session lasted approximately 2 hours and logically enveloped 3 consecutive phases. In the *pre-usage phase*, the participants were welcomed by the researchers and given instructions concerning the test procedure. Next, the objectives and mechanics of the location-based game were verbally outlined. During and after this short presentation, the test subjects were able to ask for further clarification. The participants were then requested to complete a questionnaire (on paper). This survey was intended to collect background information about the test subjects in terms of basic socio-demographical characteristics, as well as to establish previous experiences and expectations concerning digital games in general, and the WW I game in particular. To conclude the pre-usage stage, all users needed to complete the QR tag scanning tutorial to become acquainted with this particular gameplay element (see section 4.1).

Subsequently, the *during-usage phase* commenced, which spanned 40 minutes and was conceptually divided in 4 distinct intervals of equal length. Three intervals were each exclusively devoted to one of the test conditions described in section 3. Stated differently, in each of these time periods, one of the test conditions was separately activated in order to examine the influence of the corresponding QoS parameter on the test subjects' quality perception of the experience. The fourth interval on the other hand represented a period of "perfect" or "normal" gameplay in which no artificial technical impairments or manipulations were applied. This period hence acted as the reference scenario with which the player QoE findings from the other three intervals could be compared. The assignment of test conditions to time intervals was randomized, which yielded the following order: player location distortion, voice communication delay, normal gameplay and reduced player location update rate.

In the course of the playing session, 4 identical in-game questionnaires needed to be filled in by the players (via an electronic form displayed on their portable device). These surveys were evoked at the same moment for every test user, namely at the end of each of the conceptual intervals of the session. It had been explained in the pre-usage briefing that these questionnaires would pop up and that the test subjects needed to complete and submit them before they would be able to continue the game.

The in-game inquiries were included in the data compilation methodology with the purpose of acquiring detailed information related to relevant QoE aspects in each of the test conditions. The downside of this strategy is that it (briefly) interrupts the gaming experience. On the positive side however, it enables sampling of the players' thoughts, emotions and behaviors (in this case, concerning the individual test conditions) at the very moment (or at least *immediately after*) they were actually experienced. Compared to an exclusively post-usage probing method (i.e., after *all* conditions have finished), an in-situ approach substantially reduces the risk of the recall bias effect and therefore is likely to yield more accurate and reliable assessments [2]. In this study, we particularly emphasized experience dimensions related to the considered technical factors (see section 3) and to the general concepts of absorption, fun, effort, frustration and expectations. The in-game survey comprised the following 11 statements that were each measured on a five-point Likert scale [7] (ranging from “1: Totally disagree” to “5: Totally agree”):

1. I feel totally absorbed in my role in the game
2. With the information that I am receiving about the position of the other players, I am able to localize them without a problem
3. I am having fun while playing the game
4. I have to put a lot of effort in the game
5. The kind of information that I am getting about the location of objects, allows me to localize these objects without a problem
6. I expected more from the game
7. While communicating with team members I experienced technical problems
8. I feel frustrated
9. The location of the other players is updated sufficiently
10. I am able to communicate smoothly with my team members
11. The location of objects is updated sufficiently

Immediately after the actual gaming session, the participants were again convoked for the *post-gaming stage* of the study. The test subjects were presented a second paper-based questionnaire in which they were inquired about their overall experiences, feelings and thoughts after having played the game. Finally, each user study was wrapped up with a group conversation in which all participants were invited to share their experiences, to elaborate on QoE-related aspects reported on in the questionnaires and to reflect on QoE factors that were not covered by any of the questionnaires.

4.4 Quantitative and Qualitative Findings

The pre-usage questionnaire responses indicated that virtually every participant had high expectations concerning the game: a very large majority was curious to try the game (96.8 %), appreciated the possibility to communicate with other players while playing (93.4 %), liked the fact that they could assume different roles (93.5 %) and expected that the WW I game would be fun to play (96.7 %). On the other hand, only a minority had the impression that there was a story in the game (33.3 %) and that that story seemed fascinating (25.8 %). Yet, few test users were worried that they would be bored quickly or that it would be difficult for them to get absorbed in the game.

The 11 QoE-related statements that were sampled during the gaming sessions were also covered by both the pre- and post-usage surveys. The pre-usage responses indicated that test subjects attached most importance to the ‘having fun’ (Mean=4.58), ‘not having technical problems while communicating with team members’ (M=4.42) and ‘being able to communicate smoothly with team members’ (M=4.23) aspects before they had actually played the game. Analysis of the post-usage data resulted in the same top 3 list.

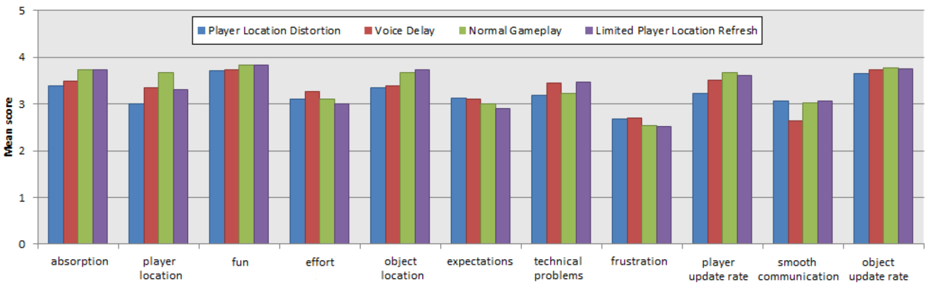

Fig. 2. Mean scores for the in-game questionnaire statements per test condition

Figure 2 compares the mean scores for the statements from the in-game questionnaires for each of the four conceptual test intervals. Before zooming in on the individual intervals, it is worth discussing the global characteristics of the results regarding the non-instrumental dimensions. It can be witnessed from the chart that users felt least 'absorbed' in their role in the first condition and that this feeling monotonously increased as the gaming session progressed. A similar yet less pronounced evolution applies to the 'fun' aspect. A possible explanation for these trends might be that the test subjects needed to get used to the game, its rules, mechanics and features before they were able to become immersed and to have fun while playing. Another interesting high-level observation is that the expectations were adjusted in the course of the gaming session, since the average scores for 'expected more from it' decrease with every condition. It was known from the pre-usage phase that the participants' expectations were high; these figures support the idea that people constantly adapt their expectations according to the context and circumstances.

In interval 1, the accuracy of the location-related information concerning other players as well as objects was rated lower than in the other test conditions. Furthermore, the artificially enforced player location distortion appears to have influenced the users' perception of location update rate (of both players and objects), since the scores in this respect were also minimal during this interval.

The participants felt most 'frustrated' during the second test condition, in which the voice communication was intentionally delayed. Moreover, they indicated that this interval required the most 'effort' from them. Finally, the rating for 'experiencing technical problems in the communication with team members' was considerably higher than in conditions 1 and 3. This difference can also be observed in statement 10 ('I am able to communicate smoothly with my team members'), for which the average score in condition 2 is clearly bottommost.

In the third interval, which was not artificially manipulated in any way, we observed the highest degree of 'absorption' in the played role and also a maximal score for 'fun'. The same goes for the accuracy of the player location information, as well as for the position refresh rate of both players and objects.

In the last condition, player location updates were disseminated less frequently. The figures however disclose that this technical manipulation did not have a notable influence on the monitored QoE dimensions (this claim is also supported by the qualitative data from the post-gaming stage, see later on). The 'frustration' of the test subjects was the lowest in this condition, as was their estimation of the amount of 'effort' that they had to invest in the game. Similarly, in terms of pleasure or 'fun', a high average score was reported. An important comment in this respect concerns the fact that the surface area of the playing field was relatively small. Whereas at the beginning of the session the players from both teams typically were actively dispersing and exploring the environment, they were near the end rather centrally clustered because the entire playing area had already been discovered. As a result, they had to rely less on the information displayed on their device (since there was more direct visual contact between players), which might account for these findings.

Although the differences between the four conditions are in some cases subtle and hardly explicit, they do corroborate that our study succeeded in relating modifications in technical circumstances to the users' (subjective) experiences.

In the post-usage phase, the participants were asked to indicate their level of frustration on a scale from 1 to 10. The mean score was 4.17 (SD=2.52). Analogous to the findings from the in-game surveys, the group discussions and post-gaming questionnaire responses revealed that the manipulated factors during the first and second playing condition were experienced as sources of frustration. One participant remarked: "We noticed the [audio] delay because we were standing next to each other, but not everyone noticed". Another user indicated that the meddling with the GPS update rate (interval 4) did not have that much impact on the gameplay: "The GPS update rate wasn't really a problem; most of the time they weren't running, so you could easily track the other players". One test subject formulated the consequences of the distortion of the GPS location for the `Commander` as follows: "As `Commander` I expect to know the precise location of my team; the lag on the positions made this impossible". The same aspect is mentioned by another participant: "My instructions didn't arrive well, and the position of the players wasn't very accurate". For one player, the artificial impairment of the communication had a severe impact on his state of mind: "I had a lot of problems with the communication and felt aimless at times". Finally, it is important to note that the post-gaming data uncovered that the technical manipulations were not the only sources of frustration. The scanning of the tags was considered cumbersome and was mentioned by several participants as a significant source of frustration. Also, the `Commander` role was found to be the least challenging because of its stationary indoor location. Finally, the portable device was judged a bit heavy and ponderous for playing the game.

Finally, it was also investigated whether the role that participants played had an influence on their experience. In this respect, a one-way ANOVA [4] was computed using player role as a factor and the scores on the in-game survey statements as dependents (see figure 3). This analysis disclosed that there were significant differences (at .05 level) between the various roles for a total of 5 aspects. A post-hoc Scheffe test was conducted to locate these differences. At the level of 'absorption' in their role, `Soldiers` felt notably more immersed than `Commanders`. Moreover, the `Soldiers` had more 'fun' compared to the `Medic` and `Commander` roles. The same goes for the 'effort' that the players put in the game: this value was significantly higher for the `Soldier` than for the other roles, and especially the `Commander`. In terms of 'expectations', the opposite is true: the expectations of the `Commanders` were significantly higher than those of the `Soldier` players. Finally, `Commanders` were considerably less satisfied with the player location update rate. This observation also emerged in the post-usage group discussions: since the `Commander` was not located in the field, precise player position information was more crucial for him than for the other types of players. In addition, due to the characteristics of their role, `Commanders` could fix their attention to the screen, whereas outdoor players also had to take notice of the physical environment; it is therefore to expect that discrepancies in teammates' on-screen locations were noticed sooner and more apparently by the `Commander`.

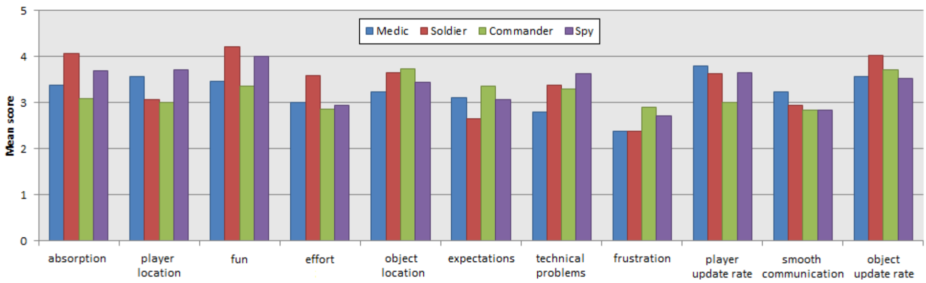

Fig. 3. Mean scores for the in-game questionnaire statements per player role

5 Conclusions

The main objective of the presented study was to explore the dependencies between the QoS and QoE concepts in the context of a mobile, location-based role-playing game. Two high-level conclusions can be drawn from our findings. First of all, it has been established that modifications in three specific technical parameters did indeed hold implications for the quality of the users' experiences. In particular, during the test condition in which no artificial QoS impairments were applied, the highest average scores for the feelings of 'absorption' and 'fun' were recorded. Secondly, for some sub-dimensions, the player reported QoE has been found to diverge depending on the assumed role. It has for instance been determined that `Soldiers` had significantly more 'fun' than `Medic` and `Commander` players and that they also felt most 'absorbed' in their role. For both global conclusions, the qualitative data nicely complemented the quantitative findings and helped to understand the identified quantitative disparities between the distinct test conditions and player roles.

Besides the general conclusions, the field study has also produced a number of interesting lower-level, specific findings that illustrate the extent of the impact of QoS performance on user experience. A notable example is that severe latency in the voice communication has been proven to complicate the coordination of players' actions, which made them feel less in control and less 'absorbed' in the game; moreover, this test condition yielded the highest mean ratings for 'frustration' and required 'effort'. The value of such fine-grained information is that it might assist software developers in their ever-present quest for providing optimal user experiences, since it informs them how best to cope with irregularities in the quality of the three investigated instrumental parameters.

Finally, a prominent result of the presented research is that the feelings of 'absorption' and 'fun' monotonously improved in the course of the playing session and that test subjects constantly adjusted their expectations of the game. This implies that, despite the artificially induced technical imperfections, the overall evaluation of the participants was positive in the sense that they found it a fun and engaging experience. This finding confirms that QoE exceeds QoS in terms of scope, since it corroborates that overall user experience is not merely determined by technical parameters (i.e., lower technical performance did not automatically result in an unacceptable player experience). As such, our study has illustrated the importance and potential influence of non-instrumental aspects on QoE and opens opportunities for future research in this regard.

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Effect of Camera and Object Motion on Visual Load in 3D Games

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Abstract. 3D video games are a popular form of entertainment that features elaborate visual compositions and settings. Occasionally, players are thrown into situations with a high amount of visual complexity, which may cause players, especially novice players, to misinterpret important game goals or mechanics, which may, in turn, lead to a diminished experience. Previous research investigated visual design, but only in terms of brightness and color contrast, no research investigated attributes of motion, their complexity in regards to visual design, and their effect on the game experience. Informed by cinema and visual perception domains, we embark on a study of 4 motion attributes: flicker, shape, speed, and repetition, and investigate their design within 6 games. We rate these games based on their complexity. We use video coding with a kappa reliability measure to identify these attributes. We then investigate the relationship between the use of these motion attributes and the rated complexity of the visual scene. We present this analysis as a contribution, and design lessons extrapolated based on the analysis.

Keywords: Game Design, Motion, Visual Composition, Visual Perception, User Experience.

1 Introduction

3D video games are popular and top selling games [1]. They feature graphically rich environments, which engulf their users and are designed with an amalgam of challenges including searching for artifacts, wayfinding towards a goal, and visual tracking of moving objects such as enemies. These challenges require players to perceive visual cues, or distinct visual elements relative to their surroundings. Game designers use visual elements to communicate to the player, by nudging, pushing, and pulling the gameplay; this technique offers players a combination of reward, challenge, and punishment in a very subtle form. Therefore, the art of composing these visual elements, which we will call visual design, is extremely important. Communicating gameplay goals to the player is one function of visual design. Designers use visual elements for many different functions, including composing the ambiance and style for the game, which includes composing ambient and atmospheric effects. This *look and feel* is often a defining characteristic of the franchise; it is what makes a game memorable.

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One challenge faced by game designers is how to control the visual composition of many elements during moments of high visual load. We use the term *visual load* here to define a measure of complexity of the visual scene. The measure of complexity relies on the attributes of the visual scene (e.g., the number of visual stimuli in the scene) and the cognitive and perceptual processing of relevant and irrelevant visual stimuli. Thus, a high visual load would indicate a very complex environment where participants may find it difficult to differentiate between important visual cues from irrelevant visual elements in the environment, thus leading to a behavioral breakdown [2], [3]. Breakdowns occur when the player misperceives characteristics of the environment, fails to learn a strategy, decision-making step. When left unchecked, breakdowns diminish accessibility and negatively impact player's investment [4].

Previous work on visual design discussed the role of color and lighting techniques [5-8] for instance to enhance emotion and support way finding. Although motion is highly perceptually salient [9], we found no research targeting the use of motion attributes in games. In this paper, we attempt to start work within this area, in the hope of carving the space towards a better understanding of the visual design process within games.

Before games, filmmakers, theatre designers, and visual artists spent many years composing their craft and documenting their techniques. The use of visual composition to direct viewers' eyes using camera, lighting, motion, and color contrast cues is well known within these fields [10-12]. Games follow similar methods, however, games are interactive and thus the ability to decipher the message encoded in the visual cues within the scene is very important. There seem to be a difference between novice and expert players in terms of how they perceive visual scenes [13]. Some scenes that may appear chaotic to a novice player may appear very well composed to an expert player. An understanding of these differences will help formulate design lessons to better develop visual designs that appeal to different groups of gamers.

In this paper, we investigate how games organize motion attributes. Specifically we ask 2 research questions: in what way do game scenes rated with low visual load constrain and organize motion respective to the camera? In what way do game scenes rated as high visual load organize motion attributes? We believe this is the first step towards developing a theory around dynamic adjustment of visual cues, similar to the work done previously on lighting [5], [14].

This paper investigates visual complexity based on theories of visual perception including the preattentive (bottom-up) processing of salient features [15], similarity [16], [17], and visual search [18] (bottom-up and top down). In particular, we video coded the occurrences of 4 motion attributes: flicker, shape, speed, and repetition, and investigate their design within 6 game scenes selected for their variety in terms of their visual load.

The organization of this paper is as follows. We first discuss theoretical foundations that we use to analyze the motion attributes within the visual scenes, in particular: borrowing from visual perception and attention theories. We follow this discussion by the methods we used to collect and code attributes in 6 game scenes. We then discuss results of the analysis and implications of our findings formulating design lessons.

2 Theoretical Foundation and Previous Work

2.1 Movement in Visual Composition

Ward [11] defined visual composition in film or television as an "invisible technique", because often several elements are used for a specific function, such as emphasizing the subject, rather than reveal the specifics of the visual elements themselves. This requires understanding human perception and the manipulation of visual design elements to engage the viewer's attention. For example, the focal point of the scene must solicit attention. Designers often negotiate multiple elements, such as camera position and subject movement to create a design that reflects the focus of attention desired.

In addition, Block [9] discussed several visual compositional elements of films, including space, tone, line, shape, color, movement, and rhythm. He stated that viewers' attentions are usually drawn to moving objects first followed by the brightest object. He also identified 4 motion attributes that influence the visual composition of a film scene: direction, quality, scale, and speed of motion.

The games industry frequently alludes to the importance of composition through interface design [1] and environment design [4], [19]. The interface is often used to emphasize the execution of explicit actions, while visual cues in the environment concentrate on more subtle design messages through channeling attention and direction of movement.

Several researchers investigated the effect of such environmental cues on path choices [7], [8]. They found that participants chose the path with a moving element, when all else is static. Other studies focused only on task efficiency with low level perceptual cues embedded into the environment, specifically color and brightness contrast, and texture along with texture [6], [20]. For [6], participants were dropped into a maze and their paths recorded to determine navigation preferences based on the low level cues. The analysis showed that low level cues alone are not reliable as most participants did not notice and did not follow the cues. The study by [20] considered both low level cues and top down goals to focus attention such as collection or finding an exit necessary to advance. The authors deduce that top-down visual features tied to goals control players' attention more than bottom-up visual features. Motion remains an under studied phenomenon especially during moments of high visual load.

2.2 Motion in Visual Perception

While no research work within games investigated the use of motion as a visual design element, most of the research on motion research can be found in visual perception and attention domains. Researchers found that motion has many expressive perceptual properties particularly in the periphery, where other features such as color change are imperceptible [21]. Some research has been devoted to identifying motion properties including speed, shape (the path a motion follows), phase, flicker (defined as discrete flashes perceived by the viewer), and smoothness were emphasized as critical motion attributes [9], [22]. Of these, shape – particularly circular motions – has been shown to be particularly important, especially where communicating affect is concerned [9], [23].

There are many prominent theories of visual attention such as the saliency and similarity of low-level features. Treisman [15] introduced the saliency map as a combination of low level features (stimulus-driven) that are rapidly perceived preattentively and without conscious thought. Additionally, Wolf's guided search theory [18] applies top-down and bottom up approaches working in parallel. Guided search can assign additional attentional priority to low-level features given a cognitive goal or task. These theories are similar to Ware's [24] psychology of visual thinking, whereby our attention is continuously biased in order to accomplish actions and complete tasks. The design implication here is to use clear features with distinct processing channels, as they are less cognitively demanding to perceive.

Another popular approach posed by Duncan and Humphrey is a similarity theory of attention [16], which extends from Gestalt psychology [17]. Similarity considers how easily goal-relevant and goal-irrelevant stimuli can be distinguished. Search efficiency and task time is low when the stimulus is different and high when the differences are subtle. In a related study, Kingstone et al. [25] applied similarity theory to analyze the coherence of motion in a visual search task. They found motion can inhibit or excite search efficiency. They predicted that: 1) search is easier when there are fewer motion groups, 2) it is easier to inhibit rather than excite goal-relevant stimuli, and 3) search gets easier as stimuli move together.

Previous works in visual attention and games have received scientific research in experimental and video game contexts. For example, researchers [26], [27] tested participant reaction time to rapid visual stimuli located on the screen center and periphery. Their results showed that gamers with more experience had decreased reaction times. However, since they didn't test these results within a commercial game, it is hard to confirm the ecological validity of these results.

3 Method

3.1 Data Collection Procedure

To investigate how designers varied the motion attributes and the relation between motion attributes and visual load, we collected 2 video clips per game. We selected 6 games for this investigation with varied visual complexity. We selected these games based on the following criteria: (a) recently produced (2009 or later), (b) received high sales, and (c) span the 3rd person action-adventure and role playing genres. All games selected received aggregated reviews from metacritic.com between 70-100, which are "generally favorable" and received "universal acclaim". The two videos we gathered were from Youtube walkthroughs. Thus, they have been viewed thousands of times.

The selection of each video clip contains gameplay with a high amount of visual load due to motion. Because the density of motion is very high, we only chose short clips, thus each clip is approximately 20 seconds in duration. Selections are from the game demo or first instance where high load occurs within the first hour of play. All clips contained one or more tasks for the player to complete, such as using weapons or tools, selecting or targeting objects, collection, managing resources with assistance from the user interface, and maneuvering through dynamic 3D settings.

Table 1. Data collection from 6 Games with abbreviations

Game Name	Abbreviation
Assassin's Creed Brotherhood	AC2
God of War III	GOD3
Prototype	PRO
Ratchet & Clank Future: A Crack in Time	RATCH
Fable III	FA3
Prince of Persia: The Forgotten Sands	POP

The selected clips were then shown to 3 additional researchers participating in the project. Researchers were asked to qualitatively rank each video game from lowest to highest amount of visual load on a 5-point scale. All researchers are familiar with attributes of motion, discussed in the next section, as they came from scientific visualization or performance arts fields.

3.2 Coding for Motion and Camera Attributes

Although all games are in 3D, each clip constrains the players view by means of the camera. For our study we tagged each clip with one of 3 camera configurations including 1) stationary, 2) follow, or 3) free. A ***stationary camera*** is stuck to a specific 3D position and is constrained to a specific direction. There may be some camera wiggle room for the player or camera, but both are in a relatively stationary position. A ***follow camera*** trails behind players moving forward or sideways along a predefined linear path. A ***free camera*** has neither stationary nor following constraints as the player has control to look and move in any direction. Figure 2 identifies the camera setting used for each clip. Clips from FA3 were stationary, GOD3 and RATCH used follow cameras, and both clips from PROTO used only a free camera. In addition to the camera constraints we also annotated instances of camera shake, occlusion, and full screen flashes.

Table 2. 3 camera configurations for each clip (C1 or C2), from each game

Stationary	Follow	Free
POP C2 FA3 C1 & C2 ACB C2	POP C1 RATCH C1 & C2 GOD3 C1 & C2	ACB C1 PROTO C1 & C2

Informed by cinema, visual attention, and perception literature, we identify four motion attributes: flicker (flashing), shape, speed, and repetition. The parameters are shown in table 3. Flicker refers to flashing or pulsing (once, repeating), the parameters for shape are (linear, circular, expansion, or expansion with contraction), speed (slow - fast), and repetition. Repetition refers to regularity or rhythmic patterns of motion such as harmonic motion. Repetition has a mathematical regularity, such as wave, sinusoidal, or oscillating forms. Attributes were annotated for all game objects, both UI interface objects (controls stuck to the screen) and non UI objects/effects.

Two raters coded for these attributes in the video clips selected. We used the kappa measure as a statistical measure of inter-rater reliability. Our kappa scores shows almost perfect agreement in all 4 attributes for the flicker, shape, speed, and repetition, with a kappa value of 0.898, 0.847, 0.9, 0.967, respectively. For each clip we compiled a list of UI or game objects that contained at least one attribute of motion that "popped out" or contained high saliency. On average 5 objects are identified per clip (min = 4, max = 8) with 68 total objects coded for all clips. Each object contained up to four attributes of motion.

Table 3. 3 camera configurations for each clip (C1 or C2), from each game

Attribute	Parameters
Flicker (flashing)	none, once, repeating
Shape	none, linear, circular, expand, expansion/contraction
Speed	none, slow - fast
Repetition	none, has repetition

4 Results

We organize results in relationship to the original research questions. The games are first ranked identifying differences in the use of motion attributes for games rated with high and low visual load. We then investigate in depth the motion attributes per clip given the camera constraints comparing games rated as high or low visually loaded.

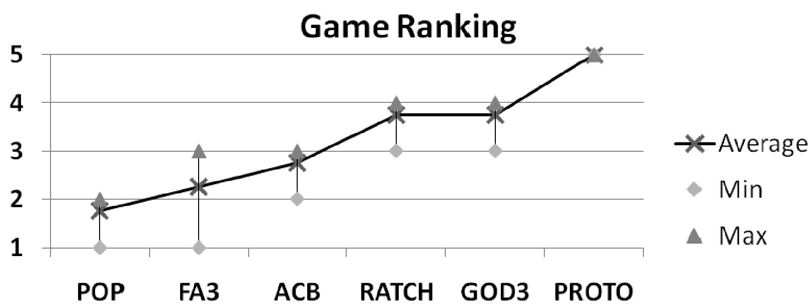

Fig. 1. Ranking of 6 games according to perceived visual load (1=least, 5=most)

Four participants ranked the 6 games from least to most visual load on a 5-point likert scale. Results are shown in figure 1. Prince of Persia was rated lowest while Prototype was rated highest. Fable3 and Assassin's Creed Brotherhood were rated neutral or below while Ratchet and Clank and GOD3 were rated neutral or above. From this ranking we can investigate the attributes further and their relationship to the ranking. While it is easy to determine Prototype has the highest load due to the free orient camera, Assassin's Creed also used a similar camera and was ranked lower than games that constrained the camera. Therefore, there is more involved than just the type of camera used.

4.1 Influence of Camera on Motion Attributes

Before discussing the attributes of motion specifically, this section discusses 2 camera techniques to organize attributes of motion. The techniques include constraining the camera to a fixed position and view or following a predefined path of travel. From these constraints we identify focal points and visual regions as organizational strategies to layer motion attributes. Focal points anchor or embellish motion to a central point of attention that is separate from the background. From this focal point multiple attributes of motion can be layered. Clips from ACB, FA3, and POP used a stationary camera. For example, fast motion anchored to a point occurred either over a static or slow moving background. In addition, the focal point duration is preserved for the whole clip or for several seconds. In figure 2 from FA3, circling bats, expansion-contraction magic particles, linear spell cast, and explosions are all anchored to the player. Yellow lines are added to the screenshot and a diagram is added for clarity. The same focus occurred in POP clip2 and FA3 clip 1.

Fig. 2. FA3 C1 circular, linear, expansion and contraction shape is tied to the player

Second, the use of a follow camera along a predefined path of travel helps separate distinct visual regions. This enabled POP, RATCH and GOD3 to excite or recede regions into the foreground or background. A simple example is in POP clip 1, which is shown in figure 3, where both the player and camera are climbing from right to left on a wall. Far below the player are dozens of army soldiers moving *slowly* while a *linear* shaped and *fast* speed fireball approaches from left to right. The effect is very dramatic as it highlights a focal point of interest over a background of slow activity. This technique is also used in clips from RATCH and GOD3 where fast, slow, and repeating motion was used to distinguish between active and inactive regions. Both games also used focal points centered on the player avatar, to communicate resource collection and combat actions. For instance, figure 4 shows a screenshot from RATCH clip 2 with dozens of excited objects above the horizon (ground is static), slow moving and repeating circular trajectories. Players must advance underneath this active area.

Fig. 3. Screenshot (left) and motion diagram (right) for POP clip 1

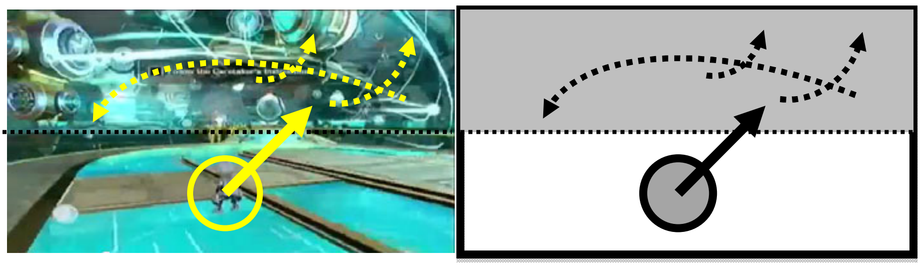

Fig. 4. RATCH, the player moves on a path between a static floor and beneath active objects

The free orienting camera, unlike the stationary and follow camera are without a sustained focal point or visual region. Games that used a free camera, ACB clip 1 and PROTO have a high visual load rating for multiple reasons. First, in every passing second there are changes in views, and thus there are constant shifts in focus from one object or region to another. Second, foci identified through expanding-contracting shapes and fast speeding objects are spread over the entire screen area, and superimposed without a clear visual hierarchy. For example, PROTO displays multiple linear trajectories at once, including 1) from enemy crossfire originating from the screen bottom, 2) a second enemy position falling backward and away towards screen right, and 3) a third enemy on the top of the screen running away from the player. At this moment there is no dominant pathway or object to orient towards. In this case fast expand-contract (explosion) and fast moving enemies occur without regularity or rhythm, which also contributes to the high load ranking.

4.2 Analysis of Motion Attributes

Next we identify four key differences in the use of motion attributes for games rated with high and low visual load. Due to limitations of space, the analysis is brief.

For the speed attribute, use of a free orienting camera with several fast moving objects has high visual load. Both clips of PROTO have many objects all with fast speed while this was not a problem in ACB with only 1 fast object. The use of a stationary camera with fast moving objects has low visual load. This was the case for FA3 and POP. It should be mentioned that in these games, fast moving objects also converged around the player avatar as a central focal point of interest, which gave the visual scene better coherence and focus as well. Games that used a follow camera, RATCH and GOD3, had contrasting fast and slow moving objects as a means to highlight both a focal point, excite, or recede a visual region. The use of both techniques simultaneously can explain the higher rated amount of visual load.

For Flicker, we did not find the amount of flashing to have an effect on visual load ratings. 11 of 17 instances of flicker were small in scale and occurred on the interface with FA3, GOD3, and ACB flashing both the interface and an embedded object simultaneously. The PROTO clips contained multiple flashing elements, however, they were not constrained to a focal point or a visual region. Unconstrained flashing with a free orienting camera can explain the higher rated amount of visual load.

The motion repetition attribute is higher in games using a follow or stationary camera. GOD3 and RATCH contained both a high amount of motion-repetition and speed variation, which contributed to their higher load ratings. These 2 games in particular had the greatest variety of motion shape attributes, but otherwise the amount or type of shape alone does not appear to be a factor separating high and low load games.

5 Implications of Visual Load from Camera and Object Motion

Player retention [4], preserving accessibility [28], and maintaining motivation [29], [30] are frequently discussed topics in the games industry. This paper considers moments of high visual load as a critical moment where players may stop playing due to a misinterpretation of visual layering or frustration. We present 3 lessons as a result of our analysis.

1. Use motion to anchor a focal point or define a region in parallel with a constrained camera. Adding constraints to the camera will help guide attention and behavior for longer time durations. Attributes of motion can be layered as long as they are anchored to a visual focal point using a stationary camera. Follow cameras can also establish a strong visual region through the use of motion repetition. Free orienting cameras not only require additional motor control, but important focal points or regions on the screen can easily become lost with the wrong point of view. Although players have more freedom and control, there is an enormous compositional cost in reducing the visual coherence.
2. Use contrasting attributes of motion to strike a balance. Games look stale if too many elements are static and can easily overwhelm when everything moves at once. Consider layering or creating hierarchy of motion by combining flicker, shape, speed, and rhythmic repetition. We found many examples where motion repetition with a variable speed and shape can excite or recede a visual region.
3. Prioritize repeating, harmonic or rhythmic motion to visually ignore or excite objects. Our visual system is wired to detect visual patterns such as similarity or coherent grouping. Use this knowledge to visually ignore or excite visual focus and promote region separation. For games with a high amount of visual load spread across a large area, repetition or harmonic motion should be used.

6 Conclusions and Future Work

Our primary contribution was to analyze the relationship between rated visual load, using a camera classifying scheme, and motion attributes, specifically flicker, shape, speed, and repetition. We found that camera configurations, specifically a stationary and follow camera, play a large role in establishing a focal point and visually separating regions. We present the analysis and resulting design lessons as the contributions for this study in the hope of building the foundation for the study of motion in visual design of games.

The study discussed has several limitations. In particular, we didn't discuss camera effects such as shaking, blurring, or full screen flashing. Low visual load situations were not included because as the previous research suggests, players can easily identify single moving targets when the rest of the scene is static. Additionally, we do not consider how designers habituate or train players to learn a visual language. Finally, stylistic differences between games have different constraints on motion. For example photorealistic games such as ACB and PROTO contain believable renditions of actions while stylistic games RATCH and GOD have amplified and exaggerated effects.

In future studies, we aim to apply a subset of this framework into a tool defined by the motion attributes and follow this by a participant study. We hope to identify more specifically the relationship between motion attributes and breakdowns in an experimental study where such attributes can be manipulated. We believe this will allow us to more objectively study the effect of motion on breakdowns and players' experience.

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Integrating Stereoscopic Video in 3D Games

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Abstract. Recent advances in commercial technology increase the use of stereoscopy in games. While current applications display existing games in real-time rendered stereoscopic 3D, future games will also feature S3D video as part of the virtual game world, in interactive S3D movies, or for new interaction methods. Compared to the rendering of 2D video within a 3D game scene, displaying S3D video includes some technical challenges related to rendering and adaption of the depth range. Rendering is exclusively possible on professional hardware not appropriate for gaming. Our approach, Multi-pass Stereoscopic Video Rendering (MSVR), allows to present stereoscopic video streams within game engines on consumer graphics boards. We further discuss aspects of performance and occlusion of virtual objects. This allows developers and other researchers to easily apply S3D video with current game engines to explore new innovations in S3D gaming.

Keywords: Stereoscopic rendering, S3D video, game engine, 3D gaming.

1 Introduction

The use of stereoscopic 3D (S3D) vision in digital entertainment technologies has increased significantly over the past few years [8]. Based on the overwhelming success of the movie Avatar and the following boost in market revenue for 3D cinema in general [12], companies try to push S3D content into other market segments like blu-rays, TV sets, TV channels, and live broadcasts [10]. Similarly, the digital games industry tries to benefit from the current interest in S3D as well. Nintendo has released the first autostereoscopic hand-held console with its 3DS [14]. Sony is pushing S3D gaming on its PlayStation 3 [22], backed up by its series of 3D television sets. Influential developers like Crytek realize S3D render techniques [20] and Nvidia has introduced 3D Vision for S3D gaming on the PC [3,11].

The addition of stereoscopic depth is believed to create a whole new experience in all of the aforementioned fields and it will eventually create a mass consumer product that will be taken for granted, just as color replaced black-and-white television [5,9,10]. One motivation for displaying 3D video in games is the integration of 3D video as contemporary media technology: In the future, people expect integrated video content to be displayed in S3D on a regular basis. This also affects video being displayed in interactive game environments, e.g. advertisement billboards in sports

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games, or on TV screens in a game world as in Grand Theft Auto 4[1]. This would require rendering stereoscopic video on a virtual screen within a 3D game world.

A second motivation arises from interactive video in games. Interactive movies, such as Rebel Assault[2] or The X-Files Game[3], were prominent in the 1990s and allowed combined interaction with pre-filmed and virtual objects. As pre-filmed material could hardly provide enough freedom for innovative concepts, recent games rather incorporate live video: The Sony EyeToy[4] and Microsoft Kinect[5] provide live video-based interaction using computer vision methods and depth-aware cameras. The game YooStar2[6] combines live-filmed video with pre-filmed footage. BallBouncer explores multi-user gaming with live video in a cinema setting [19]. However, these examples provide only monoscopic video, as of yet.

Stereoscopic vision could allow for new forms of interaction with such content, as has been demonstrated in the domain of augmented and mixed reality [17]. A crucial problem remains the correct alignment of virtual and real objects and the coherent perceptual problems [13]. A first commercial application of stereoscopic augmented reality is the AR Games set that is bundled with every Nintendo 3DS device [15]. The alignment of virtual and filmed objects is based on marker tracking and works well within a specific distance. The stereo camera configuration is fixed.

Apart from such ideal prerequisites, our work assesses the necessary steps to integrate arbitrarily configured pre- or real time-recorded S3D video into the virtual environment of digital S3D games, i.e. on a virtual screen. The next section gives an overview of our technical platform and discusses the use of stereo cameras. Subsequently, we use this platform to explore the integration of the video data into a commercial 3D game engine. As current consumer hardware and Direct3D do not support rendering of S3D video, we propose a workaround: Multi-pass Stereoscopic Video Rendering (MSVR). Our approach further explores the problem of parallax adaptation and gives a practical solution to deal with such non-trivial setups. Lastly, we discuss the solution and pinpoint the need for automatic methods of parallax recognition and occlusion handling.

2 Technical Platform

For our approach, we used a typical gaming PC running Microsoft Windows 7 Professional, with Nvidia GeForce GTX 470 graphics card, Intel Core i5 Quad-core processor, and eight gigabyte of memory. Our implementation of MSVR (see Section 3.1) was incorporated into Trinigy's Vision Engine, a professional game engine that supports video textures and custom render methods [21]. The engine provides a C++ API for development and supports Direct3D-rendering, which is required to use the Nvidia 3D Vision driver. It is widely used for commercial game titles, such as The Settlers 7, Stronghold 3, or Arcania: A Gothic Tale [21].

[1] Rockstar Games, Inc., 2008.
[2] LucasArts Ltd., 1993.
[3] Fox Interactive, 1998.
[4] Sony Computer Entertainment, Inc., 2003.
[5] Microsoft Corp., 2010.
[6] Yoostar Entertainment Group, Inc., 2011.

2.1 Camera Setup and Support

The MSVR framework supports not only pre-recorded files, but also live captured S3D video. For this purpose we integrated access to several camera systems: DirectShow-based cameras, two PlayStation Eye cameras (PSEye) based on the CL-Eye Platform Driver [1], and a pair of professional high definition cameras. For using any of these approaches, the following issues have to be considered:

DirectShow can be easily modified to support two USB cameras, but as of yet it only allows the use of two different cameras and does not support multiple cameras of the same model. However, when capturing S3D videos, it is recommended to use cameras as similar as possible in every aspect as any differences have a strong impact on binocular fusion [12].

The use of Playstation Eye cameras is also cumbersome. First, the camera's wide shape does not allow for small interaxials. Second, even two PSEyes bought together from the same shop included models with fairly different serial numbers. Thus, the received images differed strongly in terms of color, brightness, and compression artifacts, which is not suitable for good S3D vision.

In our setup we used a stereo camera rig based on the microHDTV camera element provided by the Fraunhofer Institute IIS. The cameras are very compact and support HD and Full HD resolutions at 24 to 60 Hz (synchronized). Each camera can be adjusted within six degrees of freedom. The cameras can be configured via Ethernet (image resolution, frame rate, gain, white balance, etc.) and support image transmission via HD-SDI MCX. The stereo camera rig is connected to a professional video capture board (DVS Centaurus II[7]) via HD-SDI. The data can be accessed using a SDK.

But even when incorporating only professional cameras, a common interface still allows for simple and fast exchange of input components which is valuable during development when the rig is not available. This can be crucial as stereo camera rigs are very sensitive to physical force and often require recalibration.

2.2 Nvidia 3D Vision

The 3D Vision package includes a pair of shutter glasses, an emitter used for synchronization, and the 3D Vision driver. It further requires a display running at a refresh rate of at least 120 Hz and a GeForce graphics card of the eighth generation or later. Alternatives exist with DDD's Tridef [2] and iZ3D [6]. One major advantage of 3D Vision is the automatic stereoization of Direct3D applications. The driver intercepts all calls to the Direct3D API and uses them to create S3D content which is then displayed on the monitor in synchronization with the shutter sequence of the glasses. Besides following some basic guidelines to enhance the stereoscopic quality, no additional effort is required of the application developer and the user can easily control the stereo effect [11].

Obviously, it is straightforward to display videos as textures placed on arbitrary geometry. Here the automatic stereoization becomes an issue: the driver alters the part of the standard render pipeline after clip space into two separate paths, one for each eye. This is simply achieved through a translation in parallel to the screen plane,

[7] DVS Digital Video Systems GmbH.

which is automatically added to appropriate vertex shaders [11]. Everything but the vertex positions will be identical for each view, including the source texture. Thus, depending on the depth in the scene, each image will only contain an offset version of the same texture. Therefore, the resulting image will be stereoscopic, but the video texture will only contain monoscopic information.

The driver should be able to provide two different textures, one for each view. This technique is only available with the professional version of the 3D Vision driver on high-end Quadro cards which support quad-buffered stereo where the entire render pipeline is traversed separately for each eye [16]. This allows for full control over the right and left view in the application. Since quad-buffered stereo is only available for professional hardware, it cannot be used for game development where only consumer gamer hardware can be assumed. This lack of control requires a workaround for displaying S3D video content in a game scenario. Fortunately, the 3D Vision driver offers ways to display S3D videos and photos [3] on which we based our workaround: MSVR.

3 Integration of Stereoscopic Video into a Game Scene

In this section we describe our approach of integrating S3D video into a professional game engine. We first describe our rendering method MSVR, which was briefly introduced in [18], and give further insights on the implementation. The following subsection proposes a solution for adjusting different parallaxes of S3D video content, the underlying occlusion mesh, and game engine content. For aligning depth properties of the video with those of the game scene, we give a first solution by manually setting the video parallaxes. We also show how video content can be split up and distributed within the game scene. The last subsection pinpoints problems of occlusion with virtual objects and video content.

3.1 Multi-pass Stereoscopic Video Rendering (MSVR)

The engine's default render module is extended to process the S3D video content. The content is made available to the application as a video texture, e.g. using standard DirectShow filters. Then two quads of identical size and location are created, one for each eye. Since the quads are used to display the video, they will be referred to as canvas objects. The video files contain both images in a certain alignment depending on the video format. Therefore, care needs to be taken when assigning texture coordinates to both canvas objects. As a result, the left eye image is mapped to the left canvas object and the right eye image to the right canvas object. The virtual camera and the two canvas meshes are positioned within the game scene.

During the first render pass the entire scene is rendered into the backbuffer without any geometry but the left canvas object. Before clearing the backbuffer, its content is copied onto a Direct3D surface. In the second pass the scene is rendered with only the right canvas object present and the backbuffer content is again copied onto another Direct3D surface.

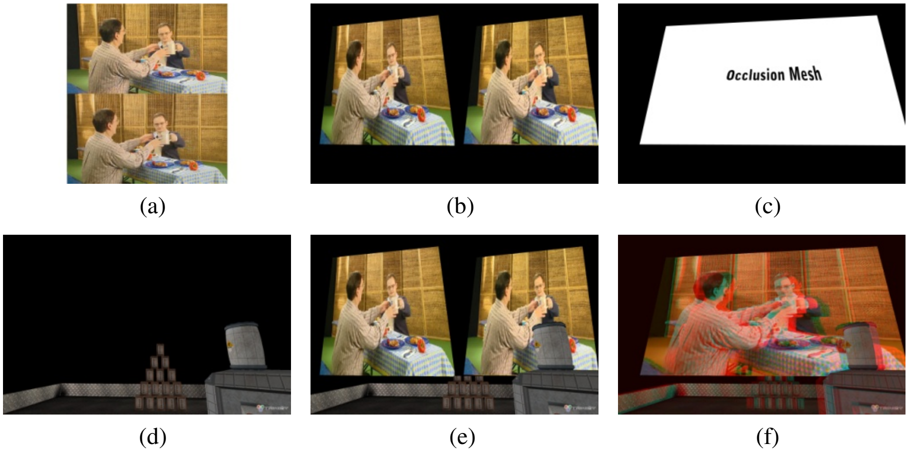


Fig. 1. The image sequence shows the general application flow and the composition of the different elements of the MSVR method. (a) A frame from the S3D video. (b) The textured canvas surfaces as stretched into the backbuffer. (c) Illustration of the rendered occlusion mesh for clarification. (d) A scene as rendered by the engine's default renderer. (e) The composition of the game scene and the stereo canvas in non-stereo mode. (f) The same composition in anaglyphic stereo mode.

During application initialization, a third Direct3D surface, called stereo surface is created which has twice the width of the backbuffer and its height plus an additional row of pixels. The previous backbuffer contents, saved onto the individual surfaces, are copied side-by-side onto the stereo surface. The additional row is used to insert a stereo tag that directs the 3D Vision driver to present the backbuffer's content in S3D [3]. To fit both views into the backbuffer they are copied using Direct3D's StretchRect method. If the display buffer is now rendered with the 3D Vision driver turned off, the screen will simply show two distorted versions of the images, as illustrated by Fig. 1b.

Since the S3D content is only copied into the backbuffer and not actually rendered, no depth information will be present in the depth buffer. Thus, if the third pass would be to render the scene, everything would be rendered in front of the canvas objects. This could mean a complete occlusion of the video content by scene geometry. Thus, the third step is to render an additional quad mesh of the same size and position as the canvas objects (see Figure Fig. 1c). The depth information produced by this render pass will now remain in the depth buffer for the following passes. This ensures that during the fourth pass, in which the rest of the scene is rendered via the engine's default render call, occlusions are correctly determined for the video display surface.

Displaying the scene without the 3D Vision driver will result in a combination of the in-game objects and the distorted S3D image pair (see Fig. 1e). If the driver is activated, the third and fourth pass will be stereoized automatically. The result will be a S3D game scene with an integrated canvas object that shows a S3D video, exemplified by Fig. 1f.

Fig. 2. The scene illustrates the three different depth settings and respective parallax differences caused by unadjusted MSVR: Note that the occlusion mesh's parallax causes a black border and that due to the differences between scene and video parallaxes it becomes difficult to fuse the images.

As with all multi-pass approaches, MSVR obviously creates performance overhead. Compared to adding mono video to a stereo scene, adding the stereo video about halves the frame rate to 30 fps in fullscreen mode. Rendering the additional occlusion canvas, however, does not alter the performance considerably (-1 fps).

Another issue results from the different screen parallaxes produced by the individual steps of the MSVR approach. First, stereoscopic image pairs are rendered to the same backbuffer locations. As a result, the displayed image shows the inherent video parallax as determined during the capture process. Second, the rendered occlusion mesh is subject to the 3D Vision driver's stereoization process. Thus, its parallax depends on its placement in the scene. Finally, the game scene exhibits parallaxes according to its depth layout as extracted by the 3D Vision driver. In our original approach [18], these three types of parallaxes were uncorrelated (see Fig. 2).

3.2 Adjustment of the Occlusion Mesh Parallax

One important issue in MSVR is a correlation between the canvas locations and the stereoization of the occlusion mesh: As the mesh is part of the scene, it is duplicated by the 3D Vision driver based on the current interaxial distance and its depth in the scene. For this reason, there will be a parallax between each eye's images of the occlusion mesh. However, the individual canvas objects are rendered to the exact same position in both views causing no parallax, except the one inherent to the video content.

To demonstrate this problem, think of the occlusion mesh as a rectangular cutout in the game engine's scene, allowing an observer to look through it and see the previously prepared backbuffer, containing the S3D image. For one eye, the cutout will coincide exactly with the stereoscopic content. For the other eye, the cutout will be moved horizontally by the 3D Vision driver, but the video texture will remain fixed. Thus, parts of the cutout reveal the blank backbuffer, ultimately resulting in a black border on one side of the canvas. The width of the border will scale with the amount of screen parallax depending on the virtual camera interaxial and the canvas' depth in the scene.

Fig. 3. Occlusion mesh border on two split video canvasses: Since the parallax of the occlusion mesh is adjusted by the 3D Vision driver, but that of the S3D video canvas is not, a black border is perceived by one eye

The effect is demonstrated in Fig. 3. Using anaglyphic glasses and looking at the image with the right eye closed, reveals the mentioned border on the left side of each canvas object while the right eye's view will be correct. Because of this border, it becomes difficult to properly fuse the images.

To accommodate for this offset either the position of the occlusion mesh or that of the canvas object in one view has to be adjusted. Since the occlusion mesh is duplicated by the Nvidia driver, the only way to adjust its parallax is to position it at a different depth and adjusting its size to still appear perspectively correct. While the idea behind this approach is simple, the actual implementation would pose several problems. For instance, adjusting the size of the mesh object would require locking its vertices; a very costly operation. Doing so every frame would cause a drastic decrease in performance.

A more elegant way could be to create a custom vertex shader for the mesh, which scales the output position of each vertex. The 3D Vision driver uses the homogeneous w-coordinate of the position vector to determine the vertex's parallax offset and with it its perceived depth. To achieve the desired depth the vertex position vector simply needs to be scaled accordingly. Since the driver operates in clip space, which is right before perspective divide is applied, this scaling operation will affect the parallax computations performed by the 3D Vision driver, but not the actually rasterized locations determined from the vertex position.

However, the purpose of the occlusion mesh is to correctly position the video element within the scene, so adjusting its depth (be it manually or with a vertex shader) would be counterproductive. Therefore, the canvas object needs to be rendered at the correct depth.

Of course, the issue could also be resolved by cropping the occlusion mesh, so that the border would simply not show. This would reduce the visible part of the images proportionally to the amount of cropping. At the same time, it would still leave the inherent disparities unchanged so that there would be no correlation between the parallax of the S3D video content and the stereoscopically rendered scene.

Instead, the offset between both canvas objects should match the parallax of the occlusion mesh to account for the horizontal shift and its depth in the scene. To accomplish this it is crucial to understand how the Nvidia driver calculates the parallax of a vertex at scene depth d. The used function is defined as follows:

$$parallax(d) = separation \cdot \left(1 - \frac{convergence}{d}\right) \quad (1)$$

$Convergence$ and d are both distances to the cameras given in world coordinates. The concept of convergence, as used by the 3D Vision driver, does not concur with the common understanding of converging eyes or camera axes. While it would be logical in the common model to represent convergence in form of an angle, it does not make sense for the 3D Vision driver since the cameras will not be toed-in, but simply translated to avoid producing vertical parallaxes, using an asymmetric viewing frustum. Thus, the convergence value is expressed by a distance measure, defining at which scene depth the convergence plane is situated. All vertices on this plane will experience no transitional offset, which means they will have zero disparity making them appear at the same depth as the display screen.

The separation is given in percentage of the image width and thus, so is the parallax value. Therefore, the formula needed to be adjusted, since it was necessary to know the parallax in units of the world coordinate system to correctly place the canvas. First, it was necessary to know the width of the image (buffer) n_w in world coordinates. To calculate this value, the distance to the near clipping plane n_d and the horizontal field of view of the virtual camera (fov_x) were necessary. Both could be obtained from the Vision Engine's render context. The width was then simply given by the following trigonometry function:

$$n_w = 2 \cdot n_d \cdot \tan\left(\frac{fov_x}{2}\right) \quad (2)$$

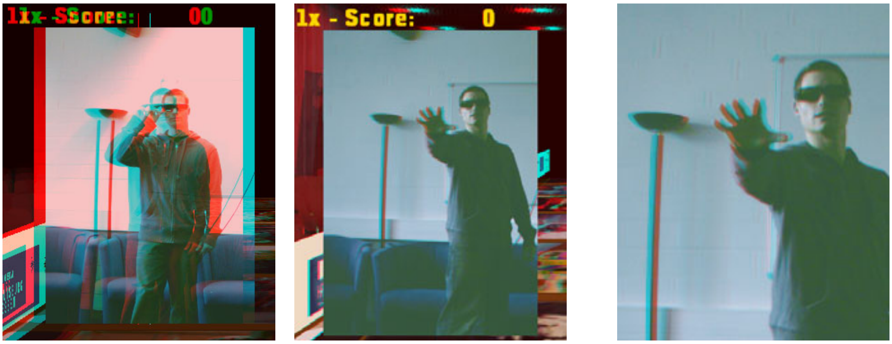
Knowing the width of the near clipping, the parallax can be converted into world coordinates by scaling it with the result of Equation (2).

$$parallax_s = parallax(d) \cdot n_w \quad (3)$$

This $parallax_s$ gives the offset in world coordinate units at screen depth. The final step left is to scale the parallax, so it can be applied to an object at the specified distance d. Since all values are given (the distance to the near clipping plane, the parallax at screen depth, and the distance to the object), the theorem of intersecting lines is used to determine the sought after parallax value as indicated by the following equation:

$$parallax_d = \frac{parallax_s \cdot d}{n_s} \quad (4)$$

Knowing the distance between the stereo canvas and the cameras, Equation (4) can be used to determine by how much the occlusion mesh needs to be translated horizontally. During each update of the stereo canvas, this value is used to translate the left eye's canvas accordingly to avoid the border problem.



(a) (b) (c)

Fig. 4. Screen Parallax: Examples of adjusted screen parallax. **(a)** Due to constant adjustment and the zero parallax calibration, the disparity of the player's image is always almost exactly equal to that of the occlusion mesh. **(b)** Screenshot taken during the zero parallax calibration explaining the concept of the artificial convergence plane. **(c)** A magnified part of (b).

3.3 Manually Fitting Video Content Depth to the Game Scene Depth

While the parallax of the stereo image borders can be correctly adjusted with the aforementioned approach, the disparities within the stereo content would still be completely uncorrelated with those of the rendered game scene. Unless the video supports complete depth information (i.e. a depth map), a complete adaptation of the video depth range into the virtual depth budget is not possible. Our approach therefore concentrates on adjusting the depth of a particular depth plane from the video in respect to a given depth plane within the game scene. As our prototype incorporates live 3D video, we explore this problem using video from the stereo camera setup mentioned before.

Our approach is based on a manual setup using a zero parallax setting. First, the stereo canvas is positioned at the convergence plane, defined by the 3D Vision driver's convergence value. Consequently, the horizontal parallaxes of the occlusion mesh and of the adjusted S3D video frames are zero (see Fig. 4 b+c). Now the video content is shifted manually until objects at a specific depth within the video also show zero disparity. For our example, this artificial convergence plane was set at the position of a person standing in front of the camera. The additional horizontal offset determined in this way is added to the result calculated by the parallax equation:

$$parallax_o = parallax_d + offset \tag{5}$$

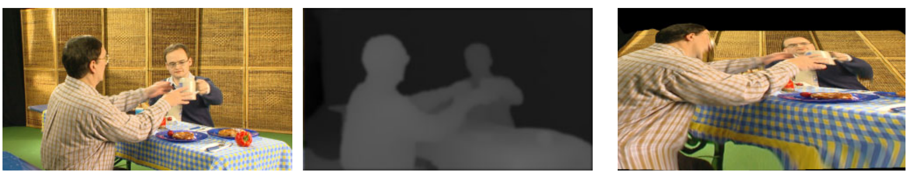
In this way the image and scene disparities would approximately coincide at all times. An example of this is shown in Fig. 4a. Since the calibration was performed manually, small errors were obviously inevitable, but if done properly, the errors are not visible to the naked eye. A challenging but very interesting task for future developments would be to perform this step in software automatically.

3.4 Splitting the Canvas

Our system allows splitting the camera image to display several parts of the image on different canvas objects (cf. Fig. 3). One application could be to identify the faces of multiple players within a video and distribute the according parts throughout the game scene.

To accomplish a split into two parties for example, two meshes instead of one are created for each eye, each with half the width of the original meshes. Additionally, the texture coordinates associated with each vertex are altered so that one split contains the left half of the video texture and the other split the remaining half.

Consequently, each split can be set completely independent within the scene. Of course, it is necessary to still treat corresponding splits, for example the left split of the left and right eye's canvas, in correspondence with the aforementioned considerations about parallax and offset to achieve the correct depth impression.



(a) (b) (c)

Fig. 5. Using MSVR for stereoscopic rendering of the video-plus-depth format (a+b). The generated occlusion mesh can be textured with the video (c) or stays hidden for z-buffer test with the game scene.

3.5 Problems of Occlusion with Objects and Video

Using S3D video in games may incorporate interaction of virtual objects with certain features of the video content, positioned at arbitrary depth layers. But, as the occlusion mesh of the video is fixed, virtual objects that shall be positioned in depth next to a video feature at large positive parallax, might be occluded. Thus, virtual objects are not enabled to extend into the depth of the video.

One simple approach would be to render such virtual objects with disabled depth test and in the correct order. In a complex interactive setup, this implicates a thorough design of positioning and animating scene objects which clearly restricts game design. Furthermore, virtual objects might occlude video features of smaller parallax values, possibly confusing depth perception.

Another approach is the use of non-planar occlusion meshes (see Fig. 5). Currently, a depth map of the video is required (as in video-plus-depth or depth-enhanced-stereo formats). It is used to create a displacement occlusion mesh. The vertices are shifted according to the depth information. The visual occlusion quality depends on the resolution of the depth map. In the future, we consider automatic extraction of depth information and updating displacement meshes through vertex shaders. For generating the required depth data in a live video situation, depth cameras and other systems as Microsoft Kinect seem promising.

4 Conclusions and Future Work

We presented our approach of rendering S3D video content in a professional game engine and discussed problems and solutions for integrating it into a S3D scene. While the multi-pass rendering approach only concerns a single technical platform, it allows other programmers, scientists, and hobbyists to develop custom stereoscopic visuals on consumer hardware. Besides stereoscopic video, any other independently arranged scenes can be rendered onto the canvasses, to circumvent the quad-buffered stereo barrier. Beyond this practical scope, the presented workings of occlusion handling and parallax integration are general problems that significantly influence the quality of S3D video display within a game scene. Our concepts give a first solution for manual adjustment and pinpoint the need for automatic methods of parallax adaptation and to generate depth data of a video. For the latter problem, future 3D video formats will hopefully offer depth meta data, as this is a major requirement for generating multi-view stereo data for autostereoscopic displays. This development highly depends on depth-measuring cameras [4] or automatic depth map extraction algorithms [7] in the domains of image processing and computer vision.

Possible future applications of S3D video are the integration as a contemporary medium within a virtual game world, and interactive S3D movies. The use of stereoscopic video may provide for better interaction opportunities: slightly changing the viewport through position shift or zooming in or out could provide for more dynamic visual exploration of a filmed scene. Depth estimation or the use of pre-rendered depth maps can allow for dynamically mixed pre-rendered/-filmed graphics with real-time animated objects. The use of live-feed S3D cameras can provide for stereoscopic augmented reality entertainment. Using MSVR, this design space can be explored using typically available graphics hardware and powerful game engine software.

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A Public 3D Visualization Tool for the Musée des Arts et Métiers de Paris

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Abstract. Useful and durable knowledge can be built upon the experience of discovering and the construction of a contextual awareness. In this article we present a tool to browse a catalog of 3D objects taken from the *Musée des arts et métiers de Paris*. The purpose of this multimedia kiosk is to enhance the visit experience by helping users to built meaningful relations between objects and scientific fields. Users select subjects of interest during the visit by collecting cards placed beside the real objects in the museums galleries. The cards are tagged with reactvision fiducial marks that enable the user to manipulate the 3D object representation on the screen. We present this tool and we focus more precisely on interaction issues both for individuals and groups in a public context and for a private use at home.

Keywords: Cultural heritage and learning, web, multimedia integration and interoperation.

1 Introduction

The article describes the analysis and solutions proposed to the remote access to the digitized 3D objects from the objects stock from the *Musée des Arts et Métiers de Paris* (Museum of Arts and Crafts). Because they are unique and fragile their manipulation for educational purposes in live public demonstrations are very limited or impossible. However these objects represent a rich complementary source of knowledge for visitors and teachers and this project propose to allow such a remote access through an educational multimedia tool. Numerous projects [1][2][3] propose multimedia display devices in order to enrich museums galleries and virtual reality, augmented reality and mobile devices bring innovative solutions to promote exhibitions. These solutions provide guidance and motivate visitors to dig further for details in a less passive relation with objects. But works [4][5] reveal some issues on user engagement towards the public interface devices and the digital content proposed. This happens mostly when the task is a challenging experience like manipulating 3D virtual objects causing users to rapidly lose focus and interest. To answer this issue, we propose a multimedia kiosk that links tightly real objects of the museum with a 3D virtual objects database by the use of simple input system based on paper cards col-

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lected during the visit. These cards serve as input devices for viewing and manipulating the 3D representations and also as a physical link to a post-visit moment. The multiuser kiosk is based on a reactvision table associated with a wide projection screen. The system tracks the cards unique identification and position allowing an easy an immediate apprehendability that triggers deep exploration. This interface should promote a rich *flanêrie* inside a content that keeps tracks, illustrates a precise subject and reveals new links between objects.

2 Learning with Digital Technologies in Museums

The museum's role in the formation of scientific literacy has been widely discussed [6]. A major issue concerns the establishment of the frontiers between the school and the museums environment. Indeed, the traditional visit guided by a teacher may result in student weariness, due to the mimic of similar methods in classrooms. In his research, Hawkey [2] argues that teachers shouldn't use museum objects just as illustrations for topics in courses and the galleries as an extension of the classroom. The new paradigms of this cooperation show that both institutions have their specific knowledge that should be respected and explored in complementary ways. The use of technology in schools and museums aims to bridge the gaps and explore the complementarities between the two specific methods and environments: the lecture and the object discovery. The visit to a museum invites the activities and experiences outside the classroom. The traditional educational tools enrich experiences for museums. In both cases this dialogue should stimulate the autonomy of students helping them building a personal experience based on a learning environment of free choice.

2.1 The Museum Specific Case

The Musée des arts et métiers in paris is a particular case in the world of scientific museum because of its historical relationship with the objects inherited from the old conservatory of techniques[7]. Objects and galleries are organized according to the object uses or specific characteristics. Inside the galleries visitors may walk freely, follow a determined path and also be supported by guide teachers of the museum with specific tours for groups with extensive demonstrations. In overall cases the visitors relationship with objects remains passive. Actually the museum offers video explanations of objects functions but they are poor in interaction and are only made for an individual use. Moreover objects that are shown in the museum represent around 10% of the overall collection. Many objects are indeed kept in a reserve. Information on these objects cannot be accessed from inside the museum and create a physical link with them is impossible. Users can consult the object list on the website of the museum but the catalog is limited to still pictures and very basic information. This section of the website is primarily intended for professionals who wish to submit applications for loans. For a personalized visit and to guarantee a close relation with objects a solution is needed to keep tracks of object choices made during the visit [8][9][10]. The Digital Backpacking project at the Austrian museum of techniques proposed an object selection strategy based on an RFID smartcard. Visitors where invited to buy the card that stores object information collected during the visit for immediate use on terminals and to keep it as a souvenir for post-visit debriefing [11]. We wish to extend this strategy and give the users a simple and cheap tangible link with objects that can also be used as input device for the multimedia kiosk and or in a web application from home.

3 Suggested Scenario of Use

We propose now to describe an use case scenario to clarify the use of our interactive 3D catalogue. The main characters are taken from a family composed by a couple and two children of 12 and 10 years old. The visit is made by the father and his two children. At the museums entrance they buy 3 admission tickets represented by small rectangular paper cards. This card has the museum logo and a unique barcode that identifies a single user. Initially conceived for controlling visitor entrances they will serve later as an individual identification in our system. The family starts the visit following a suggested path. During their visit, some objects catch the attention of the children. To obtain more information later, a child can pick one of the cards available next to the object. Over one side of each ticket there is an illustration of the object and on the other side a fiducial mark. This mark is part of the reactivision system and identifies the object and will permit later the manipulation of the virtual environment. At a certain point of the visit path, the visitors are confronted with the multimedia kiosk consisting in a tabletop device associated with big projection screen (fig.1). On the screen a galaxy of floating objects is displayed. On the table the children can touch these particles, which react to the touch by revealing their 3D representations. One of the children disposes the ticket over the table. The corresponding particle is placed near the card and reveals its 3D representation. The child tries other tickets and for each one, he gets an overview of the 3D objects. He notices that he can rotate and move on the screen this virtual object in order to have an overview of the object. Simultaneously other related objects are attracted revealing new semantic connections, possibly with objects that are kept in the reserve. He can have a closer look to these new attracted objects by clicking on them and once again the 3D representations are revealed. Other operations can be performed on selected object, such as launching 3D animations to understand object functions or rendering parts with transparency to show hidden mechanisms.

The experience lasts from 5 to 10 minutes. The child has played around with the particles and the 3d representations and he is invited to put his entrance ticket on the table. The objects close to him are stored in a remote server with his personal ID printed on the ticket. The child has new insights in how to walk the museum and have a better overview of the different fields covered by the museum. Once the family is back home they can visualize the objects but also the new links that have been created with more less time constraint with the web dedicated interface. The interface simulates the museum kiosk experience and is built with more multimedia material

Fig. 1. Paper cards representing object selection. Museum kiosk installation and basic gestures for 3D manipulation.

and external resources associated with objects. They can explain the visit to parents and friends with a visual support. By this stimulating narration act they turn passive and forgettable knowledge into active and durable. For a collaborative aspect, in that web interface they can add comments and share web-links. For school use, teachers can ask expressly a certain number of objects to be collected and easily debrief the children personal experience with their cards and make a history of their visit. Children can also exchange cards and get information from others. This system permits a simple and not expensive way to stimulate the quest for information and the cards became easy to use manipulation devices made of paper that can link the real visit experience with a virtual visit. The paper solution permits cards to be taken home and act as both as a souvenir of the museum visit and as an entry point for the multimedia devices and the website.

4 System Overview

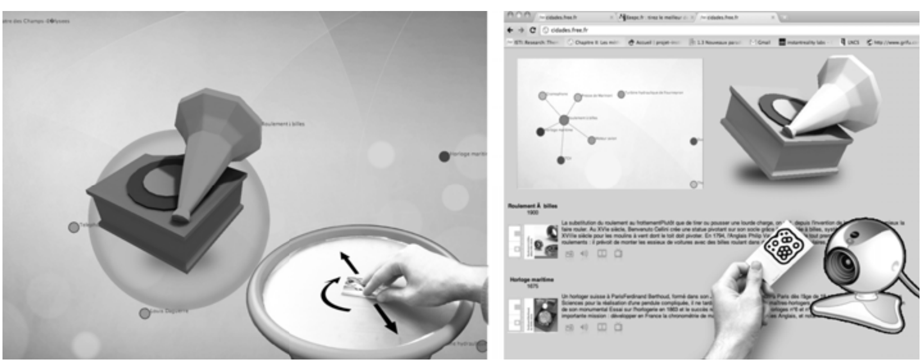

Fig. 2. Kiosk and website graphic interfaces with their related input styles: tabletop gestures at the museum kiosk and a webcam for home use

In this section, we will mainly talk about technical and design aspects of the kiosk device installation (inside the museum). The reason why we don't talk specifically about the private (website accessible from anywhere) is because this last system is a subset of the first one. It only needs a standard computer running the same Java visualization application rendered on a single screen instead of two. For the computer vision inputs, a simple home webcam is enough to allow the same set of interaction of the museum kiosk. Instead of moving the card on a tabletop, the user, at home, will present it to his webcam. The multimedia kiosk is a multitouch tabletop device that tracks fingers and fiducial markers in real-time through the computervision framework reactvision [12]. The image captured by an infrared camera sends position and angle information of the mark by a TUIO protocol understanding client that renders the visualization. To implement our prototype we have used processing as our multimedia development environment (www.processing.org). The graphical interface presents the 3D objects as a galaxy of moving spheres that we call particles. Each particle has a color computed by mixing the scientific fields segmentation of the museum according to the semantical closeness of an object to each field. (fig.2) Thus each object belongs to his original domain but they may also be related to other areas (and this appears thought the color given to its particle). We developed an XML file that stores objects tagging information with reduced data like title, author, and date reproducing what is already been implemented for the traditional web catalog. We enriched this initial tagging with the nuanced domain classification. Then for each particle we implemented a calculation of Euclidean distance in n-dimensional space, where n is the number of areas related to the individual object. This distance is used to determine the degree of similarity between objects and it sets the movement behavior of each particle. Objects are more or less attracted and with different speeds according to their similarities. The movement behavior was inspired by a metaphor of magnetic fields and the similarity distance computed reproduces physical laws of magnetism. The result is very fluid and smooth interactive experience without visual discontinuity or occluded levels of complexity.

4.1 Interacting with Particles

As a new object card is placed upon the table, the related object is highlighted giving an overview of the 3D digitized object. The fiducial mark printed on the card allows the user to move, turn and act on the 3D object. This is done by using 3 degrees of freedom offered by the card: the 2 standard translations in X and Y directions like a mouse and the rotation used to either turn the object or advance in an animation timeline. For each selected object similar objects starts to move towards it. The final pattern gives information on similarity from the surrounding objects. A series of concentric fields outlines the area of most similar and relevant objects. The user can touch attracted objects that will expand to reveal their 3D representation and turn around they're selves automatically as in a turntable metaphor. If new cards are added to the table a new net of relations will emerge taking into account the new cards and their attracted objects. Each user will have its own area on the table with possibly the same objects attracted. If a same card is used, duplicated particles will show up to avoid a lack of possible particles to be attracted. This way multiple users can enjoy at the same time the kiosk, sharing cards in a collaborative way and making new discoveries together.

5 Conclusions and Future Work

We have explored in this article a way to access a 3D database of digitized objects from the museum galleries and reserve. Our systems permit a simple and not expensive way to interact with 3D assets as they are made of paper on which are printed fiducial marks. Because these interaction devices are made of paper they can be taken home as a souvenir of the museums visit and as keys to enter the museums website. Several informal tests were conducted with the museum coordinators and with visitors. The use of cards was immediately apprehended and the manipulation of objects seamed obvious and natural. Besides the risk that every card available would be picked the possibility to bring home a key to a new web experience motivated the visitors.

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Camerawork for Comics Generated from Visitors' Experiences in a Virtual Museum

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Abstract. We present a camerawork module for representing events in a virtual museum with a comic style. The module uses four basic camera shots, i.e., internal, external, apex, and group, to compose a shot sequence of two main events happening in a museum, i.e., move and stay. This module is fully implemented in a comic generation system we have been developing for summarizing user experiences in Second Life. Visual comparison, with a baseline camerawork, confirms the effectiveness of the proposed camerawork module.

Keywords: camerawork, comic, virtual museum, metaverse, Second Life.

1 Introduction

A comic style is a promising representation for summarizing various kinds of user experiences in an entertaining fashion. Applications of the comic-style representation include summarization of activities in a conference [1], daily activities [2], video sequences [3, 4], and game-play activities [5-8]. Comic-style summaries facilitate perceiving of main events, augmenting of personal memories, and promoting of communication among user communities. In this paper, we describe a part of our current project on summarizing user experiences in a museum located in metaverse such as Second Life (SL) [9, 10]. In particular, we focus on how to perform camerawork in such an environment. In addition, we propose four basic camera shots and three camera idioms, each of which specifies a sequence of those basic camera shots for a certain situation.

Previously, we proposed in [11] and [12] a camerawork editor and an automatic camerawork module, respectively. The former allows the viewer to manually edit the camerawork of a generated comic while the latter automatically decides the camerawork of each frame based on rules derived from an analysis of online-game web-comics. However, the camerawork of online-game experiences, where major activities are related to fights against monsters and acquisitions of items, is different from that of user experiences in virtual museums, where major activities are simply moving around and staying to view exhibits therein.

In this paper, as our first step, we follow He et al. [13] in deriving basic shots and idioms beforehand. We then use them for deciding the camerawork of a selected comic frame and perform user evaluation to see their effectiveness. Story control as done in [14] and optimization of camera parameters is, however, beyond the scope of this paper.

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2 Camerawork Module

The proposed camerawork module decides a shot sequence for each scene according to one of the three idioms: **move idiom**, **single-view idiom**, and **multiple-view idiom**. For move scenes where the avatar continuously moves, the move idiom is used. For stay scenes where the avatar stays in order to view a nearby exhibit, the camerawork module uses the single-view idiom when the number of exhibits near the avatar is one and the multiple-view idiom when there are two or more nearby exhibits. Four basic camera shots inspired by the work of He et al. [13], i.e., internal, external, apex, and group, are used in these idioms. While basic shots in [13] were decided for avatars and interactions among them, our basic shots focus on the user avatar and its interactions between nearby exhibits or objects.

Figure 1 shows the camera placement and an example shot for internal, external, apex, and group, respectively, where *a* and *o* denote the avatar and an object of interest, respectively. The camera direction of each of these shots is towards the avatar's head, the second argument' center point, the center point between the avatar and the object, and the center point between the two objects, respectively. For each camera shot, three camera parameters, i.e., the camera angle, camera position, and zoom position, are decided in advance. As mentioned in Sec. 1, optimization of these parameters is beyond the scope of this paper.

Figure 2 shows the shot sequence and an example of each of the three camera idioms. We decided their shot sequences based on two cinematographer heuristics discussed in [13]: *avoid jump cuts* and *use establishing shots*. The former heuristic establishes a distinction between any two adjacent scenes. The latter heuristic allows the viewer to see all involving objects in the initial shot of a scene. The description of each idiom is given as follows:

Move idiom establishes a scene with external(a, o) so that object o is seen over the shoulder of avatar a, where o is a virtual point located at a certain distance ahead of the avatar on the avatar's direction line. Then apex(a, o) is used, in which the camera focus is directed towards the point between the avatar and the virtual point, in order to express the avatar's movement.

Single-view idiom establishes a scene with external(a, o) and then switches to external(o, a) in order to prevent shooting similar consecutive shots, where o is the nearest exhibit within a given distance from the avatar or the aforementioned virtual point if there are no exhibits nearby.

Multiple-view idiom establishes a scene with group(a, o_1, o_2) in which the nearest exhibit o_1 and the second nearest exhibit o_2 are both seen over the shoulder of the avatar. Then, in order to make the scene more exciting and lively, this idiom uses a combination of internal shots as well as single-view idioms.

For a scene of interest, the camerawork of each of its frames is decided according to the basic shot, one by one from top to bottom, in the corresponding idiom until the last frame of this scene. If there are still remaining frames when the bottom basic shot has been reached, the camerawork of the first remaining frame will be decided according to the top basic shot again. This process is repeated until the camerawork of all frames is decided.

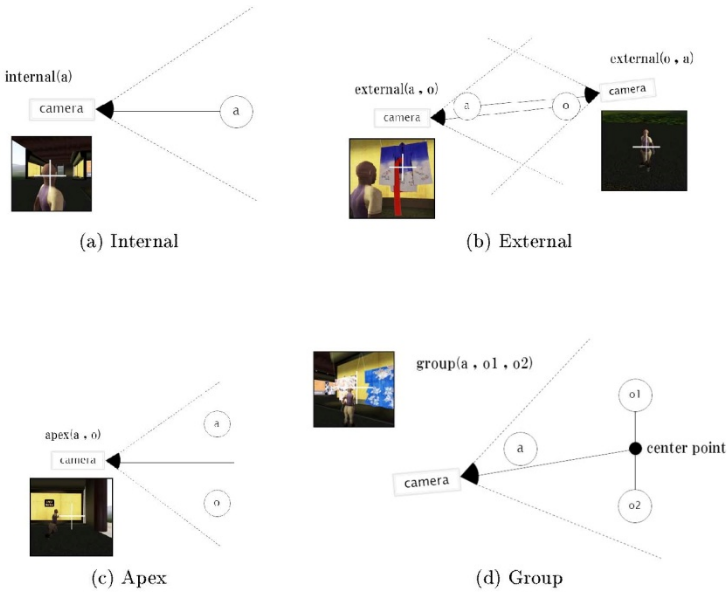

Fig. 1. Camera placement for the four basic camera-shots proposed in this work

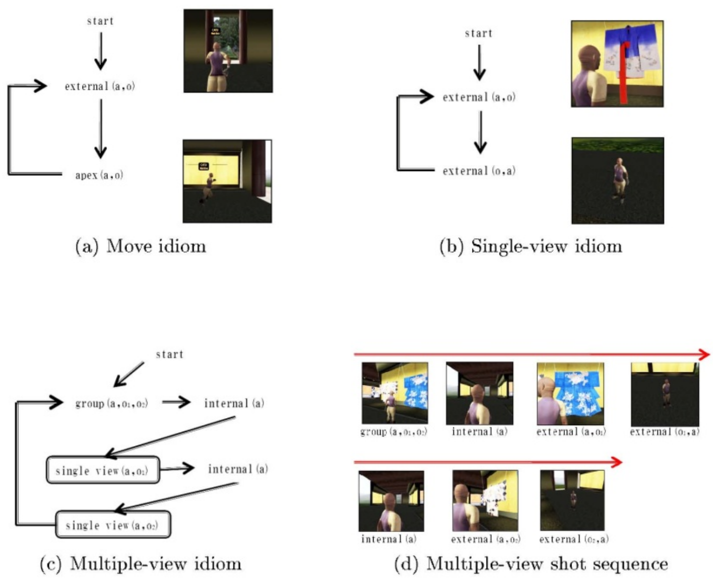

Fig. 2. Shot sequence and example shots of the three camera idioms proposed in this work

3 Results and Discussions

We fully implemented the proposed camerawork module in our comic generation system [9, 10] developed based on the open-source SL viewer program. For this work, we adopted a typical comic layout where the order to read is in the raster order, from top-left to bottom-right, and all frames have the same size.

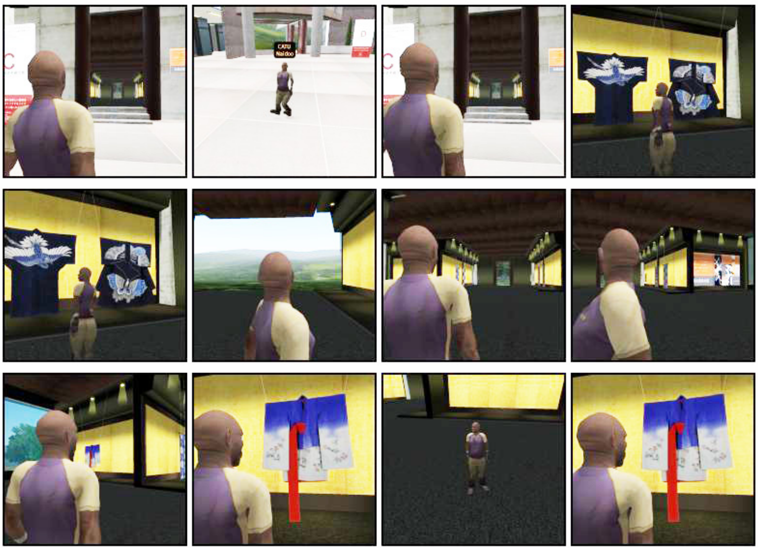

Fig. 3. Comic with the proposed camerawork

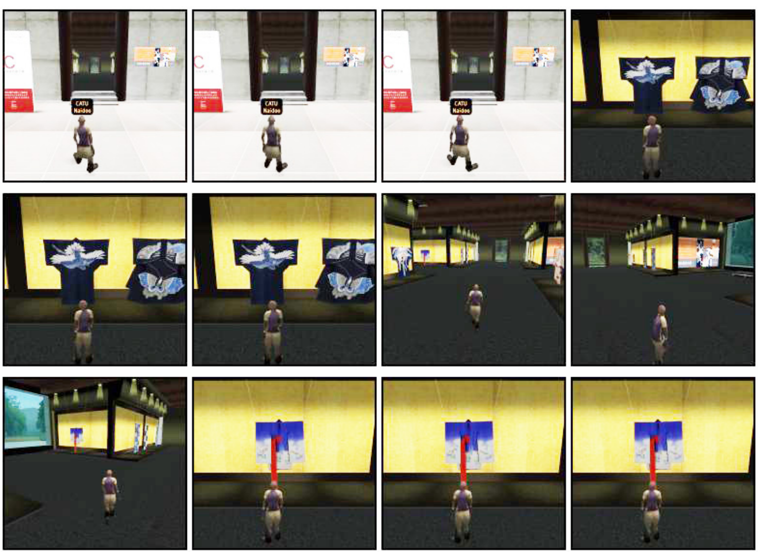

Fig. 4. Comic with the baseline camerawork

In this work, we targeted user experiences at a SL museum[1] designed and operated by members of the Global COE (Center of Excellence) Program Digital Humanities Center for Japanese Arts and Culture of Ritsumeikan University. This museum exhibits Kaga Okunizome Dyeing, kimono and bedding from the Ishikawa region in Japan during the latter part of the Edo period until the beginning of the Showa period. However, we note that our system is also applicable to other virtual museums, galleries, and exhibitions in SL as well as other metaverse.

Figures 3 and 4 visually compared comics whose camerawork was decided by the proposed camerawork module and by a baseline camerawork module, respectively. The baseline module used the same camera parameters as those of the SL viewer program. From these figures, one can see that similar consecutive frames exist in the comic with the baseline camerawork while this is not seen in the comic with the proposed camerawork.

4 Conclusions and Future Work

This paper described our camerawork module that decides the camerawork of each comic frame representing user experiences in a virtual museum. First, we decided the four basic camera shots, internal, external, apex, and group, such that the avatar movement and the avatar interactions between nearby exhibits are articulated in comic frames. Then we derived the three camera idioms, move, single view, multiple view, based on two well-known cinematographer heuristics *avoid jump cuts* and *use establishing shots*. Visual comparison confirmed the effectiveness of the proposed camerawork module in that the resulting comic was more exciting, lively and entertaining than that with the baseline camerawork.

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Towards a Unified System for Digital Film Production

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Abstract. We present a system which aids content management during the pre- and post-processing aspects of digital film production. Editors can synchronize their footage with their imported scripts to help in the organization of the video "bin". In addition to this, we provide a zoomable interface to facilitate the process and help organize pre-production media such as images, and video clips.

Keywords: zoomable, video editing, video analysis.

1 Introduction

Video editing typically involves sifting through large collections of raw footage stored in folders called “bins”. These video files are usually logged, which means the filenames are tagged with the scene, shot, and take numbers. However, this provides only limited information and the editor must still sort through large numbers of clips, maintain a list of what parts of the script they cover, and ensure that there is a consistent contrast ratio between cuts. Therefore, one of the problems we attempt to address is the lack of organization and assistance during video editing.

We present a system which allows users to import film scripts written in Final Draft® for the purpose of synchronizing text to the spoken dialogue within the video clips. Final Draft® has been selected as it is considered industry standard software. The results of aligning the script to the clip bin are displayed in a timeline visualization. In addition to this, the system we present can also be used to organize pre-production media. Collections of media such as images, and video files can be imported and organized within a unified zoomable interface.

The following section introduces work related to our system. Then we describe the details of our system in the next three sections. The first of these sections contains an explanation of the user interface elements implemented. The second describes the speech recognition aspect and the processes related to improving those results. The third section details the visualization we employ for managing the post-processing film content. Next we present a case study to illustrate the usage of our software using video files from a real student film. Lastly, we discuss future directions for our system.

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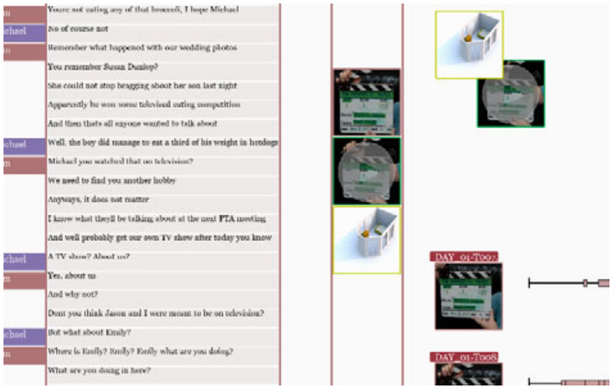

Fig. 1. A general view of our system. An imported Final Draft® script in a channel (*left*). A media channel (*center*). Several loose media panels (*top right*).

2 Related Work

2.1 Zoomable Interfaces

At a coarse-level, the user interface of our system has similarities to existing zoomable user interfaces. We will mention only the earliest examples, or those most related. In particular, Pad and Pad++ are early prototypes of this concept which demonstrated the effectiveness of zoomable interfaces [1] [2]. Two additional toolkits have since succeeded Pad++, namely Jazz and Piccolo. Jazz is a graphics toolkit for development in Java [3], while Piccolo offers zoomable features [4].

IMapping is an example of a zoomable application designed for general information structuring [5]. The author compares the iMaps created in the system as a whiteboard where information is added similar to post-it notes which can be nested within each other, and the system provides adequate navigation tools for viewing.

One last related zooming technique we have implemented is Igarashi and Hinckley's speed-dependent automatic zooming technique for large documents [6] [7]. This causes the view to smoothly zoom out while the user is scrolling a document rapidly. The purpose of which is to allow the user to quickly navigate the workspace without becoming disoriented as the perceptual scrolling speed stays constant.

2.2 Script Authoring Suites

There are three pre-production authoring systems that will be discussed here. The first is Celtx (Greyfirst Corporation) [8], the second is Final Draft® (Final Draft Inc.) [9], and the third is Story (Adobe®) [10]. These systems all allow writers and planners to create scripts and in the case of Celtx, shooting schedules and 2D layouts.

Celtx is a free software system which consists of tools that aid in the creation of screenplays and related media. In addition to a typical text editor for screenplay writing, this software provides several pre-visualization tools and a scheduling system for managing film shoots among other features.

Final Draft® is considered to be the industry standard for screenwriting and provides authors with a set of tools for formatting standards. This software provides the user with no significant pre- or post-production visualization features, but we have chosen to support this screenplay authoring format for our software since the Final Draft® files are XML-based.

Adobe® Story is one program out of a series used for film production. As with the other systems, it is used for the creation of screenplays. Importing a Story script into Adobe® Premiere allows the script to be synchronized to video files using speech recognition. Additionally, the speech synchronization feature allows editors to create rough cuts of the film. But, a limitation of this system is that the production crew must only use Adobe products during production to make use of all of the offered features. Unfortunately, it may not be feasible or desirable to use Adobe® OnLocation during filming or Adobe® Premiere for editing as the filming studio may be invested in alternate systems for these tasks. Furthermore, while Adobe® products provide tools for film editing and metadata embedding, they do not offer any options for a comparative analysis of each clip.

3 System Overview

This section will provide an overview of the system and explain the user interface elements we have implemented in our software. The focus here is on elements related to pre-production and production, with further discussion of post-production editing revisited in sections 4 through 6.

Our system attempts to address the lack of organization of media during the pre-production process as well as to aid in the selection of video content during editing. We present a zoomable workspace to aid the use of our provided tools. The workspace in our system allows the user to import several media types to facilitate an integrated view from pre- to post-production. These media types include images, video files, and text files.

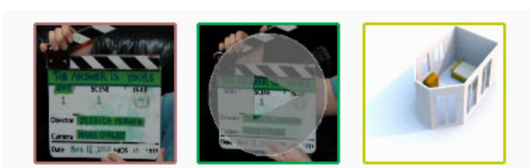

Fig. 2. Three media panels. An image panel (*left*), a video panel (*center*), and a floor plan panel (*right*).

The content in our system is represented as widget panels which can be moved or scaled, similar in some aspects to BumpTop [11]. Figure 2 illustrates examples of several media widgets in our system. Image and video panels are represented in our system simply by static thumbnail images (*left* and *center* respectively). Video panels can be invoked, which will play the video file using an embedded version of the VLC media player.

Scripts imported from Final Draft® are added to their own channel by default as shown in figure 3. As an additional navigational tool in our system, we have implemented speed-dependent scrolling [7]. This technique will automatically zoom out the view window when the user scrolls rapidly, which helps to ensure that the scrolling speeds appears more perceptually consistent to the viewer.

4 Speech Recognition for Post-production Editing

Our speech recognition program produces a list of lines dialogue which were matched from the clip, the time that the line occurred, and a confidence value for the match. We use a series of filters to help remove false matches based on low confidence and false duplicates before applying a clustering algorithm. This algorithm groups together matches that are adjacent in the actual script. We then take these clusters and use them for two processes; first to remove further false matches, and second, to interpolate occurrence times for any dialogue lines which were not detected by the speech recognition engine.

In an example using every clip covering the first scene in the film (close to 20 minutes of footage), the average accuracy of predicted lines of dialogue was 1.4 seconds with a standard deviation of 1.02 seconds. The variation is dependent on the length of the lines and the density of dialogue in each part of the clips. In most instances, the larger predicted time windows were due to longer time periods of no dialogue within the video itself.

5 Post-production Visualization

The timeline visualization allows the user to view the alignment of spoken dialogue in each video clip to the imported script for that scene. This is represented by a timeline for each clip in the bin, displayed in a vertical channel as shown in figure 3. Each timeline is populated by boxes representing the lines of dialogue from the script. The position of each box represents the time position within the clip, while the width of the each box corresponds to the approximate length of time of the spoken dialogue.

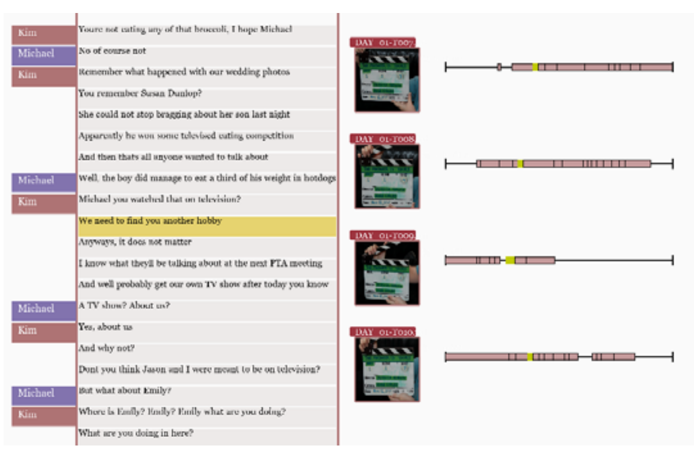

Fig. 3. A line from the script is selected (*left*). Boxes on the timelines are highlighted to show the location of the selected script sentence (*left*).

Sections of the script can be selected which will highlight the segments of the timelines where they occur in the scene. Figure 3 illustrates that after the user selects the dialogue text, the predicted occurrence time window for each clip in the bin is displayed on the series of clip timelines. This allows us to show which clips the dialog was successfully matched in, and where the line is likely to have occurred.

6 Case Study

Here we present a short case study that provides an example usage of our system. Our data set is comprised of raw movie footage from a digital film production at a university-film school. To demonstrate our system, we will focus only on clips covering the first scene of the film.

The process begins by dragging the Final Draft® script for the film onto the window of our system along with several of the clips in our scene one bin. This adds the list of clips to a channel and the system begins processing the content. The speech recognition system analyzes each file and returns a list of dialogue matches and their occurrence times. Once the analysis is complete, each entry is listed in the timeline visualization. Not all of the video clips span the same parts of the script, and some are cut short due to on-set issues with the actors.

For example, if the editor wishes to select a subset of the videos containing a key line of dialogue; it is selected from the script channel. The videos which the dialogue has been recognized in are displayed and the position in time is highlighted in the timelines for each clip.

7 Conclusion

In summary, we present a software system for aiding in the organization of content for video editing as well as offering a pre-production media organization solution. Our zoomable interface provides access to the features of the system and scales well with large script files as well as large amounts of clips in the bin. For organizational clarity and modularity, we also provide vertical channel widgets to gather media into organized groups. Furthermore, due to the potential size of scripts and video data, speed-dependent scrolling plays a key role in the navigation of the script and the general workspace.

Our speech recognition system and error removal processes are useful for synchronizing the script with the video files. During times when the software does not always match spoken dialogue to the correct part of the script, our match clustering technique is able to reasonably fill in the gaps through positional interpolation. The timeline visualization also aids in illustrating the script alignment to the clips in the bin.

Lastly, we have presented a short case study demonstrating the use of our system on real video data. However, no formal user testing has been carried out to date, though we plan to gather systematic user data in further student productions in the near future. Additionally, we intend to expand our visualization to include a multivariate comparison tool.

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Fundamentals of Stereoscopic 3D Game Design

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Abstract. Stereoscopic 3D (S3D) has (re-)emerged as a major technological trend [12]. Hence, many game designers are challenged to avoid S3D pitfalls whilst creating innovative and entertaining gameplay experiences. We analyze the challenges and opportunities of S3D game design. Based on a review of related findings in the fields of perceptual psychology and 3D movie making, we propose a catalogue of fundamental and innovative concepts for S3D game design that shall lead to new and differentiating game developments.

Keywords: Stereoscopy, game design, S3D, 3D gaming, stereoscopic vision.

1 Introduction

Current S3D products enable stereoscopic viewing for existing games (e.g. Nvidia 3D Vision, Sony Playstation 3, Nintendo 3DS). Such games often provide the same gameplay but with S3D graphics, sometimes at the cost of reduced visual quality (e.g. shadows, bloom, depth of field effects, reflections) [16]. Only little academic research on S3D games is available: Zachara and Zagal reviewed the failure of Nintendo's Virtual Boy. They describe a lack of focused design and emphasize a need for S3D game mechanics [25]. A game that is unplayable without stereoscopy is needed. Rajae-Joordens found that S3D creates an additional value for playing Quake III: Arena [17] but gives no indication for how such value can be deliberately created.

This paper systematically explores challenges and opportunities in S3D game design. We review physio-psychological and technological literature in 3D movie making to formulate requirements for designing a pleasurable experience. Based on this analysis, we propose a list of possible future innovations in S3D game design.

2 Requirements in Stereoscopic Perception and Imaging

According to Tam et al., S3D image sequences are preferred over non-stereoscopic versions; perceived depth is rated greater for S3D sequences than that for non-stereoscopic ones; perceived sharpness of S3D sequences is rated same or lower compared to non-stereoscopic sequences [21]. S3D provides additional information about spatial location, size, shape, or orientation of 3D objects [9]. Virtual scenes experienced in S3D induce an increased perceived presence [10]. Binocular vision on most current display solutions differs from real-life stereopsis: In natural viewing, the

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two major visual cues accommodation and convergence always coincide. On a flat screen display, however, the eye lenses accommodate on the display plane while the two eyes converge on other planes, depending of the current parallax. This separation, called accommodation/convergence mismatch, can cause visual discomfort [5]. Human vision has limited abilities to provide eye vergence in a certain range around the accommodated depth, related to the depth of human focus and depth of field (DOF). The resulting area of tolerance is called comfortable viewing range (CVR) and originally based on Panum's fusion area [14]. A tolerance of up to one degree around the accommodated convergence angle is recommended. Tolerance decreases with visual spatial frequency [13]. As a result, blurred objects in the foreground or in the far background may contain parallaxes beyond the recommended CVR. Movie makers even recommend using diverging parallaxes for background layers if the viewer's attention is locked to comfortable depth layers [15]. The effects are assumed to be stronger with prolonged viewing and shorter viewing distances [14].

Effectively, the CVR of a regular display is only a few centimeters behind and in front of the screen. Mapping a whole virtual scene into that range requires scaling of depth. Jones et. al presented an algorithm to calculate parameters for automatically mapping a virtual depth range into physical screen space [11]. Holliman later proposed a multi-pass rendering approach for non-linear mapping of three different depth regions into screen space [7; 8]. Dynamic depth mapping allows to dynamically fit the respective depth of scene into the comfortable range of the used display [20].

The currently focused depth layer is also called Depth-of-Interest (DOI) and providing DOF effects around this region has proven to reduce visual discomfort [2]. DOF can also cause problems, when the player focuses on a blurred object. Thus to create a dynamic and realistic DOF effect, the game needs to know what the player looks at [14]. In movies this can be achieved through direction and cinematic storytelling [20]. In a game, where the camera is controlled by the player, automatic selection of the correct DOI puts up new challenges for camera artificial intelligence.

Obviously, game mechanics of S3D games could put up game design challenges related to depth perception. Performance in precision of depth perception, or stereoscopic acuity, depends on human factors (interocular distance (IOD), accommodation ability, maximum pupil size) and external factors (distance to target, spatial frequency and luminance of target, distance from fixation, observation time).

The human factors are strongly affected by aging. While the average IOD is reportedly at 63 mm [4], it may vary between 50 and 75 mm among most adults, and down to 40 mm for 6 year old children [3]. It has significant impact on depth perception: an increased interocular distance causes hyperstereoscopy: the depth we are used to perceive within arm's range stretches into the far landscape, creating a model-like impression of large buildings [16]. Artificially reducing the IOD below normal creates a hypostereo effect, often used for close-ups and macro footage. Accommodation ability and the maximum pupil diameter decrease dramatically from 14 diopters for ten year old children down to 2 diopters among elderly people [18]. Given optimal luminance and a fixation distance of 65 cm (typical for computer displays), the authors report a minimum detectable depth difference of 0.3 mm.

Depth precision is affected by the used 3D display (driver, electronics), correlating with individual physiology of the user [6]. The resolution limits the number of perceivable depth layers, causing depth aliasing. In effect, depth resolution decreases with distance to the display plane. Slowly moving game objects might look jerky in far away depth layers on low resolution displays.

The benefits of S3D only apply if it is free of noticeable distortions [21]. Those might occur from exaggerated disparity, cross-talk, binocular rivalry, blur, compression artifacts, noise [24], or are related to geometric errors [23]. For objective assessment, 2D image quality metrics are not appropriate; 3D quality metrics are not available yet [24]. If distortions occur, viewers might experience visual discomfort that leads to decreased visual performance, called visual fatigue, often accompanied by headache, eye strain, and other symptoms [14]. Theoretically, children of age six and under are physically endangered, because their visual system still has a high degree of plasticity [19].

In conclusion, there are currently no absolute measures for ensuring visual comfort in interactive games. Thus, S3D game development always requires evaluation of visual comfort with the target group on target displays.

Table 1. Catalogue of S3D game design concepts and related considerations.

Cat.	S3D game design concepts	Perceptual considerations and possible benefits
Camera	Depth-promoting camera perspectives	Speed perception, better distance estimation, more immersive experience
	Camera interaxial adjustment	Hypostereo, hyperstereo, playing as big monsters or tiny creatures
	Non-linear depth mapping	Depth perception of both fore- and background, e.g. in racing games both track and cockpit
	Dynamic depth mapping	Maintaining stereovision comfortable and spectacular between perspectives/scene transitions
Game Challenges and Design Ideas	Depth-estimation tasks	Unbalancing depth cues e.g. texture gradient, lighting, shadows, transparency, or relative position can create optical problems, solvable through S3D
	Balancing towards easy tasks	High contrast, complex texture, bright colors, close depth ranges
	Balancing towards difficult tasks	Low contrast, simple homogeneously colored textures, far away depth ranges
	Memory tasks	No impact from S3D expected
	S3D game scenarios	Mapping real world stereo applications for gaming tasks: bullet casings, diamond reflections, etc.
	Depth-based level design	Possible impact on flow due to specifically designed variety of depth ranges in level design
Game GUI	Depth-positioning of context information and system control	Still unsolved, requires smart dynamic placement to reduce depth jumps and avoid depth cue conflicts
	Text-directed attention	Text can draw attention towards certain depth layers
Extreme S3D	Deliberate double-vision	Simulating gun-sights, image comparison tasks, simulation of drug effects
	Abusive gaming	Putting up physical strain on purpose to simulate sick characters and push towards finding a remedy

3 Stereoscopic Game Design Opportunities

Based on the aforementioned findings, the following section proposes a list of game design opportunities for S3D games (summarized in Table 1).

Interactive S3D Camera Effects: S3D can be effectively used by choosing depth-promoting camera perspectives. Super Street Fighter IV 3D Edition on the Nintendo 3DS offers an additional view from over the shoulder. Reportedly, this view may be unplayable without S3D vision, as depth perception supports judging the distance to the other character [1]. Nevertheless many current games feature over-the-shoulder-perspectives perfectly playable in monoscopic view. Further evaluation is necessary. In addition to perspective, adjusting the interaxial distance of the two virtual cameras for effects of hypo- or hyperstereoscopy (see Section 2) can be used to simulate other creatures' visual perception: hypostereo lets the player experience the world through the eyes of tiny creatures, so everything seems gigantic; hyperstereo could apply to simulate the visuals of a big monster, for which the world looks small and crushable.

The camera should keep the depth range always within CVR, e.g. through depth mapping. In racing games, for example, the best experience is distributing the depth range across the whole landscape, to maximize perceived speed. However, in in-car view, the cockpit would be rendered too closely, causing visual discomfort. Non-linear depth mapping could help to render both cockpit and the far landscape in both comfortable and entertaining depth ranges, but at an unrealistic scale. Still, interactive changes in perspective can easily alter the depth range. Cuts and scene transitions may cause depth jumps [15]. One solution could be dynamically adjusted depth mapping, which may result in unnatural morphing effects when an interactive scene dynamically switches between large depth ranges and close-up visuals. Overall, we need to find new methods for automatic adjustments of S3D cameras in games.

Stereoscopic Game Challenges and Design Ideas: Effective game effects can be achieved by deliberately creating cognitive conflicts of depth cues. Texture gradient, lighting, shadows, transparency, or relative position can be used to create optical problems, solvable through S3D. Balancing depth precision tasks depends on the target group (children, adults, elderly). Easy tasks should involve brightly textured objects close to the screen plane. Difficult tasks should present dark, homogeneously colored objects at far away depth. Despite such abstract tasks, S3D game scenarios can be found in the real world: crime scene investigators examine bullet casings using stereo microscopes; diamonds cause reflections in both eyes slightly differently, which is used to estimate value. Other game scenarios can be enhanced using depth-based level design. Similar to varying difficulty, varying the depth budget across level design might increase the flow a player experiences. In 3D movie making, depth charts are created that give an overview on the applied depth budgets over time [15].

S3D Game GUI and Information Visualization: Generally, games display status information (score, items, resources, etc.) on the image plane and world information (mission, name, properties of NPCs, etc.) spatially next to its referencing entity. Dialogues and subtitles are found in either position. In S3D, both positioning methods can cause problems: Overlaid visuals positioned in screen space conflict with out-of-screen effects and result in contradicting depth cues of occlusion and disparity. If the player's attention is directed towards distant depth planes, switching back to screen space requires eye convergence and takes effort. Also, if object-related information is displayed at object depth, other objects might occlude the text. Event alerts popping up during game play draw attention towards them and thus to their depth layer. New solutions should automatically reduce depth jumps and avoid depth cue conflicts.

Extreme S3D: Double Vision and Abusive Effects: If the two S3D views differ too much, the brain cannot fuse them anymore, leading to double vision. Games could offer two different images for the two eyes: the overlay effect could allow for comparison tasks; a character rendered in both images could be part of two worlds, each putting up different challenges; GUI elements like gun-sights could be rendered in one view only; double vision can be used to simulate drug effects. These possibilities have to be assessed upfront for possibly causing visual discomfort. A large difference in two pictures can increase ghosting effects depending on the used display technology. A user tutorial may help first-time players with such irritating effects. Such negative effects might occur on purpose, as part of abusive game design [22]. In FarCry 2, the protagonist suffers from malaria, shown through blurred and deformed 3D visuals. Wrong S3D could be used to emphasize this effect, directly causing eye strain, to push the player towards finding a remedy.

4 Conclusions

In this paper, we have analyzed previous findings on stereoscopic vision in perception and movie making. Our contribution is a list of opportunities how S3D games potentially can make a difference beyond a short-term novelty-based fascination (see Table 1). Interactive or intelligent S3D cameras, depth-adaptive GUI systems, depth-based game challenges and level design, or new visual effects need further research and case studies that demonstrate applicability and lead to innovative solutions. To ensure entertaining qualities, S3D game production requires intensive balancing of perceptual constraints and ergonomic requirements against new and innovative game design. To conclude, we strongly propose to apply S3D vision as a differentiator in game design, provided that perceptual issues are worked out. The presented list is incomplete, offering a first direction to other researchers and to the games industry. Hopefully, we can see some of these concepts applied in future S3D games.

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Affective Agents for Empathic Interactions

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Abstract. In the present work we develop an experimental setting to evaluate the influence of affect – more precisely, of simulated coherent fluctuations in mood and emotional states – in the construction of empathy in synthetic characters for interactive digital entertainment. Our goal is to evaluate whether the impression of interacting with human-like agents can be more relevant than purely utilitarian metrics for user preferences to interact with systems in certain situations. We have built affective agents to play computer games against human users, and assessed empirically the extent to which users consider more engaging to play against the affective agents than to play against agents that are easy to beat.

Keywords: Affective Computing, Digital Entertainment, Artificial Intelligence, Intelligent Agents.

1 Introduction

Research in Artificial Intelligence can be broadly organised as normative or descriptive, with very little work lying in the intersection of these two categories. Normative research has a focus on the construction of models to optimise the performance of artificial systems, thus determining how (artificial) intelligent agents ought to reason, instead of how (natural) agents actually reason [16].

Descriptive models of artificial intelligence, in turn, focus on the reconstruction of observed human performance in engineered intelligent artifacts, in order to build scientific theories of human rationality [6]. Descriptive theories and models can be useful in at least two situations, namely (i) when one is interested in understanding human behaviour, which, although not optimised, can be predicted and, therefore, either guided or exploited in constructive ways [1], and (ii) when one is interested in the construction of empathic agents, with which human users can interact pleasantly and naturally [11].

In the present work we focus on descriptive models of intelligent agents. More specifically, we focus on the construction of empathic agents for interaction with human users, in the context of digital entertainment. We consider computer games in which the user plays against the computer, and build synthetic opponents whose performance mimics that of human opponents, this way building pleasant and satisfactory experiences to users.

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We have explored the utilisation of an agent architecture enriched with a model for personality and mood fluctuations, to build synthetic opponents whose behaviour matches that of human players [10]. Preliminary experiments have indicated that this approach to build computer games does indeed create novel possibilities for the game industry, to build appealing new products for consumers. Moreover, the same technology can be used to build empathic agents for a variety of applications, such as smart homes for the routine care of elderly and disabled people, conversational agents for computer-based education and for information presentation.

In section 2 we briefly discuss related work that has been inspirational to our work. In section 3 we introduce our enriched agent architecture. In section 4 we introduce the two experiments that we have built in order to empirically assess the practical utilisation of the enriched agent architecture. In section 5 we discuss some preliminary empirical results. Finally, in section 6 we present some conclusions and proposed future work.

2 Related Work

Several projects have been developed aiming at the construction of believable agents for interaction with human users. Some of these projects have been particularly influential on the development of the present work.

The ALMA Project [5] is connected to the Virtual Human Project, whose aim is the development of a system for distance learning, in which users interact with synthetic characters in order to obtain instructive material. The synthetic characters are built using a model of personality, mood and emotional states. The main focus on ALMA is on physiological manifestations, although it also comprises a few features related to cognitive states, such as the selection of strategies for dialogues.

Making Them Remember [7] aims at the development of agents with personality and emotions, whose memory of past events changes according to emotional states. Its results have been tested in a synthetic character applied to distance learning.

The Governor of Poker[1] is a commercial product, in which users can play Texas Hold'em Poker against the computer. The computer reacts based on emotional states generated by its performance in the games. For example, if the user makes a bluff and the computer falls on it, then the computer can lose emotional control and play badly for the next few rounds.

Additional references to related initiatives can be found in the literature, as reviewed in previous publications from the authors [10]. We have furthered those initiatives, focusing on the cognitive consequences of changes in affective states.

3 Agents with Personality and Mood

We have extended a standard BDI architecture for intelligent agents, to include models of personality, mood and emotions, in such way that these models influence cognitive properties of the agent, namely the way it generates plans and its capability to perceive and interpret external events, as well as to store and retrieve past events

[1] http://www.youdagames.com/Governor-of-Poker-game-info-2818

from the memory. Emotional states also determine physiological responses from the agent, such as (in our experiments) facial expressions.

As a base architecture, we have adopted Jason[2], which is an open source framework to build BDI intelligent agents. We have extended Jason with an Affective Module and three filters, namely a Perception Filter, a Memory Filter and a Planning Filter. The Affective Model stores (static) information about an agent's personality, as well as (dynamic) information about the agent's mood and emotional state, which is affected by external events as well as by its success to build adequate courses of action in response to events. The filters are influenced by the Affective Model and determine the extent to which, respectively, the agent is going to be able to perceive and interpret external events, store and retrieve information from its memory and build effective plans.

A detailed presentation of the extended agent architecture can be found in previous publications from the authors [10]. In the next paragraphs we present in further detail the Affective Module and each of the three filters (namely, the Perception, Memory and Planning filters) used in the proposed architecture for affective agents.

3.1 The Affective Module

The Affective Module influences the three filters, and consequently how the agent perceives external events, stores and retrieves information from the memory and generates plans. Internally, the module contains and interconnects models for personality, mood and emotion. The interconnections are implemented using the model of Mehrabian [9], which expresses the relationships between personality, mood and emotion using the parameters of the Big Five Personality Factors [8], the Pleasure-Arousal-Dominance (PAD) model for mood [9] and the OCC model of emotion [14]. This model has been used with success in previous research initiatives [5, 7].

3.2 Personality

In our model, personality is assumed to be stable for an agent. We have adopted the Big Five Personality Factors [8] to model personality, which characterises the personality of an individual according to five variables (Openness, Conscientiousness, Extroversion, Agreeableness and Neuroticism). Each variable can assume a real value in the interval [-1; 1], such that -1 means the extreme opposite of a variable and 1 means the maximum value for a variable. For example, -1 for Extroversion identifies an extremely introverted individual, and 1 for the same variable identifies an extremely extroverted individual. Hence, personality can be portrayed using a vector $P = [O, C, E, A, N], O, C, E, A, N \in [-1,1]$.

3.3 Mood

Mood is a state that results from the cumulative effects of emotions over an initial state defined by personality [4]. In our work, we have adopted the model of Mehrabian [9], which characterises mood based on three variables (namely, Pleasure,

2 http://jason.sourceforge.net

Arousal and Dominance). Similarly to the model for personality, each variable can assume a value in the interval [-1, 1]. Stereotypical mood states are characterised by extreme values for each variable, and hence we have eight stereotypical values. Considering that mood is represented using a vector $M = [P, A, D], P, A, D \in [-1,1]$, the stereotypical values are [1, 1, 1] = Exuberant, [1, 1, -1] = Dependent, [1, -1, 1] = Relaxed, [1, -1, -1] = Docile, [-1, -1, -1] = Bored, [-1, -1, 1] = Disdainful, [-1, 1, -1] = Anxious, and [-1, 1, 1] = Hostile.

The initial mood state for an agent has been empirically related to personality [9]:

$$\begin{cases} P = 0{,}21P[E] + 0{,}59P[A] + 0{,}19P[N] \\ A = 0{,}15P[O] + 0{,}30P[A] - 0.57P[N] \\ D = 0{,}25P[O] + 0{,}17P[C] + 0{,}60P[E] - 0{,}32P[A] \end{cases}$$

3.4 Emotion

Emotion is a state of immediate effect and short duration. It is activated by external events, actions or specific objects, and influences physiological manifestations like facial expressions. We have adopted the OCC model of emotions [14], which describes 22 types of emotions (Admiration, Anger, Disappointment, Distress, Fear, Fear-confirmed, Gloating, Gratification, Gratitude, Happy-for, Hate, Hope, Joy, Love, Pity, Pride, Relief, Remorse, Reproach, Resentment, Satisfaction, Shame), and a set of rules that determine how these emotions vary according to external events and objects, as well as agent actions. In our model, we have implemented the OCC model based on a vector $E = [e_1, \ldots, e_{22}], e_i \in [0,1]$.

3.5 The Relations between Personality, Mood and Emotion

Personality is defined for an agent as a combination of values for the variables O, C, E, A, N. Given the personality of the agent, mood and emotion are inter-related as follows.

Initially, mood is obtained from the set of equations above. After that, the agent iteratively obtains information about the environment and external events, and updates mood and emotions, using the equations empirically defined in [7]. In these equations, E_s represents the emotional state, E_a represents the appraised emotional state, M_{cur} represents the current mood state and the α_{ij} represent constant values that characterise the cross-influences between emotion and mood [5, 9]:

Emotion update

$$E_s = E_s + filter(E_a, M_{cur})$$

$$filter(E_a, M_{cur}) = E_a + \frac{\sum_{i=1}^{22}\sum_{j=1}^{3} \alpha_{ij} * m_j}{\sum_{i=1}^{22}\sum_{j=1}^{3} \alpha_{ij}}$$

Mood update

$$M_{cur} = M_{cur} + UpdateMood(E_s)$$

$$UpdateMood(E_s) = \sum_{i=1}^{22}\sum_{j=1}^{3} e_i * \alpha_{ij}$$

3.6 Perception

Empirical research has indicated that the intensity of perception of stimuli in individuals varies according to their mood [13, 12]. We have extended Jason, so that perception now receives two new attributes: a vector indicating which emotions are associated to this perception and a vector that determines the intensity of each emotion. We have also implemented the Perception Filter, in order to select perceptions following two criteria: the perception associated to an intensive emotion and whether the result of the appraised emotions (i.e. whether the emotions are predominantly positive or negative) is consistent with the current affective state of the agent.

For the first case we have calculated a summation of the intensity of emotions and, if this value is greater than the value of the minimum intensity (I_{min}) defined by the user, the perception is selected, otherwise it is discarded. For the second case, assessment is made on the number of positive and negative emotions caused by perception. The dominant (positive or negative) type is compared to the current affective state of the agent (in all three filters, the current affective state of the agent is represented by the value of the variable P(leasure) in the mood vector). If the values are congruent, then the perception is selected, otherwise it is discarded.

3.7 Memory

According to Bower [2], there are four theories that match affective states and cognitive processes: (1) memories are more easily retrieved when an individual has the same mood as that of when they were stored; (2) the current affective state influences reasoning and interpretation of events; (3) memories with affective state similar to the current one are easily retrieved; and (4) memories associated to more intense emotions are more promptly retrieved. In our architecture, the memory of an agent is stored as its belief base. Affective states and their intensities can provide a context to influence the retrieval of information from memory, hence we have built a Memory Filter that selects information related to the current emotional state of the agent from the belief base. Stored information is tagged with the emotions associated to it, their intensity, and the current affective state of the agent.

Information is retrieved from the belief base according to the following criteria: the intensity of the emotion associated to the information must be greater than the minimum intensity defined by the user (I_{min}); the type (positive or negative) of emotion associated with the stored information must be congruent with the current affective state; and the affective state at the moment when the information was stored must be congruent with the current affective state.

3.8 Planning

The influence of affective states in plan formation is based, in our architecture, on the model of Somatic Markers [3]: before an individual makes a rational decision, the brain reduces the number of options based on somatic aspects of recent past experiences. In that model, each plan is tagged with a positive or negative marker, depending on the current emotional state of the agent. The Plan Filter makes a pre-selection of the potentially applicable plans, rejecting those that are connected to negative markers, as well as updating the tags of all applicable plans for future consideration. Somatic markers implement an adaptive behavior, which selects appropriate plans in such way as to increase the efficiency of plan selection based on congruence with the emotional state of the agent.

4 Experiment Design

We have built two experiments, in order to assess the extent to which synthetic characters endowed with personality, mood and emotion can build more engaging experiences to users than characters which do not feature these attributes.

Both experiments are online computer games, in which a user plays against the machine. The first experiment is a version of the Memory Game, and the second experiment is a version of the Texas Hold'em Poker Game.

Our goal was to assess the influence of fluctuations in mood and emotional states in the pleasure generated by playing the game in users, and whether this influence could overcome the pleasure that resulted from winning in the game.

4.1 Experiment 1: The Memory Game

The Memory Game is a two-player game, in which a deck of cards containing printed images has pairs of identical cards. The cards are shuffled and then positioned on a table facing down, so that the players cannot see their images. Each player flips up two cards.

If the cards are identical, then the player removes the cards from the game and scores one point, otherwise the player flips the cards down again and passes the turn to the other player. The goal of the game is to score the maximum number of points. Since both players can see the images on the cards that are flipped up, then both players can memorise the location of certain cards as the game goes on.

The construction of a computer game for the Memory Game, in which a human player can play against the computer, can be challenging, despite the simple rules of the game, because it can be difficult to build an engaging synthetic opponent for this game. For example, a perfectly rational opponent with perfect memory of past events can be too hard to beat, and an opponent that flips cards randomly can be too easy to beat. Even though the user feels pleasure as a result from beating the computer, our conjecture was that relevant pleasure could also result from the sense of control that results from causing variations on the cognitive and affective state of the opponent, hence users could prefer to play against the affective character, even though other, nonaffective characters could be easier to beat.

In our implementation, we have used 16 pairs of cards, as shown in Figure 1. Each image portrays a character showing one different emotion in a different intensity. Emotions are classified as negative or positive, depending on the emotional states that they evoke, and the intensity of the emotions induced by each image grows from left to right in Figure 1. A screenshot of the game is shown in Figure 2.

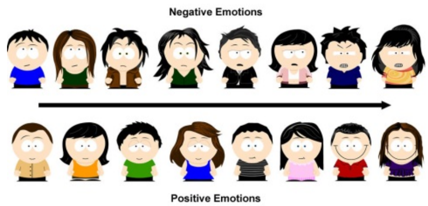

Fig. 1. Characters in the Memory Game

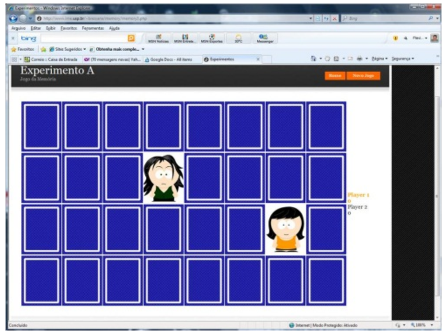

Fig. 2. The Memory Game – Screenshot

There are three possible opponents against which the user can play: (1) Random Player, which picks pairs of cards at random, (2) Perfectly Rational Player, which has infinite memory and never makes a mistake, and (3) Affective Player, which employs the architecture described in the previous sections to change behaviour depending on mood and emotional states – more specifically, the mood of the Affective Player changes depending on how successful it has been in recent previous rounds. Successful rounds increase the sense of control of the agent, which memorises the cards portraying positive emotions better than those portraying negative emotions, and vice-versa when unsuccessful rounds occur.

Simulations have shown that this strategy for the Affective Player – enhanced by random mistakes whose likelihood varies, also depending on the mood of the agent – mimics very effectively the behaviour of a human player. Our focus in the present work is whether the pleasure that results from playing against a human-like player can overcome the pleasure of winning the game.

4.2 Experiment 2: Kuhn Poker

The Kuhn Poker is a simplified version of a two-player poker, in which the deck of cards has only three cards: Jack (J), Queen (Q) and King (K), (K is the best card and J is the worst one). Each opponent starts the game with 10 chips that can be used to bet. To simplify the presentation of the Kuhn Poker, we name the players A and B. Initially, each player bets one chip and receives one card. A can then choose between raise – i.e. betting an additional chip – or check – i.e. asking to see the cards. Upon raise, B can choose between call – i.e. betting one matching chip and showing cards to see who wins the round – or fold – i.e. giving up. Upon check, B can choose between check – i.e. showing cards to see who wins the round – or raise – i.e. betting one extra chip and leaving A with the options call or fold. The winner always takes all chips on the table. In case of a draw, the chips remain on the table for the next round.

As in more complex versions of poker, in this version the players can bluff. In this experiment, we update mood and emotional state of a synthetic opponent depending on its performance on recent rounds. The skills to play, as well as to deceive the human opponent using its facial expressions vary depending on the mood.

Following the rules of the Kuhn Poker, we have limited each game to three rounds, and built the affect-influenced strategy for the synthetic opponent using tables as the sample tables presented in Tables 1, 2, 3 and 4. In these tables, the first column shows the card in the hand of the synthetic opponent, the second column shows its mood and the third column shows the corresponding action. The mood of the synthetic opponent varies according to previous rounds, in such way that positive mood and emotional states result from winning chips, and negative states result from loosing chips. The tables shown in this article feature the initial strategy of the player, which is updated according to mood and emotional states. The facial expression of the player mimics that of an intermediate player: at some points during the game it reflects the emotional state of the player, and at other points it portrays what the player wants to convey – for example, a bluffing expression of joy.

Table 1. 1st Round Strategy

Card	Mood	Action
J	Exuberant, Relaxed, Disdainful, Hostile	Check
J	Dependent, Docile	Check
J	Bored, Anxious	Raise
Q	Exuberant, Relaxed, Disdainful, Hostile	Check
Q	Dependent, Docile, Bored, Anxious	Raise
K	Exuberant, Relaxed, Disdainful, Hostile	Raise
K	Dependent, Docile	Raise
K	Bored, Anxious	Check

Table 2. 2nd Round Strategy - after a Check

Card	Mood	Action
J	Exuberant, Relaxed, Disdainful, Hostile	Check
J	Dependent, Docile	Check
J	Bored, Anxious	Raise
Q	Exuberant, Relaxed, Disdainful, Hostile	Raise
Q	Dependent, Docile, Bored, Anxious	Check
K	Exuberant, Relaxed, Disdainful, Hostile	Raise
K	Dependent, Docile	Raise
K	Bored, Anxious	Check

Table 3. 2nd Round Strategy - after a Raise.

Card	Mood	Action
J	All	Fold
Q	Exuberant, Relaxed, Disdainful, Hostile	Call
Q	Dependent, Docile, Bored, Anxious	Fold
K	All	Call

Table 4. 3rd Round Strategy

Card	Mood	Action
J	All	Fold
Q	Exuberant, Relaxed, Disdainful, Hostile	Call
Q	Dependent, Docile, Bored, Anxious	Fold
K	All	Call

In order to complete our experimental setting, we have created two other players. Our set of three alternative synthetic opponents is as follows: (1) the Random Player selects at random its bets. It also shows in its facial expression the quality of its hand (it looks happy when it has a K and it looks sad when it has a J). This opponent is very easy to beat; (2) the Affective Player behaves as described in the previous paragraphs. Its facial expressions show how it feels with respect to the game as a whole, but do not reveal how good its hand is; and (3) the Skilled Player, which employs an optimised strategy to play the game, as presented in [15]. Its facial expression remains unchanged (the "poker face") during the whole game. This opponent is very hard to beat.

Our implementation of the Kuhn Poker is depicted in Figure 3.

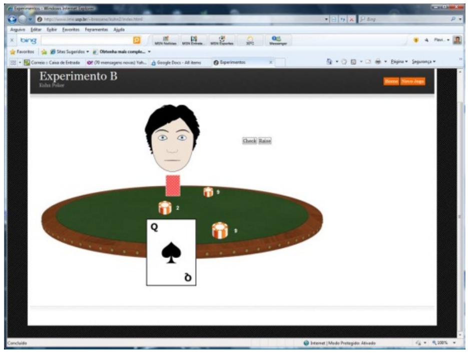

Fig. 3. The Kuhn Poker - Screenshot

5 Experimental Results

Our experimental setting, in both experiments, was as follows: we have asked volunteers to play against the three types of opponents, without explaining the difference between them. After playing a few matches against all three opponents, volunteers were asked to answer the following questions: (1) against which opponent did you enjoy playing most? (2) which opponent did you consider the hardest one to beat? (3) which opponent would you consider the most human-like?

Classical economic theories suggest that users should always prefer to play against opponents which are easy to beat. As we show in the next paragraphs and diagrams, however, this is not observed empirically. We have asked 23 participants to play the Memory Game, and 16 participants to play the Kuhn Poker.

In the Memory Game, 74% of the participants considered that the affective player was the most human-like, and 69% of the participants enjoyed playing against this player most. In the Kuhn Poker, 56% of the participants considered that the affective player was the most human-like, and 56% of the participants enjoyed playing against this player most. We have observed the behaviour of the participants while playing, and additional observations, although pointwise, are worth mentioning. In particular, one of the participants, while playing against the affective character in the Kuhn Poker experiment, started swearing against the computer when bad results weer obtained or when she suspected that the computer could be bluffing, and cheering when good results were obtained. Similar behaviour was observed with a different participant while playing against the affective character in the Memory Game.

The answers to each of the three questions are plotted in Figure 4 for the Memory Game, and in Figure 5 for the Kuhn Poker.

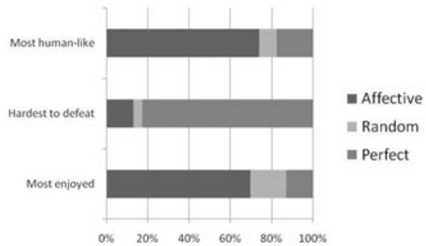

Fig. 4. The Memory Game - Survey Results

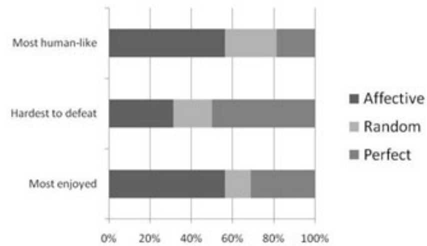

Fig. 5. The Kuhn Poker - Survey Results

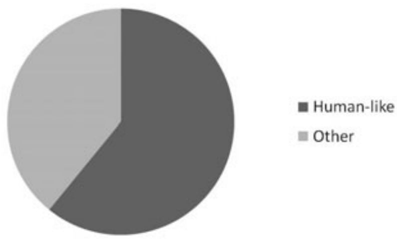

Fig. 6. The Memory Game – Preference for Human-like Opponents

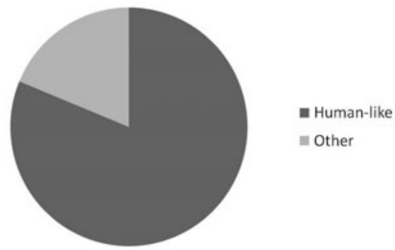

Fig. 7. The Kuhn Poker – Preference for Humanlike Opponents

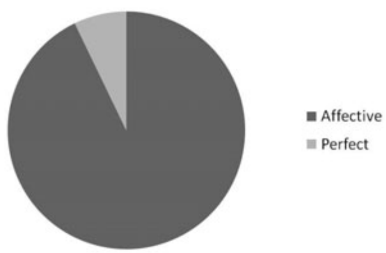

Fig. 8. The Memory Game – Specific Preference for Affective Human-like Opponents

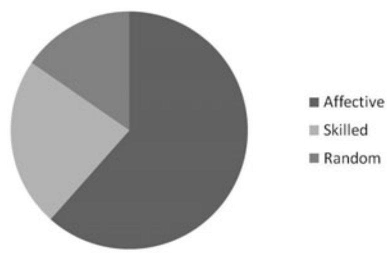

Fig. 9. The Kuhn Poker – Specific Preference for Affective Human-like Opponents

Some participants have considered that players which were not our affective player were the most human-like. Even in these cases, the majority of participants stated that they preferred to play against the opponent which, according to their evaluation, was the most human-like. 61% of the participants stated that they enjoyed most to play against the most human-like opponent in the Memory Game, and 81% of the participants stated the same thing in the Kuhn Poker. Considering only these participants, 93% have stated their preference for the affective opponent in the Memory Game and 62% have stated the same in the Kuhn Poker.

These results are plotted in Figure 6 for the Memory Game and Figure 7 for the Kuhn Poker regarding the preference for human-like opponents, and in Figure 8 for the Memory Game and Figure 9 for the Kuhn Poker regarding the preference for the affective opponent in the restricted universe of participants who had already stated their preference for human-like opponents.

6 Conclusion and Future Work

Preliminary empirical results have confirmed that human-like behaviour can be relevant to build engaging interactions with users, depending of course on the nature of the system under development. Interactive systems that are approached for clearcut reasons and desired goals (e.g. ATMs) are more likely to be expected to behave as computers instead of as simulated humans, whereas systems which are more conversational in nature (e.g. computer games, tutoring systems, museum guides, etc.) can be expected to assist the interactions, and behave in general as simulated humans. This feature can improve the empathy of information systems, and in order to build it we need well founded simulation models, based on which the cognitive responses of the system vary according to personality, mood and emotional states.

This feature, when applied in relevant systems, seems to be particularly relevant for beginning users: in our experiments, we have also asked the participants to declare how often they played computer games, and out of the participants who did not declare that they preferred the affective opponent over the other two alternatives, all participants were heavy game players for the Kuhn Poker, and all but one were heavy players for the Memory Game.

The perception of a human-like opponent induced by fluctuations in mood and emotional states seems to be more effective in simpler systems. In the case of the Kuhn Poker, which is a more sophisticated system, a competitive behaviour from the opponent seemed to suffice to convey the perception of human-like behaviour in a significant number of cases, whereas in the Memory Game the use of mood and emotions to influence the actions of the opponent seemed to be more relevant to convey the same perception.

Future work shall be devoted to further analysis of the situations in which affective agents can be most relevant for intelligent interactive systems. We shall build experiments with larger groups of participants, so that we can analyse the influence of factors such as gender, age and academic degrees to discriminate further our results. We shall also build experiments with different sorts of systems, e.g. systems containing embodied conversational agents to provide users with requested information.

Acknowledgments. This work has been partially funded by FAPESP and Microsoft Research, through their Virtual Institute joint initiative.

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Time Balancing with Adaptive Time-Variant Minigames

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Abstract. Balancing timing of tasks and abilities in multiplayer games is an important design element, but two time balancing issues are currently difficult to deal with: individual differences in experience or skill, and real-world elements that impose fixed temporal constraints on the game (as in mixed-reality games). We introduce *adaptive time-variant minigames* as a way of addressing the problems of time balancing. These minigames are parameterized to allow both a guaranteed minimum play time (to address fixed temporal constraints), and dynamic adaptability (to address temporal variances caused by individual differences). We developed three adaptive time-variant minigames and carried out two studies with them. The studies showed that the adaptation mechanisms allow accurate prediction of play time, that the minigames were valuable in helping to balance temporal asymmetries in a real mixed-reality game, and that they did not detract from the overall play experience.

Keywords: Game balance, time balancing, minigames, adaptation.

1 Introduction

Game balance is an important aspect of every game and the one that has received considerable attention from researchers and game designers [1]. There are several types of balance that need to be considered in a multiplayer game – such as balance between different strategies [2], balance between the capabilities of different teams [3], or balance between players of different abilities [4]. One main resource in many balance considerations is *time* – that is, the time required for certain activities (such as moving to a new location in the game, building a structure, or training a unit) is a resource that can be used in balancing against the resources of the other team either explicitly in terms of time or implicitly in terms of capabilities.

Some issues of time balancing can be dealt with during the design of the game (e.g., ensuring that faster units are less powerful), but two particular situations cannot be completely solved in design, leading to temporal asymmetries that must be addressed at run time. First, individual differences in experience or skill mean that two players will take different amounts of time to complete particular tasks; this situation affects a wide variety of multi-player games. Second, some games – e.g., *mixed-reality games* [5], [6] – involve aspects of the real world that impose fixed temporal constraints. For example, the amount of time it takes for a player to run from one game area to another is determined by the size of the real-world game space, and

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cannot be changed in the design of the game. If the game space is fixed, the only way to balance time is to make the players faster, which is not often possible.

In this paper we introduce a novel way of addressing the problems of time balancing, through the use of *adaptive time-variant minigames* (ATMs). Minigames are simple activities contained within a larger game, and are common in commercial titles (e.g., *Mario Party*, *Sid Meier's Pirates!*, or *Assassin's Creed* 2). Minigames can help designers balance temporal aspects because they can add time to a player's main game task or mission; however, traditional minigames have fixed difficulty, and may not provide the timing control that designers require. Adaptive time-variant minigames provide additional flexibility: in an ATM, the minigame is parameterized over a range of completion times, based on the game state and players' skill.

ATMs have inbuilt mechanisms to support both configuration of the minigame to set minimum and expected times when launched, and adaptation of minigame mechanics and parameters to influence completion time during play. The time needed for the various elements of the minigame (based on factors like speed or number of levels) can be determined when a game instance is launched. A guaranteed minimum time can be calculated using a simple formula, while the expected and maximum time can be determined empirically. The expected average time and desired variance is addressed by dynamically adjusting variables (such as the speed at which a ball moves, or the distance to a target) to increase or decrease completion time.

To test the effectiveness of ATMs as tools for balancing time, we developed four different minigames and carried out two studies using these games. The first study examined whether the minigames were able to manage time correctly in isolation, and this study showed that both the minimum-time prediction and the adaptation mechanisms worked well, leading to game times that tracked the desired values. The second study tested the real-world effectiveness of ATMs in a real mixed-reality game called *Stealth Hacker*. Although this investigation was a limited trial, our results show that the adaptive time-variant minigames were able to provide temporal balance without detracting from the main game. Our experiences with ATMs suggest that the underlying principle can be used more generally to assist designers with time balancing in a wide variety of multi-player games.

2 Prior Work

Unlike other types of media, video games are designed to generate interactive and engaging experiences [7], and game balance is recognized as a design issue that has profound effects on enjoyment – mutually influencing challenge and user satisfaction [8], [9]. Previous methods of managing the game complexity and balance, such as tuning the difficulty of static pre-defined levels, are often labor-intensive [10]. In fact, maintaining optimal game balance often needs to be a dynamic process because of the evolution of the player's behavior and skill [11]. If the game's challenges exceed the player's ability, it leads to frustration, and if challenges are lower than the player's skill, the player becomes bored [12]. Several previous approaches focus on the game's AI to address to dynamic balancing, but neglect the timing component [13], [14], [15], [16]. Bateman et al. [4] divide game balancing into gameplay balancing and player balancing for player's differing in skill and effort level.

Mixed-reality games, which incorporate real and virtual play simultaneously, face particularly acute time balancing issues. Generally, the physical portion of the game relies on existing infrastructure such as buildings, roads, and bridges, and is difficult to modify; similarly, the behavior of real world participants is dictated by physics and human physiology and cannot be altered. The majority of time balancing must therefore take place in the virtual portion of the game. Several approaches have been proposed to balance mixed-reality games. For example, online players may play on a scaled-down representation of the real playground with speeds adjusted proportionally to be appropriate for this scale [5]. *NetAttack* [17] divided players based on their roles and balanced play, but not timing based on role. In *Manhattan Story Mashup* [18] static minigames have been employed to implicitly manage game balance. Players were given a clue as a part of their 'mission' and were then asked to take a picture of the most related object within a cooldown timer, but the timer in the minigame is fixed, and variations in skill or the surrounding context do not change the duration.

Most solutions to time balancing in MMRs have presumed that virtual interfaces are point-to-point mapped to the real world – that is, that virtual players play in simulacrums of the real playground. Timing is implicitly addressed by setting virtual locomotion speeds to be approximately equivalent to expected real world locomotion speed [19]. While straightforward and easy to implement, this assumption is overly limiting and constrains the design space for MMR games.

3 Adaptive Time-Variant Minigames

Minigames are generally short, self-contained play experiences within a larger game framework, but with their own internal logic, game state, and mechanics. Because minigames have their own internal mechanics, they can be configured independently of the main narrative or action, making them an attractive alternative for dynamic balancing because the initial and goal game states can be made contingent on the overall game state without disrupting that game state when the minigame ends. Minigames are particularly attractive for time balancing because they are intended as short-duration activities, and can unobtrusively and selectively delay specific players without unduly disrupting the overall gaming experience.

Minigames, as games, have several parameters that can be manipulated to speed up and slow down the game duration. The simplest example involves controlling the scope of a repetitive task, such as shooting asteroids or aliens, where the number of times the task must be repeated changes. Another simple example is the manipulation of game physics (or physics analogues) to increase or decrease the speed of active components: for example, increasing the speed of falling bricks in Tetris can allow faster completion times because the blocks cross the screen faster. In principle, many game states could be parameterized, but in the minigames implemented for this paper we limit ourselves to the 'count' and 'physics' components described above.

To test the idea of using minigames as context-sensitive and player-sensitive time balancing tools, we implemented four minigames based on canonical arcade, board and puzzle games. The games are set in a 'computer hacking' theme, which is consistent with the larger game in which these minigames are used (see section 3.2).

- Hack-a-Computer: Inspired by the classic fairground game *Whack-a-Mole,* this game requires the player to click on a computer when it appears on the screen, then quickly return to the base of the screen to press the "Hack" button (Fig 1.A).
- Spinning Puzzle: This game is inspired by the picture puzzles from *Assassin's Creed 2*, where puzzle pieces rotate about a central axis. Players must rotate the pieces until the correct image resolves (Fig 1.B).
- Electris: Like the arcade classic *Tetris*, players guide falling electrical components to match the circuit train displayed at the top of the page. Unlike Tetris, successful rows do not disappear, making the size of the board the number of possible attempts, like the classic board game *MasterMind* (Fig 1.C).
- Brickout: This game is *Brickout*, pure and simple. Players must guide a ball using a paddle to destroy lines of bricks at the top of the screen. (Fig. 1.D).

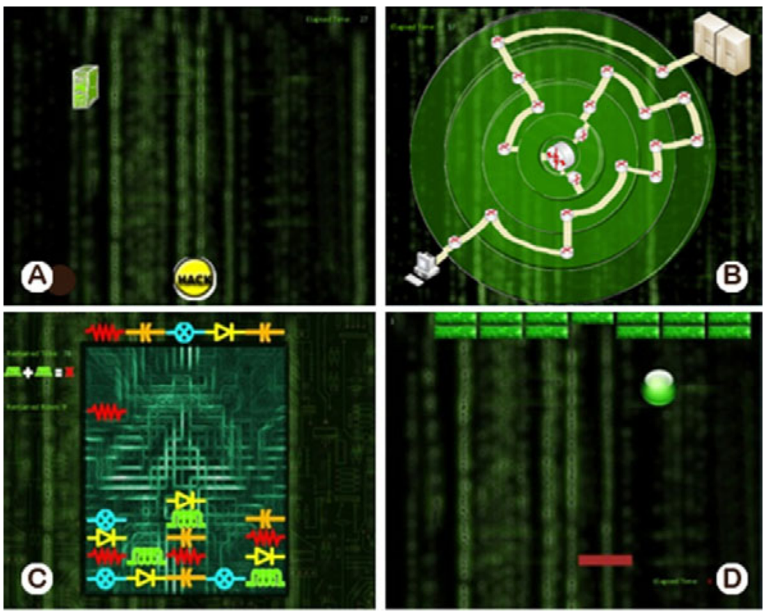

Fig. 1. Minigames: A. Hack-a-Computer; B. Spinning Puzzle; C. Electris; D. Brickout

3.1 Timing Algorithm

There are two classes of balance we are manipulating through the minigames: an overall balance based on game state, possibly set a priori, and a dynamic balance based on player ability set during play. By building games which have a configurable minimum completion time, a disguised countdown timer can be implemented. Timing balance can be enforced by minimum completion times, and adapted to expected or desired completion times. While an entire taxonomy of games and time varying manipulations is possible, we present only the proof of concept games here.

Table 1 lists the games, the manipulable parameters, the parameters used to fix minimum time, the parameters used to adapt playing time and the formula for minimum time. In principle other components such as play area could be utilized as manipulable parameters, but we only list those parameters actually implemented. In the formulae of Table 1, x_i is distance in pixels, h_i is the vertical screen dimension, v is the component velocity (ball, piece, etc.), θ_i is rotational distance and ω is rotational speed. N and n correspond to count variables corresponding to the number of elements such as pieces, bricks or targets.

Table 1. Minigame parameters and formulas

Game	Manipulable Components	Initial Settings	Adaptive Component	Minimum Time
Hack-a-Computer	Mouse speed, target size, number of targets	Target size, # of targets	Target size	$\sum_{i=1}^{n} \frac{2x_i}{v}$
Electris	Piece speed, number of lines	Number of lines	Piece speed	$N \sum_{i=0}^{n} \frac{h_i}{v}$
Spinning Puzzle	Rotation Speed, number of disks, min. # turns required	Number of disks	Rotation speed	$\sum_{i=1}^{n} \frac{\theta_i}{\omega}$
Brickout	Number of bricks, speed of ball	Speed of ball	Number of bricks	$\sum_{i=1}^{n} \frac{2h_i}{v}$

The initial settings column in Table 1 corresponds to the scale of the minigame created when the game is instantiated, configured each time the game is launched but static over the duration of a single minigame. This parameterization is meant to compensate for quasi-static temporal asymmetries. Temporal asymmetries due to player differences must be fixed at run time, and are addressed using the Adaptive Component in Table 1 which functions like a dial that can alter the speed of a game based on the player's current performance. For example, the speed of each subsequent component falling in Electris could be subtly altered to make the game proceed faster or slower during play.

Because we are able to express the minimum completion time in a closed form, we can find the minigame and initial game state that best fits the situation at run time, adding a degree of flexibility to game balancing. While the minimum time is often explicitly calculable, there is a practical upper limit to the maximum time based on player interest and game design. For example, it is possible to delay a player for thirty seconds using the Hack-a-Computer minigame, but would be disruptive to force them to play for ten minutes. Minigame selection and configuration proceeds as follows:

1. A game is selected based on its guaranteed minimum time and practical maximum time. This operation could be performed during level design, as part of the overall balancing, or dynamically based on the overall game state.
2. The base difficulty of the game is set by changing the manipulable parameters to achieve the desired minimum and expected time. Again this can be set a priori as part of game design or dynamically with game state.

3. Once a set time has elapsed (often but not necessarily the minimum time) the game can adapt the speed of the manipulable parameters to compensate for differences in player ability. This must occur during game play.

To evaluate the efficacy of the minigames and approach, we implemented a mixed reality game, *Stealth Hacker*, which pits a single hacker, playing on a computer opponent against a team of security personnel playing in the real world.

3.2 MMR Platform: Stealth Hacker

Stealth Hacker is a mixed-reality location-based game inspired by the playground game *Cops and Robbers*, played with several cops and a single hacker. The shared playground is a network of computers which the hacker attempts to infiltrate. The cops navigate this playground physically, moving from computer to computer and scanning them with smartphones (Fig. 2.A). The hacker, fittingly, moves from computer to computer virtually, by navigating a simple avatar around a network diagram (Fig. 2.B). The movement speed of the hacker, fitting the narrative, is on the order of seconds, providing the feeling of zipping across the network from computer to computer. Cops, in contrast, transit from computer to computer on foot, with elapsed times on the order of tens of seconds, fitting the Newtonian physics which governs motion in the real world. This asymmetry of spatial representation and navigation speed creates an interesting timing dichotomy: in the real world, the cops predominantly spend time moving between nodes, but spend little time at each node, while the hacker can transit between nodes quickly, and therefore must predominantly spend game time at network nodes to maintain time balance.

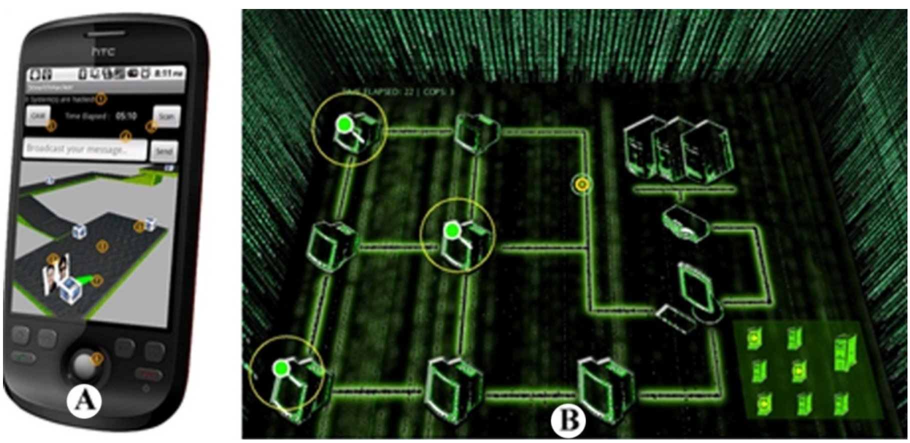

Fig. 2. A. Cop's interface on a smartphone, B. Hacker's PC interface

The cops' interface provides them with information on the location of their partners (both current location and planned movements), the last known location of the hacker, and a chat interface. When the cops scan a computer the program records the computer's Bluetooth MAC address, and transmits it to the server wirelessly. The scanned computer does not actually contribute anything other than its Bluetooth address, because the game state is managed by the server, and the hacking and scanning are simulated as minigames on the smartphones or the hacker's PC. The hacker tries to hack every computer in the network. Minigames are launched when the hacker attempts to infiltrate a computer and provide dynamic balance through guaranteed minimum and expected mean and maximum times at each node.

In *Stealth Hacker*, one of three minigames (Hack-a-Computer, Electris, or Spinning Puzzle) is allocated to an individual node when the hacker arrives and attempts to break in to the computer at that node. The game choice and its initial complexity are based on the average real-world distance from the attacked computer to the two nearest cops, based on an estimated foot speed of 4.95 ft/s [20]. The appropriate equation in Table 1 is used to calculate parameter settings that will provide a target completion time that matches the estimate of the cops' time (from the distance and speed heuristic). Once the hacker has played the minigame for the minimum time, the game adapts to allow the hacker to finish whatever tasks remain as quickly as they are able, by increasing the speed parameter listed in Table 1.

The Brickout game is given a special role. It is triggered if the hacker is caught by one of the cops. Catching the hacker occurs if a cop arrives at the same physical location as the hacker's virtual location, and 'scans' the computer. For every cop that 'scans' the hacker during a single instance of the Brickout game, an additional row of bricks appears, making the game more difficult to complete before a timer expires. If the hacker completes the game before a timer expires, they escape back into the network. If the hacker fails to complete the minigame, they are captured and the cops win. The minimum game completion time for Brickout, as set by the ball speed, is slightly longer than the average physical transit time between any two physically adjacent nodes in the network. Well-organized teams of cops therefore have the chance to 'gang up' on the hacker by ensuring that reinforcements are sufficiently close. This special case demonstrates that minigames can be tuned to manipulate game balance based on user input as well as initial game state.

4 Evaluation

4.1 Methods

Prior to evaluating the minigames in situ, we evaluated their time characteristics in isolation, to determine whether the chosen adaptive parameters did in fact improve player performance. Fifteen participants (10 male and 5 female, aged 22 to 33) played all the minigames. Players trained on each minigame at each difficulty level once to reduce training effects, and then further played each minigame once again for every difficulty level both with and without adaption. Difficulty levels for each game are shown in Table 2. The experiment ran on a Dell 6500 laptop (Intel Core 2 Duo, 2.53 GHz) with a 15-in 1800x1200 display, and standard keyboard and mouse.

Table 2. Experimental conditions for first study

Game	Difficulty Parameter	Value of Parameter
Spinning Puzzle	Number of rings	4,5,6,7,8
Electris	Number of rows	1,2,3
Hack-a-Computer	Number of targets	10,20,30,40,50

To test the ATMs in situ, we ran 9 rounds of the Stealth Hacker game described in section 3.3. MacBook computers with known Bluetooth MAC addresses were used as the physical nodes. These computers were placed over two floors in the University of Saskatchewan Computer Science Department. The maximum distance between two computers was 71.85 m and the average distance between two computers was 35.9 m. Four male players (Computer Science students mean age 27) played the game. One round of the game was played without data recording and with coaching from study organizers to familiarize the players with the game mechanics. Each player played six rounds as a cop and two rounds as the hacker. All game events and digital player-player communications were logged. After completing all nine rounds players filled out a demographic and experience survey.

4.2 Results 1: Evaluation of Minigames in Isolation

This study was intended to verify that time of completion is controllable through adaptive minigames, through *a priori* and dynamic adaptations. We found an almost linear dependence on difficulty level for all three games: completion times were faster with adaptation, and these curves were also linear with difficulty, albeit with a smaller slope. Results for the three tested games are shown in Fig. 3.

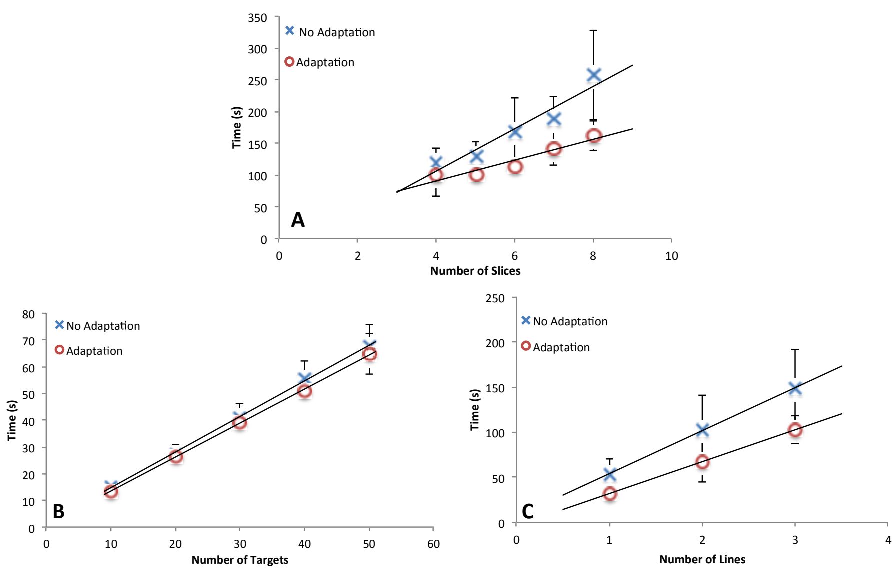

Fig. 3. Comparing average baseline and adaptive mode game play time: A: Spinning Puzzle. B: Hack a Computer. C: Electris

These results demonstrate three important properties of our adaptive minigames: first, they have linearly increasing mean time of completion with difficulty; second, there is a game-dependent decrease in completion time with adaption; third, the means and variances of each of the games are significantly different. The first result provides conveniently constant increases in completion times with difficulty. The second result demonstrates that dynamic adaptation provides a useful difference in completion times. The final result demonstrates both that player-player differences exist, and that games can be selected for not only completion time, but the variability of that completion time and the degree to which dynamic balancing aids the player.

4.3 Results 2: Evaluation in the Stealth Hacker MMR Game

The minigame calibration experiment established that the games had the properties of linearity and uniqueness, but mathematical properties alone do not make for viable games. For the approach to provide value it must dynamically adjust the challenge of each game to fit the current game state in the Stealth Hacker MMR game. We observed three outcomes: that players had positive experiences playing the game as the hacker, that the game remained balanced in opportunity if not outcome, and that the minigame timing reflected the game state at the time of instantiation.

To evaluate the subjective user experience during play, we administered a survey. Players felt that the minigames were fun (mean rating 3.6 out of 5), and added to the overall game (4 Yes, 0 No) which was also seen as fun (mean rating 4.25 out of 5). We also asked participants to rate the percentage of time they spent playing minigames (mean 62.5%) which was substantially less than the value measured from the logs (mean 79.8%), which could indicate time dilation effects related to flow [7], another indication that players were absorbed by the minigames.

We examined the balance of opportunity and outcome by determining the number of hacked systems per game and plotting an annotated node occupancy diagram for one of the shorter games played. The ‘number of hacked systems’ metric is a measure of overall balance because if the number is too small, it indicates that the hacker had little chance of winning; if too large, it indicates dominance by the hacker. The hacker hacked all seven systems 3 times, winning the game, but still managed to hack at least 3 and an average of 5.75 systems in the 5 losses. The dynamic timing balance achieved by the adaptive minigames is shown for a single game in Fig. 4.

In Fig. 4, the dark boxes represent the hacker playing a minigame and the numbered light boxes represent the three cops. The y-axis is the node location (one of the seven computers). Early in the game the cops were nearby the hacker, and the minigame engine spawned three relatively easy games. Once the hacker moved to a more distant node, a much more difficult game was spawned, which the hacker successfully completed. In the final game, a more difficult game was also spawned, as the cops were initially far away, but rapidly converged on the location of the hacker and trapped him with three consecutive rows of Brickout, shown by the occupancy of location 3 at the end of the game.

To verify that the minigame duration reflected the game state as the game evolved, we considered Fig. 4, which shows that in a single instance at least, the cops were often proximate to the hacker, while the hacker played the minigame. However, a single game does not provide compelling evidence of efficacy.

Fig. 5 shows every minigame played over all 8 conditions. The estimated average time for two cops to reach the hacker, closely tracks the minimum calculated game time demonstrating that our techniques have sufficiently high temporal resolution to capture highly variable game states. The actual time of completion follows the

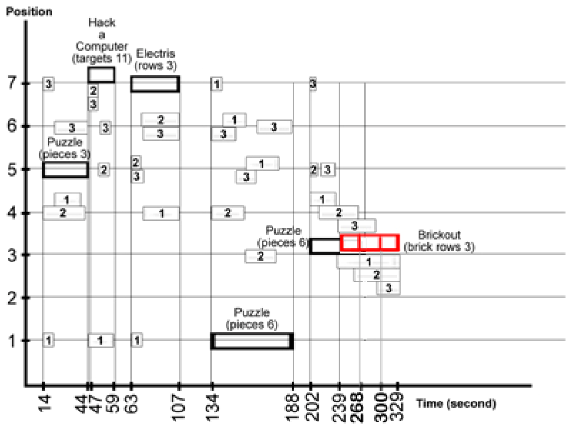

Fig. 4. Player locations and actions in a single Stealth Hacker Game

minimum values and shows variability both within and between subjects demonstrating the techniques provides game balance control without artificially limiting the game, by still allowing for player expertise and chance to play a role.

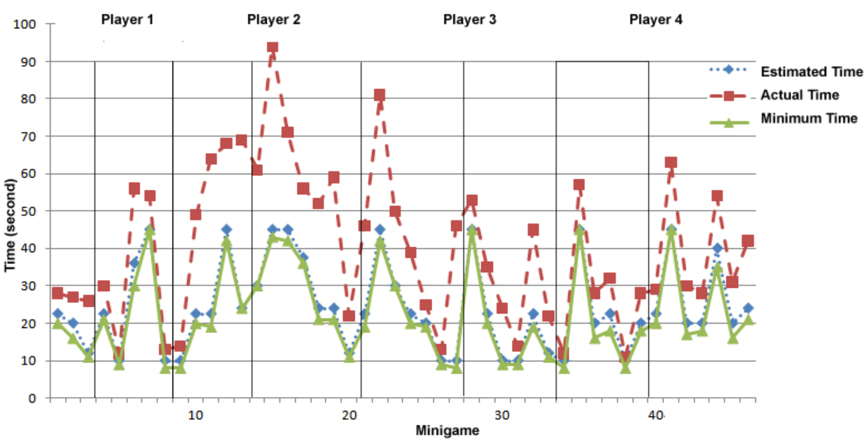

Fig. 5. Minimum completion times for all minigames in the experiment

5 Discussion

Our evaluations provide evidence for the efficacy of adaptive time-variant minigames as a mechanism for balancing time. Our first study showed that the minimum and expected times were predictable, and our second study with a real mixed-reality game showed that the minigames were enjoyable, and provided the balancing effects for which they were designed. Here we discuss further issues of generalizability, and possible improvements to the adaptation capabilities.

What other types of ATMs are possible?

The idea of adaptive minigames can be applied much more widely than just the example systems demonstrated here. The core elements of the approach involve analyzing the time requirements for each game mechanic in the minigame, determining how the game can be parameterized to control completion time, and designing an adaptive algorithm for responding to run-time events.

This process is applicable to a wide variety of game types. For example, a search minigame (e.g., *Where's Waldo*) involves visual search as the main game mechanic. The time needed for visual search is a function of the number of items that must be searched, and the time needed to evaluate each item, allowing parameterization of items to the visual differences between the target and the distracters.

Many possible game mechanics can be considered: signal detection and discrimination, pattern matching, aiming, pursuit tracking, short-term memory, spatial memory, and choice reaction tasks. The timing profiles of some mechanics have been modeled (e.g., Fitts' Law, Hick's Law, the Keystroke Level Model), permitting the use of existing models as starting points for analyzing and parameterizing minigames.

The time needed for minigame tasks involving cognition (e.g., calculation, reasoning, or mental rotation) will be more difficult to predict and will be subject to greater individual differences, and so are less useful for use within an ATM. However, even cognitive tasks could be modeled using empirical testing – that is, a mean time and a distribution around that mean can easily be found by asking a sample group to play the game during design and testing.

More complex adaptation

The minigames described here used a relatively simple mechanism for run-time adaptation – once the minimum time had been reached, players were allowed to complete the game at a high speed – but more complex strategies are possible. Adaptations should predict the actual time that a player will take with a given minigame, and also to be able to respond quickly to dynamic events. These goals must be balanced with the need to maintain a reward structure in the minigames – that is, there must be a reward for being skilled or exerting more effort in the minigame.

The dynamic time adaptation algorithm presented here was somewhat crude, but accepted by players. A more elegant solution would employ a slowly ramping, but still predictable dynamic speed increase so the player was less likely to realize that game parameters were being altered. In a more sophisticated variant, empirical testing could be used to record 'partial completion times' for the tasks in the minigame. In this approach, groups are asked to play the minigame and the time they need to achieve different milestones within the task are recorded (e.g., 90% of players might reach level three within 45 seconds). This information can then be used to adapt minigames for new players at a much finer level of granularity, exerting potentially tighter control over the completion times, while still maintaining a small step size.

6 Conclusion

In this paper we described a novel approach for balancing timing in multiplayer games using adaptive time-variant minigames. We balance timing in two steps: first, we draw from a set of minigames designed to have theoretically guaranteed minimum completion times and that have linear difficulty / time-to-completion relationships in practice. These games are then tuned dynamically as the game is being played to attempt to reach a desired expected completion time. We demonstrate that these games can provide a compelling experience for balancing a mixed-reality game, a particularly difficult time-balancing problem since computer players must be balanced against those in the real world. In the future, we hope to explore the potential for balancing other game genres using this mechanism, and to examine different adaptive mechanisms including continuous feedback and predictive modeling.

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Increasing Efficiency and Quality in the Automatic Composition of Three-Move Mate Problems

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Abstract. In this article, we demonstrate the use of composing 'experience' in the form of piece location probability values derived from a database of mate-in-3 chess problems. This approach was compared against a 'random' one. Comparisons were made using 'experiences' derived from three different databases, i.e. problems by human composers (HC), computer-generated compositions that used the HC experience (CG), and mating 'combinations' taken from tournament games between humans (TG). Each showed a reasonable and statistically significant increase in efficiency compared to the random one but not each other. Aesthetically, the HC and CG were better than the others. The results suggest that composing efficiency and quality can be improved using simple probability information derived from human compositions, and unexpectedly even from the computer-generated compositions that result. Additionally, these improvements come at a very low computational cost. They can be used to further aid and entertain human players and composers.

Keywords: Artificial intelligence, chess, composition, probability, experience, efficiency, aesthetics.

1 Introduction

A chess problem or 'composition' is a type of puzzle typically created by a human composer using a chess set. It presents potential solvers with a stipulation, e.g. *White to play and mate in 3 moves*, and is usually composed with aesthetics or beauty in mind. Compositions often adhere to certain composition conventions as well, e.g. *no 'check' in the key (i.e. first) move*. One of the earliest books on chess problems, using an early Indian form of the game, is from the 9th century AD [1]. Composition tournaments are at present held all over the world and attract competitors from diverse backgrounds [2].

The automatic composition of chess problems – pertaining to Western or international chess, in particular – is relatively uninvestigated. Especially in contrast to chess *playing* which was "*once seen as a really hard thing humans could do and computers couldn't*" [3] but is now losing emphasis in the artificial intelligence (AI) community in favor of 'more complex' games like go and Arimaa [4-6]. Perhaps a better reason than the emphasis on chess playing for much of AI history, automatic

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chess problem composition may have suffered because 'creativity', the essential component that is usually mirrored in aesthetics, is not well defined [7].

Chess problems actually provide a convenient domain of investigation for creativity or aesthetics – more so than say, music [8] or paintings [9] – since there is a clear and distinctly measureable contrast between problems by human composers and otherwise-identical move sequences or 'combinations' that typically take place in real games between humans [10, 11]. Advances in this area can be of immediate benefit to human composers and players in terms of educational and entertainment value since there is virtually no limit to the potential output of a machine.

Section 2 reviews briefly related and relevant previous work. Section 3 details the steps involved in the composing approaches tested. Section 4 explains the experimental setup and results. Section 5 presents a discussion of the results. Section 6 summarizes the main points with some thoughts on future work.

2 Previous Work

Schlosser presented an effective 'basic' method of automatically composing chess problems [12, 13]. It consists essentially of: 1) constructing a complete database of chess endgames, 2) eliminating positions that do not have a unique and optimal move sequence, and 3) selecting the 'true' chess problems with the help of a human expert. The method is therefore limited to the number of pieces which endgame databases or 'tablebases' support, e.g. presently 6 pieces including kings [14], and also depends on human expert intervention. This inherently limits the 'automatically' generated compositions in terms of scope and output potential.

Noshita explained how – for Tsume-Shogi (Japanese chess mating problems) – a board position can be randomly-generated and then 'transformed' by removing or adding pieces through certain operations [15]; a principle equally applicable to international chess. A game-solving engine can then be used to determine the solution, if any. The majority of such positions end up having no solution. Some improvements, e.g. generating compositions with more pieces, can be obtained by 'reversing' moves one at a time from a given mate position with the aid of a solving engine to test if the problem is 'complete', i.e. it has a unique solution [16].

Several criteria for determining the artistic value of the compositions can be automatically tested for but these tend to rely on confirmation by human experts, in any case [16]. The reason is likely because these criteria and their automatic evaluation techniques may not have been experimentally-validated. 'Optimization' or the removal of unnecessary pieces can be performed so long as it does not invalidate the solution. Pieces may also be added at particular points in the process [17]. Within a restricted scope, a 'reverse' method without the need for a time-consuming solving engine is possible [18], but this typically comes at the cost of more memory.

Chess problems, e.g. two-movers, can also be 'improved' a fair amount using a computer. Domain experts are first consulted in order to formalize the knowledge required to assess the 'quality' of compositions. This results in simple formulas (e.g. *first move pins a white piece* = *3* × *piece's value*) or specific weights for certain detectable maneuvers and features (e.g. *Grimshaw theme* = *45*). Pieces can then be deleted, added or replaced to improve the position [19]. Composing efficiency and quality here can be improved but mainly via somewhat computationally-intensive 'search' enhancements [20, 21].

In summary, the two main issues in this area relate to computational efficiency (processing power, memory) and quality functions (aesthetics). The first is reminiscent of the problem the AI community faced with regard to early chess playing programs, but eventually 'solved' thanks in large part to powerful hardware that became available. Former world chess champion Garry Kasparov's loss to IBM's supercomputer Deep Blue in 1997 being the prime example. That, in retrospect, is not seen as much of an achievement in AI. It is therefore preferable not to fall into the same predicament with compositions. The output of automatic composers, relative to the time they take, should be increased at minimal computational cost; this can be seen as making them 'cleverer'.

The second issue is likely due to the lack of experimental validation when it comes to quality functions and aesthetics models, and an over-reliance on expert opinion which tends to be inconsistent [11, 22, 23]. There is likely no consistent 'methodology' pertaining to how the best human composers compose problems. They tend to take their time, abide by a number of 'accepted' composition conventions, and leave the rest to personal style, experience and creativity [24]. This may be why it is difficult for computers to compose original chess problems like they do, and to do so on demand or within a stipulated time frame. In any case, aesthetics or quality in chess can, in fact, now be *assessed* computationally to a reasonable degree within the scope of three-move mate problems using an experimentally-validated model [10, 11, 25]. This minimizes or removes altogether the need for human expert intervention for chess problems of that type, and makes the process of aesthetic assessment more consistent, reliable and affordable; especially for research purposes. That model will therefore be used in lieu of chess experts, perhaps for the first time, to assess the quality of our automatically generated compositions. More details about it are in section 4. The ability to generate more efficiently compositions that 'work' is good in itself but that they are, on average, of higher quality is even better.

3 The Composing Methodology

This research was limited to orthodox mate-in-3 problems (#3) in standard international chess. The 'composing' feature was incorporated into a computer program. Two automatic composing approaches were compared, i.e. 'experience' and 'random'. The main difference between them is that the first uses an 'experience table', explained below, after step 4. The process as follows applies to both.

1. Place the two kings on random squares on the board. Accept them so far as the resulting position is legal; otherwise, repeat the process.
2. Alternating between White (first) and then Black, determine whether the next selection will be an actual piece or a 'blank', i.e. nothing. The probability of choosing a blank for White was set to 16.67% (1 in 6 chance, given the other five piece types) whereas for Black, it was set to 33.34% (twice as likely) to give White a better chance of checkmating ; compositions are generally seen from the standpoint of White winning.
3. If a 'blank', return to step 2 with the side in question having lost its 'turn'.

4. If an actual piece is to be selected, choose one of the five remaining piece types at random (equal odds) and place it on a random square that is unoccupied. Keep trying until one is found.

This is where the two approaches diverge. In the random approach, no position transformation occurs and we skip to just after step 7. In the experience approach, the experience table is used for that purpose. The table is created (beforehand) based on the rapid, automatic analysis of a chess problem database. Three databases (see section 4 for details) were used in experimentation to derive three different experience tables. Fig. 1 shows, in two columns, how the probability information may be stored in a text file.

Sq:	*36*	*3:*	*1.78*
0:	*65.33*	*4:*	*1.72*
1:	*4.8*	*5:*	*0.66*
2:	*4.33*	*6:*	*0.52…*

Fig. 1. Contents of an 'experience table'

The first line indicates the square (0-63) – upper left to lower right of the board – followed by the piece types (0-12) and their associated probabilities (% occurrence) as follows: blank, (white) pawn, knight, bishop, rook, queen, king, (black) pawn, knight etc. For instance, in this example it was determined that, in the initial positions, a white bishop occupied one of the central squares (*e4*, in the algebraic chess notation) only 1.78% of the time.

5. Based on the probability information, examine the squares immediately around the one chosen in step 4 for potentially better placement.
6. If there is a king on one of those squares, skip it. If a square is blank but has a higher associated probability value for the random piece selected in step 4, shift the random piece there.
7. If there is a piece in a surrounding square but that square has a higher associated probability value for the random piece than the one currently on it, replace it with the random one. In order to increase the likelihood of White being able to force mate, black pieces cannot replace white ones.

At this point, the two approaches converge. The 'final' generated position was set to have at least two black pieces to avoid 'lone king' mates, a minimum total of four pieces and a maximum total of sixteen pieces.

8. If a minimum piece requirement is not satisfied, return to step 2.
9. If the maximum piece limit is exceeded, discard the position thus far and return to step 1.

The following are some possible 'violations' in the composing process.

a. Exceeding the original piece set, e.g. having three rooks of the same color.
b. Having two bishops in an army occupying squares of the same color.
c. Having a pawn occupying the eighth rank.

The first two are not actually illegal but they are somewhat unconventional in compositions. In such cases, the ‘offending’ piece is removed and the process returns to step 4; this therefore does not count as a further transformation of the position but simply a ‘mistake’ to be corrected. The possibility of castling was given a ‘neutral’ 50% random probability of being legal, assuming a king and one of its rooks happen to be on the right squares. Determination of legality based on retrograde analysis was considered unnecessary for the purposes of this research [26, 27]. En passant captures, if plausible, default to illegal. ‘Officially’, in compositions, castling in the key move is legal unless it can be proved otherwise whereas en passant is legal only if it can be proved the last move by the opponent permitted it [28].

10. If an illegal position results, remove the random piece from its square and return to step 2.
11. A mate-solver is used to determine if the tentatively acceptable position generated has a forced mate-in-3 solution to it. If not, do not remove the random piece, and return to step 2.
12. If there is such a solution, the position is optimized as shown in the code below. This makes the composition more economical in form [29].

```
FOR every square
   IF not occupied by a king and not empty THEN
      Remove piece
      IF forced mate-in-3 can still be found THEN
         Proceed
      ELSE
         Return piece to its original location
      END IF
   END IF
NEXT
```

To be thorough, optimization is performed three times, starting from the upper left to the lower right of the board; white pieces first, then black, and then white again. Fewer passes proved to be insufficient in certain positions. Optimization generally increases the aesthetic quality of a composition by removing unnecessary or passive pieces and should apply equally to both the random and experience approaches to make the comparisons more meaningful.

13. If the position can be optimized, test it as in step 8. Satisfying that, consider the composing attempt successful.

The number of transformations or iterations per composing attempt was limited to 21, after which a new composing attempt begins regardless (step 1). Scant positions would result given too few iterations, and the opposite given too many. There was no implementation of particular composition conventions, e.g. *no captures in the key move*, *no ‘duals’* (see section 5 for more on this). The process as described in this section may seem more complicated than necessary. For instance, why not just draw the pieces from a fixed set and place them on the squares based on their associated probabilities in the experience table? The reason is that doing so results in less creative variation and very similar-looking, if not identical, generated compositions.

4 The Experimental Setup

For every comparison made, automatic composition was attempted 100 times for 40 'cycles'. The composing efficiency (i.e. successes/attempts) for each cycle was calculated, and the mean used as a basis of comparison. For comparisons within the experience approach, i.e. between different experience tables, the databases included: 29,453 (mostly published) problems by human composers[1] (HC), 1,500 computer-generated compositions that used the experience table derived from the HC (CG), and 3,688 forced mate-in-3 combinations taken from tournament games between at least club-level human players, i.e. rated at least 1600 Elo points (TG). From this point, mention of any of these databases in the context of composing efficiency will refer to the experience table that was derived from it. For statistical purposes, usage of the two sample t-test assuming equal (TTEV) or unequal (TTUV) variances – to establish if a difference in means was significant – was determined by first running a two sample F-test for variances on the samples (which were assumed to have a normal distribution). T-tests were all two-tailed, and at a significance level of 5%. Table 1 shows the results. The standard deviation is given in brackets.

Table 1. Mean composing efficiency.

Random	Experience		
	HC	CG	TG
23.70% (3.69)	28.03% (4.45)	28.38% (4.49)	27.25% (3.94)

The differences in mean efficiency were *not* statistically significant between any of the experience approaches. However, they were all different to a statistically significant degree when compared to the random approach as follows.

HC vs. Random: TTEV; $t(78) = 4.735$, $P<0.01$
CG vs. Random: TTEV; $t(78) = 5.087$, $P<0.01$
TG vs. Random: TTEV; $t(78) = 4.160$, $P<0.01$

Even though the improvements may not *look* very large in terms of raw percentage, they actually translate to quite a few more successful compositions than the random approach. For instance, after 10,000 composing attempts, the CG approach would have 433 *more* compositions than the random one. This is enough to fill two small books on chess problems.

Every automatically generated composition was assessed using the chess aesthetics program, CHESTHETICA that incorporates Iqbal's mate-in-3 chess aesthetics model [10, 11, 25]. The model is too complex to be sufficiently explained here but all the necessary information pertaining to its workings are available in the resources just cited. We are not attempting to further debate or justify its merits here but simply consider it validated and are applying it to *this* research. In principle, the model uses

[1] Sourced from Meson Chess Problem Database (http://www.bstephen.me.uk/); courtesy of Brian Stephenson.

17 aesthetic features (e.g. *pin, skewer, fork, economy, sparsity, material sacrifice*) common to real games and compositions, and can discriminate effectively *between* these domains but not *within* them. To give the reader some idea how the features are evaluated, one of the evaluation functions is shown in equation 1 where T_1 represents the aesthetic value of the *fork* theme, if detected, after a piece moves; *v()* denotes the standard Shannon value of the piece, *d()* the Chebyshev distance between two pieces and *r()* the 'power' of the piece. These concepts are fully explained in [10, 11, 25].

$$T_1 = f_c \times [(\sum v(fp_n) + n + (\sum d(f_k, fp_n) \times r(f_k)^{-1})) - k] . \quad (1)$$

f_c = fork constant, fp = forked piece, f_k = forking piece,
k = number of possible 'check' moves by fp

The results also correlate well with mean human-player aesthetic ratings and agree with the typical selections of experts. It is a more consistent, reliable and cost-effective alternative to the traditional approach of using one or two human experts. This is something that was not possible before due to a lack of experimentally-validated aesthetic assessment technology. Given the sheer number of compositions to be assessed, human experts would not have been a viable option here in any case. A higher score implies that the combination is more likely to be considered beautiful by the majority of human chess players of reasonable competence in the game. The model is used to evaluate *beauty* in the game, and therefore does not explicitly account for some of the composition conventions – that may have little to do with beauty or creativity per se – typically adhered to by composers. Table 2 shows the mean aesthetic scores. The standard deviation is given in brackets.

Table 2. Mean composition aesthetic scores.

Random	Experience		
	HC	CG	TG
2.104 (0.44)	2.168 (0.46)	2.178 (0.46)	2.088 (0.46)

The differences in means were *not* statistically significant between the HC and CG approaches, and TG and random, but were in all other cases as follows.

HC vs. Random: TTEV; $t(2067) = 3.259$, $P<0.01$
CG vs. Random: TTEV; $t(2081) = 3.743$, $P<0.01$
HC vs. TG: TTEV; $t(2209) = 4.121$, $P<0.01$
CG vs. TG: TTEV; $t(2223) = 4.619$, $P<0.01$

Even though the difference between say, the CG and random approaches is small, i.e. 0.074 – and therefore probably difficult for humans to perceive – it is nevertheless an improvement over the random approach, and no worse than it despite the reasonable increase in efficiency (see Table 1). An aesthetic difference of approximately 0.5 or more would be more obvious to humans [25]. Mate-in-3 compositions by humans average approximately 2.1 aesthetically whereas analogous combinations from tournament games average about 1.7 [25]. The latter, in their 'original' form, are not optimized in any way, e.g. step 12 in section 3. The aesthetic score for a combination from either of these domains typically ranges from 0.5 to 5.0; in rare cases slightly lower or higher. Overall, these results suggest that the experience approach, using a table of piece-placement probability values derived from any of the databases is reasonably better than the random approach in terms of composing efficiency, and to a small but significant degree also aesthetics (given the HC and CG).

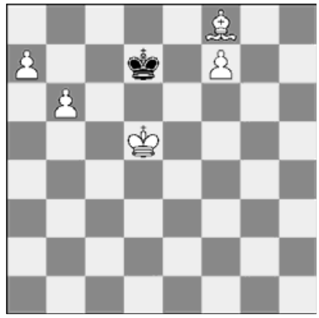
5 Discussion

The experimental results show that simple piece-placement probability values derived from a database of compositions – when used in the composing process as explained in section 3 – improves composing efficiency compared to an approach that does not benefit from that information. In two of the three experience approaches (HC and CG), a small improvement in terms of aesthetics was also detectable. The CG approach was actually included to see if the computer could also 'learn' from its *own* composing experience but this does not appear to be the case. The computational cost for these improvements is minimal, especially in contrast to any approach that involves game-tree searching [30] beyond confirming if a solution exists, i.e. the use of a solving engine.

Previous work in the area (see section 2) may not have explored this idea to improve efficiency and aesthetics because sizeable databases of human compositions are generally difficult to come by. Without the appropriate sort of piece placement and position transformation process (see section 3), the approach may also have seemed likely to converge toward a 'local maximum', i.e. the high probability of certain pieces on certain squares and subsequently similar compositions generated. In any case, until the idea is actually tested as was done here, we cannot be sure what the results would look like. For instance, without experimentation it would have been difficult to predict that 'experience' gained from a TG database would improve composing efficiency (though not aesthetics), or that compositions generated by a computer based on experience derived from human compositions would be just as effective as a *source* of experience.

Even though the generated compositions benefited from the probability values derived from a database of problems by human composers (HC), that database henceforth becomes unnecessary given the (smaller but equally effective) computer-generated one it helped produce (CG). The reason for this may be because there is a lot of personal style, taste and convention in human compositions that do not necessarily aid the strict process of composing problems that 'work' or even relate to beauty per se [11]. This 'information' may be mostly stripped away in the automatically generated compositions that result. It is important to remember that a winning composition is not necessarily among the most *beautiful*. Sometimes, though not often, the elegance of a simpler composition or an analogous combination that occurs in an actual game can be considered more beautiful by the majority of reasonably competent players than a 'difficult' composition with hundreds, if not thousands, of variations that only the most experienced composers can appreciate. Fig. 2 shows an example of this contrast; one is a 1st prize winning composition by a human composer (rather complicated) and the other occurred in a game between two chess *engines* in a simulated match (simple and elegant).

1. Qf8 exd6+ 2. Qe7 Nd7 3. Qxd6#
Alfreds A Dombrovskis,
1st Prize, Schakend Nederland
1973

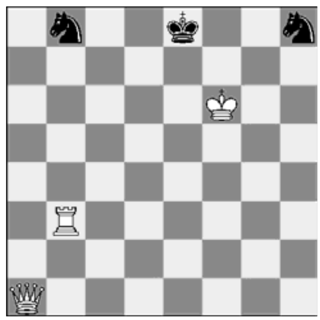


1. Bd6 Kc8 2. a8=Q+ Kd7 3. f8=N#

Rybka 3 vs. Fritz 8
2010

Fig. 2. The aesthetics of a human composition vs. chess engine match combination

(A) White to play and mate in 3 moves
1. Qg7 Ba7+ (d5/Bc7, Rh6#) **2. d4 Bxd4+** (Bb8, d5#; d5/Bb6/Bc5, Rh6#) **3. Nxd4#**
Aesthetic score: 3.95



(B) White to play and mate in 3 moves
1. Ke6 Nf7 (Na6/Nc6, Qxh8#; Kd8, Qa7, Nf7, Rxb8#; Kf8, Rxb8#) **2. Qh8+ Nxh8 3. Rxb8#**
Aesthetic score: 4.03

Fig. 3. Examples of the computer generated compositions using the experience approach

This does not mean, however, that the automatic composer can currently compete with the best human composers. Composition tournaments, and their judges, often have requirements and conventions that are not necessarily associated with beauty in the game but typically conflated with it. Such requirements or conventions (e.g. *no key move that restricts the enemy king's movement*) can be added as additional filters, if so desired, but these will likely significantly lower the number of successfully generated compositions. Like human composers, the automatic composer needs to be made 'aware' of these rules or it stands to have most of its compositions rejected.

The improvements obtained mainly in efficiency and somewhat in aesthetics using an experience table can be used to automatically generate *more* compositions that 'work' (or the same number in *less* time), and possibly more of reasonable quality.

This can be of value in terms of entertaining players and perhaps even aiding human composers (both amateurs and experts) by providing ideas they can further develop for their particular needs. Fig. 3 shows two comparable high-scoring examples of the automatically generated compositions from the pool of those generated by the HC and CG experience approaches; both the HC and CG are considered to be equivalent based on the experimental results shown in section 4. The main line is shown in bold whereas notable variations are shown in brackets. An experienced FIDE composition judge and solver, Michael McDowell, provided a detailed analysis of these two compositions – without being told they were composed by a computer or provided with the solutions – and was of the opinion that: "*In summary, to the experienced solver B has better content than A, but both score poorly for beauty and neither is of sufficiently high quality to be published in a reputable chess problem magazine.*"

The experience approach – suitably adapted – is also, in principle, applicable to other variants of the game like fairy chess and even Shogi. The only caveat is perhaps the requirement of a sizeable collection of human compositions of that type to gain 'experience' from; we would assume at least 1,000 combinations. The approach can be combined with other methods as described in section 2, possibly with improved results. Automatically composing *longer* problems (e.g. four or five-movers) – relatively rare in international chess – would likely be constrained by the strength and speed of the solving engine, and would require a suitably adapted aesthetics model.

6 Conclusion

Composing high quality chess problems requires considerable experience, knowledge, effort and time by human composers. Doing so computationally is therefore a challenge. Nevertheless, it is certainly possible to strictly *compose* problems – in principle, for any complex board game like chess – using a particular combination of techniques and technologies. Even so, many of them are computationally-intensive and therefore limit performance.

In this article, we have shown through experimentation that a simple 'experience table' can – at a very low computational cost – improve the automatic composition of chess problems in terms of efficiency and in some cases to a small degree, aesthetics as well. In order to do so, one first needs a sizeable database of compositions by humans in order to derive the piece-placement probability values; but beyond that, the compositions generated by the computer are sufficient as a source of 'experience'. A proper piece placement and position transformation strategy is also necessary to avoid convergence upon very similar-looking compositions. This idea, to the best of our knowledge, has never been tested before in the automatic composition of chess problems, but has now been shown to be a viable option. The output and entertainment potential of this technology can be considered reasonably significant.

Future work in this area would include, 1) looking at the effects of combining the various approaches of composing as described in section 2 and in this research to find the 'perfect mix' that provides the best compromise between efficiency and quality, 2) finding a way to apply the aesthetics model used at the 'knowledge level' so the automatic composer places pieces on the board with aesthetics in mind instead of just focusing on compositions that 'work', and 3) factoring in various composition conventions, in such a way that does not significantly compromise composing efficiency or beauty, in order to be able to compete with the best human composers. Ultimately, the idea of a continuous feedback loop of 'experience' should be explored to see if a computer can learn and grow from its own composing experience.

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Appendix

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Designing and Evaluating Casual Health Games for Children and Teenagers with Cancer

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Abstract. Because they offer an easy entry into play, casual games have become an increasingly popular leisure activity among children and teenagers, engaging particularly broad target audiences. In this paper, we present a casual game that addresses childhood cancer: Besides mere entertainment, a health game that focuses on cancer may serve as a clinical tool in order to teach children about the particularities of the disease and initiate discussion among cancer patients, their parents and medical staff. In this context, the results of an empirical study revealed a generally high acceptance of the health game among young patients, while parents and medical staff highlighted the educational potential of health games addressing cancer. Additionally, we discuss the challenges of evaluating digital games in a hospital setting which were revealed during the evaluation phase.

Keywords: Casual Games, Game Design, Games for Health, Serious Games, Childhood Cancer, Persuasive Games.

1 Introduction

Besides the persuasive potential of serious games which may be applied to encourage healthy behavior [1, 6], their benefits can be found beyond persuasion: Serious games generally offer the opportunity of raising awareness for difficult topics, for instance environmental or social issues and health-related topics such as disease treatment or prevention [30]. In the context of designing games for health, childhood cancer can be regarded as a particularly sensitive issue as it still presents a common cause of death among children and teenagers in industrialized countries [1, 35]. While the diagnosis severely influences regular family life, treatment is often painful and requires frequent periods of hospitalization and regular doctor's visits [10]. In addition, patients are faced with psycho-emotional problems, such as anxiety or depression [1, 23, 28]. Based on the patient's difficult situation, a need for health games dealing with their own medical condition has already been expressed [28]. In this context, games for health offer the potential of engaging patients and healthy children in play while simultaneously conveying information about cancer, but may not be fully accessible to players without prior gaming experience and persons suffering from treatment side-effects.

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This issue may be addressed by introducing casual game design principles to health games: During the past years, casual games have become increasingly popular due to their flexibility and their usually well-accessible design [19]. Their popularity is also reflected by market research evidence, suggesting that such games offer the potential to reach particularly broad audiences [5]. In consequence, there have been attempts to integrate casual game elements into numerous game concepts, such as health games [16]. This is especially important as younger audiences are hard to reach through traditional communication channels [9] but may be addressed by digital games [25]. By this means, casual health games can be employed as an alternative approach to inform kids and teenagers about their medical condition and foster communication between patients and their friends, family as well as the medical staff.

In this paper, casual game design is discussed with a focus on the integration of serious game elements, particularly addressing games for health. Based on these considerations, the game prototype *Cytarius* was developed, which aims to illustrate cancer treatment and to convey information about the disease through its background story and game mechanics. The results of an empirical study in a hospital setting revealed that the game generally appeals to children and juvenile cancer patients. Furthermore, interviews with patients' parents show a general need for games designed for cancer patients and highlight the large potential of serious game concepts to initiate communication about the disease.

2 Related Work

Entertainment technology has previously been applied to ease everyday life of ill children, for instance through community-based approaches: *Onko-Kids* is a web portal specifically developed for children and teenagers diagnosed with cancer, providing information about cancer and offering didactical animated videos about the disease. *STARBRIGHT World* is a web-based community for chronically ill children that does not address a particular medical condition, but features different mini-games without explicitly referring to a specific disease. Its beneficial purpose is based on research results suggesting that patients who engage in online platforms show higher treatment compliance, experience less pain, and develop better coping strategies [12].

Also, various health games addressing patient needs and motivation are available, which can generally be categorized as games for learning, games as distraction or games as coach [33]. Currently, a wide range of games for health focuses on learning and distraction, frequently dealing with chronic conditions, for instance diabetes and asthma [4, 21] or severe illness such as cancer [17]. Furthermore, certain health games address the issue of disease prevention [9]. Popular examples of clinically tested and commercially available health games are *Packy & Marlon*, a game which addresses diabetes [4], and *Bronkie the Bronchiasaurus*, which conveys information about asthma during play [21]. Another clinically evaluated game that directly focuses on cancer and which improves the patients' adherence to medication plans and perceived self-efficacy is the action game *Re-Mission* [17]: The player enters the game world as nanobot which fights the disease from within young patients' bodies. The game aims to convey basic information about common cancer symptoms and treatment strategies through game mechanics, e.g. enemy and weapon design. Also, more simplistic games for kids and teenagers with cancer have been designed, such as *Ben's Game* [2] and *Onko-Ocean* [23]. However, only few casual games focusing on health issues with a solid theoretical background as well as empirical research are available. Yet, the results of a preliminary study examining effects of commercially available casual games suggest that such games may foster the emotional well-being of players and lead to a reduction of depression symptoms [26] which is promising in the context of designing positive gaming experiences for kids with cancer. Also, due to their simplistic nature, casual games may be especially appropriate for diverse audiences, with special needs. To examine this issue, the following section discusses common design principles and the integration of serious elements into casual games.

3 Casual Game Design

Casual games represent an approach of designing digital games for large user groups and claim to be suitable for all audiences due to simplistic game concepts and interaction paradigms [14, 20, 32]. Recent studies report that more than 200 million persons regularly play web-based casual games, which highlights the immense popularity of such games and their potential of reaching broad target groups [5].

3.1 Characteristic Features of Casual Games

A review of existing work examining the most important features of casual games revealed five main areas which are characteristic for casual games and which are expected to have largely contributed to their success.

On a formal level, usability and accessibility (cf. [14, 19]) represent important aspects of casual game design as they significantly contribute to the user's easy entry into play [32]. In this context, it is important to provide simple controls [18] which are accessible to novice players without prior gaming experience to ease their adaption to interaction paradigms and common game metaphors [13]. This corresponds with the idea of providing comprehensive game play and mechanics in order to create an adequate learning curve [13, 18]. This is achieved by implementing simplistic game features which enable the player to easily progress through the game [13]. Furthermore, clear rules and objectives within the game as well as transparent challenges are important factors which contribute to the learnability of casual games [13, 32]. Also, positive feedback and an overall high game responsiveness are important features of casual games. First, clear feedback contributes to the player's efforts of learning the game [13]. Second, fast rewards, an adequate level of difficulty and the abstinence of player punishment support the player's motivation of engaging in play [14, 18] accounting for the overall *juiciness* of the player's individual gaming experience [14]. The integration of the aforementioned features contributes to another important aspect of casual game design, namely accounting for a certain degree of flexibility [19]. By providing flexible gameplay, gaming sessions can easily be adapted to the user's way of life, which enables players to engage with casual games regardless of other commitments [32]. Research results suggest that the support of short play sessions and a high degree of interruptibility are crucial in this context [14, 19]. Finally, casual games have to provide an appealing narrative in terms of being relevant and thus interesting for large audiences [18]. This can be achieved by integrating topics evolving around everyday life [32] and considering the popularity of contents in order to raise interest of large groups of people [19]. Providing an appealing background story is also important because the game topic is often immediately visible to prospective players. Hence, fiction represents a key factor when choosing or discarding a game prior to entering play [14].

In order to draw conclusions regarding the design of health games, the following section discusses the aforementioned features with a focus on designing casual games for children and teenagers diagnosed with cancer.

3.2 Designing Casual Games for Cancer Patients

Health games are usually regarded as a subset of serious games, which are referred to as games with a purpose beyond mere entertainment [22, 34] aiming to convey knowledge and educate the user [25]. In the context of designing games for health, serious games aim to foster healthy behavior and to inform players, or to improve the player's condition by strengthening self esteem and perceived self-efficacy [11, 17].

Regarding the design of casual games with a serious background, an integration of serious game elements such as disease-related information as well as main features of casual games, such as accessibility, flexibility and learnability has been claimed to be advantageous [34] and can also be applied to the design of games for health.

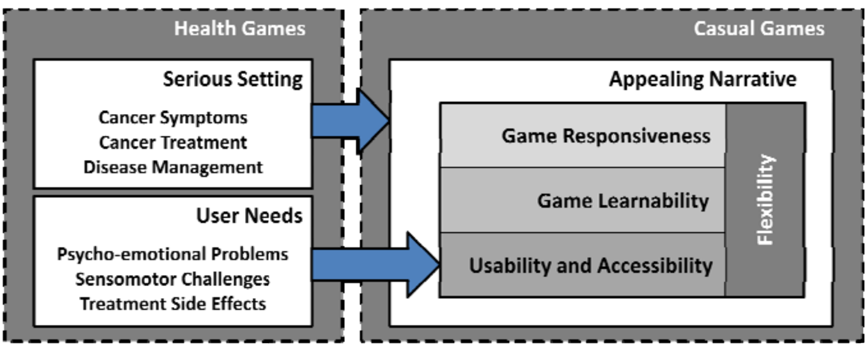

Fig. 1. The integration of serious game elements affects the design of casual games on two levels: The background story needs to be adjusted to a serious setting, and user needs have to be considered when designing core game mechanics

When designing casual games for children and teenagers with cancer, the possible impact of the disease on the emotional well-being as well as cognitive and physical abilities of juvenile cancer patients has to be considered [31]. First of all, periods of hospitalization and frequent doctor's visits require flexible games which can either be played at home or in a mobile context. Second, it is important to consider the impact of medication side effects if children are undergoing treatment, meaning that players may be weakened by medication side effects such as nausea or pain, thus game usability and accessibility as well as a high level of interruptibility must be considered. Third, providing an appealing narrative which frames the gaming experience is necessary to raise prospective players' interest and to encourage existing users to return to play regardless of their medical condition. In this context, disease-related information has to be integrated carefully as research results regarding the implementation of explicit or implicit disease references are contradictory [7, 8].

To conclude, the integration of serious game elements to create casual games for health influences the game design process in two ways (cf. Figure 1): On the one hand, the serious setting of the game has to be combined into an appealing narrative, which may be challenging if the original topic holds a negative connotation. On the other hand, additional user needs derived from the specific situation of the target audience have to be considered, therefore influencing the design of core features of casual games.

4 Game Concept: Cytarius

Based on the aforementioned considerations regarding casual game design as well as special requirements of children and teenagers with cancer, the game concept Cytarius was developed and implemented as a playable prototype. The game is set in a science fiction narrative and integrates different types of cancer and treatment options as game mechanics. Thereby, it playfully tries to inform the user about basic aspects of the disease and common treatment options.

4.1 Core Features

The *serious setting* of the game is closely related with its *narrative* and is represented by the background story and game mechanics which playfully convey information about the cause and treatment of cancer. The background story is set in space and evolves around the four planets Haima, Enképhalon, Blaston and Cytarius. While the inhabitants of Enképhalon and Haima live in peace, inhabitants of Blaston have been excluded from the intergalactic community due to selfish behavior. To take revenge, they try to infiltrate the community by rapidly reproducing themselves and gaining control over the other planets. To defeat the intruders, the inhabitants of Cytarius – genetically engineered Cytowarriors who are lead by the player – try to defend the two peaceful planets. The core mechanic of the game is the strategic application of different types of warriors, which can be chosen through an in-game menu and placed in the game area by pointing and clicking at the desired spot (cf. Figure 2). Once a warrior is added to the game, it automatically executes its characteristic behavior for a certain amount of time, e.g. it destroys all other creatures within a certain radius.

To increase the *usability and accessibility* of *Cytarius*, basic interaction paradigms and a simplistic user interface were implemented. The game requires mouse input only, which allows the player to focus on one input device. Well-readable fonts as well as high-contrast graphics were used for the graphical user interface which can easily read by patients even when playing the game from their hospital beds. During game play, a limited amount of actions is available to the player. This also contributes to the *game learnability*, which is achieved by a gradually rising level of difficulty as the player advances through the game, and the availability of different in-game speed settings. Furthermore, a comic-based tutorial introduces the most important game elements to the player. A high *game responsiveness* is achieved by providing immediate visual and auditive feedback to the player's actions, e.g. the successful application of Cytowarriors is visualized by characteristic animations and sounds.

The *flexibility* of the game is ensured by offering an in-game menu which allows the player to immediately pause the game. Furthermore, it is possible to save individual progress and return to play at a later point of time.

4.2 Game Play

In *Cytarius*, the player is offered the role of a strategic commander. To master the game, it is crucial to coordinate the activities of Cytowarriors which are equipped with different weapons which were designed based on different cancer treatments. Thereby, it is possible to control the activities of Blasts and protect the inhabitants of Haima and Enképhalon.

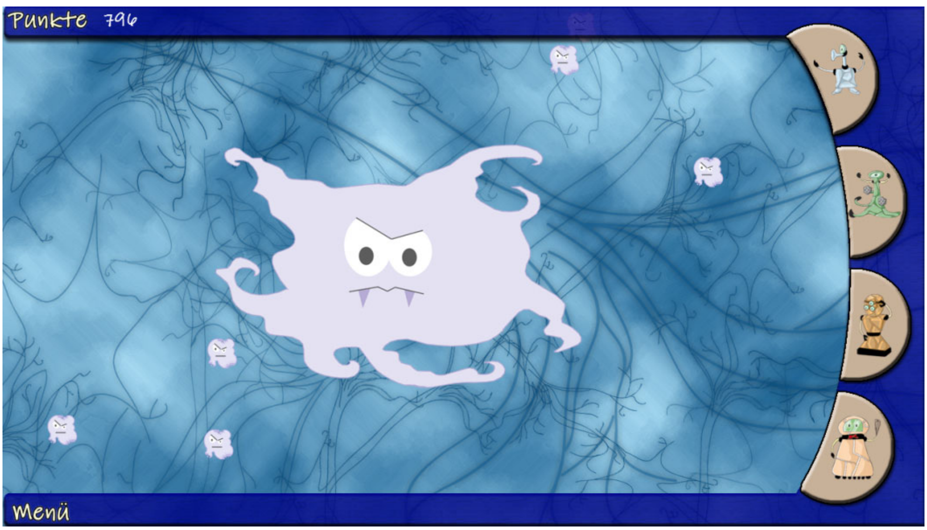

Fig. 2. Cytarius playfully conveys information on different types of cancer, for instance tumors and the development of metastases

Planet Haima: Leukemia. The background story and graphical design of the first level which is set on Haima are based on an analogy to leukemia: To win the level, the player has to fight Blasts which have infiltrated the planet. Their unregulated reproduction leads to the extinction of native inhabitants, Erys and Leucos. In order to save the planet, different Cytowarriors with features resembling core aspects of chemotherapy have to be applied to guarantee the survival of a minimum amount of Erys and Leucos while reducing the number of Blasts.

Planet Enkephalon: Tumors. On Enképhalon, the player is faced with a giant creature resembling a metastasizing tumor (cf. Figure 2), which has to be fought in order to allow native inhabitants to return to the planet. In this level, Cytowarriors may be applied to execute irradiation in strategically important areas and to reduce the amount of metastases.

The overall goal of Cytarius is to offer a first insight into processes related to cancer and its treatment options by engaging users with cancer-related game content. Thereby, the game aims to convey knowledge about the disease to inform juvenile cancer patients and to lay a foundation for future discussions of their medical condition with their parents and medical staff. Also, the game may be used to inform healthy juveniles about childhood cancer. Based on the concept described within this section, a playable prototype was implemented using Microsoft Game Studio. It was tested in the context of an evaluation with juvenile cancer patients, their parents and medical staff.

5 Evaluation

In order to integrate juvenile cancer patients in the further development process of *Cytarius* and to derive additional information regarding the design of casual games with a serious background, the evaluation was realized in two steps. First, children and teenagers with cancer were introduced to the game *Cytarius* and asked to fill out a questionnaire addressing the usability and accessibility of the game as well as their gaming experience. Second, qualitative interviews were conducted in order to gain further insight into players' perception of the game and to explore opinions of parents and medical staff.

5.1 Participants and Procedure

To evaluate the accessibility, acceptance and user experience evoked by the game prototype, an empirical study was conducted. Participants were recruited at the University Hospital Essen and the Hannover Medical School, Germany. Both stationary and ambulant patients took part in the study. The experimental procedure consisted of playing the game during a single session for fifteen minutes and answering a questionnaire. In the first part of the questionnaire, participants described their media usage and social network behavior. Subsequently, after having played the game for a 15-minute interval, game accessibility and player experience were assessed based on the Game Experience Questionnaire (GEQ [14]). Furthermore, participants were asked about their physical and psychic health condition (KINDL [26]) in order to further examine whether the casual game suited the needs and restrictions of the target audience. All variables were assessed on a 5-point rating scale. Additional to those playtesting elements of the evaluation, qualitative interviews with nursing staff and parents were conducted to examine their attitudes in regard to health games.

23 children and juveniles with cancer (17 boys and 6 girls) were able to take part in the study. They age range of study participants was between 7 and 19 ($M = 13.39$; $SD = 3.34$) years. Almost 4/5 of the sample (78%) reported having an own personal computer or laptop and 91% of the sample described to have experience with computer games while no specific genre preferences were found. Over half of the sample (12 of 23 participants) reported being registered in a social network site such as *SchülerVZ* or *facebook.*

The qualitative data consists of ten interviews with parents of children and juveniles diagnosed with cancer. Additionally, five interviews with clinical staff of the oncology departments of the hospitals in Hannover and Essen were conducted. The interviews were realized in order to explore the perception of parents and medical staff regarding their acceptance of digital entertainment for children diagnosed with cancer as well as future design opportunities.

5.2 Results

Quantitative Evaluation. Study results reveal that *Cytarius* was positively evaluated by study participants (M = 3.71; SD = 1.05), suggesting that juveniles generally enjoyed playing the game. This notion is reinforced by the observed GEQ positive and negative affective reactions. Therefore, results of a t-test for dependent sample revealed that children experienced significantly more positive (M = 3.26; SD = 1.25) than negative emotional affective reactions (M = 1.36; SD = .77) during gameplay ($t_{(22)}$ = 5.36; p =.000). Furthermore study participants seemed to specially like the game story assessed by the immersion dimension of the GEQ (M = 3.45; SD = 1.33). However participants only experienced an average flow level (M = 2.8; 1.15) as a consequence of playing the game.

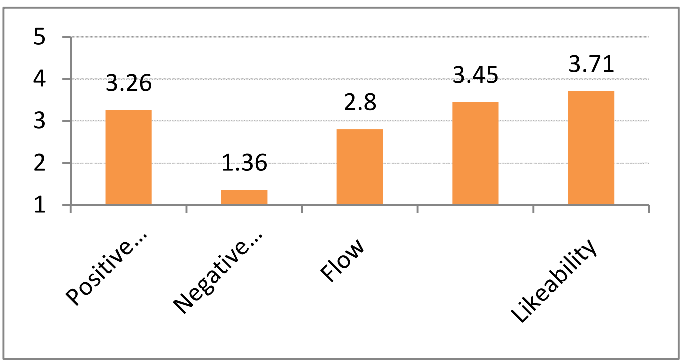

Fig. 3. Mean results of the main dimensions of the Game Experience Questionnaire as well as game likability show a generally positive gaming experience among the participants of the evaluation

In a further analysis, the influence of participants' demographic characteristics on the evaluation results was analyzed in order to investigate game adequacy for different subgroups. The results of a correlation analysis revealed a significant negative correlation between participants' age and game likeability (r = -.572; p = .004), suggesting that especially young participants liked the game. In congruence with this finding, the participants' age was also found to be negative interrelated with the story evaluation (r = -.524; p = .010) and flow (r = -.486; p = .019) dimension of the game experience questionnaire. The results suggest that young participants liked the game (M = 4.19; SD = .936) and enjoyed the story (M = 4.04; SD =1.17) more than older participants (M = 3.18; SD =.947; M = 2.81; SD =1.25, respectively). No significant interrelations between participant's age and positive (r = -.085; p = .699) or negative emotional reactions (r = -.076; p = .729) were found.

The assessment of patients' health condition (KINDL) was necessary in order to analyze if a patient's physical or psychological restrains affected game enjoyment. In general, most participants reported having no difficulties in operating a mouse (92%) or a keyboard (88%). The results of the KINDL questionnaire revealed that the participants' physical (60.5 of 100 points) and psychic (70 of 100 points) health condition was relatively normal in comparison to a healthy juvenile population (75 and 83 points, respectively). However, a correlation analysis revealed marginal interrelations between the participants' physical health condition and the GEQ dimensions game flow ($r = -.380$; $p =081$) and positive affect ($r = -.379$; $p =082$), suggesting that decrements in the patients' physical health also influence the quality of their individual game experience.

Qualitative Evaluation. When questioned about the use of digital media among their children, six out of ten parents reported to restrict their children's access to the computer. However, a majority of eight out of ten parents agreed that playing games specifically designed for cancer patients would be beneficial in terms of learning about the disease and developing adequate coping strategies. The most frequent argument for a cancer related health game was augmenting their children's understanding of their medical condition (4 of 8 parents). Furthermore, parents claimed that games might be used to initiate discussions about the disease and generally foster an optimistic, open approach to dealing with cancer. In congruence to these assertions, medical staff interviews unanimously revealed the need for a health game that entertains and interconnects juveniles while learning about their medical condition. Despite the numerous entertainment activities offered in the oncologic stations, medical staff reported that only few patients take part on it due to treatment side effects: Their preferred activities were playing video games and watching TV.

5.3 Discussion

Results suggest that participants generally enjoyed playing the game. This is reflected on positive affective reactions elicited by playing the game. Moreover, especially young patients liked the game and its story. However no significant difference on flow experience was found between young and older patients, suggesting a comparable gaming experience among the participants. Furthermore, interviews with parents and medical stuff revealed an existing demand for a health oriented casual game, due to children's main interest regarding gaming and the necessity of fostering children's communication about their medical condition.

On a general level, evaluating *Cytarius* in a hospital context was challenging as certain restrictions regarding the procedure of the evaluation were present which partially derived from the participants' condition as well as the hospital setting. First of all, the patients' condition did not always allow them to take part in the study without interruptions. Furthermore, despite the general interest to take part in the study, some patients were simply not in the psychical or physical condition to participate. Second, stationary patients are usually placed in shared bedrooms, thus the evaluation often could not take place in a quiet environment as many patients were too weak to leave their beds. Finally, appointments for the evaluation had to be treated with a high flexibility as the patient's condition often varied on a daily basis depending on treatment routines.

6 Conclusion and Future Work

In this paper, a theoretical analysis of casual games with a focus on creating casual health games through the integration of serious game elements is introduced. Based on these theoretical considerations, the game prototype *Cytarius* is presented, which addresses the issue of childhood cancer. An evaluation of a playable game prototype for children and teenagers with cancer suggests that juvenile cancer patients generally enjoy engaging with such a game. Furthermore the potential of casual game concepts to initiate further discussions about their medical condition is highlighted, an idea which is supported by results of interviews with parents and medical staff.

The development of the game prototype *Cytarius* has shown that serious game elements may easily be integrated into casual game concepts. Regarding the acceptability and accessibility of the game, the results of the evaluation suggest that *Cytarius* provides a generally enjoyable gaming experience for kids and teenagers with cancer. The results show that the game is suited to be played in a hospital setting, and that it is widely accessible to its players despite cognitive and physical consequences of the disease. However, age-related differences in the participants' ratings also reveal that the current game story and the graphical design may not be equally appealing for all audiences and should be subject to future design considerations. In order to draw conclusions regarding possible positive effects of regularly engaging with casual games for health on cancer patient's medical condition (similar to those observed among cancer patients playing *Re-Mission* [17]), further research is necessary.

Future work includes a longitudinal clinical evaluation of *Cytarius* featuring a larger sample size and additional game elements. Also, it is planned to extend the existing game prototype into a fully playable casual game offering connectivity to social network websites, e.g. *facebook*, and featuring social game mechanics such as the integration of friends into play. Thereby, we expect to reach a broader audience including healthy adolescents and inform them about the difficult situation of peers who have been diagnosed with cancer.

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Art and Technology for Young Creators

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Abstract. The general research goal that motivates this work is the aim to produce new knowledge at the intersection between art and technology. The practical goal of the project reported in this paper is to strengthen pupils' interest in computer science and art and to present pupils with possibilities of becoming creators of digital media rather than pure consumers. To reach our practical goal a group of researchers and artists designed and implemented a workshop program for children based on the open source software tool Scratch and the artistic idea of ReMida centers based on recycling and reusing waste materials. The workshops have been documented by notes and pictures which serve as data for workshop evaluation.

Keywords: Children, art and technology, Scratch, open source software, ReMida, recycle, workshop, new media art, interactive art, creativity, child-computer interaction.

1 Introduction

Computer literacy has been proposed to be of equal importance in today's society as literacy that more traditionally refers to people's communicative competencies through skills of writing and reading [6]. The term refers to the ability to understand and to make oneself understood through computational materials. To be fluent in the digital world includes designing and creating and thus goes beyond activities as browsing and interacting [11]. Even if computers have entered schools and are pervasive in the life of young people today, few learn to program [11].

Our argument is that computer literacy can be learnt in a context in which technology is combined with art. To implement this idea, we designed and ran a workshop program with the following goals: 1) strengthen pupils' interest in computer science, 2) strengthen pupils' interest in arts and 3) present creative alternatives of digital media use as opposed to pure consumption of video games.

In this paper we present experiences from designing and conducting a workshop program where children collaboratively engaged in creating interactive artworks that react to events in the physical world. Children used the Open Source Software (OSS) Scratch, home made sensors, and recycled materials. This paper is structured as

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follows. Section 2 presents relevant research. Then Section 3 describes planning and implementation issues of the workshops. Next, Section 4 evaluates the workshop goals based on empirical data and presents implications for future workshops. Section 5 concludes with a further discussion and ongoing research work.

2 Background

The graphic object-oriented programming language Scratch has inspired a number of researchers and educators worldwide. Scratch, developed by the Lifelong Kindergarten Group at MIT Media Lab, makes it easy for beginners to get started with creating interactive stories, animations, games, music, and art and share them on the web [11]. Programming in Scratch is done by dragging command blocks from a palette into the scripting pane and assembling them in stacks [7].

Conducting workshops is a common approach in order to introduce groups of children to first programming languages. A lot of research deals with children as users of programming tools, e.g. [10] [3] [13]. Burke and Kafai [4] emphasize the double benefit of supporting both the learning of programming and the learning of writing by situating digital storytelling within the context of programming.

Another study reports on Scratch programming experiences of urban youth in an after-school center and includes an analysis of their use of programming commands and concepts over an 18-month period [7]. The findings related to the experiences of the youth show that they associated Scratch with activities that support creative and personal expression. Peppler and Kafai explored various media arts concepts in workshops conducted at after-school centers in their efforts to bring media arts into design work [10].

3 The Computer + Art = Creativity Workshops

Our research concerns exploring the strategy of combining programming activities, recycled materials, and the physical environment to create new media art in workshop settings. The workshop goals, as declared in the application that enabled funding to the project, are: Through encouraging creative expressions in the intersection between art and technology, the goal of the workshop program is to: 1) strengthen pupils' interest in computer science, 2) strengthen pupils' interest in arts and 3) present creative alternatives of digital media use as opposed to pure consumption of video games.

3.1 Context

The concrete focus of our workshops is the OSS Scratch and the Reggio Emilia education philosophy of reuse and creativity. Each workshop lasted two days. In the first workshop the participants were 15 pupils from School A. In the second workshop the participants were 14 pupils from school B. All children were 12 years old. The pupils were divided into three groups. They worked in these groups during the whole workshop. Each group had two computers.

ReMida centers work according to Reggio Emilia education principles [1]. This means that the initiative for creative actions should spring from the child itself. ReMida centers are magic places with a lot of appealing objects where children start to work without being activated by adults. The adults act as assistants.

The workshop theme was ‘A Fairytale for the Future’. Fig. 1 depicts the context of the workshop and zooms on two scenes in which the pupils are using Scratch.

Fig. 1. Left: An overview of the room with the three groups in a tutorial setting; Center: Three girls are using Scratch; Right: Two boys are using Scratch

After studying the available documentation provided at the Scratch website, we designed a plan consisting of nine main steps to be executed in two days.

1. Short demonstration of a Scratch project
2. Make physical characters, take pictures and edit cutout images. Each group was given the task to create two 3-dimensional characters of recycled materials and import digital images of these into Scratch (Fig. 2).
3. Scratch tutorial first part: sprite animation, change costume, movement, sound and graphic effect
4. Make a storyboard and start making scenes in Scratch. A fairytale should be programmed in Scratch and progress as a result of some kind of interactivity between the audience and the artwork triggered by sensors.
5. Scratch tutorial second part: change scenes, synchronization (broadcast and when-receive), check the value of a variable, actions from sensors.
6. Finish programming. The connections from Scratch to the physical world by means of light, sound, and touch sensors should be implemented by home made sensors connected to the PC by Arduino boards.
7. Decorate a room for exhibition and install artworks (see Fig. 5 center and right).
8. Presentations (See Table 2 and Fig. 5 left).
9. Closing discussion (see Table 3).

Six interactive artworks were made during the workshops. The Scratch projects can be found at the Scratch Web site published under the name artentnu2009. The scripts have been modified so that the projects run without the originally used Arduino boards and connected sensors.

3.2 Research Method

Organizers were two artists, one PhD student, four master students, one senior researcher, and one project manager. One of the artists was the responsible for

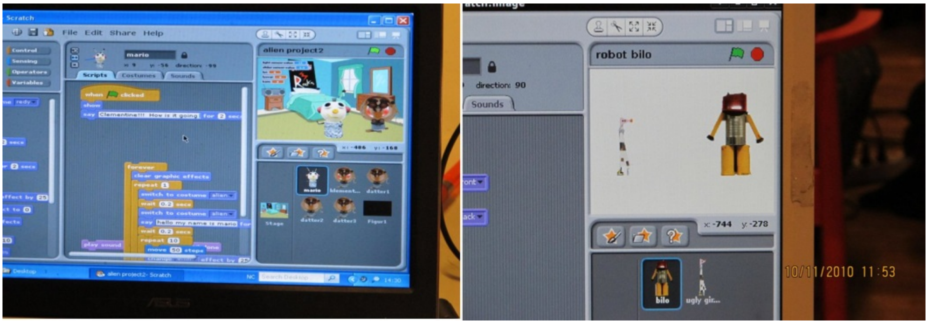

Fig. 2. Giving life to characters in Scratch

ReMida and the other (hereby called the programming artist) has a background as a technology artist. For each group there was an assistant and an observer. The assistants task was to offer help if the pupils had questions and to motivate them during the process.

How to evaluate one person interest in science in general and in computer science in particular is an issue that has been addressed for example in [3] by asking people directly about their interest in programming (respectively art) before and after a science in society event. In our project, there was an initial agreement between the project manager, the two artists, and the senior researcher that this kind of questionnaire based research should not be carried out during the workshop time to avoid stealing time from the creative activities. We agreed that we would take pictures, videos, and notes during the workshops and that the interviews with the pupils should be run after workshop completion.

Data was collected from participant observation. Participant observers take part in proceedings while observing and recording activities and interactions [8]. We took 360 pictures, 197 short video clips, and field notes (all available at [2]). Moreover the produced Scratch projects were saved at the MIT Scratch web site. Concerning permission, we asked the school teachers about the possibilities of taking pictures and publishing them. The teachers replied that all pupils had given permission to the school to allow use and publication of pictures.

Field notes, pictures and video material analysis have been systematically analyzed in order to address the research goals. In the process of selecting pictures we have kept the most relevant pictures and deleted all the pictures we took of the objects to be animated and all the pictures about irrelevant interaction between pupils and master students. We selected 190 pictures which have been classified according to tags like ‘Scratch’, ‘Physical’, ‘Artist Programmer’, ‘joy’, ‘boredom’, ‘concentration’. All the field notes (recorded by six people) have been collected and transferred into digital form in an observation report. Relevant video material has been selected and transcribed ad verbatim.

4 Evaluation

In this section we evaluate the three goals by observing and reflecting about the collected data.

4.1 Goal 1 - Strengthen Pupils Interest in Computer Science

The majority of the pupils had no previous experience with Scratch or similar programming environments. With its simple graphical interface, Scratch proved to be suitable for supporting an exploratory approach from the beginning. The pupils intuitively engaged in testing out the effects of snapping different programming blocks together. During the tutorials some of the basic programming concepts were demonstrated and explained, such as sequence, looping, conditional statements, variables, synchronization, real-time interaction and random numbers. Our notes include several observations of discussions that indicate that pupils developed vocabulary with Scratch terms. This understanding can imply an interest in programming. When the pupils were left to work on Scratch they seemed to enjoy playing with the sound blocks and recording their voices apart from being able to make the sprites move and change costumes. The conversation fragment in Table 1 exemplifies how two pupils used programming terms while working in Scratch.

Table 1. Conversation Fragment, first workshop, day 2, three girls, S, J and V are programming

```
S: We need a repeat

J: Yes, repeat until, where can we find that one then?

S: On sensor or something?

J: We can't have loud, we can use timer and then we
need a time control or something ... what if it doesn't
touch then?

S: Then it must just continue to walk, so it is spot on
then? do we want something else? We need to send,
broadcast scene? What is missing then? Probably
something, yes? that it is going to turn pink? that is
under sensor . . . When space is pressed change colour
effect. We need control then!

J: Isn't it when touching? But we need another thing
inside? yes? go to control then?
```

The girls, S and J, use the terms that they see in the Scratch command palette. This conversation demonstrates a learning activity even though it is not possible to evaluate the specific understanding they have of the terms they are using. Other conversation fragments indicate more understanding as the pupils reflect about why a specific behavior is occurring. In the wake of one such reflective discussion, one pupil enthusiastically uttered: ‘I am going to download this program at home!’.

Other observations indicate that a number of pupils found it difficult to use Scratch. The second Scratch tutorial introduced concepts that were more challenging to grasp, for instance actions from sensors. In order to clarify how sensors trigger interactive actions, the pupils could have been more included in the process of making the sensors and connecting these to the Arduino board and the computer. One group however, explained well how the audience could interact with their artwork. The fragment in Table 2 illustrates understanding and interest.

Table 2. Presentations, boy (B) and girl (G) explain their artwork, first workshop, day 2

B: And that light sensor that you are holding ... will trigger the computer to broadcast the second scene, while the touch sensor will trigger the robot to show a speech

G: In the game there will be a chase, a giraffe chasing the robot, and you have to participate in the chase by trying to help the robot. You can help the robot by speaking into the microphone and then you will get ... you can speak into it and say help me or get away or go hide or anything and that will make the robot go into the corner or something?

Our transcriptions of conversations between children show that some children are explaining programming concepts in their own words and this demonstrates understanding.

4.2 Goal 2 Strengthen Pupils Interest in Arts

ReMida's rich collection of recycled things initiated an immediate creative process within all the groups. The pupils started their projects by making the physical characters. They were experimenting with materials in various shapes, colors and sizes. While the characters were created, the pupils discussed their personality traits and behavior. As the characters gradually got an identity, the story of the fairytale started to develop. This enabled the pupils to get personally connected to their work from the beginning.

Fig. 3 and Fig. 4 respectively show pictures from the activities of making the characters and pictures. We recommend taking pictures of the physical characters different movements as this can be more simple and effective in the process of producing animation compared to using the graphical editor. Furthermore drawing a storyboard proved to be a useful activity for achieving a common understanding of the plot of the fairytale.

Fig. 3. Pupils work with their physical artifacts

Fig. 4. Artists take pictures of physical characters

Table 3. Closing discussion, second workshop, day 2, PA is programming artist, B is boy, G is girl and SC is several children agreeing

```
PA: Want to hear from you about what we have been
doing, was nice to get to know you… Was anything
difficult?
G: To learn the Scratch-things, all of the Scratch
things…
B: Just got more and more difficult, in the end you had
to take over (says to PA)
PA: But it seemed like things worked out better today
eventually?
SC: Yes, indeed it did, especially after today's
tutorial
PA: Anyone want to continue with Scratch?
Majority of the children raise their hands
PA: What was the most fun?
SC: To make the figures
PA: Was it worth it (all of the work) when you saw the
results?
SC: Yes
```

The pupils needed to make a set of artistic choices in Scratch such as deciding which backgrounds, movements, sounds and music to use. Furthermore they had to choose by which means the audience should be able to interact with their artwork. Light, sound and touch sensors were available in order to make the connections from Scratch to the physical world. One of the groups created a fairytale about the alien Mr. Mario and Clementine who fall in love. Each time the light was turned on a new baby was born. During the presentation there was great curiosity to find out whether the next baby would be a girl or a boy. This element of surprise resulted in many babies, but also much laughter and proud faces. In the sea monster project the pupils invited the audience to step on a touch sensor. This action first activated the fairytale to start and then the sea monster to come out of the water.

Fig. 5. Left: Presentations; Center and Right: Preparing for exhibitions

The pupils decorated a room for exhibition (Fig. 5). These rooms became important parts of the artworks. The pupils could use all of the ReMida material including a large collection of second hand furniture, smaller interior objects, textiles and different lighting possibilities. Use of these materials enabled the pupils to create the atmosphere they had envisioned for their artwork. A majority of the pupils seemed to really enjoy using the physical space in this manner. One girl excitedly uttered: 'I just love decorating houses. I love decorating everything!' And another girl replied: 'Oh oh oh this is so cool!'.

One of the groups worked especially devotedly to create a specific atmosphere. This group regarded the whole space of the exhibition room as their artwork and created an underwater-like atmosphere that would aesthetically fit the Scratch project. One of their physical characters, the monster boat, was for instance given an extra dimension by attaching its adjustable mouth to a rotating fan to get a continuous open-close movement.

Finally, the pupils were able to share their works and experiences with each other during the presentations (See Fig. 5 left and Table 2). Before allowing the audience to interact with the artworks, the pupils explained what the fairytales were about. Some pupils also explained how they had used Scratch and which sensors they had implemented. As activities, the presentations were successful in order to celebrate the feeling of accomplishment. Furthermore it was valuable for getting information about the pupils overall understanding and reflections from the process.

The pupils seemed to collaborate easier when working with physical materials than when programming. In the closing discussion (see Table 3) many children agreed that the most fun part was to make the figures. An important aspect of the creativity process is to offer pupils a broad variety of artistic elements [5]. Combining Scratch, recycled materials, sensors and physical space is a means to break from conventional expectations by encouraging interest in both art and technology at the same time.

4.3 Goal 3 Present Creative Alternatives of Digital Media Use

What was the overall response of the pupils? The workshops in general successfully engaged the pupils as new media artists. In [11] Scratch technology is evaluated to be a driver for digital creativity by giving a message about the positive and creative sides of exploiting such technology in children settings. Our analysis of the pictures shows a situation that is more nuanced than the situations described in [11]. Fig. 6 shows situations in which the boys and girls are happy or playful, tired or bored, and concentrated. Table 4 gives a conversation fragment that can be read together with the left picture in Fig. 6. The fragment and the left picture give evidence to the fact that creative production of new media experiences can be a source of entertainment.

Table 4. Conversation Fragment, first workshop, day 1, PA is programming artist and A is assistant, two boys, R and B, are experimenting with controlling the graphic effects by speaking into the microphone

```
B: Let's change something else, whirling
R: Ok, it's because of the loudness, the louder you
speak the more it changes
PA: Did you try to make an army by command?
B: This is totally funny! Hey, loudness, let's add it
to something else (screams into the microphone)
A: Can you notice a change? What changes?
R: Yes it changed, but it doesn't last for long
A: Why not?
R: I think it is because we don't have a wait command
after it
```

Fig. 6. Happy, bored, and concentrated while engaging in art and technology activities

All tagged pictures are available at [2]. It is possible to count the number of pictures that convey a notion of happiness, concentration and tiredness. However, this information would not be objective as photographers are trained to take pictures of joyful situations so there could be an overrepresentation of these positive feelings. A deep observation of a few pictures and subsequent reflection can bring important insight in the relationship that the individual develop to the making and fruition of the objects of art and technology.

There were noticeable differences between the pupils' ability and motivation to understand concepts in programming activities and motivation. In the first workshop the activities were carried out according to the initial plan. For this group of children this set up seemed to work well. In the second workshop however, we decided to alter the order of two planned activities as it became apparent that several pupils started to lose their motivation and experienced problems during programming the final scenes in Scratch. By starting the activity of decorating the rooms they could still be engaged with the project while being able to use their creative expressions in a different manner. This was a strategy that enabled the children to regain motivation for completing the projects in Scratch. We suggest that workshop organizers can account for different groups of children and different individual interests by designing a workshop activity plan that supports a flexible working style. By this we mean that if the children lose concentration during one activity they should be able to continue with a different activity that is still related to the project. Pupils' different interests can be taken into account by offering a variety of tools and activities. Scratch, physical artifacts and sensors make up a set of tools that fulfill different interests when exploring art and technology.

5 Discussion and Conclusions

In this paper we presented experiences from designing and conducting a workshop program where children collaboratively engaged in creating interactive artworks by using Scratch, sensors, and recycled materials. We explored the potential of this physical/digital combination as a means to increase pupils' interest in art and technology and to introduce them to become creators of new media artistic expressions.

We can reflect on the digital versus physical dimension by referring to the work in [3] whose goal is to empower collaboration, learning, and design by using digital technology and at the same time taking advantage of human abilities to grasp and manipulate physical objects and materials.

Our findings indicate that combining physical artifacts, programming languages and sensors is a promising approach to increase interest in both art and technology, in a workshop setting. When creating digital art the following three conditions should be strived for: 1) active engagement in the learning process; 2) personal connection and 3) creating projects that are of value to a larger community [9]. The philosophy behind Scratch is a constructionist theory of learning, thus that people learn best when they are active participants in design activities [10]. The ReMida philosophy [1] is similar. Our workshop program did encourage active engagement in learning process. Furthermore there were several levels of expression. First the personal level; second collaboration in groups of two; third cooperation in the group of five: last presentations for the whole class. Findings from our study give the following implications for future workshop programs:

- Choose technology that is low cost and possibly open source in order to encourage children to be able to continue with the activities at home or in school settings. This is motivated by the discussion in Section 4.3.
- Programming concepts should be carefully and pedagogically explained. This guideline may sound obvious. We reflected and discussed on whether the programming concept synchronization (broadcast and when-receive) was too advanced for the available workshop time and also the workshop goals. Inter-object communication (communication and synchronization) is one of the most complex ideas in Scratch [7]. Tutorial presentations are not always effective and concepts need to be repeated to individuals and small groups when they struggle with understanding them. We refer concretely to the conversation fragment in Table 4 in which the programming artist and the assistant ask questions to the pupils to make them reflect about what they are doing and learning.
- The process of making own characters (as opposed to only using the ones offered by Scratch) contributes to a more personal connection. This is supported by the evaluation in Section 4.2.

- Taking pictures of the physical characters different movements can introduce an extra perspective when producing animation compared to using the graphical editor.
- Drawing a storyboard is useful to achieve a common understanding of the story's plot.
- Organizers should design activities that support a flexible working style to account for different groups of children.
- Children should collaborate in subgroups of two when using Scratch. This is supported by the evaluation in section 4.1. Concretely, the fragments in the tables report conversations between couples of children. Here, we refer to the study reported in [12]. An interesting finding of this study is that the highest levels of interest were displayed in situations where the children were working as a team on a goal that they had jointly adopted. This is consistent with the findings of previous studies which suggest that cooperative goal structuring can facilitate learning by providing a context for peer tutoring and by adding social motives such as social responsibility and social approval [12]. In addition, these studies indicated that the optimum learning situation is not one- to-one, but two children to one computer so that they have the opportunity to stimulate each others thinking.
- Letting the children present their projects for each other is an important part of the learning process.

There is an ongoing research work that aims at a further evaluation of the workshops by interviews conducted three months after the workshops. Preliminary results show that the pupils have good memories of the workshop activities and are positive to this kind of activities.

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A Narrative Game as an Educational Entertainment Resource to Teach Words to Children with Learning Deficits: A Feasibility Study

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Abstract. We describe the use of an entertainment computer narrative game to teach words to a child in a special education process. In order to observe the potential of this kind of game, we chosen a child who has difficult to learn some words using a basic computer tool at writing learning special education environment. The results showed that narrative games and its entertainment resources can be a good way to allow child reads and writes words considering different sentences and contexts, as well as, resources of the game can be a useful strategy to engage child on the storytelling.

Keywords: Narrative game, writing, special education.

1 Introduction

Computer games can be useful educational tools because they are fun, as well as, they motivate students, support learning and increase students' learning capacity [8]. This kind of game supports students to improve their mental and intellectual skills, once it encourages students to participate in a more enjoyable, fun and productive class [2]. Piaget [4] discusses that games are directly related to the children's development.

Games can be classified as [7]: recreational, cooperative, educational and narrative. Narrative games use storytelling which people participate within the game story, telling facts, events and story details in a collaborative and attentive manner [3]. An example is a game called RPG Role Playing Game where people need to create a story together.

In RPG, there are participants and the master, who usually is the most experienced player and his/her task is to present the story to the participants, with characters, their characteristics, scenarios [7].

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In this context, this paper presents feasibility study done by four different disciplines, which are computer science, special education, occupational therapy and psychology, from the Federal University of São Carlos (UFSCar) in Brazil, related to the use of a narrative game computer game to support a child at writing learning special education environment.

The feasibility study goal was to observe the narrative game potential to teach some words to a child who has learning deficits. For this propose, a narrative game with RPG characteristics was chosen because an educator as master can create a story considering child's knowledge, characteristics, likes and learning deficits. Child as participant can practice and learn how to write some words during the story.

This feasibility study focused on observing and documenting (1) how child uses a narrative game, and (2) the effects of entertainment storytelling in language learning in order to observe if it can help a child, who had difficulty to learn some words through a current tool, used in special education environment at UFSCar, called Read and Write through Little Steps (LRWLS).

1.1 Read and Write through Little Steps (LRWLS)

LRWLS [5] uses the “stimulus equivalence theory”. In this theory, reading and writing skill can be taught through stimulus using wrote words, spoken words, pictures which students need to relate to each other [6]. There are many types of lessons in LRWLS, such as: hear a word and type it, hear a word and click on figure which represents it, etc. Through these lessons, it is possible to identify what kinds of writing or reading deficits students have because considering students game interaction, this tool can show a report about what words were not typed correctly; what are correct words and how students typed it, etc.

Therefore, educational professionals, using this tool, can identify students who do not know how to write or read specific words. For example, words which contain the letter pairs NH, RR, CH, SS. Educational professionals have noticed that this tool is a good way to teach words [5] yet some students have difficulty on learning some words. Because of that, we decided to perform a feasibly study to investigate the use of a narrative games to teach words taking into consideration story context in order to help children learn while they are playing and having a good time.

1.2 Narrative Game

There are some narrative games in Brazil [1], of which we have chosen one called Contexteller because it allows the creation of stories with any scenarios and characters. We wanted to have the possibility of creating a story according to students' knowledge, characteristics, likes and learning deficits. Other narrative games [7] only support games with fixed sets of characters, characteristics, scenarios and themes. Contexteller was also developed by the Computer Department at UFSCar, making it easier to modify.

Contexteller is a narrative game inspired in Role-Playing Games – RPG [7]. Fig. 1 shows the interface of the game, allowing the players (mater and participants) to see their card (I) with a specific text area where players can type their messages, their dice (II), and (III) another text area which allows players to read all the messages sent to each other during the composition of the collaborative story. In area (IV), the card, with another color and size, represents the master of the game, and area (V) shows to other characters' card.

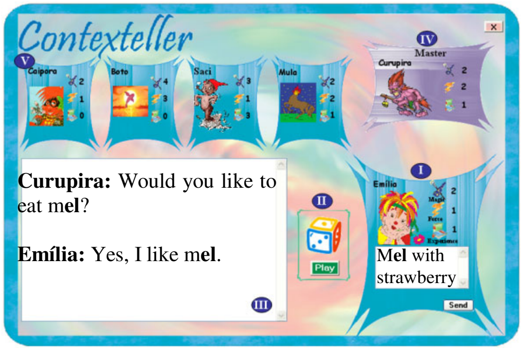

Fig. 1. Interface of Contexteller

The dice (II), which is also part of the RPG, shows the players whether a particular action is possible, or not [7]. For example, to raise any object it is necessary to have the value of the Force element equal or greater than the value of the object weight. This weight is defined by value of the dice thrown by the player. Thus, the player can raise the object if the value of the Force is equal to N and the value of the dice is from 1 to N. If the value of the dice exceeds N such action will not be possible because the value of the weight of the object is more than the value of the Force element.

2 Feasibly Study

There were 2 steps in the feasibly study: (1) showing narrative game to child in order observe how s/he uses a game (2) teaching words through narrative game considering his/her deficits.

Participant – It was used the reports from LRWLS tool in order to identify a child who had difficulties to learn some words using this tool, that is, a child that did not write correctly in the lessons. Our subject was an 11 years old girl that did not write correctly words which contain any vowel followed by the letter l. For instance, c**al**do, m**el**, m**ul**ta, etc (in English juice, honey, fine, etc). It is important to say that we chosen just one child because we think that it is important to know more about a different activity before doing it with a lot of children. **Objective** – To observe if a specific narrative game can help child to learn some words, such as c**al**do, m**el**, m**ul**ta (in English juice, honey, fine). **Hypothesis** – Storytelling can allow child to see specific words in a story, created for this propose, and then write them. This process can help her to learn in this sequence: seeing words when Maters types them; seeing words to copy them in a story; using words in different sentences and moments of the story. **Method** – Researchers created a story considering child's knowledge, characteristics, likes and taking into consideration these words. Because of that, the context of the story was defined in order to allow the use of them.

2.1 First Step

We talked to the child about what she liked watching on tv, movie, etc, in order to collect information that would help us create a story which she could identify with. This information was used to create a story for Step 2 which we intended to teach words. In this step, the objective was to show a narrative game to her in order to observe how she uses it. It is important to say that during both Step 1 and 2, there were two researchers with child, one to tell the story with child and another one to note observations and to help her. Table 1 shows part of story that we told with her.

Table 1. Part of the first story

Characters	Messages	
Master	Let´s go to enter in this castle?	
Participant	Yes	
Master	What do you think there are in this castle?	
Participant	tuy	This wrong word represents child's mistake. She typed (brin**c**edos instead of brin**qu**edos which are in English (tuy and toy).
Master	I like **toy** too What kinds of **toy** are there inside?	
Participant	doll	
Master	What kind of doll?	
Participant	Barbie	
	…	
Master	Let´s go to make a doll party?	
Participant	Cul	She typed (lega**u** instead of lega**l** which are in English (cul and cool).
Master	**Cool**, what kind of party?	
Participant	Fantasy	
Master	**Cool**, what is your favorite fantasy?	
	…	
Master	What do you want to play with **toy** or to study at the party	
Participant	Toy	

Through this story, we could start observing the potential of storytelling to support child on learning process. For example, when child typed "tuy", we started writing this word in a correct way "toy" in order to help her to observe the mistake. It is important to say that we did not say anything about this mistake to her during the story because this correction process could discourage her to tell story. Nevertheless, she wrote the word correctly after. We can´t say that she learned the word yet she had a possibility to see and type this word many times.

Other interesting information was about the word "cool" because child wrote "cul" and immediately we used the same strategy described above, i.e., repeating this word during the story. In this case, the child said "oh cool has double 'o', no 'u' (showing cool which master typed)". Then, we noticed that child can notice a mistake during a story without master says "you are wrong or this word is not correct".

We also noticed that she did not pay a lot of attention in the story because most of the time she spoke a lot and wrote short sentences. In contrast, in her little moment of attention was useful to notice a mistake and to write a word correctly.

We decided to make another session in this Step 1 without teaching specific words because we wanted to understand more about the potential of narrative game before using it to teach some words. We continued with the same context story. In this session, we noticed that story is a way to observe if children learned a word. For example, child already learned some words like chess and piece but she did not type them correctly during story. According reports from LRWLS tool she had a good performance with these words yet she did not know how to write them during story.

Considering narrative game options, we started using dice in this story. She liked to see the movement of the dice a lot and after seeing a number on it. There is an animation which moves the dice when Master releases it and this animation also shows a number between 1 to 6 when child clicks on it.

Using the dice, it was possible to observe how entertainment options can help child´s interest and engagement because she paid more attention in this story to know exactly when she could use it. In contrast, we noticed that she did not understand the dice goal considering RPG role. She liked playing the dice to compare its value with Master´s dice value because both of them played the dice at the same time, in this story. After this comparison, she checked who had the higher dice value and asked to play again. We played the dice three times and she laughed a lot. Then, we continued with the story and sometimes the Master released the dice.

2.2 Second Step

In this step, we started teaching words through narrative game considering her likes and deficits. , i.e., we created a story considering what she liked to watch on tv, movies, etc., and some words that she did not know how to write, such as: c**al**do, m**el**, m**ul**ta (in English juice, honey, fine).

Our goal was to teach two words during the story which are m**el** and c**al**do. Firstly the Master tried to teach the word m**el** but she did not write it. After, four attempts Master tried to teach another word in order to change the story a little beat. Nevertheless, she also did not write c**al**do. Through this experience, we noticed that it is very difficult to try to teach two words in the same story. Then, we decided to teach only one in each story.

In another session, we decided to talk to child about the story in order to explain that the story was related to m**el** (honey), then, we could play the dice if someone wrote this word. The master decided to show her that she typed the word correctly saying "*good"* and releasing the dice. It was curious because she played the dice and she wrote after *"I want to play the dice again"*. Master wrote *"ok, but you need to write what you like to eat with m**el** before"*, and she wrote another sentence with m**el**.

In order to observe child learning process, we continued with the story about m**el** in another session. We wanted to observe if child could write the word correctly in different sessions. The story was about dessert which contains m**el**. When child wrote desserts which contain m**el**, she played the dice. In this story, she had a good participation. Because of that, Master and she could write about the taste of m**el** and who animal does it.

3 Discussion

This paper presents a discussion about the use of a narrative game to support children from special education to learn words. We noticed that this kind of game can be useful to support children to repeat the same word in different sentences and contexts. In contrast, it is not easy to ask a child to repeat a word during the story. The Master needs to be precise about what they want in her/his writing. For example, it is not good to write *"What food do you like to eat with honey?"*. It is better to write *"we are going to tell a story considering the word honey"* in the beginning of the game. This way can help children to understand what they need to write in the story. We also noticed that story is a way to observe if children learned a word. For example, some words that child already learned such as: **x**adre**z** and pe**ç**a (in English, chess and piece), she did not type them correctly during story.

It is very important to say about the necessity of entertainment resource in order to stimuli the child during the story. Our case was the dice, it was a useful and fun strategy to encourage child to write the word m**el**. In contrast, it is important to design simple entertainment resources. In our context, to teach words to child with learning deficits, we needed to keep the focus on teaching words instead of to teach entertainment resources from narrative game. We could not spend much time on teaching game resources because our objective was to teach words. Because of that, the game and its resources need to be easily and friendly in order to support children to learn how to write and, its resources cannot be a challenge where children also need to learn about.

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Future Delta
Motivating Climate Change Action Grounded in Place

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Abstract. In this paper we discuss the Future Delta game, as a time-forward 3-D visualization and simulation tool that aims to motivate actions and behavioral changes and to educate players about climate change mitigation and adaptations solutions and challenges. The game simulation is situated in a recognizable community locale: the flood-prone neighborhood of Delta, BC. Combining climate change modeling, socioeconomic scenario analysis and 3D modeling of real places with engaging soundscapes and imagery, our game is designed to make climate change science and solutions more salient and understandable to the layperson. The project comprises a game simulation and dynamic 3D visualizations of future local climate change scenarios to provide an environment for experiential learning tied to place attachment. The project builds on a foundation rich in research, experimentation, and production in the topic of climate change in Delta, but extends previous work into a new representational platform of virtual game. An initial testing of the game shows that engaging with the game strengthened the user's belief that action can be taken to mitigate climate change and increased their support for more transformative social changes to achieve climate mitigation and adaptation.

Keywords: Serious Games, Climate Change, Experience Design, Immersion, Interactivity, Landscape Visualization, Behavioral Change, Attitudes.

1 Introduction

Global climate change is one of the most urgent and far-reaching environmental issues ever to have affected society: what we decide to do today determines which world future generations will inhabit. Scientists from the Intergovernmental Panel of Climate Change (IPCC) estimate that we have 10-15 years in which to implement drastic reductions in greenhouse gas emissions if we are to avoid "dangerous" climate change and severe impacts such as destructive floods, droughts, forest fires, wind storms, and massive socioeconomic disruption [1]. However, despite two decades of science from the IPCC and others, we are still struggling to turn the trends around: a serious gap remains between the information available on climate change and societal understanding of and engagement in its implications and available options for mitigation and adaptation [2]. The aim of the Future Delta game is to help close the

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knowledge/engagement gap and motivate action by bringing together climate change scenario modeling and 3D game simulation, with interaction and communication design, in order to build and test an innovative tool for exploration and simulation of climate change challenges and solutions. This approach may bring the communication of climate change science to a new level, reinforcing a sense of urgency about the changing climate, accelerating awareness while building capacity and a sense of agency for future change.

The Future Delta game is situated within a recognisable locale and situation: the flood-prone community of Delta, BC. The project depicts a section of Beach Grove Road in Delta, BC, which encapsulates many climate change challenges, projected adaptation, technology and policy options, and provides choices and influences on a neighborhood scale. This theme is used to orient users by giving them an interactive experience of how the community within this locale could mitigate causes and adapt to local impacts of climate change. With this project, we have achieved a detailed neighborhood visualization and animation in an interactive virtual environment setting, as an initial proof-of-concept on a very limited site (www.futuredelta.ok.ubc.ca).

2 Literature Review

Landscape visualization represents actual places and on-the-ground conditions in 3D perspective views, often with fairly high realism [3]. Stock et al. [4] have developed a landscape-planning tool with a game-engine called SIEVE (Spatial Information and Visualisation Environment), which allows users to explore scenarios in a real-time 3D environment, with an automated landscape model-building capability. In the field of scientific visualization, virtual reality can act as a tool for data presentation, exploration and analysis, drawing on a wealth of artistic representation methods and perceptual psychology for inspiration in design and realization [5]. Visual stimuli can trigger innate and instant reflexes and feelings, which can be persistent even in the face of new information [6]. Nicholson-Cole [7] describe the promise of landscape visualization for conveying strong messages quickly, condensing complex information, engaging people in issues of environmental change, and motivating personal action. Engaging experiences embed narratives as a dramatic structure for interaction [8], where users have an active role, exploring things that are both attractive and unknown [9].

Scientific knowledge, stakeholder interests, political powers and public opinion all play an important role in improving policy-making that motivates action and change [10]. In practice, the complexity of climate science provides an obstacle for clear communication that is a critical barrier for social change, policy making and implementation. These underlying communication problems might be resolved through game play situated through local political frameworks and stakeholder input. Game simulations can enable a safe environment for experiential learning, rewarding engagement with local climate challenges and adaptation solutions as well as policy testing. Further, 3D game simulation enables the ability to dynamically visualize real places and complex multi modeling that can provide meaningful linkage across local and global climate change scales. Games and simulations provide situated cognition and give individuals the opportunity to play and replay situations, see the projected outcome of their choices, test out different strategies that are often impossible in real life. In simulations, learners aren't just active, they are actors. In game simulations the concept of place plays an important role in creating emotional attachment. An emotional engagement with a space results in experience of place identity [11] where an aspect of our understanding of self develops in relation to a physical space. An effective learning experience can be linked to the degree of presence felt by the game player. A high degree of presence can be created by using an environment familiar to game users to get them emotionally involved in the game [12].

Major research goal of the study is to explore multiple aspects of perception, motivation, understanding, and change of behavior through learning with regard to climate change issues communicated through an educational game:

– Does the immersive, interactive virtual environment facilitate a change of people's attitudes, understanding, or behavior regarding climate change impacts, mitigation or adaptation?

3 Methods

3.1 Game Design

The Future Delta project builds on the scenarios that resulted from a Local Climate Change Visioning Process (LCCVP) in Delta in south-western BC. The LCCVP is a process for envisioning local futures with a goal to localize, and visualize climate change effects at a neighborhood and community level, based on regional climate modeling, scientific advice, and local stakeholder involvement [3]. Four alternative future scenarios were developed where local conditions match global climate change scenarios projecting out to 2100. These scenario worlds projected alternative emissions scenarios, differences in climate change impacts, and the alternative responses that a particular community can take to adapt to and mitigate global climate change. The Future Delta game builds on the LCCVP, but extends it into a new representational framework fostered by the communicative power of interactive multimedia within a virtual landscape design. The static 3D visualizations of the LCCVP became the developmental sketches for the alternative storypaths of an interactive 3D game simulation repository focused on a section of Beach Grove road in Delta, BC.

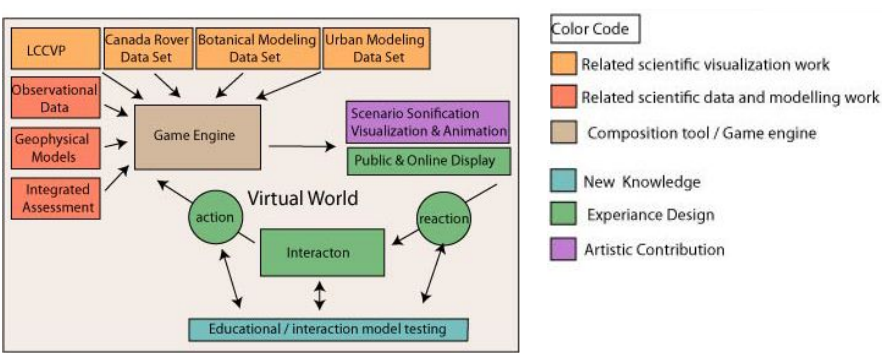

Fig. 1. Future Delta Game Engine Diagram

The hyper-realistic modeling of Beach Grove Road is based on observational data, such as terrain data, maps, etc, while the simulation models are based on geophysical and integrated assessment models. The repository of 3D models consists of comprehensive selection of tools, technologies and policies for adaptation and mitigation. The animations and behaviour repository consist of the people and animals, and present and projected future natural cycles, such as flooding and storms animations. The focus of Future Delta was placed on building an engaging and realistic interactive virtual environment and 3D modeling that encompasses solutions to carbon footprint reduction and flood management. With this project we achieved a detailed neighborhood visualization and animation in an interactive virtual environment setting.

3.2 User Test Methods

The exploratory study consists of a quantitative and a qualitative part: First, 26 students were asked to fill in quantitative pre-/post-questionnaires before and after using a prototype of the game in a 90 minute testing session. Second, in-depth qualitative interviews were conducted with 10 local and non-local experts from the fields of architecture, biology, geography, education, the game industry, climate science, and local government. In the quantitative pre-/post-questionnaires, participants were asked to rate their levels of concern, urgency, attitudes and understanding with regard to climate change impacts and actions; responsibility and willingness to change their individual behavior before and after playing the game. Results from the pre- and post-questionnaires were compared through the Wilcoxon test as non-parametric version of a paired samples t-test, performed in SPSS 14. The qualitative expert interviews followed a script that ensured that all participants had a comparable experience of the game (30 minutes). While exploring the game, they were asked to "think-aloud" about their interaction with the game environment and their comments were audio-taped. After exploring the game, participants were interviewed for about 20 minutes with regard to a qualitative interview script. Questions referred to the usability, representation style (quality of representation and interactivity) and motivation, understanding and learning about local climate change issues.

4 Results

4.1 Interaction with Future Delta Environment

The core objective of the game simulation is to communicate climate change mitigation and adaptation challenges and solutions specific to the flooding risks and low-carbon/energy needs of neighborhoods in the municipality of Delta, BC. The Future Delta environment enables a player to explore a section of Beach Grove Road, Delta BC from a first person perspective. The player can implement measures to mitigate and adapt to climate change over the period of 100 years, from year 2010 to 2110 in Delta, BC. There are ten turns in the game, each one marking the ten-year period. The mitigation and adaptation options are categorized in three areas: individual, governmental and industrial. Each option that can be implemented belongs to one of these three areas and affects the resources (money, water and food), adaptation measures and carbon footprint. The user interface includes bars that indicate how many resources are available, whether the carbon footprint targets are met and whether the community is protected with adaptation measures. Through these bars, the player is able to determine how many resources they can allocate to improvements as well as holistically check their progress in the game.

Fig. 2. Present Day Beach Grove Road, Delta (left) and Flooding risk in Delta (right)

With the central goal of creating a sustainable environment resistant to climate change in mind, the player can explore the environment in search of information. Specific objects within the environment glow if they have research information for the player to view. The player approaches the object and clicks on it with the mouse. A full-screen panel appears with the information, which consists of an upgrade that the player can implement. When the improvement is built, there is a visual marker of the user's stamp on the environment. The effects of each improvement are also visualized for the user in information windows and indicator bars. There are additional environmental effects such as storm surges, heat waves and flooding that increase in frequency and intensity and are directly linked to the carbon footprint. The player can interact with non-player characters that wander about the neighborhood and enquire about their opinions concerning the changes the player has made to the community. If the player is doing a particularly good job at climate change mitigation and adaptation, the characters are very friendly and compliment the player on specific achievements he or she has accomplished. If, however, the player is not doing such a good job — for example, he or she has exhausted a critical resource like food and water — the characters are visibly upset. The purpose is to help the user gain a fuller understanding of the different options available at the different levels of society, individual action, industry and government.

4.2 User Tests Results

The sample (n=26) of the quantitative survey consisted of 2 professionals and 24 students younger than 39 years, 13 male and 13 female, with a self-assessment of their computer game experience above average (mean = 3.43 on a scale from 1 to 5) and a minimum education level of high school diploma; two students had a community college degree, five an undergraduate and one a postgraduate degree. The concern about climate change in the overall sample was rated as 3.54 on a scale of 1 (no concern) to 5 (high concern) with two students believing that climate was not a threat at all. The average thought that climate change will start to have serious impacts some time in between 20 to 50 years from now. In the pre-questionnaire, the majority of students agreed with the statements that a) the federal government (80.8%), b) corporations/industry (88.5%), c) environmental organizations (76.9%) were "responsible for doing something about climate change". Smaller portions thought that also scientists (69.2%), local/municipal authorities (57.7%), community organizations (65.4%), their own friends and families (69.2%) and they, themselves (69.2%) could do something about climate change.

According to the Wilcoxon test, the game simulation did not change levels of concern or urgency about climate change nor did the respondents report an increase in their understanding of climate change impacts. However, a significant change of attitudes (α=0.046) took place towards supporting more radical statements such as a) "our society must be gradually changed by reforms (such as policy change and technology incentives)" to the statement that b) "our society must be radically transformed such as changing our energy needs, how we build, how we get around, etc." Other options were c) no action at all or d) only actions that will not impact individual lifestyles. In the pre-questionnaire 57.7% supported the modest change option a) and 30.8% option b), whereas 34.6% supported option a) and 42.3% option b) radical transformative change in the post-questionnaire. The other key finding was that a significant increase of respondents rated the responsibility of local authorities higher than before playing the game. This finding is very promising because the game focused on the experience of opportunities for climate change mitigation and adaptation on the local level. There was also the tendency that people's self-reported feelings changed from feeling disempowered to being more optimistic and a higher percentage of respondents started believing that actions against climate change could be taken. However, those trends were just not clear enough to be significant (α=0.059 for a change of feelings and α=0.070 for the belief that actions could be taken). In contrast, there is no trend for more people planning individual changes of behavior.

The qualitative interviews provided suggestions about the prototype's strengths (visual representation of buildings and vegetation) and weaknesses (storyline and feedback mechanisms) and how the game prototype could further be developed by clarifying the role of the player and his goals, giving more consistent feedback and balancing the reward system. The suggestions guided the debugging and finishing phases of the game development.

5 Conclusion

The Future Delta project unites several disciplines including game design, artistic expression, climate science, scenario modeling and visualising technologies. Through dramatic multimedia expression and virtual reality game play, the project goal was to move towards a deeper awareness, wider community engagement and sense of urgency, reaching people that climate science often fails to reach, and providing clear choices for feasible local actions. Players can explore future scenarios, trade-offs and uncertainties on the path to a sustainable local future. Players experience landscape change over time through a form of virtual time-travel to illustrate different climate change consequences through high realism, dynamic animation and soundscape design, in an expressive translation of the science of climate change in a poetically charged space. The analysis of the pre-/post-questionnaires shows that the game does not change concern or understanding of climate change, but the experience of mitigation and adaptation options did strengthen the user's belief that action can be taken and increased their support for more transformative changes of society to prevent climate change. In the pre-questionnaire, a large portion had felt disempowered by the rather abstract global threat of climate change whereas the post questionnaire seems to show that the localized proactive approach of the game made people feel more empowered and optimistic. The lessons of Future Delta informed a follow-up proposal for an educational game about energy consumption and renewable energies on the local level.

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Sound in COLLADA

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Abstract. Standard or normalized file formats exist since many years to write/read/exchange 3D scene descriptions. However, these descriptions are mainly for visual contents. Options given for sound compositions of 3D scenes are either lacking or poor. In this paper, we propose to include rich sound descriptions in the COLLADA standard, a commonly used scene language. Our work relies on a research project, the goal of which is to define and develop a sound engine for virtual cities. In this context we have implemented and experimented a first version of sound descriptions in COLLADA.

Keywords: COLLADA, Dynamic Audio, Audio Scene Description, Soundscape, Virtual Cities.

1 Introduction

The CEDRIC (Computer Science laboratory of the CNAM) is involved in TerraDynamica, a project funded by the French government. The purpose of this three-year project started in 2010 and developed by a dozen of academic and industrial partners is to bring life to TerraNumerica, a static virtual city. This virtual city (Paris in the experiment) will be used for numerous applications from safety simulation to art installation. Bringing life is basically putting animated characters in the city. Nevertheless, making pedestrian and car agents behave properly wouldn't be realistic if they were muted. Even though sounds are often simply noises in a city, they still carry important information for real or virtual citizens. The integration of sounds in TerraDynamica is one of the tasks assigned to the CNAM in this project.

Nowadays, spatial audio is considered as an essential element to deliver a more immersive and believable virtual reality experience. A sound is not merely an emission from a source. That is, sound waves can be absorbed (attenuated), reflected or refracted by the medium. Audio in soundscape theory, architectures and video games, is characterized by its strong relationship to space regarding both analytic and creative perspectives. This non-linear relationship exists through time and is developed within many cross-disciplinary works [1].

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Numerical simulations of the propagation of the sonic wave in acoustic spaces are presented for architectural design. In some interactive media, such as video games, dynamic factors are then added-up in accordance with the gameplay design. In addition, game sound middleware provides a choice of high-level runtime capabilities, such as aural levels of details [2], interactive spatialization mixing, and runtime reverberation and filtering [3].

TerraNumerica, the static part of the city, composed by the terrain, roads, buildings or furnishings, is depicted in a database which is translated to a [1]COLLADA document in order to be utilizable in several applications. Moreover, to be consistent, the visual contents of dynamic agents are also described in a COLLADA file, whereas sound capabilities are not. Consequently, two solutions were then possible for us to add sounds to this virtual muted COLLADA description: First, to describe the whole sound scene independently in a convenient file format that would be generated from the database; Second, to add the sound description in the visual scene description.

Since computing an image viewed and computing a sound heard from a given position in a virtual environment both require a common set of data, it would be disk and memory consuming to duplicate the mutual information. Furthermore, the time required to generate, read and interpret both files would be greater then with a single file in which data is optimized. Hence we have chosen the second solution: to add the sound description in the COLLADA file that has already been used to illustrate the visual elements.

Using visual data for audio purpose is not always done. For example, OpenGL, the well known graphic library, uses transformations that do not affect sound sources and listener positions of OpenAL. On the other hand, some scene description standards have tried such a mix: Java3D on the API side or VRML V2 on the file format side, having sound sources included in the scene graphs and modified by transform nodes. MPEG4 BIFS, inspired by the VRML scene graph, also includes such capabilities, although sound parameters in those files or API are poor compared to what is possible to be done in sound environments nowadays through the use of DSPs [4].

From the earlier goal of adding sound capabilities to TerraDynamica, we ended by inserting sound nodes to the COLLADA file format. The proposition of these sound nodes is the scope of this paper. In the next section we describe the sound attributes and nodes to be embraced to the COLLADA files. Before concluding and presenting our future works, we present the implementations developed to practically validate our approach based on analysis of city soundscapes.

2 Audio Scene Description in COLLADA

Every object or piece of world material in a game or film has a sound it would make if you interacted with it [1]. A sound world is built upon interactivities. As a consequence, we are seeking a scene descriptor in order to plot out the sound behaviors characterized by the dynamics.

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[1] COLLADA documents are XML files, usually identified with a .dae (**d**igital **a**sset **e**xchange) filename extension.

2.1 Audio Nodes in Scene Language

A scene language is essentially a formal and hierarchical illustration of a virtual space itself and the objects located in this space. The language can be interpreted by a rendering program that will generate, either in real time or in batch, a perceptive (animated image and sound) representation of the scene. Each node of the hierarchy may contain some properties of an object (location, geometry, physical properties…), the procedural descriptions of the object behaviors which can be triggered by events, and the instructions to be followed by the renderer. The following figure represents a scene described in MPEG4 and VRML.

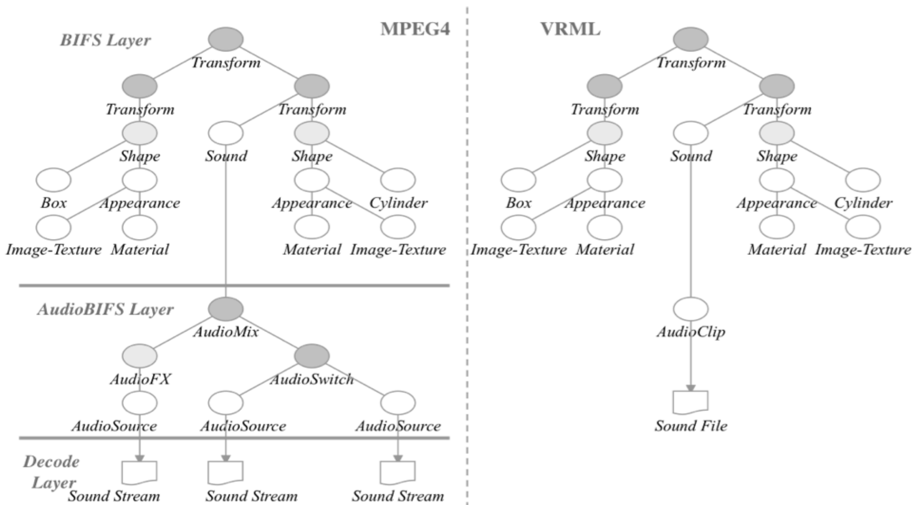

Fig. 1. MPEG4 and VRML scene graphs with sound nodes

MPEG4 [5, 6] provides probably the most advanced scene language considering the sound aspect. As one can see in Fig. 1, the BInary Format for Scenes (BIFS), which is the scene graph of MPEG4 is almost equivalent to the VRML2 scene graph. The main difference between the two scene graphs is that a BIFS can be streamed and can evolve over time if the MPEG4 server sends modifications to the client. For offline interactive or automated contents, MPEG4 has exactly the same paradigm as VRML2: the use of ROUTEs to chain behaviors for nodes to others.

In terms of sound nodes, both VRML2 and MPEG4 may describe the sound behavior of an object of the scene. VRML2 can only refer to an AudioClip which is a sample sound file given through an URL. In contrast, MPEG4 supports sounds that can be a mix of sample sound files (AudioMix), symbolic sound files (MIDI), real time sampled or symbolic streams of sounds. At each step of the mix, some effects (DSP) can be applied to the corresponding stream (through AudioFX nodes), depending on local or global parameters, properties of the scene, and real time events. For example, a sound node could be a mix of a synthetic wind with a sampled music, the level of which would be according to the current level of dramaturgy (real time computed parameter). Depending on the stream that a sound node is connected to, the room ambiance can be computed either by a physical or a perceptive algorithm. No parameter is given explicitly in the BIFS for one method or the other. It is stream-dependant; hence a communication is a request between the stream generator and the MPEG4 client and server. It requires a heavy on-the-fly calculation to transfer stream based on the user's actions, the scene's evolution and the required renderer.

To our knowledge, the ability to interpret the whole capabilities of MPEG4 scene description has never been implemented. Nonetheless, MPEG4 defines the main structures that must be considered in the design of sound nodes in scene languages even if some recent research capabilities, like sound Level of Detail, have to be added.

In our project, COLLADA [7, 8, 9] is selected as it defines an open standard XML schema from which digital contents of assets can be easily retrieved. COLLADA is an intermediate format for transporting data among various graphic tools and is widely used in applications from Google Earth to most of the games on PS3. The current status of COLLADA contains "visual" and "physics" scene descriptions. The visual part is the classical one, with some extension like the ability to include rendering programs (shaders node). The physics part defines physical properties (mass, elasticity…) of object used. The two descriptions are distinct but there is a mapping between the corresponding objects. The sound description has not been considered yet. The next section describes some basic sound functions that we propose to be specified and implemented in a renderer of COLLADA.

2.2 Sound Nodes in COLLADA

As in the MPEG4 scheme, we shall be able to attach sound streams generated by different methods. Sampled files, symbolic sound files (SAOL), sampled streams or symbolic streams are available and the choice among which depends on the type of objects. A pedestrian, for instance, may have his voice in a sample file whereas the footstep is a synthesized stream. Whatever the origin of the sound is, it is specified by an URL leading to a sound asset or a script, and will be spatialized by algorithms chosen by the COLLADA player. To leave such an open possibility for rendering the sounds spatialization, some parameters must be given in the description of the scene.

As opposed to MPEG4 which relies heavily on client-server architectures, we intend to minimize communications between stream processors and the sound renderers. With MPEG4, to render a spatialized sound with occlusions and reverberation, the parameters needed must be given in the stream processor. The parameters are not attached to/described in the MPEG4 scene directly. Based on the sound renderer selected, these parameters must be computed from some data enclosed in the scene graph to match the visual scene. Hence, a sound stream that does not communicate with either the MPEG4 client or server, holding the BIFS structure, will not be reusable in a different scene. For this main reason, we suggest appending a set of parameters to the COLLADA scene specification so that both physical and psycho-acoustic renderers can produce correct sounds.

Introducing sounds in scene induce an important question about the notion of graph scenes. Historically a graph scene was defined to specify the static part of the scene, in other words, is a typed language but not a procedural one. Yet by nature, sound is dynamic. Of course the types of dynamics object can be specified, except if we consider that the main goal of such a language is a realtime rendering, the specification of the time and interactive behaviors becomes more and more important. Interactions were introduced in VRML and MPEG4 with simple signals like "mouse click" and the ability to route a signal from a node to another. More complex synchronization scheme was introduced in MPEG4 based on SMIL (XMT-O) [11]. In COLLADA, complex dynamic behaviors are either embedded in a block of source code where you can program features or point to an external procedure. We think that some more general and explicit control scheme should be provided. In the following we make suggestions, although the implementation and the core of this problem is out of the scope of this paper.

We suggest that a sound extension of COLLADA should meet the following goals:

1. Be compatible with the spirit and the syntax of COLLADA.
2. Avoid as much as possible specifying data that are already in the scene description. For example, the room geometry should provide some of the data needed to render the acoustic with a physical method. Physical parameters of objects should be used in physical sound synthesis. In COLLADA, the visual scene and the physical scene are defined as separate hierarchies. To keep the same principle and as a consequence of the two preceding items we suggest adding an Audio Scene. Subsequently, a COLLADA model will be defined by a visual scene, an audio scene and optionally a physical scene. An object of the visual scene can be associated with an object of the audio scene, sharing parameters like the coordinate systems, the location and orientation or the same geometry. However, this mapping is not mandatory. The auditory scene can rely on perceptive and sound design principles not directly related to the location of the objects in the visual scene. It seems to us that this idea is important for fictional applications like games or art installations.
3. Have all the capabilities of MPEG4 and support advanced developments in sounds that were not included in MPEG4. It can be, for example, clustering of sound sources [2] and [10] or realtime synthesis of Foley effects. As a consequence, the following atoms, constructors, libraries and parameters should be either a part of the standard or may be considered as allowed extensions:
    a. Parameters of an object that specifies, either from a physical point of view (acoustic color) or a perceptual one (room ambiance), the acoustic of the object. This should be applied as an acoustic element equivalent to "material" in the visual scene.
    b. Sound sources can be generated by various methods. So we suggest a "sound" node with, for example, some parameters like directionality and volume. This node is the equivalent of "light" in the visual scene. We suggest that a sound source may be qualified according to some semantic and staging point of view. In the next section we propose, as an example, to classify sound sources according to three levels of a soundscape. This is an instruction given to the render to cluster and localize sources in the spatialization step of the sound pipeline. The file format of a sound node must be specified. For instance, the background of a scene can be a loop on a single surround sound file in Ambisonic B format.

c. Microphone, which is the sound counterpart of "camera". A Microphone may be mono, stereo or multi-channel (spatialized sound) and has a given directivity.
d. Basic DSP functions that transform a sampled sound file or stream into another one. This is the counterpart of the nodes "effect" and "shaders" in the visual scene.
e. Constructors of complex DSP - the language used to construct a complex sound node:
   i. Mixers: to transform m sound steams into n sound streams.
   ii. Synchronizers: clocks and timers, play, stop, pause, sequential, parallel playback.
f. Synthesizers that transform a virtual sound file or stream into a sampled one; analyzers that transforms a sampled sound file or s stream into an event, a parameter or a virtual sound stream; and time to spectral transformations.
g. Instructions for the sound renderer: synthesis, DSP algorithm and parameters, mixing instructions depending on the real acoustic (binaural, transaural, multichannel 5.1…).

3 A First Implementation

3.1 Goal of the Experiment

To have a first demonstration of the capabilities of our proposal, we have developed a parser for some of the language elements presented in the previous section and used it in a TerraDyamica demonstration. The image renderer used was Unity (http://unity3d.com/unity/) the sound renderer was Fmod (http://www.fmod.org/). Our implementation choices have been inspired by the analysis of soundscapes [12, 13, 14, 15], and in particular the video game Prototype [3].

3.2 Dynamic Urban Soundscape

Sound in the urban environment can be considered from both spatial and descriptive point of views.

The well known soundscape theory proposed by Murray Schaffer [12] is a useful tool to describe the spatial content of a sound environment, including cities [16]. The theory divides what is audible into three layers of space: background, midground and foreground. Furthermore, soundscape is a source of information about the current state of the environment [17]. Its "acoustic coloration" varies along with weather. Soundscape brings clues regarding the physical nature of the environment and an appreciation of the space surrounding the listener.

According to different listening points of interest, we can apply semantic filters to spread dynamically individual sources within the soundscape perspective. Sound descriptions dedicated to the urban environment and categorization based on everyday users' experience of the city have emerged [18]. These specific studies allow for understanding how urban soundscape is heard from a qualitative and functional point of view.

The techniques used to simulate the urban soundscape range from layering of prerecorded sounds to various methods of synthesis [19, 20, 21, 22].

Prototype, a Radical Entertainment game, is indented to create a dynamic ambience of New York City [3]. Not separating the city zone-by-zone with detailed sounds, the desire was alternatively to base the ambience on the objects inside the game world and their relative densities, populations, and emotional states. To do so, they broke the ambience down into three “tiers:” background, midground, and foreground.

- The background ambiences were a quadraphonic track of the more distant perspective recordings of Manhattan: a Central Park background and a rooftop background that would fade based on the position of the listener.
- The midground layer was composed of a collection of grouped components in the game world, including grouped pedestrians, vehicles and infected crowds.
- Lastly, foreground ambiences were a composition of sounds from single objects in the environment, played based on the changes of state of these objects.

A smooth transition from foreground through midground to background provides a sense of aural depth of the field while limiting the number of individual foreground sound components thanks to the support of the midground ambiences.

Besides Prototype’s audio levels of detail approach, several source clustering strategies have been described on the basis of geometry and resynthesis [10].

3.3 Basic Sound Node

To construct a basic sound node in COLLADA, we first list a few essential audio properties that must be taken into account, such as the playback frequency and the volume level. Allowing for future maintenance and extension, it is our intention to study and follow COLLADA’s present schema of graphic elements and to keep the overall structure coherent.

The first element we would like to add into is <sound>, which will specify a sound source along with a set of its properties. In COLLADA, the nodes named <library_*s> are the libraries containing pieces of elements <*>s which can be later referred to and used in other elements. Here we have the node <library_sounds> that declares a module of <sound> elements.

Table 1. Attributes of the <sound> element

id	xs:ID	A text string containing the unique identifier of this element. This value must be unique within the instance document. Optional.
sid	sid_type	A text string value containing the scoped identifier of this element. This value must be unique within the scope of the parent element. Optional.
name	xs:token	The text string name of this element. Optional.
frequency	float	A float value that indicates the playback frequency for the sound in Hz. Optional.
volume	Float	A float value that indicates the volume for the sound. From 0.0 (silent) to 1.0 (full volume, default).

Here is an example of a <sound> element that refers to an external WAV asset.

```
<library_sounds>
  <sound id="CarEngine_1-sound" volume="0.8">
    <init_from>
      <ref>./sounds/CarEngine_1.wav</ref>
    </init_from>
  </sound>
</library_sounds>
```

3.4 DSP

A number of basic DSP effects, such as parametric equalizer, high-pass and low-pass filters, and reverberation, are being applied to help make sound compelling in virtual worlds. According to the regulation of organizing data sets that we introduced in advance, customized <dsp> elements will be stored in the container <library_dsps>. Categorized DSP effects with their specific parameters are then scripted as the child elements of a <dsp> node.The following is an example of a <dsp> element with its child elements. <library_dsps> provides a library in which to place <dsp> elements.

```
<library_dsps>
  <dsp id="default-dsp">
    <parametric_eq count="6">
      <enabled>true true false true false true</enabled>
      <q>80.0 160.0 500.0 2000.0 5000.0 12000.0</q>
    </parametric_eq>
    <lowpass_filter>
      …
    </lowpass_filter>
    …
  </dsp>
</library_dsps>
```

3.5 Streaming Sounds

A <sound> is embedded or external referenced file data. It declares the storage for the acoustical representation of an object. A <stream>, on the other hand, is a generalization of <sound> that can link multiple <sound> resources into a single object. It states the positioning of the sound sources and their perspectives in the auditory space.

The following is a <stream> node that holds a single car engine sound. A car dsp with pre-defined parameters is employed.

```
<stream id="car_1-stream" type="3D" pov="FOREGROUND">
  <loop>0</loop>
  <instance_sound url="CarEngine_1-sound"/>
  <instance_dsp url="#car-dsp"/>
</stream>
```

One can also create a playlist of sounds in a <stream> element with random or sequence playback. The following shows an example of a <stream> node where three sounds are randomly chosen from ten car engine sounds. The three sounds output a stream in 3d and will loop forever.

```
<stream id="car2-stream" type="3D" pov="FOREGROUND">
  <loop>-1</loop>
  <create_list count="3" shuffle="true">
    <instance_sound url="CarEngine_0-sound/>
    …
    <instance_sound url="CarEngine_9-sound/>
  </create_list>
  <instance_dsp url="#car-dsp"/>
  <group target="individual_vehicles-group"/>
</stream>
```

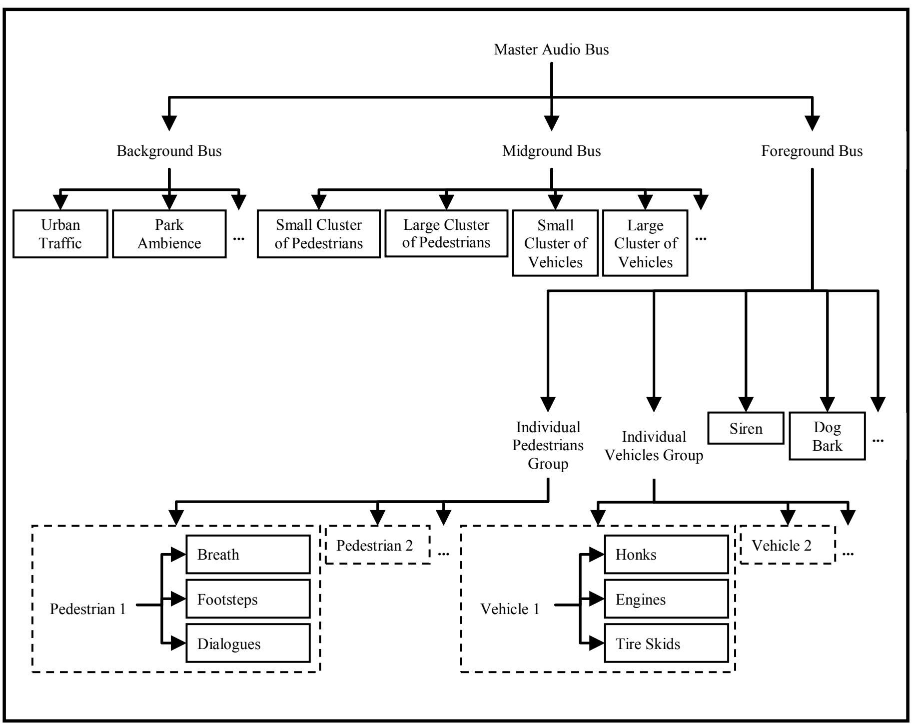

Fig. 2. An example of COLLADA audio scene hierarchy

3.6 Soundscape Hierarchy

In our audio scene hierarchy in COLLADA, sounds are divided into background, midground and foreground, based on Schafer's soundscape theory.

We have an ambient surround background that is not associated with a visible object and is not localized. A midground sound is stereo, linked to a clustered group of motion objects and situated in the barycenter of the group. Each foreground sound is mono and conventionally scripted within a single COLLADA dae file with the character or object it belongs to. In this way, the sound position will be simultaneously updated in real time.

Here is an example of how a stream can be put into an audio scene.

```
<library_visual_scenes>
  <visual_scene id="DefaultVisualScene">
    <node id="car2" name="car2" type="NODE"/>
  </visual_scene>
</library_visual_scenes>
<library_audio_scenes>
  <audio_scene id="DefaultAudioScene" name=”Vehicle”>
    <node id=”car2” name=”car2”>
      <instance_stream url=”#car2-stream” target=”#car2”/>
    </node>
  </audio_scene>
</library_audio_scenes>
<scene>
  <instance_audio_scene url=”#DefaultAudioScene”/>
  <instance_visual_scene url="#DefaultVisualScene"/>
</scene>
```

According to the principle of creating dynamically clustered objects in the visual part of COLLADA (dynamic LOD), we have to separate the description of the localization of midground sounds from the description of the visual cluster. Therefore, we create a COLLADA document which is purely constructed by acoustic ingredients and an overall sketch of the aural scene in the game environment. Another element type declared in this file is <group_streams>, which defines a group that shares the same properties (format, DSP to be applied…). By indicating the target attribute in its <group> child element, a <stream> becomes a part of a certain grouped stream. Notice that the derived streams of a <group_streams> must be in the same perspective as its mother group.

The following demonstrates how to assign the stream "car2-stream" to the group "vehicles-group:"

```
<stream id=”car2-stream” type=”3D” pov=”FOREGROUND”>
  …
  <group target=”./main_aduio.dae/vehicles-group”/>
</stream>
```

4 Conclusion and Future Works

This paper demonstrates achievement of enhancing COLLADA standard with sound representations. With the fundamental basis of audio scene structured in COLLADA, we begin to build an editor tool for sound designers' convenience to easily add aural properties into COLLADA documents, as well as a parser tool for program engineers to retrieve information of the sound scenery from dae files. Our future work follows three directions:

We will define a coherent and complete proposal of sound descriptions in COLLADA and propose it as a draft to the Khronos standardization group. We are continually working to understand the needs and to experiment with sound features in different uses of virtual cities. For instance, adaptive audio in virtual cities is not merely a continuously streaming content. It, cued by time or movements, shall be able to travel among different perspectives from background via midground to foreground and vice versa. Motion objects can be transferred into another state by an event trigger; so does sound [23]. At last, we are implementing these features of our COLLADA proposal under a variety of rendering engines (e.g. Unity, OGRE, Panda3D, etc) with a choice of audio middleware (e.g. Fmod, Wwsise, OpenAL, etc).

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A Deeper Look at the Use of Telemetry for Analysis of Player Behavior in RTS Games

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Abstract. This paper describes the analysis of a simple, free-to-play Real Time Strategy game called *Pixel Legions*. In developing this analysis, we worked with the developer to instrument, collect, and analyze telemetry data. Due to the specifics of the designers' inquiries, we developed a visualization system that enables us to answer specific micro-level questions in a way that is easy for the designer to understand how players learned and played the game. Our contribution constitutes the system we built and the analysis we developed to answer the questions imposed by the designer.

Keywords: Video Game, Visualization, Telemetry.

1 Introduction

AAA franchises have massive budgets of tens of millions of dollars but offer large rewards; the most recent published sales figures of Call of Duty reported was hitting the $1 billion dollars [1]. To strengthen the sales and the design of games, user research is often conducted. While different methods for user research and player behavior analysis have been used, recently telemetry (records of events in the game) analysis has been widely adopted [2]. Telemetry data allows designers to investigate play behavior from a large (and sometimes all the) playing population. Thus, it has two advantages; it is: (a) representative of the player population since it is not a small artificially sampled population, and (b) an ecologically valid record of the play sessions, i.e. not a time slice played under lab conditions.

For at least a decade, telemetry has been used and shown to have an instrumental role in developing and refining the design of Virtual worlds and MMOs [3]. This is important due to MMOs' and virtual worlds' nature as they rely on players retention to stay in business. As the industry shifts to franchises and MMO type games, an understanding of how to use telemetry data to analyze and understand player behavior for refining design becomes essential.

Research on user behavior analysis using telemetry has been underway for sometime; Drachen and Canossa have used GIS to visualize death behavior in Tomb Raider [4] and machine learning to organize that behavior into groups [5]. Also, companies have instrumented their games and discussed the value of analyzing telemetry in terms of finding bugs [6] and maintaining the market [7]. While such endeavors investigated telemetry analysis of First Person Shooter (FPS) games [8]

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and Role Playing Games (RPGs) [9] games, none of the previous work discussed analysis of Real Time Strategy (RTS) games. RTS games have some similarities to FPS, but their gameplay mechanics are different, relying more on strategy in management and control of resources. Methods for analyzing an RTS game thus rely on analysis of strategies of action over time. Additionally, most RTSs are composed of a series of independent matches that do not impact each other and contain tens to hundreds of units controlled by a player, and thus are also different from an FPS and RPG, where the game is inherently connected through the multiple levels. This makes RTS telemetry analysis unique, as players can jump in an out of matches with no real guiding narrative to their actions, which makes questions around player motivation and behavior prediction rather challenging.

Due to these differences, studying the use of telemetry in RTS game analysis is an important endeavor. This paper discusses a case study highlighting the use of telemetry to study user behaviors. The paper approaches this analysis through collaboration with the designer of the game called *Pixel Legions* [10]. The goal is to uncover techniques and analysis methods that are valid to the RTS domain and are adaptable within a game production pipeline. During this process, we also found that current visualization methods provided by off the shelf tools were not suitable. This is due to two reasons: the tools are often (a) too generic and thus need much work and effort in part of the designers or producers to fit the RTS analysis needed, e.g. GIS, and (b) static and do not show temporal spatial relationships, e.g. tableau or heatmpas. In our research, we were inspired by several previous research on visualization systems, e.g. VU-flow [11]. Building on these research projects, we developed our own system, called *Pathways*, which is similar to previous visualization research work (specifically VU-Flow), but adapted to the RTS game domain by adding several features allowing designers to see outcome in addition to interactively displaying player behavior in both the spatial an temporal dimensions, as will be discussed later.

Therefore, this paper presents two main contributions: (a) a case study analyzing telemetry of an RTS game, and (b) a system that allows designers to analyze player behavior within a match outlining several important factors, including how players played the match and the strategies they used to win. In the next section we will review the related work, then discuss the RTS game we used for this case study. In section 4, we describe the telemetry recorded followed by the analysis we conducted on the game. Then we close by discussing the limitations and future work.

2 Related Work

Understanding players' gameplay behaviors is currently an important research direction for the industry and academia. Researchers explored several methods including focus groups [12], think aloud protocols [13], surveys [13], and psycho-physiological sensors to study emotions and affect [14]. While these methods show great promise, they are often constrained by small samples and short play session times [15]. As a result, there has been a move towards using telemetry data as a method of player behavior analysis [3]. In earlier stages, the main goals were to use telemetry to find outliers for further investigation (i.e. finding cheaters), balance the economy or look at what assets players are using [3]. Initially, gameplay telemetry was only collected on MMOs with a centralized server due to the ease of collection and the necessity to balance the game to keep players playing [3]. As more personal computers and consoles became connected to the internet, the ability to use telemetry to find and prioritize bugs and improve games in development became more common [16] [17]. Telemetry is still primarily analyzed using either off the shelf tools like Tableau (Tableau 2011) or custom made visualizations using a variety of programming languages. More recently, Drachen and Cannosssa proposed the use of machine learning methods to classify players [5] for the game Tomb Raider Underworld (Crystal Dynamics, 2008).

A common problem with working with telemetry is how to analyze the results. How and what to visualize has been looked at in some detail. For Halo 3, researchers used simple heatmaps showing death frequency superimposed on the game level; thus investigating underutilized locations [8]. In addition, Hoobler et al. used heatmaps to give spectators watching players playing *Return to Castle Wolfenstein: Enemy Territory* a comprehensive understanding of where players were on the map, their general status, and statistics about the different teams [18]. For RPGs, the time spent in combat, inventory management, and conversations are important, and thus visualization and analysis for these behaviors are as well [19].

Current visualization techniques could visualize parts of the data collected from a game; a heatmap, for example, will show intensity, but is typically non-interactive and only visualizes one or two events. Most visualizations showing movement in space, such as geotime [20], are either designed for a small number of events (at most 100) or cost prohibitive to most video game designers. For example, GIS was mentioned earlier as a tool for creating elaborate static visualizations; a single license of GIS costs roughly $20,000 with plugins costing around $5,000 each, a single license of GIS will hire a good artist for half a year and is a more definite ROI for the studio than a single tool for analysis. VU-flow is one of the closest visualization tools to Pathways, like GIS it is designed to visualize large number of paths in 2-dimensional space in an aggregate manner but is focused on visualizing player movement (flow) [11]. VU-flow is focused exclusively on the visualization of movement, and thus would not be applicable to the analysis of RTS games that often require multiple types of events (movement, death, unit creation, etc.) to be visualized at once to give a good understanding of what happened within a match. Also as mentioned earlier, an RTS game has different mechanics from other games rendering such visualization techniques unsuitable or impractical. Therefore, for this problem, we adapted some of the previous work found in the visualization literature to the domain of RTS games by developing a system called *Pathways* discussed below.

3 Pixel Legions and Questions of Interest

In this paper we discuss an analysis of player behavior in an RTS game called *Pixel Legions* [10] – a fast paced Flash based RTS in which players control both a base that produces squads of pixels over time and the squads themselves; the objective for each level is to defeat the opponents by destroying their base. *Pixel Legions* is in many ways a basic RTS. RTS games usually have two main mechanics: the first is some form of an economy; nearly every RTS has some way for the player to gather resources which they can then spend to acquire units. *Pixel Legions* uses the simplest approach, squads of pixel spawn from the base every few seconds (no resource gathering is necessary). The second mechanic is the control of units by issuing orders and locations to go to. In *Pixel Legions*, the player moves pixel squads and the base by drawing a path from the object to the intended destination; this is done by clicking on the object and clicking on the intended destination, which will cause the object will move towards the destination. Much like other RTS games, a squad will automatically attack an enemy object if they are within attacking range (touching). Additional mechanics include increased damage if two squads are attacking the same opponent from different angles, powerups, hazards, and blocks that push objects in a direction. Levels can be skipped or directly jumped to at any time.

Figure 1 shows a screenshot of level 7 of the game. The player (green) starts on the opposite side of the map from the enemy (yellow), the colored squares represent the base where the pixel squads spawn and the white line is a move command given to the base (it originates on the base). The large stripped circle in the middle is a barrier that prevent movement through it; and the semi-opaque polygon enclosing two groups of pixels indicates that they are engaged in combat. *Pixel Legions* is comprised of 24 levels, with the first level being a heavily scripted tutorial introducing the basic mechanics. Levels 10, 20-24 (level 24, see Figure 2) are boss levels, the rest of the levels reinforce and introduce new mechanics, such as flanking in level 3, powerup locations in level 7 (see Figure 1) or specific gimmicks, e.g., level 17 forces the bases to continuously move in a circle.

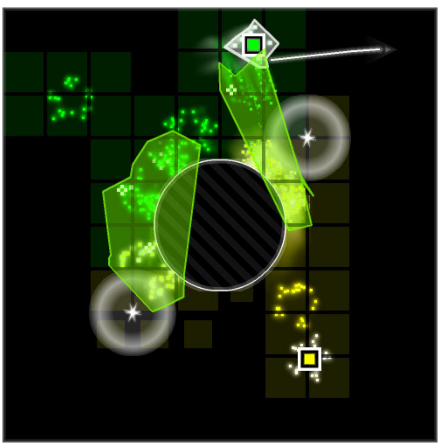

Fig. 1. A screenshot of Pixel Legions level 7, the player is in the upper left and the enemy the lower right. The white line represents the path the base's will move along. Moving the base to one of the power pylon circles increases unit production and any units going through the power pylons have upgraded attack power.

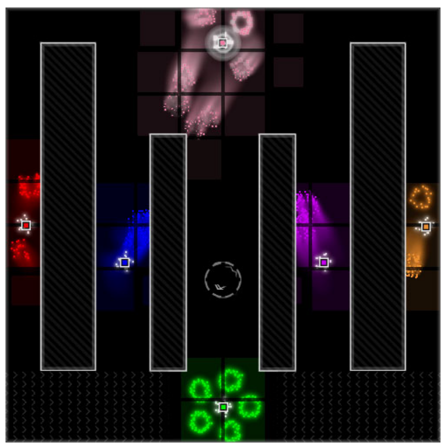

Fig. 2. A screenshot of the 24th level of Pixel Legions: a boss battle with the boss at the direct top (pink) and the player the direct bottom (green). The circle in the middle pushes anything entering it in the direction of the arrow.

Given this game as a case study, we developed a set of questions of interest that were a combination of our own and those from the game designer. These questions fell into two different types: *Macroscopic* questions – questions that deal with players actions between matches, and *Microscopic* questions – questions that deal with their actions within a match. In order to keep the discussion to a reasonable level of detail, we will focus on the Microscopic questions in this paper. These questions were:

1. Are the players doing what the designers expected?
2. Are there specific actions that can be associated with wins vs. losses?
3. Are players learning how to play a level?

4 Telemetry Collected

A unique session id was recorded for each event as a way of correlating the otherwise independent events. The collection rate was set to 2% of all sessions on the client side to avoid overwhelming the server with data. The system was built with a client side flash API that allows programmers to send events with a single line of code. The data for the event was then sent to a server, which subsequently inserted it into the database table for that event.

We collected the following telemetry:

- Level information: level start and level winning
- Movement information: base movement every 5 seconds to avoid overloading the collection system and slowing the game down
- Death information: squad death including location, time, and team that it belonged to as well as killing team

The dataset analyzed was from the release of the game on the Pixelante website to the present.

5 Results and Analysis

Before we begin discussing the analysis we performed, we will first cover some terminology. Due to a limitation in the telemetry collection system, we were only able to collect data on a per-session basis, not per player (i.e., we have no way of knowing if two sessions are the same player). Thus, we will refer to *sessions* when talking about the collected data and *players* when we refer to possible actions of theoretical players. Given that a single session could play a level multiple times, we will refer to *matches* when we indicate the data that may include multiple playthroughs of a single level and *level* when referring to the specific level of the game.

The analysis deals with how a player plays within a given match. Since the tactics a player employs might change over the course of playing a single match, we needed a way to analyze the individual actions over time. We developed *Pathways*: an interactive visualization system that visualizes multiple players' movement through a match in a 2 dimensional space. The goal of *Pathways* is to visualize a large number of different sessions at once in order to give a visual sense of commonalities that could inform designers or analysts. *Pathways* was a result of several iterations with the designer and other experts within the research team. It is unique in several ways:

- It represents player movement through space and time. For example, in figure 3, we see player's base's movements represented using the white line with arrows.
- Different events, such as item usage in an RPG or kill location in an FPS, are mapped to different visual elements, such as dots, squares, or triangles. Figure 3, shows pixel squad death locations visualized as dots utilizing.
- It also includes a time slider at the top of the window (as shown in figure 3) for the user to interactively scrub through the timeline.
- It also shows player behavior synchronized through time and split by outcome. Figure 3, shows all of the recorded matches of level 7 where win and loss conditions are tracked through time. This gives the designer a way to analyze what players did in both conditions at the same time in an easy to see and analyze way.

We applied *Pathways* to the *Pixel Legions'* dataset. Pathways visualizes base locations over time; it uses a line and arrows to show the path of the base, and colored dots to show squad death locations (colors were associated with the team the squad belonged to); both event types were visualized at 10% opacity to utilize overdraw to give a better sense of what the average behavior was (it would show up darker due to more objects being in the location). Below we discuss the analysis we performed to answer the questions discussed above.

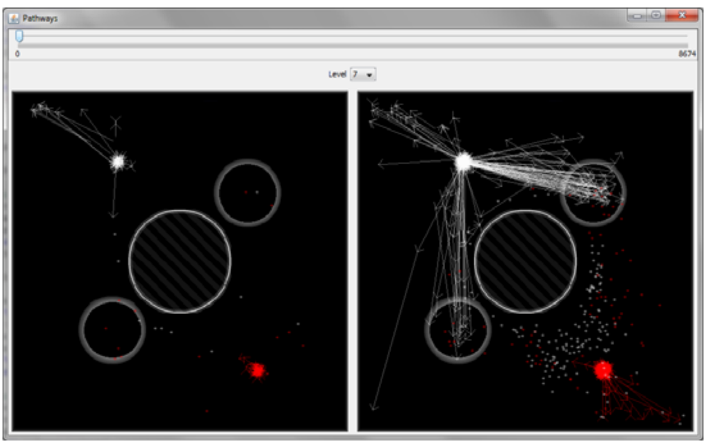

Fig. 3. A screenshot of the Pathways visualization system visualizing part of the data from level 7. This represents the first 10 seconds of gameplay.

5.1 Are Players Doing what the Designer Expected?

The major strength of telemetry is checking if players are playing the game how the designer intended. To get at this question for *Pixel Legions*, we looked at specific levels where mechanics were introduced to see if players were taking the "correct" actions for the level in order to win. Figure 3 is an example of level 7 of Pixel Legions visualized in *Pathways*. As was mentioned above, level 7 introduces a new gameplay mechanic; specifically it introduces the power pylon, an object on the map where moving your squads through them makes them more powerful for a short period of time and your base will produce units faster if it's on the object. The locations of the power pylons in level 7 are the white circles in figure 3. Since figure 3 shows the first 10 seconds of all matches visualized at once, we can determine that in the matches that were won, players moved to the power pylons earlier (indicated by the mass of white arrows at the pylon's locations on the right hand side) than the matches that lost (no arrows over the pylon locations on the left); in addition we can see that there were more squads killed near the red base in matches that won. This indicates that players understood that they need to capitalize on these resources fast in order to succeed, the matches that resulted in failure probably were the result of the player being defensive and didn't capitalize on the power pylons allowing their opponent to overwhelm them. The interesting part about figure 3 is that even in winning matches players moved their bases into the same defensive position (the lines and arrow pointing to the upper left hand corner of the map); this could be the same player making small, incremental, changes to their default strategy (moving the base defensively) until they won or different players utilizing the same strategy.

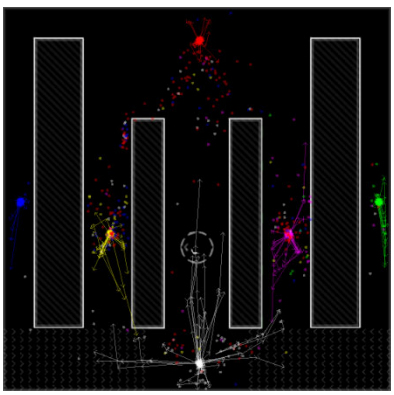

Fig. 4. losing level 24 playthroughs in Pathways

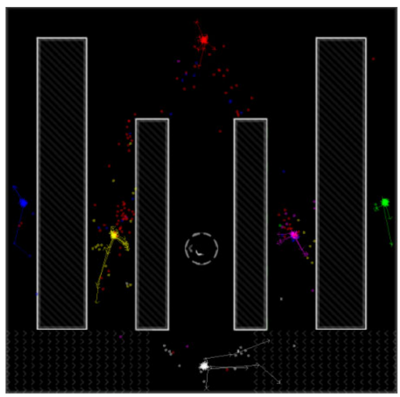

Fig. 5. winning playthroughs of level 24 in Pathways

5.2 Looking at Strategies for Win/Loss

By separating the data according to outcome, winning strategies can be easily seen. Figures 4 and 5 show the losing and winning views respectively for level 24 visualized in *Pathways* at 25 seconds into the level. The major difference is in the number of players who tried to move up the middle and sides. Moving up the middle does challenge the red team (the boss) and possibly move it out of the way but it exposes the flank of the player to the other teams. Moving the player base to the sides places it in a more defensive position by using the force arrows that push enemies towards the middle defensively but the same force arrows also force the player to focus on moving their own base (making the game harder) or risk it moving back to the middle(a number of matches showed this behaviour). Keeping the player base in the middle allows the player to minimize exposure to the boss (allowing it to kill off opponents) also giving them time to focus only on moving their using to kill off one of the 4 closer colors.

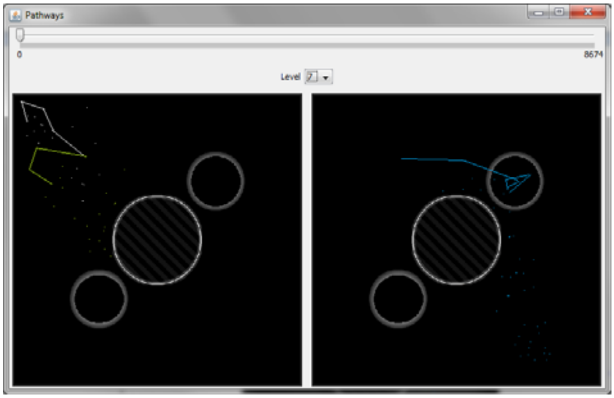

Fig. 6. A mockup of a single session's matches of level 7 visualized in Pathways with filtering and color remapping done. The first match is in white, the second in green, and the third (winning) in blue.

5.3 Learning

One major weakness of pathways in its current form is that the ability to "drill down" on the data via selection and filtering is not implemented; we currently cannot select a certain line (or lines) of interest and visualize on the session's match data. Although the current aggregate form is useful for some forms of analysis, investigating learning within a match could more easily be assessed by looking at a single session's matches for a given level to see if strategy changes over matches. Thus, in order to answer questions about learning, we need to visualize only the session of interest's matches of the given level at once using some visual variable to distinguish them (most likely color where the first match is white, the second is blue, third green, etc.) so that the analyst can easily compare between them. This was left to future work. However, a mockup of what this might look like for level 7 can be seen in figure 6. In figure 6 the different match/rounds numbers (first, second, third) are mapped to white, green and blue respectively; because the blue path is on the right it is the winning match and when comparing the different match's paths together we can see that the winning round capitalized on the power pylon (it goes into the circle in the upper right) while the others do not; thus we can see that the player learned to utilize the power pylon in order to win.

6 Discussion and Limitations

Much of the analysis conducted on *Pixel Legions* is applicable not only to RTS games but any game in which there is a degree of player choice. We would argue that in any multiplayer game there is an interest in what players are doing on a microscopic level (within a given match). Revisiting the questions we have:

Microscopic questions:

1. Are the players doing what the designers expected?
   Using *Pathways* we were able to visualize all session's plays of a given level, this allowed us to test if the players were utilizing the mechanics introduced and see how quickly they utilized them within a single match. The greatest strength and most common application of telemetry is in answering this question, so *Pathways* would work well for other genres.
2. Are there specific actions that can be associated with wins vs. losses?
   We visualized the two outcomes separately in order to identify any specific behaviors associated with each one; we were able to see that in a specific level, moving to a specific location quickly often resulted in a loss. Investigating winning vs. losing behavior is important to many other genres besides RTS as it gets into the question of balance; if a particular item consistently leads to a win, then it diminishes strategy and potentially makes the game not fun.
3. Are players learning how to play a level?
   Due to limitations in *Pathways,* we could not analyze specific sessions to see if they are learning to play the level. However, we showed a mock up of an extension of the system we are planning to implement that will get at that question. Learning is important for many types of games.

As mentioned earlier, telemetry data doesn't tell us why a session skips; it is a record of a player's behavior, multiple different intents could lead to the same behavior. It could be that players liked level 12, but without asking the players directly, it's impossible to know.

In addition to this limitation with telemetry, the data is also noisy. Figure 5 shows play throughs extending to 8764 seconds or roughly 2.4 hours! This is most likely an artifact of timestamps and a player possibly pausing the game midway through the level and coming back hours later. Removing long play sessions by considering them as erroneous would "clean" the data but at the same time the removed play sessions could be interesting stories about play style, perhaps that player jumped from the 5th level? Or perhaps they tried something no-one else did and refused to give up?

As it has been mentioned earlier, the fundamental weakness with the recorded telemetry is that ids are for a given session and not a computer or specific player. The possibility of two session ids belonging to the same player means that you cannot determine if the multiple sessions that played through a given level with similar tactics were the same player using their own tactic or two different players who happen to have a similar tactic; in short, the external validity of the sample set is suspect. The lack of player id also made it impossible to tell if the data collected was an actual player or the game designer testing a level.

In addition to the weaknesses in the collected telemetry, *Pathways* does not support selection, filtering, or remapping color to different variables within the data which makes the analysis of a single session's data require modifying the program code.

7 Conclusion and Future Work

In conclusion, we analyzed *Pixel Legions, a basic RTS,* to understand what kind of analysis is possible for an RTS game using telemetry. We found that visualizing gameplay data within specific levels using *Pathways* showed whether players were playing the game as the designer expected and was able to uncover winning vs. losing behavior strategies. While telemetry and *Pathways* had several limitations, the method discussed and the case study provides valuable lessons on the use of telemetry and visualization for analysis of RTS games.

We are currently working with Relic Entertainment to apply the analysis methods to their games, and thus rectify some of the limitations we had with *Pixel Legions* telemetry data. In this collaboration, we are using *Pathways* on data from *Dawn of War II* or *Company of Heroes.* In addition to our work with Relic, we also intend to extend Pathways to add selection, filtering, and color remapping to allow analysts and designers to investigate if players are learning the mechanics introduced in specific levels.

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Realistic 2D Facial Animation from One Image

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Abstract. In this paper we present a novel complete framework for creating realistic facial animation given only one neutral facial image as an input data. Our approach is carried on in a two-dimensional image space, instead of three-dimensional space. In addition, we employ an advanced computer vision method (digital image matting) as well as conventional image processing techniques (texture synthesis and image warping) in order to express more realistic facial animations. The major contribution of this work is showing how facial animation with a variety of realistic expressions can be generated very efficiently, where not only main facial components (e.g., eyeball, eyebrow and lip) but also pseudo-depth values obtained from their alpha mattes are utilized in our system. Simulations with real image confirm that our scheme produces high quality facial animations with an ease.

Keywords: two-dimensional facial animation, matting, warping, texture synthesis, realistic expression, pseudo-depth.

1 Introduction

Facial animation, the goal of which is to express the realistic appearance of a facial movement, plays an important role in a variety of applications including games, film productions, advertisements, educations and recently mobile contents. Hence, the creation of realistic animated faces is one of the most complicated and challenging tasks in computer graphics and computer vision areas. Conventional 3D physics-based models in facial animations used computer graphics are based on a three-dimensional anatomical model of the facial structure and a representation of its surface [1], [2]. These works would be definitely laborious and time-consuming. A major drawback of the three-dimensional facial animation approaches is its high computational cost of modeling and rendering. One of the earliest works on facial animation is done by Parke [3], [4], [5]. The Parke's parameterized facial model which can be generated as a mesh of three-dimensional points controlled by some parameters, is widely used in various fields including movie production studios so far because of its efficiency. Our proposed scheme is carried on in a two-dimensional image space without constructing three-dimensional facial reference model, under the Parke's assumption of facial expression animated by a set of parameters, so that the extensive computational cost problem can be overcome effectively. Moreover, our

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method is combined with existing some techniques (i.e., digital image matting [6], texture synthesis [7] and image warping [8]) dealing with extracting main facial components (e.g., eyeballs and lips) and restoring corrupted components for natural facial expressions. In this paper we introduce a novel complete framework for creating realistic facial animations given only one neutral facial 2D image as an input and show its high quality simulated results.

2 Related Work

For realism of the facial expressions, a detail like gaze direction is very important visual factor, but most of the image-based facial expressions [9], [10] just focus on subtle changes like facial wrinkles rather than an critical visualizations of facial components (e.g., eyeball and lip) movements. In the case of 3D physics-based facial animation [1], [2], 3D models of eyeballs must be designed manually and then would be utilized for eye movements as rotation of the models. In Bitouk et al. [11], they introduced a framework for creating a speech-enabled avatar from a single image by taking advantage of a 3D facial model for deformations of a prototype face. One of the main weak points of these works is that lots of manual efforts for 3D reference modeling are required, and which works would be definitely laborious. Hence, digital matting which is a kind of region segmentation method, has been widely used in image editing and film production application lately for providing an efficient way of tackling a complicated composition [6], [12], which makes it possible to extract facial components very accurately and realistically in our work.

3 Realistic 2D Facial Animation from one Image

Our system consists of three modules: facial feature points extraction, facial components extraction & reconstruction, and facial expression parts.

3.1 Normalization and Facial Features Extraction

For 2D image-based facial animation system, it needs to extract the major feature points from an input face image firstly and then use it as a set of parameters for animating (i.e., image warping and components moving in here) facial movements. In this work, we semi-automatically extract the facial feature points from a neutral face image by incorporating SVM classifier [13] with our manual editing procedure.

Before extracting the major features, the face normalization should be performed by applying affine translation (1) based on user-defined points (e.g., both eyeballs locations) in order to define all feature points in a constant feature space:

$$\hat{a} = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix} \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} a + \begin{bmatrix} t_x \\ t_y \end{bmatrix}, \tag{1}$$

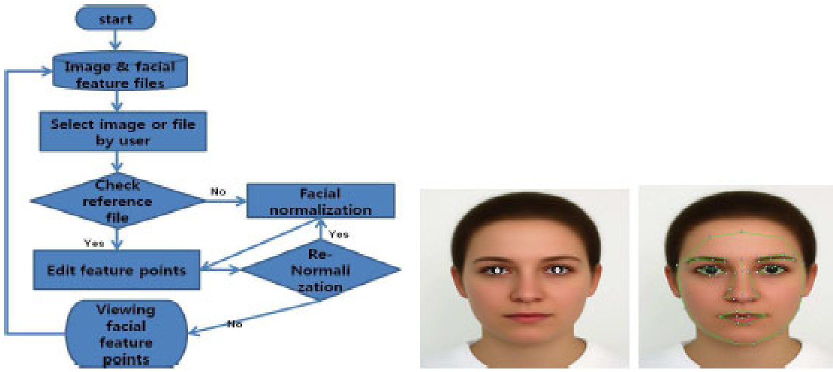


Fig. 1. Module of facial normalization & feature extraction. Flow chart(left), raw input image and both eyeballs used for normalization(mid), normalized image & defined 61 facial feature points(right)

where the variables s_x, s_y, t_x, t_y, and θ are for the horizontal and vertical scaling, translation and rotation, respectively. a and $\hat{a}$ are feature points of two static eyeballs in each raw and normalized face images. In here, we provide two modes depend on the count of feature points (i.e., 21 or 61 feature points mode can be selected by user). Meanwhile, both the computational cost and the animating realism according to the count of feature points are in a trade-off relationship.

3.2 Facial Components Extraction and Reconstruction

Once the defined feature points have been extracted semi-automatically, key facial components (e.g., lips and eyeballs) for making expressions are also segmented through a digital matting method [6]. The goal of digital matting is to estimate the opacity, the alpha matte, under an assumption that each pixel value is a linear combination of the corresponding foreground and background colors, which can be represented as following equation:

$$c_i = \alpha_i \boldsymbol{f}_i + (1 - \alpha_i)\boldsymbol{b}_i, \tag{2}$$

where $\alpha i \in [0, 1]$ represents the pixel's foreground opacity; $ci = [c1i \cdots cni] \in R^n$, the color vector; $f\,i = [f1i \cdots fni] \in R^n$ and $bi = [b1i \cdots bni] \in R^n$ represent the foreground and background color vectors at *i*th pixel, respectively.

However, it is hard to generate a perfect matte from a given image without any prior information(e.g., which is given as a trimap) because the matting problem (2) is intrinsically ill-posed. In here, we take advantage of facial feature points to construct facial component templates which are equivalent to trimaps of each component (see Fig.2, Fig.4(b)). We also exploit each alpha matte obtained from digital matting later for assigning pseudo-depth values to the component subregions. Moreover, the obtained each eyeball is not complete image because some pixels in each eyeball are occluded by the eyelid. Therefore, we exploit a texture synthesis method [7] for restoring the corrupted partial view(see Fig.4(c)).

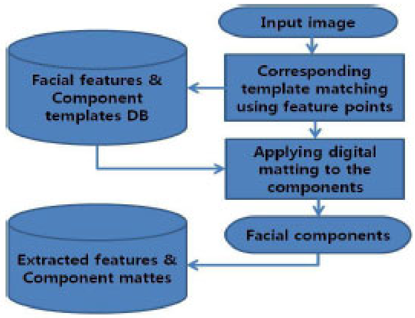


Fig. 2. Module of facial components extraction

3.3 Facial Expression

The changes like gaze and lip movements are very critical visual cues for realism of the facial expressions. We create realistic animation on a 2D face image by using conventional image warping method [8] as well as the obtained alpha mattes for representing pseudo-depth values. In order to express an independent movement of the lower lip, the $z$values of the lip are defined as follows:

$$z_m = c * |\hat{y} - y_m|, \tag{3}$$

where z_m and y_m are coordinates of the lower lip. c and $\hat{y}$ are a coefficient and jaw pivot point (see Fig.3), respectively. The lower lip region is separated from other regions by referencing the alpha values in their regions. That is, if specific alpha values are more than a defined threshold, their object would be regarded as a fore-(e.g., lip) or background(e.g., eyeballs) region. Also, we formulate the lip opens with different angles γ as follows:

$$\begin{bmatrix} \hat{z}' \\ \hat{y}' \end{bmatrix} = \begin{bmatrix} cos\gamma & -sin\gamma \\ sin\gamma & cos\gamma \end{bmatrix} \begin{bmatrix} \hat{z} \\ \hat{y} \end{bmatrix}, \tag{4}$$

where $\hat{z}$ and $\hat{y}$ are coordinates of the closed lower lip, $\hat{z}'$ and $\hat{y}'$ are coordinate values when opening the lower lip. After projecting the translated coordinate values to the given image space, we just consider $\hat{x}$ and $\hat{y}'$ values as a moving lip coordinates. Similarly, the movements of both eyeballs would be defined as the lips translation (4). In addition, we use a two-pass mesh warping method proposed by [8] for animating a variety of facial expressions.

4 Results

We perform several experiments with real face image in order to validate our proposed scheme, and show some test results with various expressions. As shown in Fig.4 (a) and (b), the eyelids in the eyeball regions are not affected from the segmented both eyeballs. Such a delicate alpha matte of the eyeball makes it possible to animate in an efficient way more realistic facial appearances. Fig.5 shows a variety of results generated from just one face input image of Fig.1. Any facial animation is synthesized as sequential movements of each facial component. Our system is developed in C++ with openCV lib.

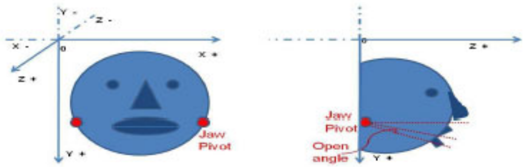
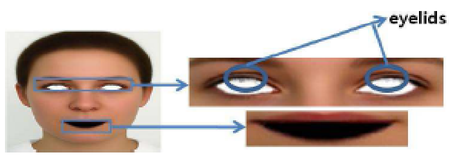
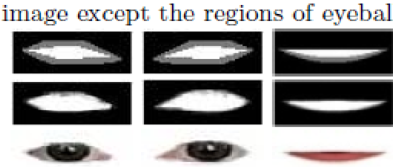


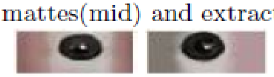
Fig. 3. Description of lip opens



(a) Face image except the regions of eyeballs and lip.



(b) Trimaps(top), alpha mattes(mid) and extracted components(bottom).



(c) Complete textures of both eyeballs.

Fig. 4. Results of components extraction & reconstruction

5 Conclusions and Further Works

We have presented a realistic facial animation method with one two-dimensional face image. The major contribution of our proposed facial animation method could be summarized as follows: it shows how the facial animation with a variety of expressions can be generated realistically and easily, where main facial components extracted through the digital matting as well as pseudo-depth values inferred from the obtained alpha mattes are exploited in the system. Hence, there are some room for

Fig. 5. Simulated results

improvement in our work. Currently the facial pose is limited to a frontal face. It is desirable to extend various facial poses for more realistic facial animations. Empirical results with real image confirmed that our method generates high quality frontal facial animation very efficiently.

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Filtering Joystick Data for Shooter Design Really Matters

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Abstract. Designing satisfactory, quick and precise control schemes for shooters on consoles remains one of the major game play programming challenges today. Besides the application of game situation specific control aids like soft locking even simple and game unspecific filtering approaches can improve the control quality significantly. In this paper we will objectify and quantify this effect that is well known among game developers as heuristic knowledge.

1 Introduction and Related Work

First and third person shooters play an important role on the current generation console market today. Those games are played with a controller consisting of two analogue sticks and follow the control scheme first introduced by the game Time Splitters on the PlayStation 2 [1]. In this scheme, the right analogue stick is used for aiming and looking and the left analogue stick is used for moving around the world. Especially the aiming function is more difficult to implement than on a PC shooter like Unreal [2], as the precision and range of an analogue stick is lower than a PC mouse.

Input schemes in general represent an important factor as they make up one third of the total interactivity cycle of listening, thinking and talking as explained by Crawford [6]. Input control schemes fall under the category of the listening aspect. It is well known to the experienced game developer that control schemes make up for a large part of the game play experience. Within the human computer interface community a series of publications for the analysis of pointing devices exist. MacKenzie et al. have analyzed aiming on several game related pointing devices [3,4]. The second paper includes an analysis on several variations of the Wiimote. These works used Fitt's task to measure aiming performance as also described in [5] and elaborate on the characteristics of the aiming device itself. Fitt's task requires aiming at a randomly selected marker out of a predefined set. In our measurement we generated target spots randomly with a predefined sum of distances.

In order to overcome the inherent difficulties of the analogue sticks of consoles basically two approaches exist today. One approach is to use contextual information to assist the gamer in aiming at objects. Frequently used is soft locking where the aiming point automatically gravitates towards a target, when it comes close to it. For instance this technique is used in the game Halo [7]. The variations of softlocking

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assists and their impact on player performance and game balancing were recently analyzed in the work of Bateman and Mandrick et al. [8].

Other practically applied approaches are context insensitive filtering approaches as described by Lürig [9]. In general, the subject of input data processing from joysticks got little attention in the academic scene yet. Exceptions are publications where joystick data is used to steer physical devices (see e.g. Chestnutt et al. [10]).

In this paper we focus on the analysis of the filtering approach and explain under which conditions and how it has advantages. As a basis of experiments a XBOX 360 controller was used. Besides always applying a simple and tight dead zone filter we compared (a) no filter, (b) a square type input filter, and (c) the combination of the square type filter with a damping filter and a ballistic filter.

The square type filter simply maps the input value to the sign attached square value. The dampening filter constitutes a low pass filter that is applied to the input. The ballistic filter has works as a high pass filter. Specifications of those filters are found in [9]. The square type filter and the damping filter were used by one of the authors in the game Splintercell Essentials and the PSP version of Ironman. Design and calibration of those filters are based on experience and experimentation.

Running through the complete analysis we deduced the following practical guidelines for a game where the user applies the right analogue stick for aiming or moving a reticule. These guidelines are also the hypotheses that are discussed in the result section.

1. The aiming velocity to move to the correct position is improved significantly by the square type filter and gets further improved by adding the damping filter.
2. The lower the frame rate is, the lower is the aiming velocity. Especially there is a significant drop in the step between 20 and 30 fps. The frame rate has no influence on filter performance. If one filter is better than another for one frame rate it remains the same for all frame rates.
3. Learning effects from repetitions exist. Inexperienced gamers exhibit larger learning effects than experienced ones. The advantage of the additional damping filter over the pure square type approach becomes significant with experienced gamers.

These conclusions are drawn from an experimental series that is based on automated logging of data while test participants are playing a game. This approach therefore falls into the category of applying quantitative methods in game design. The method is also referred to metric game design (see [11]). This is an approach that becomes increasingly popular in online game design and is also picked up by academia like in the publication of Zamitto et al. [12].

2 Test Design and Procedure

Measuring values on a control scheme in an actual game is difficult because in a real game many effects accumulate and causal dependencies can be hardly isolated. We opted for the implementation of a specific test bed that avoids those problems. Within the measurement program a test participant has to steer a reticule with the right analogue stick of a XBOX 360 controller over several markers shown on the screen.

Participants were asked to complete a series of 64 aiming trials. Participants were not given any practice period prior to the experimental trials so they could not familiarize themselves with the experimental procedure. In each trial the participants saw a target marker and were asked to steer a reticule as fast as possible by using the right analogue stick of the XBOX controller. After reaching the marker, another marker appeared which the participant should reach as fast as possible. Each trial consisted of ten target markers visible one at a time.

A marker was considered reached when the reticule came to a complete halt within a radius of 10 pixels of the target. Target markers were generated randomly. In order to provide comparability, markers were always 100 to 300 pixels apart and the distance of two consecutive hops between markers was always 400 pixels. As a consequence, the total distance covered for 10 markers was always 2000 pixels. The screen resolution was set to 1024*768 pixels. Several measurements were taken while a series of ten markers are completed.

This test bed was chosen because it reflected well the basic shooter mechanics of aiming in a very isolated and easy to measure way. In shooters the player also has to move a reticule over a defined target and then needs to press a fire button. Measurements were extracted during the experiment for a trial of 10 markers.

The study was a 4*4 design. The predictor variables were filter technique (no filter, square type filter, damping filter and ballistic filter) and frame rate (60 fps, 30 fps, 20 fps and 15 fps). As a consequence the latency time between joystick input and shown frame were 16.67ms, 33.33ms, 50.0ms and 66.66ms. All factors were within-subjects and there were four repetitions of each condition. The orderings of each condition were randomly assigned to each participant to compensate for possible learning effects across conditions. The criteria were total time to finish each trial (in seconds), proximity time (time within 50 pixels to the goal in each trial, measured in seconds), travelled distance with the reticule on the screen (in pixels) and travel velocity (calculated by travel distance/total time).

A series of 64 trials got automatically executed with each participant. The final results got written to three comma separated value files that can easily be imported into Excel for further analysis. Thirty volunteers participated in the study as part of study requirements in psychology at the University of Trier (Germany), with age ranging from 18 to 29 years, mean 21.6. Thirteen participants were male. Participants' game playing experience was also recorded, as it is possible that this is a confounding factor. Seventeen reported having experience with game consoles. The two statistical methods applied in this study are the and the Bonferroni-Holm t-Test procedure [13].

3 Results

To test our first hypothesis, we performed a 4 (filter) * 4 (frame rate) * 4 (repetition) repeated-measures ANOVA on the proximity times with game console experience as a between-subjects variable. We chose proximity time for our main analysis because we think that here the influence of filter techniques will be seen most clearly in the data. It will be recalled that we suppose that filter techniques improve control quality. In particular, the damping filter seemed most promising to us. A significant difference for filter technique ($F_{3,81}=52.936$, $p<.001$) was found. Post-hoc, Bonferroni-Holm corrected (2-sided) t-tests revealed that the damping filter led to significantly shorter proximity completion times than the square type filter (t_{28}=2.93, p=.007). The square type filter led to significantly shorter times compared to the no filter condition (t_{28}=5.19, p<.001). The square type filter is even better than the ballistic filter (t_{28}=5.543, p<.001). The ballistic filter is better than no filter (t_{28}=4.162, p<.001). The ranking is therefore: Damping filter led to the shortest times, the square type filter was second, the ballistic filter third, and the worst was no filter. As the damping and the ballistic filter had the square type filter as a preprocessing step, the additional component in the ballistic filter itself made things worse. This is no surprise as the ballistic filter has the opposite impact of the damping filter.

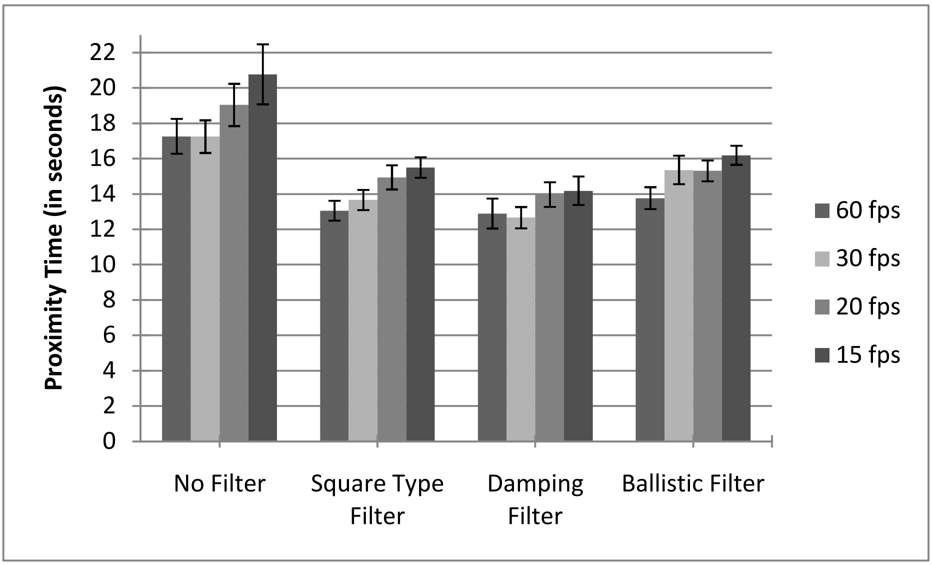

Fig. 1. Proximity times by filter technique and frame rate. Error bars show standard error

Our second hypothesis concerned the influence of frame rate on control quality. Our primary analysis was here the aforementioned 4*4*4 repeated-measures ANOVA on proximity times. A higher frame rate should lead to shorter proximity times. The analysis revealed highly significant differences in proximity times regarding frame rate ($F_{3,81}$=18.304, p<.001). Post-hoc, Bonferroni-Holm corrected (2-sided) t-tests revealed that proximity times for the highest frame rate (60 fps) were slightly shorter than for the condition with 30 fps, but this difference did not reach statistical significance (t_{28}=1.971, p=.059). The proximity times in the 20 fps frame rate condition were significantly longer than in the 30 fps frame rate condition (t_{28}=2.849, p=.008). Therefore, a higher frame rate led to shorter times in our aiming task. This effect was most pronounced between the frame rates of 30 fps and 20 fps. The latter (and even more the frame rate of 15 fps) should be avoided to improve control quality.

Interestingly, the frame rate had no influence on the filter performance: the interaction of frame rate and filter did not reach statistical significance ($F_{9,243}$=1.279, p=.249). In another 4*4*4 repeated-measures ANOVA we analyzed whether frame rate had an effect on travelled distance. This is not the case ($F_{3,84}<1$).

Our third hypothesis is concerned with learning effects from repetitions. To verify this assumption we computed the 4*4*4 repeated-measures ANOVA on proximity times mentioned above. A significant influence of repetition was found ($F_{3,81}=17.36$, $p<.001$). Post-hoc, Bonferroni-Holm corrected (2-sided) t-tests revealed shorter proximity completion times with every repetition (Trial 1 to Trial 2: $t_{28}=2.584$, $p=.015$; Trial 2 to Trial 3: $t_{28}=4.249$, $p<.001$; Trial 3 to Trial 4: $t_{28}=2.832$, $p=.008$). As stated in the introduction, we found larger learning effects for inexperienced gamers. The interaction of repetition and game console experience was significant ($F_{3,81}=6.214$, $p=.001$). For inexperienced gamers the difference between Trial 1 and 2 was not significant ($t_{11}=2.128$, $p=.057$) whereas the differences between Trial 2 and 3 ($t_{11}=3.377$, $p=.006$) and Trial 3 and 4 ($t_{11}=3.95$, $p=.002$) were significant. The inexperienced gamers got faster with every repetition. Experienced gamers showed a significant improvement from Trial 1 to 2 (t16=2.503, p=.024) and from Trial 2 to 3 ($t_{16}=2.997$, $p=.009$) but not from Trial 3 to 4 ($t_{16}<1$). Experienced gamers did not get faster after the third trial.

Furthermore, we took a closer look at the interaction of filter and game console experience, which was also significant ($F_{3,81}=13.808$, $p<.001$). This interaction could also be interpreted as a learning effect. Maybe experienced gamers need other filter techniques or take better advantage of certain kind of filters. In post-hoc, Bonferroni-Holm corrected (2-sided) t-tests the difference between the square type filter and the damping filter was significant for the experienced gamers ($t_{16}=6.503$, $p<.001$) but not for the inexperienced gamers ($t_{11}<1$). Thus, the proximity times were significantly shorter using the damping filter, if the user has game console experience. For inexperienced gamers in our experiment, using the square type filter did not lead to significantly longer proximity times than using the damping filter.

4 Conclusion

In this paper we showed that applying filters for analogue joysticks on joypads may significantly improve aiming velocity in shooter type playing scenarios. Several filtering types and their consequences were discussed. Of the discussed filters the damping filter that contains the square type filter as a preprocessing step was the best. This is consistent with the observation that the ballistic filter is worse than the square type filter, as the impact of the ballistic component is the opposite of the damping component.

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Naming Virtual Identities: Patterns and Inspirations for Character Names in World of Warcraft

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Abstract. The abstract should summarize the contents of the paper and should People are increasingly interacting via online services - from forums, online communities, social networks and online computer games. While there has been considerable research on the motivations and communication of people online, as well as the social environment provided by online services, large-scale analyses of the virtual identities people use online are rare. In this paper, the first large-scale analysis of virtual identities in the massively multi-player online game WORLD OF WARCRAFT® is presented based on a dataset of nearly eight million avatar names and associated information. The results presented highlight the inventiveness of the names the users of WORLD OF WARCRAFT® express in terms of naming their virtual identities and the varied nature of the sources of inspiration for these names, which range from mythology, literature, popular culture, real-world names and others. The results also indicate that how players name their characters is influenced by the aesthetics and game function of the characters. The server type also appears to have an impact on player naming strategies, with role-playing servers forming a distinct cluster from Player-vs-Player type servers. Additionally, the analysis presented reveals that character name frequencies follow, similar to real-world names, a power law distribution.

Keywords: online identity, WORLD OF WARCRAFT®, character, avatar.

1 Introduction

A virtual identity or online identity is a social entity that an internet user establishes in an online community. One of the many forms of online communities in existence are formed by players interacting in the context of Massively Multiplayer Online Games (MMOGs) [1]. These digital games form entire virtual societies where users control avatars, or more precisely characters, interacting with the elements of the world as well as with other players [2, 3]. Online identities are of scientific interest because technological development has enabled people to interact via networks on a worldwide basis, not the

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least through Internet based applications [4]. Digital online games form a vehicle of entertainment and socialization, and the number of users are increasing with the increased adoption of networked technologies in contemporary society [2, 5, 3]. Understanding how people operate online, the identities they assume, motivations for behavior and their interactions with each other and various environments (web forums, online games, social sites ...), is vital to the evaluate the effect network technologies have on human society as such. In the specific context of digital online games, the analysis of game characters (identities) is also of interest because it builds understanding of the people that play these games, whether for research- or commercial purposes. From the perspective of game development, analyzing characters informs design about the associations that the target audience have with specific names or features, thereby acting as a guide towards the design of e.g. non-player characters (artificial agents), where name, appearance and other features can be matched with the mindset of the players to evoke specific reactions. Hundreds of MMOGs are currently in existence, although one dominates the market in terms of the sheer number of people that play the game and form part of the associated online community: World of Warcraft (released 2003) with its reputed 12 million players[1]. WORLD OF WARCRAFT® (WOW) is fantasy-themed. The players control a customized character, which forms the main vehicle for interacting with the virtual environment, and the creation of which is a source of considerable attention from the players [6]. The game poses a variety of challenges, including various types of quests, teamwork assignments, as well as an in-game economic system [7]. The player will at any one time control one character, but can have multiple characters. Rather than interacting within the same virtual environment, players are distributed among hundreds of copies of the game (also called realms) [8].

Characters in MMOGs such as WOW have several traits that appear with more or less consistency across games of this type, notably: an appearance (typically a 3D avatar), specific abilities related to the game mechanics (which determine their effectiveness in different contexts), a name (usually the only truly unique feature of a character in a specific game), relationships with other characters, specific behaviors, and MMOGs typically contain some sort of character development system, although this can be limited to changes in e.g. appearance. Finally, characters often have a degree of persistence, which can cover years of real-time [2, 3]. In WOW, the characters the players control have names that are unique within the context of a specific realm. Creating a character is a process of making a set of foundational gameplay choices, e.g. a player must choose a race (e.g. Human, Orc), which impacts on the appearance of the character, and a class (e.g. Shaman, Mage), which impacts on the abilities of the character (e.g. a Warrior is a close-combat specialist). Previous research on WOW R indicates that character name, appearance and functionality are somehow linked (e.g. [9]), however, previous research is limited in terms of sample size and adopts informal methodologies. Here a mixed-methods explorative approach is adopted, based on 7.93 million characters from WOW. This is the first time - to the best knowledge of the authors - that a large-scale investigation of games has focused on virtual

[1] According to the developer, Blizzard Entertainment:
http://eu.blizzard.com/en-gb/company/press/pressreleases.html?101007

identities. The methodology presented thus forms a contribution in its own right, in addition to several new insights, e.g. that the appearance and game function influences the names chosen for characters. Essentially, the names players give to characters on Role-Playing, RP, realms show differences from those of Player-vs-Player, PvP, and Player-vs-Environment, PvE, realms. The sources of inspiration for character names were investigated for a sample of 120,000 characters, indicating diverse sources of inspiration for character names, and that names with a negative semantic meaning (e.g. ”Nightmare”) are more than six times as common as those with a positive meaning (e.g. ”Hope”).

2 Previous Work

There is a substantial amount of research on virtual identities in online environments, notably Internet web communities, although most of this from sociological and communication perspectives, with limited large-scale quantitative work [11]. To the best knowledge of the authors, large-scale (millions of users) computational studies of the names people adopt in virtual environments, web communities and similar, have not been carried out before. However, Massively Multi-player Online Games (MMOGs) as WOW have for the past decade attracted the attention of researchers, notably sociologists, etnographers, design researchers as well as people working with communication and economy (e.g. [2, 12, 5, 6, 3]).

The investigation of the players of MMOGs have also included the mining large-scale user-telemetry datasets, mainly for the purpose of either investigating the players themselves [13, 14], informing game development [15] or for the development and testing of data mining algorithms for complex datasets [16]. Although prior large-scale work on user telemetry mining has not focused on the identity aspect or names specifically, it is worth mentioning as future research may show that e.g. motivations for play and the choices made during character generation correlate. User telemetry is in the context of digital games quantitative data about player-game and player-player interaction, and is generally compiled in databases from logs provided by game clients, or alternatively by extracting data directly from game servers [15, 14, 16]. Any action initiated by either a player or the game software can be recorded, from low-level data such as button presses to in-game conversations. In the current case, the user telemetry is mined from a repository (the WOW census site) which obtains the data from the game. The relationship between players and characters in digital games has formed one of the main lines of investigation [2, 17, 18]. However, while the virtual identities of players and the social dynamics of game world communities have been the subject of hundreds of research papers, only a limited number of these consider the names of player characters in detail: [19] examined the cross-modal compensation between name and visual aspect in WOW avatars (player characters), based on a non-random sample of 1261 names. The study was limited to consider whether name properties were affected by the visual aspect (human vs. non-human differentiation only) of the character. A main conclusion was that female names contained more vowels than male names. [20] investigated the relationship between the ”capacity” of characters (their skills and abilities in terms of game mechanics) and their appearance. The study is qualitative and the sample size is unspecified, but the author concludes that capacity and appearance is connected and provides a means of player identification. [9] Collected a non-random sample of 1366 names of WOW characters, including race, class, gender and level information at the time of observation. The work appears to be purely observations, as the author does not write how the names were analyzed nor any statistical properties of the dataset, but conclude that names for all races in the game were ”equally strange, odd and funny”, and that there was no observable difference between low-level and high-level characters.

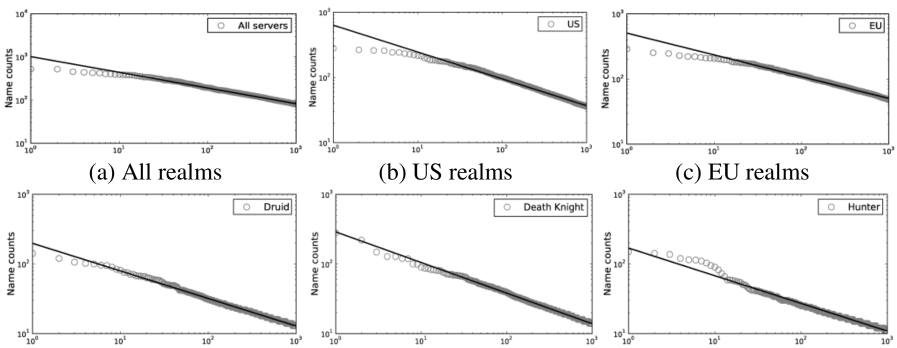
Table 1. Basic statistics of the character name dataset. We collected a total of 7,938,335 character names. The realm-types specify if the particular world is hostile (PVP), friendly (PVE), or targeted towards role playing (RP) which prohibits non-medieval character names.

(a) Location			(b) Realm type		
Location	# characters	# unique names	Realm type	# characters	# unique names
All	7,938,335	3,803,819	PVP	3,128,464	1,869,481
Europe (EU)	3,378,589	1,820,269	PvE	3,884,205	2,207,478
United States (US)	4,559,746	2,495,960	RP	619,892	499,481

[9] Also describes a hypothesis that names between RP-servers and other server types would differ, but is not able to verify this (any methodology used is not described). The author does, however, describe a variety of sources or inspirations for names, including various mythologies, but no analysis of e.g. relative frequencies of these sources. [9] Also communicated with an undisclosed number of players about the sources of the inspirations for their character names, obtaining a variety of explanations. He highlights that: ”in WOW R it is the name more than appearance that distinguishes avatars, and thus players, from each other”, referring to the limited customization options available in terms of character appearance, but the virtually unlimited options in naming characters, despite the restrictions imposed by the game’s Terms of Use. While an in-depth study of a few cases, the work of both [9] and [20] lacks evaluation and the sample size to hold substantial explanatory power.

3 Statistical Analysis

We gathered all 7,938,335 character names from the 50 largest guilds on each EU and US WOW realm from the WOW census site www.warcraftrealms.com. 4,559,746 character names belong to US players, 3,378,589 to EU players. The amount of character names distributes almost equally on Player-vs-Player (PVP) and Player-vs-Environment (or Engine) (PVE) realms. Role-Playing (RP) realms make only less than 10% of the total number of names. Detailed numbers on the used dataset can be seen in Table 1). For a statistical analysis of the distribution of the name frequencies, we first preprocessed the dataset and replaced any special characters (e.g. the acute accent ”`”). Then, we computed histograms of name occurrences for each realm or realm-type. Overall, we computed 35 different histograms from selections of the original data. The selections correspond to realm types (All realms, US realms, EU realms, PVP realms, US-PVE realms, . . .); the various classes (Priests, Druids, . . .) and races (Trolls, Orcs, Humans, Undead, . . .). The total number of counted character names varies among the different categories, going from a few hundred thousands to approx. 8 million for the "All realms" category. The number of unique character names follows a logarithmic function dependent on the total number of characters, as can be seen in Fig. 3(b) i.e. that increasing the number of names in a sample provides diminishing returns in terms of increasing the number of unique names.



(a) All realms (b) US realms (c) EU realms

(d) Druid class (e) Death knight class (f) Hunter class

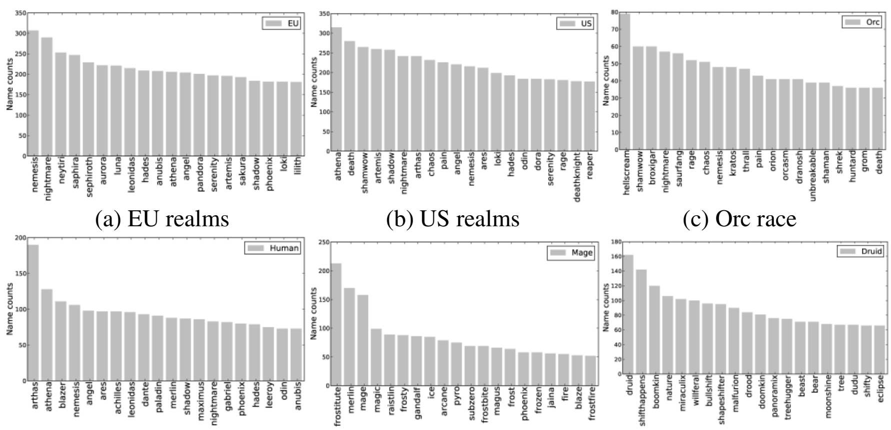
Fig. 1. Rank-frequency plots for different selections of the character name dataset. Both axes are logarithmically scaled. The y-axis denotes the total count for a particular name, the x-axis denotes the rank index (the left most ranked name has the highest number of occurrences).

3.1 Character Name Frequencies

It is known that the frequency of family names in many countries follows a power law distribution. Informally, this means that the second most popular name appears half as often as the most popular name, the third most popular names appears half as often as the second most popular name, and so on. Formally, a quantity x obeys a power law if it is drawn from a probability distribution $p(x)\ \alpha\ x^{-\alpha}$, where α is the scaling parameter or exponent [21]. Power laws are commonly found among various quantities in physical, biological, and social systems. In certain contexts they are referred to as Zipf's or Benford's law (see e.g. [22]). Popular examples include the number of citations of scientific papers, word frequencies in books, or populations of cities. As a thorough review of power law distributions is beyond the scope of this work, we recommend [23] for a general introduction and insights in their explanation. While it is reasonable to assume a power law distribution for the character name frequencies, after all this seems to be very similar to the distribution of real-world family names [10], there are two important preconditions that make character names differ from family names: First, a character name might only appear once per realm. While players are sometimes using special characters (e.g. German umlaut) to get around this limitation, it still influences the possible choices for a name. Second, unlike family names or real names, the choice of a name is unrestricted, only certain names that violate the Blizzard Naming Policy are forbidden (but see below).

For validating the power law distribution assumption, we fit a linear function to the logarithmically scaled rank-frequency plots of the 1000 most frequently occurring names. Some resulting rank-frequency plots of the name frequencies can be seen in Fig. 2, and of the fitted linear function in Fig. 1.

The power law assumption holds for all 35 separate data selections. The overall worst accuracy for the linear predictor is achieved for the "All realms" category and achieved a standard error σ of 0.0025, see Fig. 1(a) ($\sigma = \sqrt{\sum_i^n (x^i - x'^i)2/n}$, where x' denotes the predicted value and n the number of considered names). Note that σ is computed for logarithmically scaled values (also note that fitting a linear function is not the most accurate way of verifying a power law assumption [21], however, given the very high accuracy of the linear fit this is negligible). A first important finding from the analysis is that all character name frequencies follow a power law distribution. With an increasing total number of character names, e.g. for the "All realms" category, it shows that the standard error σ is increasing. However, the approximation accuracy is still high. A possible reason for the increased σ might be the constraints imposed on character names (e.g. the *one name per realm* constraint).



(a) EU realms (b) US realms (c) Orc race

(d) Human race (e) Mage class (f) Druid class

Fig. 2. Ranked character name counts for different selections of the character name dataset. Each plot shows on the y-axis the total number of name occurrences, and on the x-axis the corresponding name. The x-axis is sorted s.t. the most frequently occurring name comes first. It can be seen that the name counts roughly follow a power-law distribution.

3.2 Character Name Distributions

For comparing the name distributions across categories, we embedded the histogram L1-distances into a 2D space by means of Isomap [24]. The resulting embedding can be seen in Fig. 3(a). Categories (different realm-types or classes) that are close together also have a similar character name distribution. Categories that are far away from each other have a smaller overlap in character names. Fig. 3(a) shows two important findings: First, the names on US and EU realms have a rather large distances. However, this does not apply to Role-Playing (RP) realms. The plot shows that RP realms seem to have a larger overlap for US and EU realms. Second, there seems to be a separation in character names between the more human-like (Human, Blood Elf, Night Elf, Draenei) and less human-like ("bestial")/human-proportioned (Troll, Undead, Orc, Tauren, Dwarf, Gnome) races. A possible explanation for this might be the uneven distribution of male and female characters and names for certain races. We found that for the less humanlike races, there is a tendency towards male characters, whereas for the more human-like races we observed more female characters. However, in showed that this is not the reason as for only male and only female character names the results look almost identical.

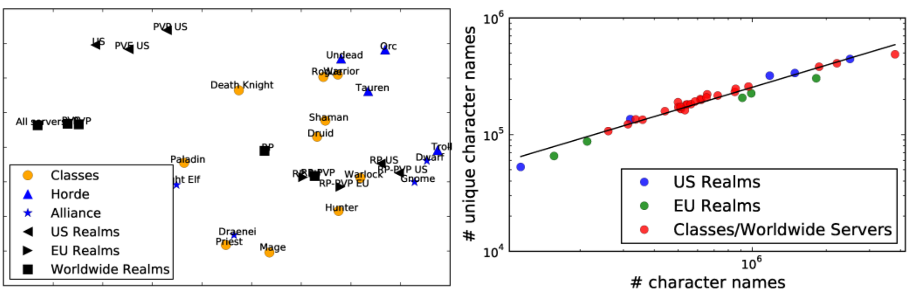


Fig. 3. Fig. 3(a) shows 2D-Isomap projection of histograms of character names for different categories. Categories which are closer together (e.g. "Undead" and "Orc" in the upper right part corner) have a larger overlap in character names. Fig. 3(b) shows the ratio of unique names and total number of names for different categories: the x-axis shows the number of unique names per category, the y shows the number of players. Both axes have a log-scaling.

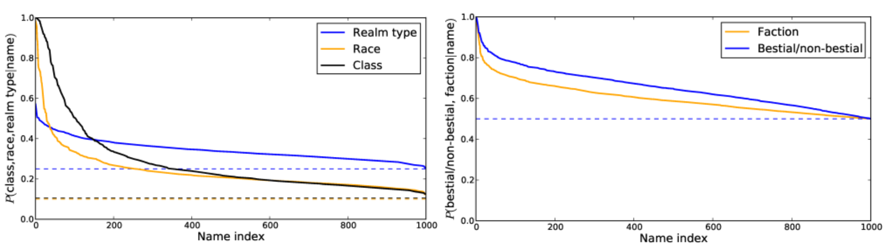


Fig. 4. Probabilities for a specific class, race, server type, faction (Horde or Alliance), and human-like/less human-like race given the character name. The probabilities are evaluated for the 1000 most popular names and the highest probability is selected. Afterwards, the names are sorted according to their highest probability. It can be seen that, for example, the player class (left figure) and faction (right figure) influence character names to a certain extent. The dashed lines denote probabilities for random selection for the corresponding feature.

To further investigate the separation in character names according to races or classes, we evaluated a simple predictive model for character names. The idea is to estimate conditional probabilities of a particular class, race, or server type given a character name, e.g. how likely is it that a character named ”Gimli” is a ”dwarf”? We estimated these probabilities for the 1000 most popular names as we here have a sufficiently large sample set (probabilities are normalized by class/race/server-type priors s.t. we do not punish seldom selected classes etc.). In particular, we were interested in the uniqueness of a specific name with respect to a particular class or race. This indicates which variables influence player naming decision. Some results can be seen in Fig. 4. The most influential features appear to be the player class, player race (which of course influences human-likeness), however, the server type and faction also give hints on player naming decisions.

4 Sources of Inspiration

In order to evaluate the sources of inspiration for the names people give their characters in WOW, a variety of computational approaches were considered. However, the sheer variety of character names in the dataset (approximately 3.9 million. Note that umlauts were removed during pre-processing, so any names like ”Gändälf” and ”Gandalf” were aggregated) eliminated all standard computational approaches. We therefore opted for an explorative categorical coding [25] approach for a sample of 1,000 character names. Rather than randomly selecting these, the most common names in the dataset were chosen. This has the effect of increasing the effective sample size, as the 1,000 most common names in the dataset comprise the names of 128,058 characters. While a respectable sample size (roughly 100 times larger than e.g. [9]), this represents only 1.6% of the total dataset, which means that making inferences from the sample to the entire dataset should only be done on an indicative basis. 38 coding categories were defined, 10 occurs only once, 11 from 2-10 times (Table 2). Determining the inspirational source for a character name is an exercise in estimation, due to the sheer variety of potential sources. For example, the name ”Raziel” stems from cabalistic theory and is the name of an angel. However, the same name has also been used for computer game characters, in fiction books etc. A similar problem exists for the names associated with Greek, Roman, Germanic, Nordic, Mesopotamian and Japanese mythology located, e.g. ”Odin”, ”Athena” or ”Amaterasu”. These names have been used in different contexts (film, literature, games) and in these cases it was necessary to code the names after the original myth they stem from. This does not mean that the players using these names were inspired by reading books about mythology, but at least it provides an accurate point of origin for the names. In comparison, names such as ”Naruto” and ”Luthien” are easier to place. The first stems from a major Japanese manga series of the same name, whereas the latter stems from J. R. R. Tolkien’s fantasy world. Neither name has been used in other major contexts, which means that a best case for the source of inspiration of the names is the major popular culture/literature works they originally appear in. The most common category is real-world normal names (186), e.g. ”Ella”, ”Yuki” and ”Jack”. As with names originating in mythology, at least a proportion of these normal names can also be found in popular culture (film, TV, games etc.), and it therefore cannot be determined what the exact source of inspiration for the players adopting these names were. In order to explore the potential sources of character names, searches were performed on Google and web-based resources like Wikipedia.org. Care was taken to explore multiple potential sources in depth where these were apparent. 697 names could be identified and classified in this manner Table 2. The remainder were nouns and verbs of unspecified nature but semantic meanings. Tentatively, these can be categorized into three classes: 1) Negative (156 counts): These are names that have “negative/dark” connotations, for example ”Nightmare”, ”Sin”, ”Fear” and ”Requiem”; 2) Positive (22 counts): These are names with distinct positive/”light” connotations, e.g. ”Hope”, ”Love”, ”Pure”; 3) Neutral (125 counts): These are names with no obvious negative or positive connotations, e.g. ”Who”, ”Moonlight”, ”Magic” and ”Snow”. Future analysis will go into more detail with the semantic meaning of these categories.

Table 2. Coding category and corresponding frequency counts based on the 1000 most popular character names

Count	Coding category	Description
186	Normal name	Common name
156	Negative (semantic)	Unspecified noun or verb with negative connotations
125	Neutral (semantic)	Unspecified noun or verb with neutral connotations
79	popular culture (film and TV)	Reference to a character from a movie or television show (including animated series)
73	Greek myth	Name of an entity in Greek mythology
47	popular culture (games)	Reference to a character in a digital game
43	popular culture (comics)	Reference to a character in a comic book series
39	Class reference	Reference to a character class in WOW
39	Fantasy literature	Reference to fantasy literature
22	Positive (semantic)	Unspecified noun or verb with positive connotations
18	Biblical	Name from the Bible
18	Game functional	Reference to the function of the character class
18	WOW myth	Reference to a name/place in the WOW world or history
17	Kabbalistic belief	Typically the name of an angel in Jewish mysticism
15	Humor	Humoristic name
15	Nordic mythos	Name of an entity in Nordic mythology
11	Performance reference	Reference to the performance of the player’s character
10	Egyptian myth	Name of an entity in Egyptian mythology

In summary, a number of conclusions can be drawn: 1) Regular real-life names are the most common (186 counts). 2) Names with negative semantic meaning were more than six times as common as those with positive meaning. The reason for this tendency can only be speculated about without an in-depth inquiry among the players of WOW, but is possibly related to the emphasis on conflict in the game. 3) 164 names have an origin in mythology or the Bible, with Greek mythology being by far the most popular (73 counts). 4) 174 names in the list relate to popular culture, mainly characters from digital games (e.g. ”Zelda”, ”Raiden”, ”Kerrigan”), films, television series (manga series like ”Bleach” and ”Naruto” being particularly popular), and comic book superheroes (e.g. ”Goku”, ”Hawkeye”, ”Electra”). 5) Of the 39 references to fantasy literature, only four do not stem from the works of J. R. R. Tolkien. 6) Character names to a substantial degree are in breach of the Terms of Use of WOW[2]. The restrictions specify that names can be only one string of text, with no special characters and of limited length. This is enforced during character creation. Names may not be offensive, or belong to a popular culture figure from e.g. film or TV (something players blatantly ignore), contain or be similar to a trademark, have religious significance, be related to a real-world person (131 counts of ”Chucknorris” occur in the dataset) or related to any of Blizzard's Warcraft products, but the name ”Sylvanas” occurs 129 times and ”Jaina” 148 times, both names of WOW characters)[3]. The restrictions on names - apart from the physical limits on text string length etc. - appear to be somewhat unenforced, maybe due to the challenge of collating and updating lists of all potential names in breach of the Terms of Use, and cross-comparing these with the millions of player character names, would be extremely resource demanding.

5 Conclusion

The study of online games and the people who play and interact through them is of importance to the general evaluation of how new technologies impact on human behavior [2, 5, 3, 1]. Investigating the identities of players in online games is of direct value for two main reasons: 1) It informs about the people who play these games - whether as objects of research inquiry or for target group analysis in the context of game marketing; 2) It provides information for the design and development of games in terms of how names, appearance and other features of characters are perceived by the players, and thus e.g. guidelines for how to utilize these features in the design of non-player characters (artificial agents) to evoke particular associations in the players. The research presented here provides evidence for a staggering variety in the names chosen by players of WOW R - 3.8 million unique names in a sample of 7.93 million, which is notably remarkable given the restrictions imposed. It highlights the imaginativeness employed in naming characters, indirectly supporting earlier work such as [6, 19] in concluding that the choices made during the character creation process are important to the players. Character names also follow the same kind of log-distribution as real-world names - despite MMOGs being only about 1.5 decades old and restrictive in terms of name choices. The analysis also shows that the appearance of a character and its functionality within the confines of the game plays a role when a player of WOW selects a character name - to a degree where it may be possible to develop predictive models which can assist game developers to evaluate player populations based on character names and similar sparse data.

The link between name and character features is also evident in the marked difference in the names given to characters from the ”non-bestial” vs. ”bestial” races (including, surprisingly, the otherwise non-bestial but also non-humanly proportioned Dwarves and Gnomes), where predictive modeling indicates a strong differential(Fig. 4); or the differences in names when viewed across character classes (Fig. 2). It is also

[2] *http://us.blizzard.com/en-us/company/legal/wow_tou.html*

[3] The names can also be found in the WOWCensus system *www.warcraftrealms.com*

shown how the kinds of rules that provided for interaction between players impact on how they name their characters - as is evident in the contrasts between PvP and RP servers, similar for choice of race. The work presented here also emphasizes the variety of inspirational sources evident in the sampled character names.

The work presented also posits new questions, e.g. why certain types of name inspirations are more common than others, and why there is variance in the diversity of names within specific classes of the game, e.g., characters of the Mage class exhibit a higher variety of names than for the other classes. There is also a variety in how many times the most popular names occur - for example, the name ”Hellscream” is the most popular among the Orc characters (almost 80 counts), but for the other races the most popular name is more frequent (e.g. Draenai over 130 counts of ”Neytiri” and for Humans over 180 counts of ”Arthas”). The quantitative analysis presented here does not permit any conclusions to be made about these questions, which require communication with the players directly, but opens up the perspective that the distributions of names is not random but highly affected by the environment they are used in relation to. Possibly, this is also the case for other types of online environments, although the lack of large-scale analysis of online identities in e.g. web forums or social networks prevent any conclusion to be made in this regard.

Due to space limitations, we could only present a fraction of results developed based on the described dataset. Additional results based on another dataset from the WOW
armory will be reported on elsewhere or in an extended version of this paper (please note that results from other data sources support results presented here). In addition, future work will focus on adding to the details of the results presented, investigate approaches such as topical profiling (the definition of association strengths between words via mining the internet) for automating name classification rather than explorative coding, add additional character features to the analysis and examine correlations between sources of inspiration for names and character features, aiming to improve the predictive potential of name-based classification.

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The Looking Glass: Visually Projecting Yourself to the Past

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Abstract. Memories define us as individuals and are considered a special aspect of one's life. We try to preserve our memories as much as possible by taking pictures, videos, or through any form of documentation that we can revisit later on in our lives. Our goal is to design an immersive system that allows rich documentation of the past and interactive 3D-revisitation of the stored reflections in the future. Our prototype system, *the Looking Glass* captures human experiences and allows users to interactively explore them. Our system, unlike classic methods of documentation, extends the experience of visiting memories beyond viewing, and affords an immersive interactive experience. *The Looking Glass* is envisioned to provide a 3D visual experience of revisiting past scenes, allowing a more entertaining and emotionally engaging personal approach to re-experiencing past memories. This short paper presents our research motivation and design approach, details our implementation efforts, and current prototype.

Keywords: affective interaction, immersive media, interactive art, 3D scene extraction, 3D motion capture, time travel, self-reflecting entertainment computing.

1 Introduction

Documenting the past has been a part of human society since the dawn of civilization. Humans were, and still are, documenting their lives with any media accessible to them, from cave drawings to books, journals, and so forth. Our current technology provides plentiful means of documenting the past, such as pictures and videos. We document our past so that we can revisit our past experiences at a later time, to be able to recollect them in case we forget, or to be able to contribute and share them with our various communities, or in order to contribute to a collective knowledge. However, the most common reason for documenting is often very personal; we want to be able to hold on to moments for a little longer, to be able to somehow revisit a cherished memory.

With our current technology, our methods of revisiting the past are limited to viewing, listening, or reading, and the rest is left to one's imagination. A person may be content to just view the past, but we argue that the ultimate way of revisiting it is through time travelling (regardless of whether this is a physically impossible

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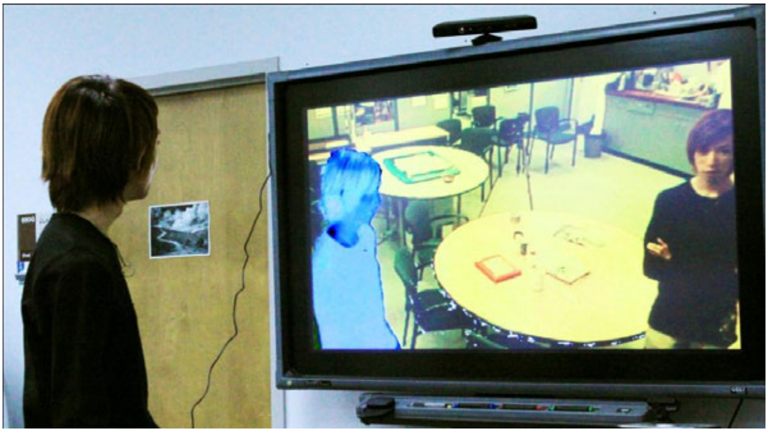

Fig. 1. *The Looking Glass* is an interactive installation exploring a limited time traveling technique. It projects a user to a captured scene in real-time.

endeavor). Through time travel, a person will be able to see and re-experience a memory first hand. One will be able to encounter past entities, travel to places which may have been physically altered over the years and visit them in their past form, and meet and interact with people that occupied these past spaces and may have been long gone since. We believe that being able to interact and participate while reflecting on past memories will be dramatically more engaging than simply viewing a past scene, or hearing or reading about it. While our current exploration goal is to seek the artistic and entertainment value of this idea, it may also lead to psychological and rehabilitative applications, such as assisting people dealing with painful past events in their lives and with posttraumatic stress disorder (PTSD) [6], or perhaps, maybe helping people with conditions affecting memory such as Alzheimer's disease. We believe that through active presence and immersion, users will have a higher emotional engagement when they revisit past memories, making the experience more engaging and personal.

However, we currently do not have the physical means to travel back and forth in time, thus revisiting the past in the said manner is practically impossible. As a substitute, we are designing *the Looking Glass*, an interactive installation which attempts to explore a limited variant of time travelling.

Inspired by *scenedows* and *slow glass,* in Bob Shaw's *Light of Other Days* [7], which are engineered glasses used to trap light for a definite amount of time allowing it to capture reflections of sceneries and or people, thus creating an illusion of a 'captured scene', we are designing an interface that attempts to perform this 'capture a scene' action. Since our inspiration emerged from the story's physical form of glass, we designed our system such that it allows its users to see their reflection in the scene itself. Our prototype is named *the Looking Glass* in lieu of Lewis Carroll's novel, *Through the Looking-Glass*, where in the main character, Alice, enters an entirely different world, which is somewhat reflective of her own, through a mirror [2].

In this paper we present our current prototype of *the Looking Glass,* an interactive 3D documentation and revisitation installation which is designed to provide a limited time travel-like experience, enabling 3D interactive revisitation of past memories

(Fig. 1). We believe and argue that the ability to project oneself into the past in a rich, 3D immersive manner can open up novel layers of revisiting memory, well beyond simple viewing.

2 Related Works

We detail here a few related works that address the issue of Time and its representations. Jussi Ängeslevä and Ross Cooper created a system called *Last Clock* [1] which displays a space's history and rhythm through an analog clock-like visualization of time. According to them, the created mandalas of archived time show an overview of a given space's dynamics, history, and complex information such as captured activities and motion. These are continuously updated and can be used to inform people who are unfamiliar with certain spaces about a space's dynamics.

Another relevant effort is Gutwin's *Traces* [3], – a visualization of past movements which helps users gain interactive awareness and perceive one another more clearly and accurately. Gutwin's work was later extended in *Timeline* [5], a visualization that allows users to rapidly explore the history of a video stream to gain better insight about the activities and availability of other people.

The *Family Window* [4] is a domestic media space that allows the connections of separated families through video connection. The *Family Window* has a 'time shift' capability which records videos containing activities and then sends it to the other household for viewing at a later time. Through the 'time shift' mode, families separated by time zones can pretend to be at the same time and place. Similarly, *CU-Later* [8] was designed to by-pass the time difference between two locations to connect people together.

While these projects are closely related to our work, we believe that *the Looking Glass* is unique. *The Looking Glass* is an attempt to visualize the past in an interactive fashion not for communication purposes, but rather for self-reflection. The visitor's experience is the focal point of our design. The past entities being revisited, places, and people, may be long gone, and we are not trying to by-pass time to communicate with them. *The Looking Glass* also attempts to push the revisitation experience into the realm of 3D immersion, employing 3D scene mapping and motion capturing techniques to create a revisitation experience which is as interactive as possible.

3 Design and Implementation

Our current prototype for *the Looking Glass* is designed to allow real-time capturing and storing of past scenes, as well as a later projection of a visitor into the past scene through augmented reality. Our current prototype is using the Microsoft Kinect, with its available OpenNI (Open Interaction) development kit[1], and is coded in C# WPF. *The Looking Glass* prototype makes use of the Kinect's ability to capture video feed and depth information. The video feed combined with the range data allows future reconstruction and 3D rendering of the previously captured scenes.

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[1] From the OpenNI website: http://www.openni.org

For *the Looking Glass'* to be an integral component of people's lives, we envision that it should be able to capture scenes "infinitely" such that a person can browse and ultimately revisit any point in the past, within the physical confines of the system's field of view. Once installed, the Kinect should no longer be moved, and is capturing the scene continuously. Also, the system should be non-intrusive; almost invisible to the people being captured, to remove the awkward feeling of being watched or recorded which may affect the genuineness of a scene being captured. With this in mind, we have implemented *the Looking Glass* to act like a mirror with a computer monitor acting as the mirror itself, while the Kinect sits nearby acting as a sort of physical ornament (see Fig. 1). Through this setup *the Looking Glass* acts as ubiquitous furniture, a part of the room itself; this makes it non-intrusive.

The main functionalities of *the Looking Glass*' current prototype are *capturing* and *revisiting*. Our current design does not include audio capturing, a feature that is supported by the Kinect, and we are hoping to integrate in our future design.

Capturing. *The Looking Glass*, in its current prototype is able to capture scenes and its corresponding depth information. However, this is far from the envisioned system which captures scenes infinitely. We currently do not have any means of recording data infinitely; hence, we have designed *the Looking Glass* such that it only captures scenes when instructed to do so. Although this limits users to only be able to revisit select scenes from the past – those which were captured, we believe that it still allows us to explore our design concept and gain user feedback. Once a satisfying amount of data has been captured, the user can choose to stop capturing. After capturing, the system will create an ONI type file (OpenNI's file format that can contain a Kinect video feed and corresponding depth information) labeled with the time it was created. These files are used by *the Looking Glass* for later revisits to past scenes.

Revisiting. The current prototype of *the Looking Glass* we present here is able to let users view previously captured scenes, and is able to project them as visitors into the scene which is currently being viewed. It maps the visiting user, with regards to depth information, into the past scene being visited (Fig. 1 and 2). However, it still does not support 3D rendering, limiting the exploration to the static point of view of the Kinect. In a short term, we are planning to implement 3D rendering of scenes to enable the visitor to explore the scene from any point of view as they wish to.

Although the current prototype does not render in 3D, the recorded scene is accompanied by corresponding depth information from the Kinect allowing the prototype to project a visitor into the scene in accordance with their spatial relationship to that of the past scene. It allows the prototype to occlude the users whenever there is an entity in the captured scene that should be occluding them based on their location. In essence, while in viewing mode, the visitor is able to walk around and experience the scene while their current-time projected image on the scene may be dynamically occluded by past scene entities. This arguably allows the user to visually blend with the past scene, creating an illusion that they are a part of it.

We have also incorporated a function within the view mode which colorizes the past feed and the present feed (see Fig. 2). This separates the present and the past in a more visually distinctive manner (Fig. 1 and 2).

Fig. 2. *The Looking Glass* projects a user into the captured scene as a ghost-like blue figure, while the captured scene is tinted yellow for an 'old sepia photo' effect

4 Preliminary Evaluation

No formal studies have been conducted yet to evaluate the current prototype for *the Looking Glass*. The following evaluation of the prototype is based on a preliminary design critique of the system done with a few members of our lab. The current prototype of *the Looking Glass* is still far from our time travel vision. Interacting with it in its current phase is an interesting visual experience, but quite limited, arguably not that different from viewing a video.

However, we did observe that the interesting spatial interaction with past entities makes the interaction with *the Looking Glass* interesting and entertaining even in its current limited form. Visitors can be obscured dynamically and occluded by past entities or even past replicas of themselves. Alternatively, visitors can also obscure and occlude past entities, or emerge by spatially walking through them (i.e. visitors visually entering the scenes by penetrating through their past selves.) Moreover, because any physical activities can be captured and revisited, we see applications to our approach for documenting and following personal progress, for example when learning a new physical activity such as a baby's first steps, a set of new dance moves, or a sequence of Karate Kata movements.

5 Future-Work and Conclusion

Humanity's interaction with time, as well as time travelling has always been and will still be a topic of philosophical exploration, and science fiction. While we cannot physically travel back in time, emergent technologies and techniques are now available such that we can develop a system that allows us to mimic time travelling. In this paper we have presented our attempt to pursue this goal, expressed through *the Looking Glass'* design approach and current prototype.

Over all, the current prototype of *the Looking Glass* is lacking in necessary functionalities that would bring it close to mimic time travelling. However, we believe that the current prototype hints at the potential of our approach, and we hope that within the next iteration of this prototype, we will be able to demonstrate a 3D immersive approach that will change the way users revisit memories, making the experience more personal and engaging.

Taking note of the problems found through the simple design critique of our prototype, we are currently working on the next prototype of *the Looking Glass*. The most important feature that we will be integrating into the system is the 3D reconstruction of scenes, giving the visitors the ability to change point of views. We believe that this will allow a dynamic, physical exploration of the past scene, making revisiting the past a more genuine and engaging experience. Another change we are exploring is to support a more aesthetically pleasing color palette when viewing on colorized form; for example, colors that have been selected with regards to art color theory. Also, we are exploring ways of incorporating sound into captured scenes.

Through these, re-experiencing the past can become a more informative and engaging, and closer to the goal of mimicking time travel.

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BrainHex: Preliminary Results from a Neurobiological Gamer Typology Survey

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Abstract. This paper briefly presents a player satisfaction model called BrainHex, which was based on insights from neurobiological findings as well as the results from earlier demographic game design models (DGD1 and DGD2). The model presents seven different archetypes of players: Seeker, Survivor, Daredevil, Mastermind, Conqueror, Socialiser, and Achiever. We explain how each of these player archetypes relates to older player typologies (such as Myers-Briggs), and how each archetype characterizes a specific playing style. We conducted a survey among more than 50,000 players using the BrainHex model as a personality type motivator to gather and compare demographic data to the different BrainHex archetypes. We discuss some results from this survey with a focus on psychometric orientation of respondents, to establish relationships between personality types and BrainHex archetypes.

Keywords: player types, player satisfaction modeling, play patterns, neurobiology, social science, survey.

1 Introduction

An extensive range of different personalities play games. They do so for myriad of different reasons. When digital games were first developed, they tended to focus on a single principle of play catering to just one specific play style, often dictated by the hardware limitations of the time (e.g., *Pong* and related games were constrained by limitations in display technology). More recently digital games make use of multiple game mechanics, often structured over many levels, thus extending appeal to players expressing many different kinds of playing preferences. Prior game research in emotions of play and player satisfaction modeling reveal experiential distinctions that connect to neurobiological systems [4].

Exploring the gaming preferences of diverse players offers significant advantages for the development of games that cater to different demographic players groups, which is considered a factor for higher sales. Such insight can be valuable for marketing a game or for creating games with a more personalized experience, and may also benefit artistically motivated games by establishing a conventional

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framework of game design to be subverted, deconstructed or otherwise manipulated in the pursuit of artistic goals. In the field of player satisfaction modeling, typologies of playing preferences can provide a theory basis for technical modeling approaches.

BrainHex is a top-down approach (similar to psychometric evaluations), taking the inspiration for its archetypes from neurobiological research, previous typology approaches, discussions of patterns of play, and the literature on game emotions [3]. While BrainHex is based on neurobiological research literature, it is currently not a model using neurobiological techniques (but rather questionnaires) for its evaluation. In the following, we will introduce the seven BrainHex archetypes and their specific traits. For a discussion of the literature leading to the creation of BrainHex, please also see Bateman and Nacke [2]. We will then present and analyze a demographic survey of psychometric types in the context of the BrainHex archetypes.

2 The BrainHex Model

Each category within BrainHex should be understood, not as a psychometric type, but as an archetype intended to typify a particular player experience. Thus, BrainHex types can be understood as a qualitative presentation of an underlying implicit trait framework, with the descriptions combining hypothetical expressions of neurobiological research with observational case studies of players.

1. **Seeker:** Following research by Biederman et al. [5], the archetypal Seeker is motivated by interest mechanism, which relates to the brain area processing sensory information and memory association. Encountering richly interpretable patterns produces endormorphin, which in turn triggers the pleasure center [4]. The Seeker type is curious about the game world and enjoys moments of wonder.
2. **Survivor:** While terror is a strong negative experience, some people enjoy the intensity of the associated experience. The neurotransmitter related to this type is epinephrine, the chemical underpinning of excitement, which enhances the effects of dopamine (triggered when rewards are received). The state of arousal associated with epinephrine becomes that of terror as a result of the action of the fear center, which becomes hyperactive when a situation is assessed as frightening (based on prior experience, and certain instinctive aversions). It is not yet clear whether the enjoyment of fear should be assessed in terms of the intensity of the experience of terror itself, or in terms of the relief felt afterwards.
3. **Daredevil:** This play style is all about the thrill of the chase, the excitement of risk taking and generally playing on the edge. Game activities such as navigating dizzying platforms or rushing around at high speeds while still in control typify the implied play preference. The behavior related to this type is focused around thrill seeking, excitement and risk taking, and thus epinephrine, which was already mentioned, can be seen as a reward enhancer.
4. **Mastermind:** A fiendish puzzle that defies solution or a problem that requires strategy to overcome is the essence of fun to this archetype. Players who fit this archetype enjoy solving puzzles and devising strategies, as well as focusing on making the most efficient decisions. Whenever players face puzzles or must devise strategies, the decision center of the brain and the close relationship between this and the pleasure center ensures that making good decisions is inherently rewarding.

5. **Conqueror:** Some players are not satisfied with winning easily—they want to struggle against adversity. Players fitting the Conqueror archetype enjoy defeating impossibly difficult foes, struggling until they achieve victory, and beating other players. They behave forcefully, channeling their anger in order to achieve victory and thus experience fiero [6]. When mammals face difficult situations, their body produces epinephrine (adrenalin) and norepinephrine, the former producing arousal and excitement and the latter are being associated with anger and combative tendencies. Anger serves to motivate opposition and to encourage persistence in the face of challenge. Testosterone may have an important role in this behavior.
6. **Socialiser:** People are a primary source of enjoyment for players fitting a Socialiser archetype—they like talking to them, they like helping them, they like hanging around with people they trust. Players whose preference for play fits this pattern tend to be trusting, and they get angry at those who abuse their trust. This behavior connects to the social center, and which is the principal neural source of oxytocin, a neurotransmitter demonstrated to have a connection with trust.
7. **Achiever:** While a Conqueror can be seen as challenge-oriented, the Achiever archetype is more explicitly goal-oriented, motivated by long-term achievements. This distinction can be subtle, but it is nonetheless important: preference for Achiever-style play is rooted in 'ticking boxes', while preference for Conqueror-style play is rooted in defeating challenges. The satisfaction felt on attaining goals is underpinned by dopamine (and hence the pleasure center) but should be understood as being ultimately obsessive in its focus. Achievers prefer games amenable to ultimate completion. While the pleasure center is related to this preference, the decision center likely plays a role: subjective reports from players tending toward Achiever-style play show a compulsive fixation on reaching goals.

3 Demographic Player Type Survey

Predating this study were two demographic studies, known as DGD1 which identified play styles from Myers-Briggs typology in conjunction with a series of questions concerning playing preferences. Following case studies supported the qualitative validity of the suggested four types: *Conqueror*, *Manager*, *Wanderer* and *Participant*, which correspond broadly to Conqueror, Mastermind, Seeker and Socialiser of the current BrainHex archetypes [3].

To increase the number of respondents and in the hope of providing a more reliable data set for statistical analysis, the BrainHex study (launched in August 2009) was branded as a game personality survey that would compute the individual player types based on a few questions (similar to a psychometric type survey). It was not expected that the BrainHex types reported in the results would be objectively verified by the results, but rather that the data gathered would be open to a variety of analyses capable of yielding possible elements of a future trait theory [3].

3.1 Methods and Participants

The survey was launched through the website www.brainhex.com and a custom PHP script was developed to gather demographic and playing preference data alongside computing the preferential order of the BrainHex 'classes' (i.e. archetypes) and anonymous survey respondent identification. The survey was split into several parts. The first part collected demographic information (e.g., year of birth, gender, geographical territory). Participants who knew their Myers-Briggs-Type (a personality type test) could select it from a drop-down menu.

The second part of the survey presented participants with several statements that were connected to the different BrainHex player archetypes from early pilot testing. Each player type had three statements (e.g., Seeker: “Looking around just to enjoy the scenery.”) that needed to be rated on an arbitrary scale with the answers “I love it!” (1), “I like it.” (0.5), “It's okay.” (0), “I dislike it.” (-1), and “I hate it!” (-2).

The third part of the survey then presented seven strong identifying statements for each BrainHex archetype that would need to be rated on a scale from 1 (worst) to 7 (best) in order of preference (e.g., Seeker: “A moment of jaw-dropping wonder or beauty.”). The PHP script computed the sum of the three statements and the ratings to get the BrainHex archetype, which would be directly presented to the participant.

At the time of analysis, the survey had been taken by 50,423 participants. The gender split between respondents was not equal as this variable is hard to control for in an open field survey (88.6% male). The survey language was English, and it seems that the survey was most appealing to a North American audience (49.8%). The survey was also popular in Western Europe and the UK (27.9%), followed by Eastern Europe or Russia (8.2%), Australasia (4.3%), and South and Central America (4.3%). The majority of the respondents played regularly, most of them every day (66.2%).

4 Preliminary Results

These results will primarily be concerned with analyzing psychometric type responses to the questionnaire, based on MBTI preferences. These preliminary results can be considered a follow up to the original DGD1 study, which focused on MBTI [3].

4.1 Psychometric Types and Player Types

Most respondents fell into the INT categories, meaning more respondents seemed to be part of an introverted psychometric type. For the analysis of psychotypes and their distribution within each of the player classes, we excluded all answers without an MBTI type. This resulted in 11,526 responses for the following analyses. The dataset limited only to the people who answered the psychometric type question was individually split 4 times for each dimension to conduct separate analyses.

When divided between Extraversion and Introversion, BrainHex archetypes show a preference for Introversion. A chi square test showed differences (all $p<.001$) for Achiever ($\chi^2=344.20$), Conqueror ($\chi^2=618.17$), Daredevil ($\chi^2=117.60$), Mastermind ($\chi^2=1087.20$), Seeker ($\chi^2=883.20$), Socialiser ($\chi^2=125.33$), and Survivor ($\chi^2=240.17$).

The same split was performed upon the Thinking-Feeling dimensions for each BrainHex primary class. Within the Seeker, Achiever, Socialiser, and Survivor class, there seemed to be a greater preference for Feeling than in the other primary classes. In general, all classes seem to be dominated by Thinking. This is supported by differences (all $p<.001$) for Achiever ($\chi^2=95.72$), Conqueror ($\chi^2=649.21$), Daredevil ($\chi^2=90.24$), Mastermind ($\chi^2=765.73$), Seeker ($\chi^2=121.02$), Socialiser ($\chi^2=28.72$), and Survivor ($\chi^2=57.49$).

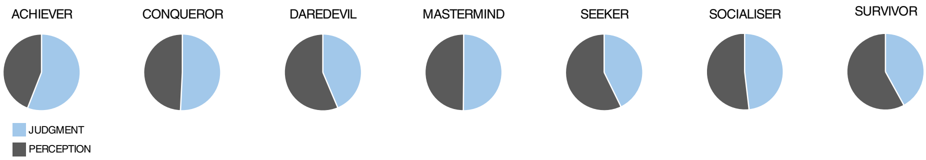

Fig. 1. MBTI Judging and Perceiving groups broken down by BrainHex primary archetype

Compared to the other dimensions, there is no clear dominating type in the Judging and Perceiving dimension (shown in **Fig. 1**). For Conquerors (χ^2=0.79, p=.38), Masterminds (χ^2=0.01, p=.93), and Socialisers (χ^2=1.42, p=.23) both Judging and Perceiving preferences are equally represented without differences. Interestingly, the Achiever type is significantly dominated by Judging preferences (χ^2=15.98, p<.001). Daredevils (χ^2=9.16, p=.002), Seekers (χ^2=49.27, p<.001), and Survivors (χ^2=18.73, p<.001) are all more likely to show Perceiving preferences.

Finally, for the Intuitive and Sensing dimension, the split was more obvious across all BrainHex primary classes. This is supported by significant differences (p<.001) for Achiever (χ^2=248.03), Conqueror (χ^2=757.50), Daredevil (χ^2=171.99), Mastermind (χ^2=1310.27), Seeker (χ^2=1006.79), Socialiser (χ^2=374.56), and Survivor (χ^2=231.08).

5 Discussion

From those respondents knowing their Myers-Briggs type, there was a clear skew in the data towards preferences for Introversion, Intuitive and Thinking, which was also prevalent in each of the BrainHex archetypes in this subset of the data. The first of these findings—the greater incidence of Introversion preference—verifies the finding of the original DGD1 study [3], which connects an interest in digital games with a preference for Introversion. The high incidence of Intuitive preference may be a consequence of the branding of the survey, which appears to have attracted more gamer hobbyists than those in the wider market for games.

In the context of the BrainHex archetypes, it is striking that Seeker, Survivor, Socialiser and Achiever should show a greater incidence of Feeling preference. The three archetypes that skew most heavily towards Thinking are concerned with intensity of the fight-and-flight response (Conqueror and Mastermind via fiero, Daredevil via excitement). Conversely, Seeker, Survivor and Socialiser can be understood as *aesthetic* archetypes: Seeker concerns the aesthetics of wonder, Survivor the aesthetics of horror, and Socialiser the aesthetics of interpersonal relationships. Achiever, while not being obviously aesthetic in its focus, is also notably disconnected from fight-and-flight play.

Thinking preference is usually associated with emotionally detached decision-making and Feeling with empathic decision-making; these results suggest an alternative interpretation of this measure in terms of preference for *fight-or-flight play* versus *experiential play*. This suggests a possible play theory trait distinguishing between direct visceral rewards and more nuanced aesthetic preferences.

The results in terms of Judging versus Perceiving preference conform to what would be expected. This axis expressly distinguishes goal-orientation (Judging) from process-orientation (Perceiving). Individuals preferring process-orientation may well be interested in the quality of the eventual outcome, but are not as motivated as goal-oriented individuals to actually *complete* the process. The preference process-orientation for the Daredevil, Survivor and Seeker archetypes is consistent with their definitions, since (along with Socialisers) these players are less concerned with goals and more interested in the quality of their immediate experience.

These preliminary results are only the tip of the iceberg. A considerable volume of data remains to be examined. In comparison with its progenitor, the DGD1 survey, in terms of Myers-Briggs typological axis, the BrainHex data seems to verify the greater incidence of Introverted preference among gamer hobbyists. However, DGD1 actively typed respondents, while BrainHex asked respondents to provide their Myers-Briggs type *if known*. This might have produced inherent biases, depending on the distribution of knowledge of MBTI.

For identifying elements of a trait theory of play, distortions in the sample are less relevant since any significant pattern is evidence for a possible trait. Our results suggest these traits: preference for (1) visceral play, (2) aesthetic experience, (3) obsessive play, and (4) experiential play. It is also possible this is simply two traits: (A) visceral versus aesthetic play, and (B) degree of goal-orientation. Further investigation is required to distinguish these scenarios from the four-trait alternative.

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ZenTrader, an Emotion-Reactive Interface

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Abstract. We explore the concept of interactive technology that is implicitly controlled by emotions, via wearable physiology sensors. We describe a proof-of-concept emotion-reactive stock trading software that interrupts trades that appear to be entered under an unusual amount of stress. We describe a galvanic skin response (GSR) sensor armband that broadcasts stress events via Bluetooth to a prisoner's dilemma game application on an Android phone, which alters its behavior when the user is stressed. We carried out pilot evaluation of this system's effects on the consistency of decisions made under stress.

Keywords: interactive technology, finance, GSR, EDA, stress, galvanic skin response, implicit control, wearable, affective computing, proactive computing.

1 Introduction and Related Work

The idea of computers that can anticipate our emotions and react accordingly, first envisioned in the early 2000s[17, 20], is potentially attractive in many domains, such as entertainment, education, health care, finance, and services. However, few such applications have emerged, due to various challenges[17]. Sensors of physiological metrics are complicated and difficult to deploy or wear outside of the lab. Emotions are difficult to predict from raw sensor data, especially when different models may be required for different human activities. Finally, the interfaces and interactions being implicitly controlled by human emotions may require different design considerations than the interactions controlled by explicit input.

To date, several emotion-reactive entertainment applications have been developed. StartleCam[5] is a camera that detects when its user is startled via electrodermal activities (EDA, aka. galvanic skin response), and snaps a picture. 2Hearts is a novel musical instrument that extracts variables from two people's heartbeats in order to create music[12]. Very recently, a system was developed that also used galvanic skin response to create bookmarks within audiobook tracks when the reader is interrupted by external stimuli[14]. In parallel, there have been some research on quantitatively modeling the emotions of people in specific activities based on physiological metrics, such as in learning[6] or during gameplay[10], which may allow future games to make more sophisticated and reliable predictions of players' emotions.

In this project, we explore the emotion-reactive concept in stock trading. Trading is rather dissimilar to entertainment, as it is result-oriented instead of experience-oriented, and yet also similar, as emotions, stress in particular, often play a critical role in determining results. On the market, the best opportunities or the signs of

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danger are often erratic and time-sensitive, yet the intention of trading is to produce profit consistently. As a result, a trader sitting in a desk for hours or weeks waiting for potentially important events can suffer from severe anxiety[13]. This anxiety often contributes to irrational, inconsistent behaviors[4], such as excessive risk taking or deviating from strategic and execution plans. Previous studies have monitored the physiology of traders [8, 9] and Poker players [19]. Results confirm that decisions with real financial stakes tend to cause stress, which manifests as measurable difference in physiological metrics, such as galvanic skin response, heart rate, and body temperature... The involvement of real financial stakes in emotion monitoring experiments is apparently critical in obtaining such results.

Passive sensing and display of stress level have been recently explored for trading, Panasonic[15] and Philips[16], have created wearable prototypes that incorporate both a GSR sensor and a display to visualize the traders' stress-level. For monitoring stress caused by exposure to addictive substances, the AutoSense system[18, 21] use wearable sensors to communicate wirelessly with a mobile display. However, all of these systems are passive displays of emotions, which could very well be ignored in the heat of the moment.

In this paper, we introduce ZenTrader, a trading system that tailors its interface and allowable actions to the trader's stress level. The system is implicitly controlled partly by the stress level to proactively warn against anxious behaviours. It can also suggest background tasks, such as market research or strategic planning, whenever the stress level is low. The net effect is to keep the trader in more of a "flow" state [3], where cognitive and emotional functions are at their peak. To date, there have been only a few such applications that use physiological sensors for implicit control, and there appear to be none in the finance domain.

In the context of related works on physiological sensing, wearable devices, and implicit control already discussed, our contributions to Interactive Technology are i) identifying that trading and other stress-sensitive activities do not need to have a wearable interface (instead of existing mobile interfaces), but the subconscious act of sensing moments of stress requires continuous, constant availability, and so benefits from wearability; ii) proposing that interfaces for stress-sensitive activities should be partly controlled implicitly by the stress level; iii) prototyping a wearable GSR sensor, which updates a stress-reactive application wirelessly.

2 Conceptual Design and Proof-of-Concept Prototype

In the mental model of a traditional computerized trading platform (Fig. 1), the trading software (computer) is static and passive, with an input facility. Even if the input facility can be as complicated as a script of trading strategies, instead of single trades, the computer is still a passive thrall to the will of the user. However, various infamous incidents in the financial industry, such as the Fake Bankruptcy of United Airline[11], suggest that the will of users may not always serve their best interest.

At any given moment, people output not only their rational thoughts, but also their emotions. ZenTrader attempts to respond to both the explicit and emotional inputs (Fig. 1). ZenTrader still consists of a trading application running on one or more devices. This application still takes explicit commands from its user. However, since emotions took a part in forming those commands, these emotions must also be an input into the application. Emotions are often subconscious, so they have to be sensed. A sensor worn by the trader autonomously and constantly measures various physiological metrics, interprets this data as shifts in stress levels, and informs the trading application. When a trade is entered while the stress level seems abnormally high, the trading application interrupts the command, forcing the trader to think twice or to type in a rationale. On the other hand, at moments where the user's stress level is so far below even a normal baseline, the system would suggest some trading, market research, or strategic planning activities.

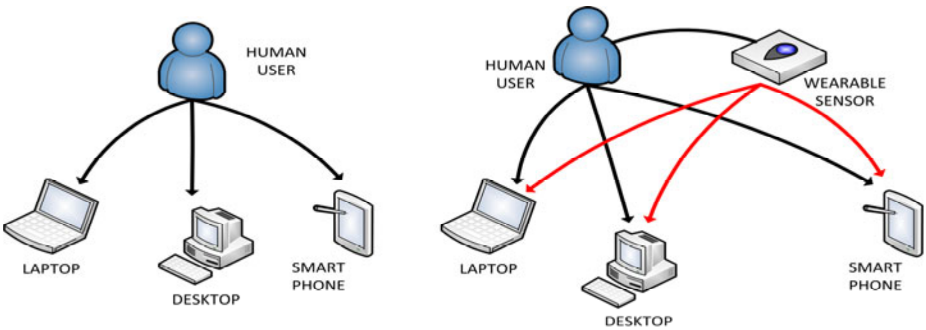


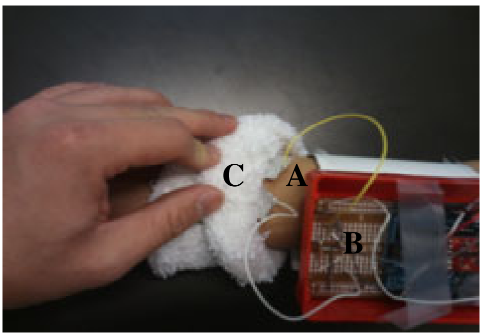
Fig. 1. Traditional Mental Model (left) vs. Emotion-Reactive Mental Model (right)

To evaluate the emotion-reactive concept, we simulate the trading application in our prototype with a noisy iterative prisoner's dilemma game to facilitate repeatable, controlled experiments. We realized that scientifically evaluating the effectiveness of the concept with real market condition is not practical for this stage of our research. Nevertheless, the low-fidelity prisoner's dilemma game prototype still contains all the elements of the ZenTrader mental model, such as the wearable GSR sensor, wireless broadcast, and a target application that receives and reacts to this broadcast. We originally planned to implement a GSR, skin temperature, and heart rate sensor, in order to triangulate the three data sources and produce a more reliable stress indicator. However, to simplify the prototype and keep the size and weight small, we decided to use only GSR. We developed our prisoner's dilemma application on the Java-based Android OS, and linked to the wearable GSR sensor via Bluetooth. We built our own GSR sensor armband instead of using an FDA-approved commercial solution, such as ThoughtTechnologies's ProComp[1] or BodyMedia's Sensewear[2], because we also seek to investigate the problems in tuning the form factor of a wearable GSR sensor.

The prototype form-factor consists of a wide, elastic armband to distribute the weight (roughly that of a cellphone) and create a secure grip. The armband is attached to the sensor unit housing with Velcro to facilitate testing with different wearing position and orientation. During development, the GSR electrodes were not attached under the armband (Fig. 2), but pressed into the skin by another elastic armband, so that the location of the sensor and the distance between the electrodes could be tuned. In the final design, the electrodes are secured to the main armband and pressed tightly against the palmer (under) side of the wrist.

The GSR sensor circuit is built on a plain prototype board. The GSR sensor data is fed serially to an Arduino Uno board, with a Bluetooth Mate modem that acts as a wireless serial pipe to send signal from our Arduino-board-mounted sensors to the Android target application. We developed our target application using Amarino, an open source (LGPL) library that allows Arduino to send and receive data to/from an Android device[7]. The signal processing and stress event recognition logic are built into the target application, not the sensor unit, because this logic is application / domain-specific. We first take a 3-minute baseline of the user's GSR when he/she is calm each time the sensor is worn. The Android-based application will collect the data into a buffer of four seconds, which is compared to the baseline when full.

When the user chooses Defect or Cooperate each round, if the difference between the baseline and the moving average GSR data exceeds a predetermined threshold, a stress warning will appear in the top text box (Fig. 3), and the phone will vibrate, forcing the user to choose (think) twice per round.



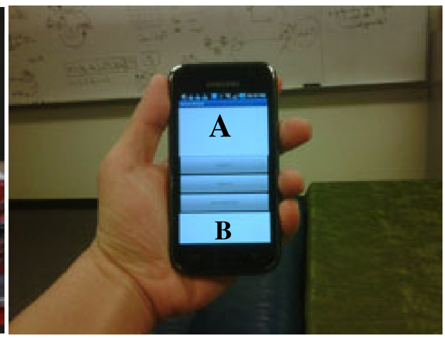


Fig. 2. (Left) Low-Fidelity prototype form factor. (A) The electrodes (aluminum) are detached from the main armband and circuitry (B) for position tuning using another elastic armband (C).

Fig. 3. (Right) Android phone with sample application (prisoner's dilemma). (A) Top Text Box: game text (pay-off matrix) and stress warning, Top Button: Defect, Middle Button: Cooperate, Bottom Button: Create Baseline, (B) Bottom Box: skin resistance graph.

We tuned a threshold in the prototype so that the system would identify a stress event within 10-15 seconds of an unexpected, strong, and persistent stimulus, such as very loud music. The baseline data and the on-going data are buffered and averaged to reduce the responsiveness of the sensor enough that it will not respond to startle or orienting responses, which are immediate reflexive behaviors to short-term stimuli, like a tap from behind. For trading and game applications, the sensor should identify moments when there are persistent responses in skin conductance, which indicate on-going changes in arousal level. More importantly, tuning the system to ignore short-term involuntary reflexes is crucial for wearability in daily life. The GSR sensor in our prototype indicates "arousal", not any well-defined state of emotion, but persistent arousal is a good initial estimate for stress in trading, because extreme, on-going emotions, either greed or fear, can cause stress. Creating a more rigorous quantitative model of stress specifically for trading environments is out of the scope of our work at this stage, but this work paves the way for more field testing that will enable the construction of such a model.

3 Pilot Evaluation

We ask the research question: “At the point of decision-making, do interrupting warnings about stress induce more consistent, systematic behaviours?” We chose to conduct a small-scale pilot evaluation of the system, using a prisoner’s dilemma (PD) game task that provides an analog to trading. The subjects play fast-paced 3-player iterative PD games. The control subjects use a normal version of the game that is not stress-aware, and the experimental subjects wear the sensor and use the emotion-reactive version of the game. The pay-off matrix is procedurally tweaked after certain random number of rounds, so that the optimal strategy changes between sets of rounds. The experiment measures changes of strategy between sets of trials, identifiable by who wins each set, and also by the ratio of Defects and Cooperate. We obtained some promising results from the pilot experiment. The subjects using the device seemed to be more consistent with their first-set strategy, regardless whether this strategy was still favourable later.

4 Conclusions

In this paper, we explored the concept of applications that actively respond to human subconscious input by the use of continuously available wearable sensors. We described the mental model for such an emotion-reactive trading system, and built a proof-of-concept prototype involving a prisoner’s dilemma game. We also carried out a small pilot evaluation, finding initial promising results. We believe that there are many challenges in the design, implementation, and adoption of emotion-reactive systems, but the challenges can be overcome. As physiological sensors become more reliable, more wearable, and more fashionable, the ubiquity and social acceptance of wearable sensors would increase. As API’s that connect sensors and devices, such as Amarino, become more mature and available on more platforms, it will be easier to implement sensors with wireless broadcast.

Our work has several limitations, which we intend to address in future projects. Only a small pilot evaluation was conducted, limiting the validity of the results. A more robust methodology consideration and a more extensive experiment are needed. The armband sensor, though relatively light and wearable for a prototype, is still quite unwieldy for practical use. We believe that it is possible to miniaturize and house this sensor unit in a wrist-watch-sized enclosure, by printing the entire GSR sensor circuit on one chip. Finally, we believe that a longitudinal field study of traders, with real financial stakes, would be needed to identify real-world issues.

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Measuring the Impact of Knowledge Gained from Playing FPS and RPG Games on Gameplay Performance

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Abstract. Understanding players' gameplay behaviors, performance abilities, and interests is a growing research area due to its utility in developing knowledge and theory that can enhance game design. Much previous research exists within this area, however, none of these works deeply investigated player behavior and its relation to knowledge/skills gained by playing specific genres. This topic is important, as knowledge gained from playing different genres influences players' game behaviors. Knowing the details of the skills gained and their influence on performance will allow designers to make informed decisions about their game design given knowledge about target audience's playing habits. In this paper, we address this issue. In particular, we discuss results of a study conducted with 35 college participants to explore the influence of prior gaming experience, specifically with Role Playing and First Person Shooter games, on knowledge/skills related to their ability to navigate and solve spatial puzzles in 3D games.

Keywords: Game user research, Game performance metrics, Game usability, Game users, User gaming experience, Player modeling, Video games.

1 Introduction

Video games have been on the market since the 1980s. As a result, there are many skilled players who learned genre conventions. Designers are now challenged with creating games for ones who have accumulated skills/knowledge and others who are either casual gamers or inexperienced [7, 10]. Many previous researches have investigated the players' gameplay experience, including their emotions [15, 4], motivations [16], play styles [22, 25], and behaviour [5]. Several models were proposed to measure players' satisfaction including GameFlow [19]. In addition, several researchers proposed a set of heuristics to evaluate the game experiences. Desuvire et al. [7] proposed Game Approachability Principles as "the level of helpfulness in a computer game for new and inexperienced players." Lemay et al. [16] proposed a semantic differential approach to understand the players' various experiences regarding their attitudes by using a list of "bipolar adjectives". Authors argued that players' perception of a game/genre will affect their performance and skills. Other studies reported that mastering game tasks and challenges is connected to game enjoyment [14]. Sherry [18] stated that too easy games result in boredom, and too hard games can be fru-

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strating. On the other hand, Klimmt et al. study [14] showed that game enjoyment can change with increasing playing time. High number of successes and few failures at the beginning of a new game could increase the enjoyment however that could result in boredom when game experience improved. There are several methods for gathering players' feedback e.g., usability methods, surveys, observation, playtesting, and ethnographic methods [6, 12, 13]. Lately, game telemetry and visualization have been proposed where it provides a large quantitative, time-stamped data for tracking and analyzing user behavior. Microsoft Game Labs did extensive user testing for Halo 3 [20]. Mellon [23] used telemetry to locate gold farmers. Ducheneaut et al. [9] used logs of player chat in Star Wars Galaxies to infer patterns in social behavior. In addition, several researchers have used data from players' behavior to construct player models [3]. Bartle developed one of the first player models by studying people playing MUDs (Multi-User Dungeons) [2]. He categorized players as Socializers, Killers, Adventurers, and Achievers. Recently other researches discussed different approaches (game metrics [8], neural network [5], game AI for creating challenging opponents [11], etc.) to construct models of the players. However, none of these previous works investigated the knowledge gained from experience with particular genres and its impact on gameplay. In this paper we present a study with 35 participants to investigate the influence of experience accumulated through playing specific game genres (described by Rollings and Adams [1]), First Person Shooter (FPS) games and Role Playing Games (RPG). We believe skills gained from playing different kinds of games are varied since their game mechanics are different e.g., FPS games require good eye/hand coordination and quick reaction time [18], while RPGs are related to logical thinking and problem solving [18]. We investigate the effect of these learned skills on solving 3D spatial puzzles in 30-minutes of playing *Tomb Raider: Underworld* (Eidos Interactive, 2008).

2 Pilot Study

Our questionnaire guides us in clustering players based on their prior experience with FPS and RPG games. We sent it to 4 experts in game user research industry to ensure content face validity. We then conducted a pilot with 3 RPG experts, 3 FPS experts and 4 non-gamers. Since self report is an unreliable measure as people often underestimate the time they spend [22], the questionnaire [23] tries to remedy that by asking specific details on games based on advice from experts. The questionnaire was promising in differentiating between FPS and RPG gamers. It found *RPG gamers were playing FPS games more than FPS gamers playing RPG games.* Additionally, *RPG gamers were more flexible in playing games in the other genre* (e.g., FPS).

3 Study Design

35 participants were recruited from SFU SIAT. We ended up with 13 FPS, 9 RPG, 9 non-gamers, and 4 outliers who either played the game before, or were not rated as FPS/RPG/non-gamer based on the questionnaire. We did not consider outliers in the

statistical analysis to keep the consistency. We were not interested in gender or age influences, and used homogeneous participants; They aged 21-25 (4 between 27-32) and over 80% were male. *Tomb Raider* was chosen because it is a 3D game (for measuring 3D spatial puzzles and navigation), fairly new (to decrease number of outliers), not RPG or FPS but had some elements of both, and a linear game with distinguishable obstacles for defining metrics (Table 1). Since most of the metrics are not subjective, one experimenter collected them manually through video coding.

Table 1. Performance metrics for measuring skill level.

1	Total time (min)	7	Items collected e.g. health/diamond (yes/no)
2	Number of solved obstacles	8	Skip the cinematic between levels (yes/no)
3	Number of deaths (fall off, enemies)	9	Number of events of shooting at enemies
4	Read instructions on screen (yes/no)	10	Movement (fast, medium, slow)
5	Number of checking tutorials/maps	11	Frustration with controller (low, medium, high)
6	Ask for help/hint (yes/no)	12	Time to solve obstacle (sec): Obstacle 1-15

4 Results

Questionnaire: In this experiment, the dependent variables were number of RPG games played, maximum playtime per RPG game, number of FPS games played, and maximum playtime per FPS game (each participant inserted the total number of hours played per each FPS/RPG game in the questionnaire; for each participant the greatest number was considered as the maximum playtime per game). The independent variable was the prior gaming experience groups (FPS/RPG/ non-gamer). Since the significant difference between non-gamers with other two groups was seen in ANOVA, we present statistical results of FPS and RPG gamers through the Mann-Whitney U Test (Table 2). Comparing the average number of FPS and RPG games played shows RPG players played *significantly* more RPG games than FPS shooters, however they did not differ in the number of FPS games they have played. Comparing the average of maximum playtime per FPS and RPG games, a significant time investment difference was found between FPS and RPG gamers for playing an RPG game (RPG gamers played more, $p<.05$) but not for playing an FPS game ($p>.05$).

Game Metrics: In this experiment, the dependent variables were the numerical variables from the *game metrics* (Table 1). The independent variable was the *prior gaming experience* (FPS/RPG/non-gamer). The data was analyzed using one-Factor ANOVA (Table 3). There was a significant difference for the number of solved obstacles between FPS gamers and the other two groups, $F(2,28) = 8.53$, $p < .05$. Post-hoc test (Tukey) confirmed *FPS players were able to solve more obstacles than RPG players and as expected non-gamers* while there was no *significant* difference between RPG players and non-gamers. Comparing the average time (sec) took players to solve each obstacle we found that *FPS gamers spent less time than RPG gamers in solving obstacles* (Figure 1). ANOVA (Table 4) showed there was significant difference between non-gamers and other two groups for obstacles 1, 4, and 5 ($p<.05$). Results of Mann-Whitney U Test for FPS and RPG showed there was a significant difference in the mean time of FPS and RPG players on obstacle 4, z =-1.905, p < .05 and obstacle 11, z =-2.155, p < .05.

Table 2. Mann-Whitney U Test on the grouping variables Game Genre

	Man-Whitney U	Z	Asymp. Sig. (2-tailed)*
No. of RPG games played	15.0	-2.916	**.004**
No. of FPS games played	41.0	-1.180	.238
Max playtime per RPG game	15.5	-2.891	**.004**
Max playtime per FPS game	49.0	-.638	.523

***p** < .05. Significant effects are typeset in bold.

Table 3. and **Table 4.** ANOVA for the independent variable prior gaming experience

Dependent Variable	F(2,28)	p*	η2	power
No. of solved obstacles	8.535	**.001**	.379	.948
No. of checking maps/tutorials	4.024	**.029**	.223	.670
No. of deaths	1.592	.221	.102	.308
No. of shooting at enemies	1.119	.341	.074	.227

Dependent Variable	F(2,28)	p*	η2	power
Obstacle1	4.317	**.023**	.236	.703
Obstacle4	4.539	**.02**	.245	.726
Obstacle5	5.434	**.01**	.287	.803

Analyzing qualitatively we noticed Obstacle 1 and 2 included a flaming hallway, a switch to open a door and climbing on a ledge. Non-gamers spent more time getting used to the controllers, the game environment and the abilities while FPS/RPG gamers just passed (majority of players did not notice the ledge right away). Obstacle 3 involved new game mechanics for all the groups. Players need to get close to the edge of the pit to jump and grab the narrow ledge on the wall to pass the pit. Many participants reported the ledges were unnoticeable which explains the peak for obstacle 3 in Figure 1. This was evident especially with, 23% of FPS, 25% of RPG and 67% of non-gamers asked for help from the observer after spending a good amount of time. The observer believed that FPS gamers being faster and their attitude tended to be more risky and impatient e.g., FPS gamers jumped toward the wall or the pit while they still did not find the ledges. The mechanics used for obstacles 4-5 are similar to obstacle 3. FPS and RPG gamers did not differ much, but compared to non-gamers there was a big difference. This is because FPS and RPG gamers are used to learn from games and use the mechanics again. Thus their learning time can be much quicker than non-gamers. Obstacle 6 requires players to dive underwater where they may encounter sharks. They can either escape or shoot at sharks; 85% of FPS, 66% of RPG and 56% of non-gamers shot at the attacker sharks. This is due to FPS gamers are used to shooting within the games they play. Obstacles 7-9 needed players to navigate underwater to find two keys. Players' behaviors were almost the same for those who could get through (eight FPS, three RPG and two non-gamers). The majority of players got lost in obstacles 7-8, where they believed game design could be improved through using more efficient lighting and maps. Obstacles 11-12 were a combination of jumping and climbing in a dark room. FPS gamers generally spent less time and were able to navigate with little problem. Although some of the FPS gamers claimed they were PC gamers, the differences captured through qualitative observations among FPS gamers were minimal. For RPG gamers the difference between PC gamers and those who are used to controllers was more pronounced. *Non-players showed the highest frustration level and the slowest movement*, whereas *FPS gamers showed the lowest frustration level and the fastest movement.* Additionally, analysis showed there was a significant strong positive correlation between the number of FPS games played and the number of solved obstacles r=.548(31), p(two-tailed)<.01 but not with number of RPG games played. There was a significant strong positive correlation between hours spent weekly on playing video games and the number of solved obstacles r=.443(31), p(two-tailed)<.05.

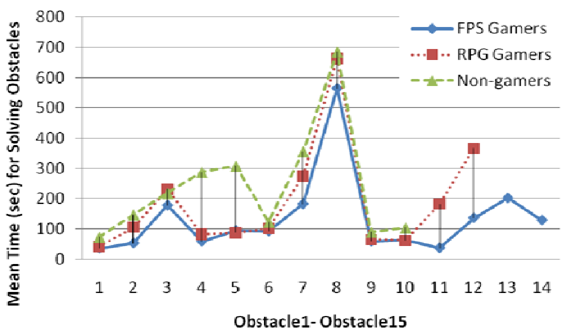

Fig. 1. Average time (sec) for solving Obstacle1-15

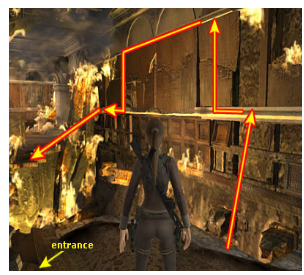

Fig. 2. Obstacle 3 [21]

5 Conclusions

The results implied that *non-gamers' behavior was more similar to RPG gamers than FPS gamers* in terms of the time it took them to solve the puzzles; there were five obstacles with significant time difference between FPS and non-gamers (Obstacles 1, 2, 4-6) while there was only one obstacle that yielded significant differences between RPG and non-gamers (Obstacle 5). We believe visual search and/or the actual learning abilities cause these differences. Another interesting finding was that the more FPS games they played the more obstacles they solved; this was not true for RPG games. By uncovering these skills further, we can develop theories that can guide developers into designing more accessible games. It should be noted that this is a difficult research area and although we tried to keep the limitations of the study low, there are some. Having only one rater for observation of frustration and movement may not be enough to establish validity and more participants is needed to establish generality. However, the amount of time for video coding outweighed this desire. Further research is needed to investigate what abilities give FPS gamers the observed playing navigation difference, is it visual attention, visual search or reaction time difference? In addition, this study only looked at RPG and FPS gamers, what other differences exist in terms of skills in 3D games between different types of players?

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The Effect of Privacy on Social Presence in Location-Based Mobile Games

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Abstract. Location-Based Games (LBGs) have been gaining both academic and industrial interest in the past few years. Utilizing location information, LBGs enable users to extend their social game-play from cyberspace to the real-world. However, sharing personal information particularly the physical location of users is likely to raise privacy concerns resulting in eroding players' social experience. To further explore this issue, we investigated the impacts of two attributes of privacy, avatar realism and location-awareness, on the players' perceived social presence during a designed LBG. The results indicated that the social presence was not significantly affected by the applied privacy configurations. However, players' negative feelings decreased when photographic images of players were used as their avatars. Further, players desired to share their physical location and sacrifice location privacy in order to track other players. Our findings suggest that a well-designed LBG can lessen users' location privacy concerns.

Keywords: Avatar realism, Location awareness, Social presence, Location-based game, Location privacy, Location-based service.

1 Introduction

GPS-enabled phones provide social networks with the novel opportunity to access the physical location of individuals by revealing nearby friends and places of interest. In addition to social networks, digital gaming has also tried to adopt location sharing technologies to extend its game-playing boundaries outside of cyberspace and into the real world.

Location-based games (LBGs) are in a new class of entertainment that bridges between real and virtual environments. In LBGs, players are usually required to move (change their geographical locations) in the real environment to follow some virtual cues (such as virtual treasures) provided by their hand-held devices.

The publicized information in above social location-sharing applications can either foster their social connections or is utilized for entertainment purposes. On the other hand, disclosing personal information (including physical location) can raise privacy concerns [3], [7]. People may want to share some sensitive information with close friends, but are less likely to desire to share the same information with unknown parties.

In recent years, there has been an increasing number of scholars investigating location privacy in the domain of location-based services [2], [8], [10], [13]. Almost

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all of the literature in this area focuses on location privacy as an essential issue which should be addressed.

However, they mostly base their studies on security technologies and approaches preserving the user's location information from unauthorized entities. Surprisingly, there are few studies which empirically examined the effect of users' feeling of location privacy on their experience [3], [8], [19].

Location privacy is basically an important issue in the design of location-based applications with high social potential such as location-based social networks and games in which the social experience of the users plays a very important role in popularity of the service. However, to our knowledge, there is no prior work specifically focusing on the privacy aspect of location-based games and its influence on social experiences during the game.

One factor that makes location-based games (LBGs) unique is their focus on providing users with the opportunity of playing with or against some other players utilizing location information. However, other types of social location-sharing applications mostly aim to facilitate social interaction between users using location information. Furthermore, it is very likely that players do not know other players before and after their game-play sessions. Conversely, there are other, more intimate types of social applications, where people usually interact with their friends or families. This distinction is particularly important in studies of location privacy in social location-sharing applications.

Regarding these distinctions between location-based games and other social location-sharing applications and the significance of privacy (and particularly location privacy) in all social location-sharing applications, specific studies should be conducted to explore the potential effects of privacy concerns in the LBGs.

In this study, we examined the effect of revealing physical location and users' facial identity on the quality of the experience of playing a location based game. While there have been some studies on location privacy, there is no work, we are aware of, that tackled other attributes of privacy (such as revealing facial identity through avatars) and its effect on the quality of game experience in LBGs. We chose social presence as the basis of measuring the quality of social experience in this study.

1.1 Social Presence

The highly credited definition of social presence pioneered by Short et. al. [18] explains social presence as *"the degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships"* (p.65). They measured SP as "*a subjective quality of the communication medium*".

Biocca and his colleagues [5] believe that the simple presence of another body or awareness of it may not be a satisfactory definitional basis for social presence. Consequently, a more comprehensive definition should elaborate additional levels of psychological involvement beyond "attention". Biocca and his collaborators provided a subtle definition conceiving social presence as the sense of "access to another intelligence" [5]. In their definition, the body (virtual or physical) is a medium representing cues to the intelligence animating the body. Moreover, social presence is not activated unless the users sense a minimal intelligence through the other's reactions to the user and surrounding environment (either mediated or unmediated).

Almost all proposed definitions and measures of social presence are constructed based on theories in a direct communication between two interactors in a mediated environment. The question remains to be answered is whether the current measures of social presence can be applied to gaming context. de Kort and her colleagues [12] mentioned three major differences between digital gaming and communication technologies which should be considered when applying any current social presence measure to gaming experiences:

1. The majority of digital games are primarily designed for a single user with the opportunity of playing with or against some other players added later on. On the other hand, communication technologies aim to facilitate social interaction between users.
2. Communication technologies are initially intended to transfer the user's thoughts and ideas and then to present a task, whereas in digital games, the task accomplishment is prioritized more highly than the communication part.
3. Digital games are developed to fascinate and engage players. On the other hand, communication technologies are not primarily intended to motivate and fascinate the involved users.

de Kort et. al. [12] developed a Social Presence Gaming Questionnaire (SPGQ) based on the Biocca's work [6] to characterize and measure social presence in game experiences. They have evaluated their measurement on different genres (such as FPS, RPG, action adventure, sports games) played on PC, a console, or even mobile phones and reached a satisfactory sensitivity and validity.

1.2 Avatar and Avatar Realism

Despite the considerable amount of literature discussing the concept of avatars, there is no unified definition of the term avatar in virtual reality studies. Avatars are literally defined as the models representing users' behavioral and/or embodiment [1]. Through avatars, people can express their emotions and engage in social activities. People also construct virtual identities by embodying themselves via digital avatars.

There is contradictory literature exploring the influence of anthropomorphic avatars on social interactions. Although Koda and Maes [11] reported that more personified avatars have been rated more engaging and likable, Nowak et. al. [16] showed that people perceived less anthropomorphic images more credible and likeable.

This study is only concerned with avatar realism in terms of an appearance of a simple icon within a smart phone display. Therefore, issues of human morphology and behavior, although important, are not addressed and are not considered as part of this work. Thus, in regards to this study, a more realistic avatar is a realistic 2D image depicted in an icon within a smart phone display.

1.3 Location Awareness and Location Privacy

Location privacy is even more concerned with location-based social applications. Social applications basically rely on revealing information to strengthen social ties or to establish a more engaging social activity. Hence, it is expected that social location-aware applications are highly based on users' dissemination of location information. On the other hand, location is a sensitive attribute since a person can be easily accessible through his/her current (or past) location information.

Some researchers tried to address this paradox by conducting user experiences on location-based services that focused primarily on privacy issues and social interactions. Barkhuus et al. [2] studied a social location-awareness system called "Connecto" in which users were able to either manually or automatically tag their location information and share this tagged data amongst a group of friends. Interestingly enough, no participants expressed any privacy concerns during the interview sessions that occurred after the experiment. Barkhuus et al. argued that the usefulness of the system might be the reason that no privacy concern was reported even when participants were directly questioned about their privacy. However, their study was aimed for a socially-driven location sharing in a small group.

In an effort to study privacy concerns in location sharing applications that allow users to share their location with a wider range of people, Tang et al. [19] conducted a similar study. They created hypothetical sharing scenarios for socially-driven (vs. purpose-driven) conditions and asked participants to disclose their locations by using semantic and geographic labels. They observed that most participants were willing to "forego some privacy if there is a clear benefit". However, their findings are limited by the small sample of nine subjects in their experiment. In addition, they also used hypothetical scenarios instead of real conditions which might discredit the ecological validity of their findings.

To the current time, there are a few studies regarding the impact of location-awareness on social behaviors within the context of LBG. Of these studies, Nova et al. [14] explored the effect of disclosing location information on the performance of collaborative tasks in a location-based game. Participants were divided into two groups, one with a location awareness tool by which players could see their teammates' location, and another without any location awareness. Players in the group who were relying just on the self-reported positioning system were more engaged in communication with each other to express information about their location and their decisions. Although they did not try to investigate privacy in a location-based game, their findings indicated that revealing location information does not necessarily improve a task performance in a social experience in an LBG. However, it is worth noting that in their experiment, players knew their teammates before the experiment leading to a less concern of privacy.

The other research into LBGs are mostly based on deploying a game for a specific purpose such as education [4], to show the potential of a specific positioning technologies in designing a game [9], or to propose a principle for designing a more engaging location-based game [17]. These studies did not consider the possible effect of the players' feeling of privacy on their social experience during an LBG.

2 Method

To explore the influence of privacy on the social experience of the players in a location-based game, we designed a treasure-hunt LBG, called "Catch Treasures" on the iPhone platform.

2.1 Participants

28 students (aged between 19 and 30 years old) participated in the experiment. One participant accidentally logged out the game during his play session and could not

finish the experiment so his data was excluded from the analysis. Participants were recruited from a participant pool and received course credit as an appreciation for their participation.

2.2 Groups of Privacy

We implemented four different privacy conditions in the studied game. The privacy categorization depended on whether players were able either to locate other players or to see their iconic images on the map. These conditions are as follows:

Avatar-realism, Location-awareness (AL): considered as the least private situation, people could see both the physical location of other players and their facial image.

Avatar-realism, No location-awareness (AN): players could just see the real image of other players on a separate panel in the left-bottom corner of screen.

No avatar-realism, Location-awareness (NL): a player could see the location of other players on the map. However, other players were represented by a small red circle instead of a static image.

No avatar-realism, No location-awareness (NN): has the least amount of information sharing. This was because players were left unaware of another players' location and their associated images.

A week before the experiment, participants were asked to email the experimenter an iconic image of themselves showing their distinguishable face so that this image could be imported directly into the game as their avatar icon.

Since the participants were undergraduate students studying in the same department, it was highly possible that they had previous social connectedness. Therefore, to ensure that the social presence of players can be sufficiently affected by the designed configurations, we decided to use "fake players" competing with our real player.

In order to simulate the movements of fake players in the experiment (against the actual player), two tested players were asked to play the game alone before the study. The game recorded all of their movements and achievements and replayed these movements in the actual gameplay during the experiment. The results of a pilot study indicated that players could not notice that they were playing against fake players. Thus, showing the believability of the simple AI developed here.

2.3 Procedure

Participants signed the consent form and completed a five-minute questionnaire about their demographic information and previous gaming background. Afterwards, they received their user ID to log in the game. They were also given instructions about the game-play and the goals which they should accomplish to win the game. Players were required to walk to the physical location of rewards elements (represented on the map) to capture them and increase their scores.

Once the player logged in the game with their previously disclosed ID, s/he was assigned to one of these privacy conditions. Depending on the privacy-category assigned to the participants, they could see a screen very similar to one of the conditions in Fig. 1. The experimenter was virtually following subjects during the

Fig. 1. Privacy configurations of the game

game to ensure their safety and to prevent any external distractions from occurring during game-play. The experiment was conducted on SFU Burnaby campus and took about 45 minutes including the 20 minute game-play. After finishing the game, subjects were asked to complete a post-study questionnaire measuring social presence and asking about their experiences during the game.

2.4 Measure

In this study, we used the social presence gaming questionnaire developed by de Kort et al. [12] which is inspired by Biocca et al. [6]'s measure of social presence.

3 Results

The players' social presence measured by participants' answers to the social presence for gaming questionnaire [12] is demonstrated in Fig. 2.

The social presence varies from 0 (very low) to 4 (very high) in this measurement. The one-way ANOVA conducted for privacy configurations indicated no significant effect of factor "Privacy Configuration" on "Social Presence".

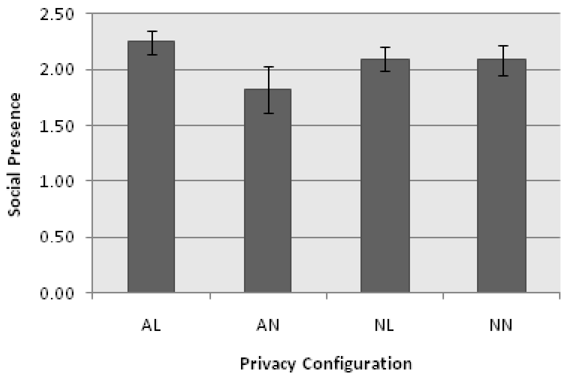

Fig. 2. The perceived social presence of players in each privacy configuration

Investigating de Kort et.al.'s measure [12] in more detail revealed interesting findings. According to de Kort et al.'s instrument, social presence consists of three components: Psychological involvement components including Empathy and Negative feelings and Behavioral involvement components. Fig. 3 demonstrates the effect of privacy configurations on components of social presence.

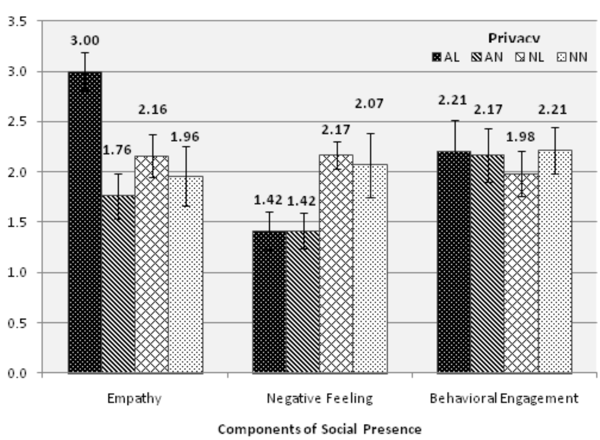

Fig. 3. Effect of privacy configuration on the components of social presence

3.1 Empathy

The ANOVA test indicated a significant effect of privacy configuration on Empathy (F=4.592 p=.012 < .05). The post-hoc analysis on privacy configurations using Tukey α statistics indicated significant differences between AL and AN conditions (p= .012 < .05) and between AL and NN conditions (p=.031 < .05). The findings suggest that players with the least private conditions had more empathy towards other players during the game-play session.

3.2 Negative Feelings

Since there was a violation of the assumption of homogeneity of variances a traditional ANOVA cannot determine any significant difference between privacy configurations. Instead, the Welch test indicated a significant difference (p= .008<.05) between configurations of privacy. The post-hoc analysis using Games-Howell test also showed a significant difference between AL and NL conditions (p = .039< .05) and also between AN and NL conditions (p=.007 < .05). Results suggest that photo-realistic avatars may decrease the negative feelings of players towards other players in the tested game.

3.3 Behavioral Involvement

The ANOVA test on "behavioral involvement" indicated no significant effect of privacy configuration on this component (F= .193, p=.900) suggesting that aspects of behavioral involvement were not significantly affected by the applied privacy configurations.

In the post-study questionnaire, participants were also asked to choose their preferred [privacy] condition to play the game. The results of players' preferences are represented in Fig. 4. As indicated, 85 percents of participants (23 out of 27) preferred either the AL or NL condition in which they were sharing their location with other players and were also able to track the other players on the game map. The result suggests that participants were willing to share more location information during their game-play session to be able to locate other players on the map.

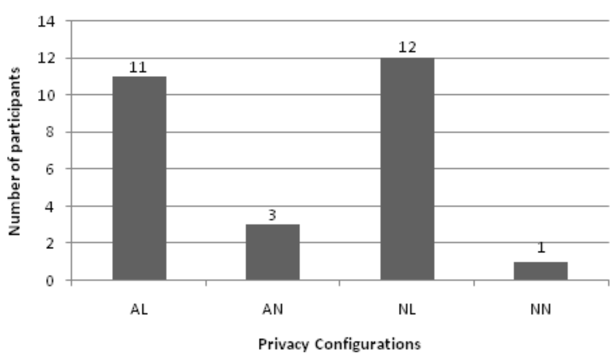

Fig. 4. Participants' preferred game-playing condition

4 Discussion and Conclusion

Social presence is highly dependent on social cues in the social experience. Lack of communication channels (either verbal or non-verbal) can erode social presence. One of the potential benefits of using avatars in mediated environments is to convey social cues and reduce uncertainty in interactions [15]. In this study, using the photographic images of the participants, as their avatars, did not significantly affect their perceived social presence. Our findings also indicated relatively low social presence in all conditions even in presence of photo-realistic avatars.

This can be explained by lack of implemented interpersonal communication channels such as a chat system in the game. We deliberately did not include any communication facility for the players in the game to ensure that social presence is mostly affected by the applied configurations during the game. The only available social cues for participants were the players' static avatars on the screen and/or their movements. However, those avatars were unable to interact with the other players' avatars during the game.

In addition, players had no prior knowledge about other players involved in the game which might lead to the low amount of perceived social presence. It has been argued that lack of previous familiarity of participants with other involved people in a social task can lead to the less social presence [20] in online environments.

Social presence is a multi-dimensional concept without a widely accepted definition; thereby, a comprehensive understanding of the impacts on social presence cannot be simply derived by few potential factors, communication channel and avatar realism in this context. To further explore the possible influence of the applied privacy configurations on players' social presence, we investigate the effect of each configuration on the subscales of the applied measure of social presence.

4.1 Empathy and Negative Feelings

de Kort et al. [12] described empathy as the "positively toned emotions towards co-players" (p. 7). The findings of our study indicated positive effect of the least privacy condition (AL) in which players were sharing both their physical location and photo-realistic avatars in the game-play session. This could be explained by the mutual trust between the players as a result of revealing more information by other players.

Findings of our experiment also indicated a negative impact of "Avatar realism" on negative feelings of players during the game. Participants who were aware of other players' photographic images (AL and AN conditions) reported the least amount of negative feelings regardless of their awareness of other players' location.

Surprisingly, the results showed the potential effect of revealing location information on empathy (positive feelings) while the negative feelings of the players were not significantly affected by revealing location information.

These results are virtually consistent with findings that people playing against a "locally co-present other" reported higher empathy than those playing against a mediated opponent [16]. Interestingly, they also found that negative feelings were not significantly affected by physical distance.

Players in a location-based game are between these two environments. They play in a mediated environment, but on the other hand, in a shared physical (and virtual) environment. This particular characteristic makes LBG experience distinct from gaming experiences in either virtual or physical presence of co-players

4.2 Behavioral Involvement

Behavioral involvement in measure of social presence [12] in gaming describes "the degree to which players feel their actions to be dependent on their co-players actions" (p. 7). Therefore, it is well expected that in the absence of active social verbal/non-verbal interpersonal communication in the tested game, behavioral involvement is hardly affected.

4.3 Privacy Sacrifice

In previous works, people reported to have more concerns with privacy in location-tracking services comparied to position-based ones [3]. Conversely, in our experiment setup, players were positive towards constantly sharing their locations during the game. Fig. 4 indicates that around 85% of the participants preferred to play in the conditions where all players were aware of other players' locations.

One important factor which can contribute to the participants' desire to reveal their location information is the location-sharing context. One of the significant differences of social applications and games is that in the majority of games, the task accomplishment is prioritized more highly than the communication part. On the other hand, social applications are primarily designed to facilitate social interaction between users. It is likely that players were fascinated and engaged enough in the game tasks such that they were less concerned about social interactions, information sharing, and consequently their privacy during the game. In a competition LBG, players might be more eager in location awareness of other players than making social connections to pre-plan a winning strategy. For instance, imagine a player finds another player very close to a collection of coins. This situation might motivate the player to try different strategies to avoid the possible lost condition.

4.4 Limitations

Despite the general focus on social location-sharing services, this study particularly explored two aspects of privacy in a location-based game. Although various similarities between social LB services and LBGs can be encountered, the findings of this study might not be directly extensible to other social LB services without further investigations. Meanwhile, our designed game was based on a competition among individual players. Even in the context of LBGs, contrary results might be observed when other possible social interactions such as collaboration among players exist.

In addition, we posited the concept of social presence as the ground to explore the social experience of players during the game; however, social presence might not be the best measurable indicator of the quality of a social experience.

We are aware that a comprehensive understanding of a concept (privacy in LBGs in this context) cannot be inferred by the obtained results from a limited number of participants (28 people) in a specific population (students aged 19-30). However, we believe that people even in this specific age are still good representatives of potentially social applications and are likely to constitute a considerable portion of active users in future LBGs.

Finally, if people play this game in the real life, different results might be obtained when they play against their friends, or against total strangers.

Despite the mentioned limitations of this study, our findings indicate that the potential enthusiasm towards game-play in an LBG might lessen the privacy concerns of players particularly in terms of location privacy. Furthermore, this study implies that the mere sharing more personal information cannot enhance the potential social connectedness among players. We speculate that an engaging location-based game can decrease the users' concern of privacy leading to more popularity of the game. This suggests that location-based game designers should put more effort on the design of the game to make it more exciting for the players and consequently to lessen the users' concern of privacy.

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VivoSpace: Towards Health Behavior Change Using Social Gaming

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Abstract. Social gaming is now surpassing traditional gaming in terms of the total number of players. We describe our research in creating *VivoSpace*, an online social network application that applies the rapid uptake of social gaming to the domain of serious games for personal health. Specifically, VivoSpace aims to leverage social gaming to motivate positive health behavior change. A user centered design process has begun for designing VivoSpace based on an initial user inquiry questionnaire that revealed key motivations for using online social networks and users' thoughts on health. Interview feedback of the paper prototypes highlighted reluctance to share particular types of health information and apprehension in logging daily information. However, people were fond of the social aspect of sharing personal health information in the context of group challenges and participating in group health activities.

Keywords: VivoSpace, health behavior change, online social networks, serious gaming, user-centered design.

1 Introduction

Online social networks have proven that people can be highly motivated to become part of a community activity, participate in group activities, enter personal information regularly and form committed behavior patterns. Social games like Zynga's Farmville[1] and others are surpassing traditional gaming in terms of ongoing participation [6]. They have sparked an innate need for communication and belonging that has led to a committed user group. Conversely, living a healthy life remains elusive for many. While many people realize the importance of maintaining a healthy lifestyle and often feel that they can live a healthier life, they often have difficulty in managing their health. At a community level, a healthier population can lower healthcare costs; therefore, it is not surprising that many public health initiatives exist that encourages citizens to live more healthy lives [e.g. 4].

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[1] http://www.farmville.com/

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There are several theoretical models that articulate the motivations for health behavior change. The *health belief* model describes the importance of an individual's perceptions on the benefits and barriers to changing their health behavior [7]. Furthermore, the *Social Cognitive Theory* on health behavior change includes one's perceived self-efficacy, and it includes social factors such as perceived facilitators and impediments to good health behavior [2,19].

These theories provide an interesting vantage point toward understanding the individual and social contributions to health behavior change. However, despite some studies [10,13] it is still unclear how social networks fit into these models. The following research question then emerges: ***how can an online social network and social games be designed to motivate positive health behavior change?*** Toward answering this broad question we present the current design and evaluation of *VivoSpace*, an online social network application that is designed to motivate positive health behavior change.

First we review research that has been conducted with respect to social networks for personal health behavior change. Following this, results from a questionnaire are presented to understand motivation to use social networks and change personal health behavior. We then describe VivoSpace's paper prototype and the interviews we conducted to obtain feedback on our prototypes. Finally, conclusions and future work is discussed based on the described results.

2 Background and Related Work

There have been some studies that have looked at how online social networks can be used to motivate health behavior change. A preliminary framework for online social network to motivate health behavior change has been developed [8], called the **ABC** Framework. The framework identified three main components: individual aspects such as **A**ppeal and self-efficacy, social aspects such as **B**elonging and influences, and temporal aspects that include **C**ommitment.

The **A**ppeal determinants for motivation to use online social networks include providing and getting information, convenience, entertainment, maintaining interpersonal connectivity, social enhancement and self-discovery [8,9,15,20]. The **A**ppeal determinants for motivation to change health behavior include individual incentives, perceived beliefs, perceptions on one's self-efficacy and perceptions about outcomes [8,7]. The **B**elonging determinants for motivation to use online social networks include social categorization, social connection, sense of belonging, social identity and social comparison [8,9,3,18]. The **B**elonging determinants for motivation to change health behavior include subjective norms, environmental cues and social incentives [8,2,19]. For **C**ommitment, the determinants for use of online social networks are derived from organizational commitment, and they include affective, continuance and normative attachments [8,1]; for motivating health behavior change, there are stages of health behavior change that include pre-contemplation, contemplation, preparation, action and maintenance [8,17]. The ABC Framework will be used to assist the user-centered design process by formulating the points of inquiry.

Related work indicates that social support through online communities is important to patients managing health problems [10,16]. Individual and social aspects have been explored for diabetes patients that are controlling their diet, exercise and medication [11,12,13]. In these studies, individual reflection and communication with educators was provided by a mobile application. Furthermore, visualization and reflection of social activity has also been used to improve health outcomes in elderly patients, where visualization of a patient's current social activity increases social behavior [14].

There have also been many commercial products that combine the collection of personal wellness and health data with social supports. This includes the nike+ system[2], where personal running information can be logged and users can participate in group challenges and discussion forums. Similarly, Ayogo's Healthseeker is a Facebook application that combines one's social network and serious gaming for health management.[3]

3 Initial User Inquiry

Initially we used a questionnaire to test the validity of the ABC Framework [8] and then used the framework to provide points of inquiry for the design of the VivoSpace social network application. Our aim is to gain insight into end-user motivation through well-tested models. Online and paper questionnaires were used to obtain feedback on both: 1) their motivations in using online social networks and 2) their motivation in changing health behavior.

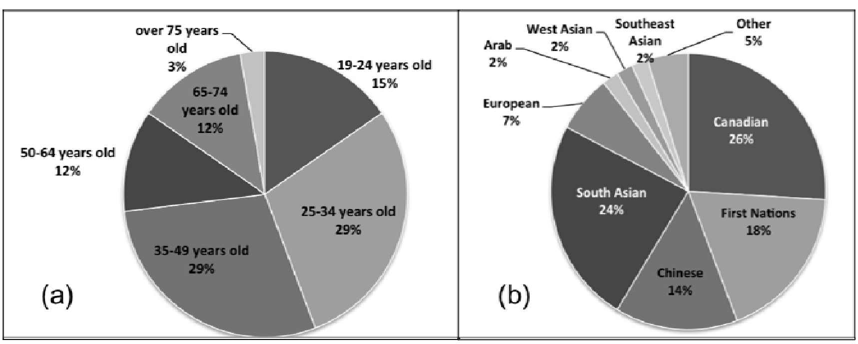

Fig. 1. Demographic distribution for 104 questionnaire respondents. (a) Shows the age distribution, and (b) shows the distribution of ethnic identity.

3.1 A Look at the Respondents

104 respondents from a diverse adult population were asked about their motivation to use online social networks and their thoughts on their health behavior. The

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[2] http://nikeplus.com

[3] http://ayogo.com/

respondents were 52% women and 48% men. The age distribution as shown in figure 1 (a) is quite diverse ranging from 19 to over 74. The participants' ethnic identity is very diverse with representation from 13 different ethnic groups as shown in figure 1(b). The most represented ethnic groups are Canadian, South Asian, First Nations, and Chinese.

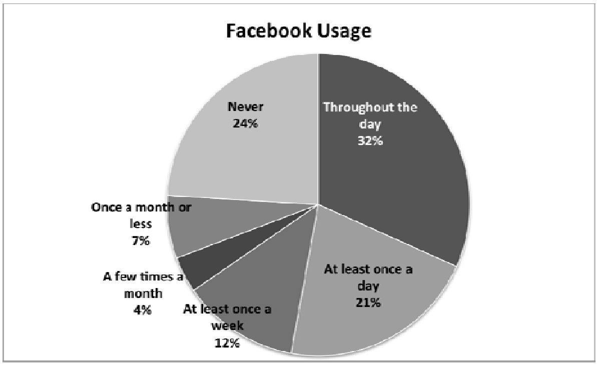

Fig. 2. Frequency of usage for Facebook by questionnaire respondents

The respondents were users of technology to varying degrees. 94% owned computers with 82% of all respondents using their computers throughout the day. 53% of respondents used Facebook at least once a day and only 24% said they never used Facebook (figure 2). 36% had used LinkedIn and 29% had used Twitter. 38% of respondents had used an online community.

3.2 Motivation to Use Online Social Networks

Understanding the motivations to use online social networks is applied in the design of VivoSpace to ensure the social game builds committed behavior. The participants were asked about their motivation for using online social networks or online communities. 86 respondents answered these questions. The points of inquiry are based on the ABC Framework [8], the Uses and Gratification Theory [20,15,9], the Common Bond and Common Identity Theory [9,18], and the Social Identity Theory [3]. Figure 3 shows the key motivators based on individual determinants or the ***Appeal*** components of the ABC Framework. Most individual determinants show as being strong motivators, including: *maintaining connection with people*, *easy access to friends*, *getting information* and *entertainment*. The least favorable motivations reported were *to learn more about oneself* and *to enhance social position*.

When the data was stratified by age groups and ethnic groups and one-way ANOVA analysis was conducted, certain ethnic groups were more motivated to use social networks for social enhancement. ANOVA analysis revealed that Chinese and South Asians were motivated to use online social networks for social enhancement more than Canadians (p=0.003). Table 1 shows the descriptive statistics for these three ethnic groups, where the 5-point Likert scale was numerically defined as 1 is *strongly disagree* and 5 is *strongly agree.*

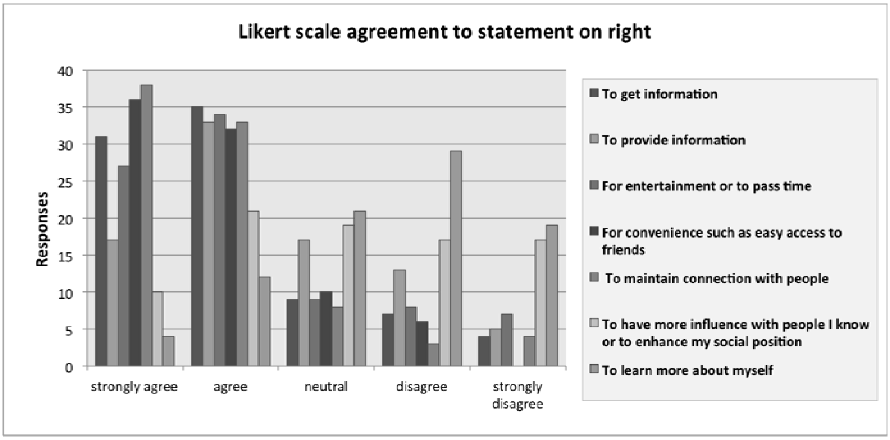

Fig. 3. Responses from 86 respondents for individually based motivation to use online social networks

Table 1. Descriptive statistics for 3 ethnic groups using 5-point Likert scale (1=strongly disagree and 5=strongly agree) that resulted in a significant difference are shown here. These responses were for the question "*I use online social networks and/or online communities to have more influence with people I know or to enhance my social position*"

Ethnic Group	Average Response	Number of Responses	Standard Deviation
Chinese	3.53	15	0.915
South Asian	3.47	15	1.246
Canadian	2.08	25	1.115

The respondents were also asked about their social motivations to use online social networks. This inquiry was based on the Common Identity and Common Bond Theory [18,8]. This is shown in figure 4. Generally, respondents felt stronger about *connecting with similar people* than *belonging to a group or community*, but both showed strong motivation. 54% agreed or strongly agreed that *they use online social networks to connect with similar people*. 36% agreed or strongly agreed to using *online social networks to belong to a group*.

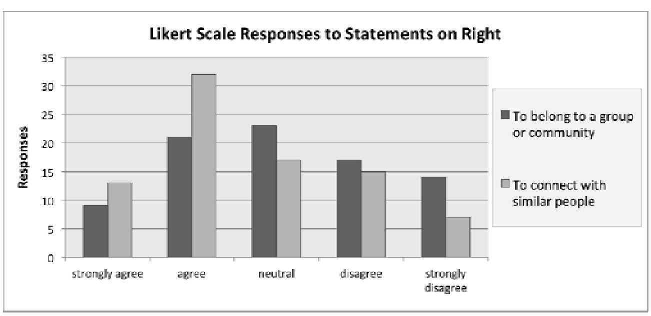

Fig. 4. Responses from 86 respondents for socially based motivation for using online social networks

3.2 Thoughts on Health

102 of the 104 respondents answered the questions inquiring about their thoughts on their health. Figure 5 shows the results. Generally respondents felt that they were living a healthy lifestyle, understanding how to live healthy, eating healthy food and exercising regularly. However, interestingly, the majority of respondents felt that they are capable of living a healthier lifestyle. Most respondents also recognized the social influences on health.

Once again ANOVA analysis was conducted on this data to understand the differences between the age groups and ethnic groups. The ANOVA analysis revealed that there was a difference between the age groups in their perceptions of *eating health food* (p=0.036). Respondents aged 65-74 years old (average Likert scale = 4.36) felt that they ate healthy food more than those aged 25-34 years old (average Likert scale = 3.66).

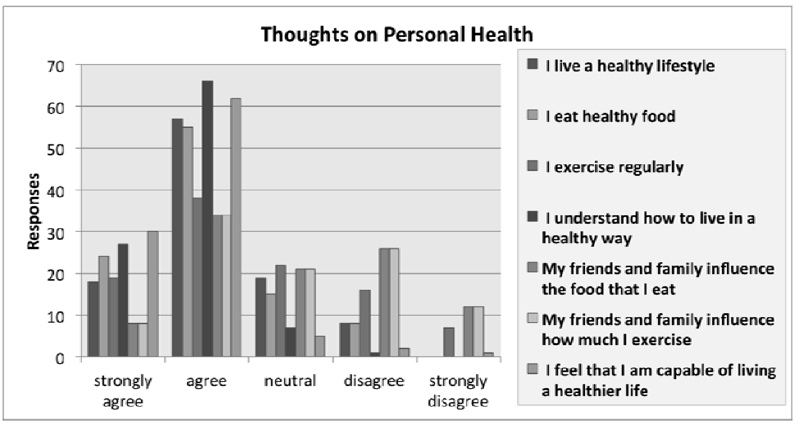

Fig. 5. 102 questionnaire respondents' thoughts around personal health management

4 VivoSpace Prototype

Based on the data gathered from the user inquiry and the ABC Framework, which is based on existing theoretical models, we began the design of Vivospace. Initial paper prototypes provide relatively high-fidelity aesthetics to allow us to obtain feedback on both the aesthetic appeal as well as how users feel about its use.

Figures 6 and 7 show 2 of the 14 pages that were developed. The overall design of the paper prototypes included three main frames: the organization pane, the digital asset pane and the content pane. The left pane is the organization pane and it contains items such as an overall scale to see how the user is performing in terms of their health behavior, a calendar that allows the user to enter upcoming events such as a dinner engagement with friends and also has the ability to invite friends to events, a to-do list that will allow the user to manage all their action items whether they are health related or not, and finally a list of the friends or contacts on the VivoSpace system. The right pane is a consolidation of the user's digital assets such as music, photos, movies and links that will be connected to their iTunes and/or other digital storage locations either online or on their personal computer. This pane also has connections to online communities that are part of VivoSpace, including a restaurant community where users can rate restaurants and suggest healthy menu items, a recipe community that allow users to share recipes, and a health community to allow discussions around specific health topics. These two panes are meant to build the **A**ppeal dimension of the theoretical framework by linking to digital assets such as music and other informational needs of the user such that health is not separated from other parts the user's life. The central and most prominent pane contains all of the content, including a timeline where users enter their health related activities, a Facebook-style newsfeed and a dashboard.

Fig. 6. Timeline is where users are able to log their daily activity and share with any portion of their social network or not share it

The timeline page (figure 6) is where users log their daily health activity. Based on this activity, VivoSpace provides the health information for that activity such as calories and sodium consumed or calories burned. For example, a user can add that they had a specific restaurant meal and a couple of glasses of wine; the system will look up the health related information for this activity such as total calories, amount of sodium and amount of saturated fat, and return that information. This will change the user's perceptions of how their behavior affects their health, which is central to what the theoretical models have said influences health behavior. VivoSpace also provides the user with the ability to link a health activity to their social activity; for example, this user had that restaurant meal with two friends who are also on VivoSpace. This will provide the user with feedback on social influences on their health, as there may be certain friends who are good influences, while others are not. This visibility into the user's social determinants should motivate them to change their health behavior as defined by the ABC Framework. Specifically, the **B**elonging dimension of the theoretical framework to motivate health behavior change includes the subjective norm determinant. The user can also share any of the information in the timeline with all, none or a portion of their social network. The activity for friends can be seen in the Facebook or Twitter-style newsfeed page.

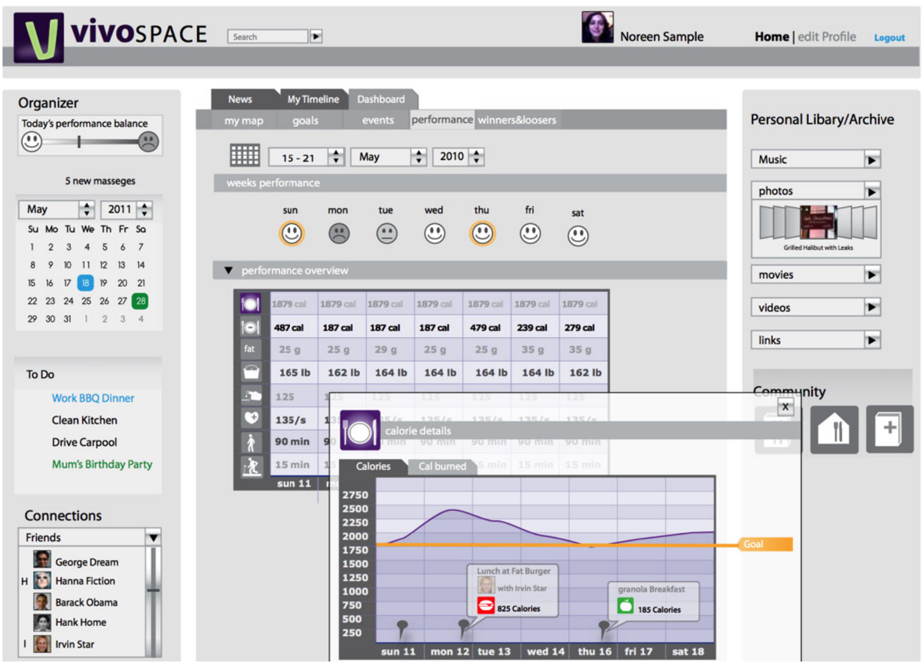

Fig. 7. Dashboard of weekly performance with flags displayed on the graph to show what activities that were logged on that day

Figure 7 shows a *health dashboard* based on the information that was logged. The user's health performance is shown initially in a narrow channel as happy and sad faces with higher fidelity information provided below. Users have access to a full graphical view of various health variables with annotations of activities that were logged. The "Winners and losers" tab on the dashboard show how the user is performing when compared to their friends. This tab provides a true social gaming experience. The top three and worse performing friends are shown for each day to build social motivation. The "my map" tab provides a geospatial view of ones movements and location of activities. The prototypes also include profile presets, where users can select which health variables they wish to see. Users can also view and select evidence-based seals such as "Diabetes Safe" or "Low in Saturated Fat"..

5 Feedback on Prototype

11 adults (4 women and 7 men) were interviewed to obtain feedback on all 14 pages of VivoSpace's paper prototypes. The participants were regular users of technology and social networks. One participant used social media throughout the day, checking their friend's status updates every few minutes. 9 used either Facebook or Twitter several times everyday. One respondent stopped using Facebook, but continued to use Twitter a few times a week. Figure 8 shows a photograph of all 14 pages laid out during one of the interviews. First, each participant was through the functionality for each page, and then they were asked questions based on the ABC Framework.

Fig. 8. Photograph of all 14 pages of the paper prototype laid out during the interviews

394 comments about VivoSpace were collected and analyzed. They were coded into 10 categories and then each comment is grouped into related themes [5]. Table 2 shows these 10 categories with the number of comments for each category and the number of themes that emerged in each category.

Table 2. Qualitative analysis of feedback of VivoSpace showing the categories, number of comments in each category and number of themes that emerged in each category.

Category	# of comments	# of themes
Difficulties with VivoSpace	91	20
"Likes" about VivoSpace	84	17
Recommendations	82	23
Dislikes about VivoSpace	37	9
Positive about VivoSpace's ability to influence health	29	7
Positive about social aspects	21	4
Design Aesthetics	16	8
Temporal aspects	20	3
Negative about social aspects	10	7
Explanation of other electronic health products	4	2

Table 3 shows the themes that emerged from the category "*difficulties with VivoSpace*". The main concern was the perceived difficulty in entering information, as it was felt that inaccurate information would make the system less effective. Privacy concerns were also raised, as it was felt that health information is personal.

The second most frequently mentioned was concerns around privacy of health information. Specifically, participants voiced concern around whether they would be willing to share unhealthy behavior, and some felt that they would not share health information at all. Many felt that access to the digital assets (personal library) did not fit the scope of Vivospace, and that the prototypes had too much information.

There were many aspects of VivoSpace that participants liked. Table 4 shows the themes that emerged from this category and the number of comments for each theme. The most frequently mentioned was that logging of health information would be helpful, which is at odds the perceived difficulty in logging this information. The dashboard was the page that was most liked, as well as the recipe sharing aspect of the prototype. The participants liked certain design elements such as the personal preset icons. Encouragingly, participants did like some of the social gaming aspects such as the "winners and losers" and the idea of using social networks to track life behavior.

Table 3. Themes emerging from *Difficulties with VivoSpace* category

Theme	# of comments
Too difficult to enter information & data collection concerns	20
Privacy: not wanting to share unhealthy habits or any health information	13
Too much material	10
Digital assets/personal library does not fit	7
Lack the motivation to use the system	4
Not wanting to join another social network	4
Sees difficulty in adding a recipe	4
Privacy: willing to share a portion of the post/entry what you are doing but not the nutritional info	3
Seals are not trustworthy	2
Only health conscious people would find it enjoyable	2
Concerned about how recipes are shared	2
Needs a certain amount of people to be interesting	2
Better to provide broad guidelines than numbers	2
Privacy Concerns: Not wanting to share the information	2
6 other items mentioned once each	

Table 4. Themes emerging from *Likes about VivoSpace* category

Theme	# of comments
Personal health/life logging would be helpful	16
Likes dashboard	16
Likes recipe sharing aspect	9
Likes the personal presets icons and/or filtering option	8
Likes winners and losers	8
Likes the idea of social network to track life behavior	5
Likes newsfeed / familiar Facebook feel	4
Likes having all information in one place	3
VivoSpace would help one to organize one's life	3
Likes mymap	3
Likes calendar	2
6 other items mentioned once each	

The participants shared many recommendations to improve VivoSpace (table 5). They were very encouraged by the idea of social gaming and there were numerous suggestions to create challenges to allow groups to assist one in achieving their goals.

Another recommendation was to make one's health goals more central to the design. The participants were concerned about managing another online social network, so they suggested that VivoSpace should integrate with existing social networks like Facebook and/or Twitter.

Table 5. Themes emerging from *Recommendations for VivoSpace* category

Theme	# of comments
Creation of challenges or groups working together to achieve a goal	20
Goals need to be more central	12
Need to integrate with existing social networks and online calendars	7
Better to allow for customized dashboards and trackers	7
Needs an incentive system	6
Need to collect other types of information	5
Have rankings rather than winners and losers	3
VivoSpace should remain focused on health information	2
Create badges / sharing of others achievements	2
Health information of friends on Winners & Losers should include other information	2
Suggestions for dashboard	2
System needs to provide recommendations & encouragement on how to live and organize one's life	2
Need to be able to customize the to-do list and calendar colours	2
5 other items mentioned once each	

6 Conclusions and Future Work

The ABC Framework shows strong validity based on inquiry on motivation to use online social networks and change health behavior. Therefore, the ABC Framework was used as points of inquiry for the initial stages of design for VivoSpace. The current prototype design and evaluation of VivoSpace has presented some encouraging results in the creation of a social game for promoting health behavior change. Interview participants were fascinated by the socialization of health information and suggested the creation of challenges and group health activities as motivational features. However, the privacy issues raised still need to be resolved: the next iteration of the design needs to consider how best to create a fun social gaming experience with health information, while providing the user with a sense of control over their privacy.

Based on this feedback, we are currently reworking the design of VivoSpace. The main changes anticipated include: simplicity in its use by allowing user to log aspects of their health; allowance for the creation of challenges that the user can invite specific friends to participate in; making goals central to the design; and showing friends' activities that are most beneficial to their health.

These changes will be incorporated into a medium fidelity prototype that will provide an interactive system. Usability studies will then be conducted to evaluate the medium fidelity prototype. The results from the usability studies will be used to create the next iteration of the system. Specifically, a high fidelity prototype will be developed. This prototype will be used to conduct a field evaluation of VivoSpace to answer the question on how social networks combined with social games can be used to motivate health behavior change.

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Wisdom about the Crowd: Assuring Geospatial Data Quality Collected in Location-Based Games

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Abstract. The idea of outsourcing geospatial data creation tasks to the crowd (volunteered geographic information, VGI) has become quite popular in the field of geographic information science (GIScience). As one approach to VGI, location-based games (LBGs) have been shown to be successful in motivating non-expert users to collect and tag geospatial data. However, the central VGI problem of data quality has so far not been solved satisfyingly. Previous studies show that games that reward their players for in- or post-game data reviewing can assure only a validation rate of about 40% of the data. We address this problem with a new LBG design pattern, based on game rules that encourage players to take the decisions of others into account while making their data collecting decisions. We empirically evaluate the new pattern by comparing the positional accuracy of data collected with two different rule sets for the LBG *GeoSnake*. Our pattern is shown to result in a significant accuracy improvement.

Keywords: location-based games, crowdsourcing, volunteered geographic information, geospatial data, data quality, game design.

1 Introduction

Ahn and Dabbish (2008) [1] have shown that regular internet users can be motivated by games to work on simple tasks creating outputs that are useful for serious applications, like search engines, without any kind of incentive other than entertainment. Using web-based games like the ESP game (see [1] or *http://www.espgame.org/gwap/*) they were able to gather huge amounts of data, in the referenced case semantic tags for images. Projects, such as OpenStreetMaps (*www.openstreetmap.de/*), have picked up this idea for the domain of geospatial data and count on enthusiastic amateurs to map the world for free.

Matyas et al. (2009) [8] have demonstrated that Ahn's idea can be adopted for the creation of geospatial data with the help of location-based games (LBG). But they reported that, unlike in a pure web-based context, volunteers of LBGs are rather reluctant to review the data created by other players.

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The main contributions of this paper therefore are: We first propose an approach to assure the geospatial data positional accuracy collected in a LBG, without introducing a special review board like in [5] for example. It is inspired by the idea of the wisdom of the crowd [9] and realized as a game design pattern, in the spirit of Björk and Holopainen's [3], that can be integrated into any geospatial data collecting LBG. Instead of adding an ex-post quality assurance process it succeeds in "persuading" players to create accurate data by taking into account the decisions of others while making their data collecting decisions.

As a second contribution, this paper empirically evaluates the new game pattern and shows that it results in an improvement of positional accuracy. A study was performed in an experimental setting with the location-based game *GeoSnake*.

The rest of the paper is structured as follows: in the next section, we will give a short overview on related work. Section 3 introduces the wisdom-about-the-crowd pattern and the location-based game *GeoSnake*. The game has been used in an experimental setting in a case study (subsection 3.1 and 3.2). We summarize our findings in section 4.

2 Related Work

The usage of LBGs to gather geospatial data has been discussed in the game research community for some years. Capra et al. (2005) [4] were among the first to mention this possibility. Since then, various LBGs have been introduced that allowed the collection of various types of geospatial data as a by-product of game play.

CityExplorer. [8] was the first LBG designed with the primary goal to collect geospatial information. In *CityExplorer* players create complex geospatial data sets, composed of two GPS coordinate pairs, image data, and a semantic tag.

The central problem that remains open for all LBGs so far (see also [8] for an overview) is how to guarantee the quality of the collected data sufficiently well. So far either none (e.g. [6]), or a point-based review system (e.g. [2, 5, 8]) is used to validate the correctness of player-created data. Interestingly, e.g. [2, 5, 8] reported nearly the same results of how much data was actually reviewed by the players of their games. The review rate lies always between 30% to around 40%. Though one can argue whether these studies constitute a representative sample, they give a strong hint that the upper bound for the quota of data that gets checked with a review system is indeed around 40%. Thus, more than half of the collected data can be regarded as of unknown quality. While the quality indicators of the hardware (e.g., a GPS device) could be known and used as measures, the players could still have provided erroneous data on purpose. So the review system also serves the role of an anti-cheating tool [8] and cannot be replaced so easily by hardware characteristics alone. The game design pattern presented in the following section therefore strives to assure quality and fairness at the same time.

3 Wisdom about the Crowd Gaming: GeoSnake Study

To overcome the above mentioned limitations of a game-based review system we propose a new kind of quality assurance strategy for LBGs. It is important to note that the positional accuracy is not primarily affected by the ability of the player to handle a GPS receiver and his or her knowledge about geodetic datums and map projections. Almost all issues requiring technical background knowledge are handled by the game software. The major problem associated with recording the position of a geographic object relates to semantic ambiguities. A building may have several entrances - which of them should be used to mark the position of the building? There are even more alternatives for extended objects such as streets or regions. For example a query on Google Maps for the "Otto-Friedrich University of Bamberg" returns the coordinate pair 49.90763,10.90466. But the same query on Bing Maps results in 49,89378,10,88595. Single expert data collectors have obviously problems to solve the semantic ambiguity problem, so how should non-trained volunteers have a chance to solve it? Clustering multiple recordings from different volunteers also doesn´t solve the problem as the cluster center will certainly end up somewhere without a semantic meaning to the real-world place.

With this question in mind we propose the following general game design pattern:

Wisdom about the crowd

Description: *Players are retained to take into account the anonymous majority decision of the other players when generating game-based geospatial data.*

Consequences: *The pattern is tailored to provide a kind of implicit quality control mechanism for geospatial data creation LBGs. However, we do not expect the crowd to outperform experts with respect to quality - a claim associated with the original wisdom of the crowd idea by [9]. Also, the basic mechanism is different from that of typical wisdom of the crowd approaches. It mimics a review strategy by trying to motivate the players to create data that most of the players can agree on, not with an external reward (or punishment) system but by a specifically designed game rule. The players are "lured" to provide agreeable data on their own. It thus goes beyond the traditional reviewing system, such as the peer reviewing of [5] or [8], as the data is after all indirectly evaluated by all players and not just a few players that happen to be on the review board. Note that the pattern is somehow similar to the approach used in [7] but uses an anonymous crowd as the "opposing" player and not just a single one.*

3.1 Set-Up

We will demonstrate the usage of the pattern with the introduction of a simple LBG, *GeoSnake* - a variant of the popular video game *Snake*. Like the video game, *GeoSnake* is a single-player game. In contrast to the genuine, players have to visit a known number of places and choose appropriate GPS coordinates for them. Players get points for every place visited. Points are deducted if a player crosses his previous path (one point) or takes a path twice (two points) - so every street can be seen as a one-way street and the tail of the snake is growing alongside the path the player takes continuously. Now this might appear easily done, in a real world city wide game field it is quite a challenge. Please not that for a non-experimental setting a multiplayer game would be more appropriate as a design for a location-based geospatial data gathering game (see [8] on this subject).

For *GeoSnake*, we formulated the following two game rules for how the players should pick a GPS coordinate for a place in the game. The first one is the normal rule that one would expect as a result from the game description we gave above: *Choose a GPS coordinate that identifies the place without a doubt, so located inside or as near as possible to the place (called V1).* The second one represents the implementation of the wisdom-about-the-crowd game design pattern: *Choose a GPS coordinate, that you think the other players also chose (called V2).* For V1 points were awarded as long the chosen GPS coordinate was reasonable near the place in question. For V2 only those players received points whose coordinate pair belonged to the biggest cluster of coordinates for a given place.

The hypothesis is that the players will produce more accurate geospatial data under rule variation V2 than under variation V1.

To judge the accuracy and therefore the quality of the provided geospatial data we proceed as follows with the GPS coordinates of V1 and V2: (1) We compute the individual cluster centers for all places used in the game and then (2) we measure all distances between the cluster centers and the associated GPS coordinates for a place. So we end up with a table that holds all distances for a GPS coordinate to its associated cluster center for both rule variants. To evaluate the effect of the employed rules a generalized linear model (GLM) is estimated:

$$\mu = E(distance|rule, time) = h(\beta_0 + \beta_1 rule + \beta_2 time)$$

GeoSnake was used in the case study to test the hypothesis provided above, to control for learning effect after rule switching. Therefore, the case study has a randomized treatment selection. *GeoSnake* was played by a group of 15 students and employees of the university of Bamberg with a background in either computer science (4) or humanities (11). Gender was mixed with 5 male and 10 female participants, age mean was 26,6 years.

To be sure to collect the same amount of GPS coordinates under each rule (V1 and V2) we had two game fields each with six places for the players to choose GPS coordinates for (1V and 2V). We then used a pseudo-random allocation of player, rule and place set. So each player actually had to play two rounds of *GeoSnake* in course of the case study, for e.g. the first participant played with the places of 1V with V1 and then played on 2V using V2. Then we used 2V under V1 and 2V under V2, etc.

3.2 Results

For the reason of estimating a GLM with canonical link of a Gamma distributed response with the *R* software, the directions of the effects have to be interpreted oppositely in table 1 as *R* reports the inverse as response. Using the above explained GLM (equation 1) the results show that rule 2 is better than rule 1 on a significance level of 0.05. See table 1 for the result chart from *R*.

Table 1. Source: *GeoSnake* Game. Remarks: *** < 0; ** < 0.05; * < 0.1

	Coefficient	Std. Error
rule 1 (Intercept)	0.014***	0.002
rule 2	0.008**	0.003
time	-0,0002	0.0002

To illustrate this finding figure 1 pictures two examples of data sets, one for a street and one for a building from the places of the game field 2V. The red dots show GPS coordinates chosen using rule V1 and the blue dots using rule V2. It is easy to see that rule V2 produced a much more denser cluster of GPS coordinates than rule V1.

Fig. 1. Visualization of the chosen GPS coordinates for two *GeoSnake* places, a street (left image) and a building (right image) on game field 2V

Note that the building - right image of figure 1 - can be accessed from two sides, the entrance point on the left - where all blue dots are placed - is the main entrance. The right entrance, chosen by three players under V1 (red dots), is a secondary entrance where one can enter the building coming from the nearby bus station. Players under V1 obviously didn´t care that much about the quality of the resulting geospatial data but more about the game itself - not crossing their way later in the game for example. Under V2 it seems that it is just the other way around or put differently that our implemented game pattern made them more aware of the underlying semantic ambiguity problem as discussed at the beginning of this section.

The street example (left image of figure 1) supports this impression. Here the blue dots are centered around the middle of the street - after the game several players reported that there is a well-known coffee shop located. The players choosing the red dots were actually more concerned that when they entered the street that they had to go a long way to avoid taking that way twice or crossing it. So they took the most favorable decision from a game play perspective.

These examples demonstrate how the implementation of the wisdom-about-the-crowd pattern into the *GeoSnake* game "tricks" players into providing geospatial data that the majority of the other players can agree on. Furthermore it prohibits that the players only think about the game when creating the geospatial data but also about the quality of the data with regard to the semantic ambiguity problem.

4 Conclusions

In this paper we have shown that the 40% participation rate that is common for review systems of geospatial data creation location-based games to date can be overcome by implementing the wisdom-about-the-crowd design pattern. We presented the general design pattern and the location-based game *GeoSnake* to illustrate its use. Additional we used our game in the course of a case study to validate the hypothesis that with our proposed game pattern the spatial accuracy of the collected data can be increased. Open interviews and detailed data analysis point out that these results are independent of the point-based game rewards used in *GeoSnake*. Related work suggests that when geospatial data creation is paired with a location-based game, players are more concerned about the game and not so much about qualitative data creation. The results from the *GeoSnake* use case study indicate that this behavior changes when our proposed design pattern is applied to such a game.

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An End-to-End Framework for Multi-view Video Content: Creating Multiple-Perspective Hypervideo to View on Mobile Platforms

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Abstract. We present a work-in-progress novel framework for the creation, delivery and viewing of multi-view hypermedia intended for mobile platforms. We utilize abstractions over creation and delivery of content and a unified language scheme (through XML) for communication between components. The delivery mechanism incorporates server-side processing to allow inclusion of additional features such as computer vision-based analysis or visual effects. Multi-view video is streamed live to mobile devices which offer several mechanisms for viewing hypermedia and perspective selection.

1 Introduction

This paper presents a novel framework for production, delivery and consumption of multi-view hypervideo targeted towards mobile devices. Each of these three components are separate projects within our framework and each represents a current work-in-progress infrastructure with the aim of providing modular and simply connected systems. The novelty of our work comes from the combination of these components targeted towards multi-view and mobile platforms, with the addition of computer vision infrastructure to enhance the user experience.

The framework we present here includes many components which are tied together. We introduce a mobile networked camera system which can address cameras uniquely and stream data from them to any platform. To organize and annotate the generated footage we present our authoring tool for multi-view hypermedia along with our semantic description we use as the base language of the video metadata. The image and semantic data is processed on servers and then delivered to mobile devices over a transport middleware developed specifically for image processing and transfer. Finally, we describe our mobile platform multi-view hypermedia viewers which receive the data and present it in an intuitive manner to the user.

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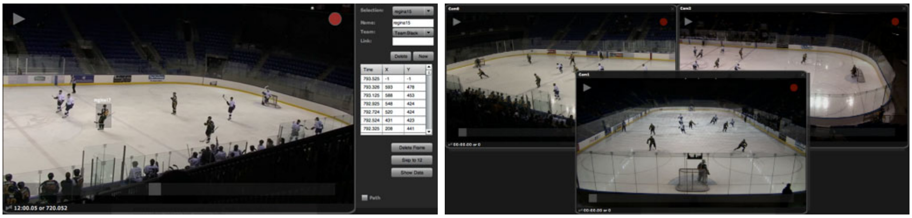

(a) Object annotation editor (b) Multi-view video annotation display

Fig. 1. Within-video objects annotated with position and identity information (a), supporting multi-view annotation (b)

2 Related Work

Most related work to this area is in video authoring, annotation tools and hypermedia viewers, since complete frameworks are rare. Annotations in video visually emphasize objects in a video stream (shown as a bounding box in Figure 1) and by serving as an anchor between objects and additional information. Annotated videos are also often referred to as hypervideo [9], which resolves the linearity of video structures and so creates a non-linear information space. Among others, HyperCafe [8], HyperSoap [3], and HyperFilm [7] are considered to be the first research projects that integrate video annotation as a core concept. All of these projects focus on a separation of the presentation and authoring component and so omit functionalities to support collaboration needed in a multi-user environment. Since then various commercial products have surfaced such as VideoClix [10] or ADIVI [1] presenting annotated video content over the Internet for single use only. VideoClix is unique in that it does not visualize the annotations in the video players. Users have to actively search for annotations by moving the mouse pointer over possible video objects of interest. The ADIVI system, however, visualizes all annotations in the video player by means of a half transparent shape and a solid frame. Both applications allow users only to interact with the annotations and so to perceive additional information but not to create their own annotation in the Web based video player. Support for multi-view video content is not integrated in both user interface concepts.

3 Mobile Multi-view Video

The work presented in the following sections describes the formation of a framework for creating, annotating, processing, delivering and viewing of multi-view video data designed for consumption on mobile platforms. We have defined a camera abstraction framework for access to video streams from many imaging devices; our hypermedia creation tool can annotate multi-view video with spatio-temporal information such as location within frame or a frame-based event (e.g. a goal in a hockey game). The footage, either live or annotated, is sent across the network over our transport abstraction architecture either for further processing (e.g. background subtraction or player tracking) or immediate delivery to the mobile platform for viewing. Our mobile platforms receive the multi-view footage and present it to the user. Through a variety of view and object selection mechanisms the user can navigate the footage in a meaningful way.

We intend our framework to incorporate video from many different sources; we have developed an abstraction over camera and video types for simple access on any platform to live or pre-recorded image data. The Unified Camera Framework (UCF) [5], is a camera access scheme for uniform camera access and configuration. We have created an abstraction layer over image and camera access which supports existing standards, and can support new cameras through its extensible framework. In order to provide an access system with the necessary level of abstraction, UCF contains: a generic image description; uniform access to cameras across platforms; configuration of all cameras up to their capabilities; and an addressing scheme to allow access to any camera on the network.

3.1 Hypermedia Creation

Our research domain currently focuses on annotation and viewing of ice hockey games filmed from multiple angles. This provides a rich video data set and generalizes to many other types of multi-camera annotation and viewing contexts. The use of many cameras is common in sports broadcasting, to ensure a good view of the various players and the array of different actions.

We imagine that environments such as ours will be critical for support of future hypermedia. Interactive, annotated video allows users to share particular content in a scene without requiring the notion of a shared video clip. In effect, annotated video provides anchors that provide means of non-linearly moving through spatio-temporal video content. For example, in sports, this functionality supports the following example functions:

1. Users can specify that a particular object should remain in view so that cameras angles are automatically adjusted to keep a player in view
2. Links to hypertext data such as statistics associated with the selected player
3. Users can send hypervideo anchors to indicate a particular event, so the
    4. entire clip need not be viewed
5. Users can view the event from a particular perspective

Authoring operates in two modes - object selected and object not selected. The main difference is the visualization of active areas uses bounding boxes to give more information to the user annotating the video; once the user has selected an object to annotate (or created a new one) all other active areas are hidden and only the current object is visible, to avoid click confusion, a state where the active area visualizations hide the video and make it harder for the user to see the current object.

Multi-view video is also changed from a single Video Player with view switching to a multiple Video Player interface so that more than one view can be seen simultaneously. This provides the user with different perspectives from which they can disambiguate players when occluded in the active view. Each Video Player has its own editable Information View to provide information on the object.

Semantic Description. The description of multi-view video content for rich media application underpins the framework we have designed. We have several requirements of the description: 1) Incremental updates; 2) Temporally variable and static content; and 3) Multiple platform/system support.

(a) iPhone Video Player (b) Nokia Video Player

Fig. 2. The iPhone (a) and Nokia (b) rich media players for multi-view video. The iPhone within-video objects are highlighted with relatively large icons for simpler touch access. The Nokia version uses background masks cropped with the annotated bounding boxes to highlight individual objects, which can be selected using the 4-way joystick on the phone.

The semantic description we provide uses a hierarchical structure to emphasize the nature of items belonging to larger components e.g. frames belonging to cameras. The format uses a top-level node (Session) to indicate which event or part of the event the data corresponds to; all other nodes are held within this one. There are then three other high-level nodes to partition the logical parts of the data: Cameras, which contains information on the devices used to capture the event as well as information corresponding to data collected by the devices, such as Frames; Scene, a description of the event as a whole which allows for three dimensional locations to be defined, and other scene information; and finally Objects, which holds all temporally constant information about the event (such as a hockey player's name or number).

3.2 Processing and Delivery

In our framework images and content are optionally processed by servers and sent across the network to the mobile viewing platforms. This allows us to add visual effects, use computer vision and also resample and compress the images to be more suitable for transfer to mobile devices. We use the Hive [2] layered architecture transport middleware to accomplish both the processing and delivery in a single step.

Hive was created to help simplify distributed processing and development of reusable modules. A Hive system consists of a number of drones which are connected into one or more swarms by an application. The term drone is used to describe a device or service which uses Hive for communication and is remotely configurable.

Drones can also be connected together to form a processing pipeline (swarm) [4]. Configuration and connection commands are issued by applications to set up a swarm to accomplish a specific task. Applications can construct multiple swarms in order to perform various complicated tasks simultaneously then collate the results. Applications and drones are both Hive modules.

Due to the abstraction layers over each task in the Hive architecture, we can substitute different implementations for the layers. For this paper we wrote separate layers for mobile devices, mainly due to the separate platforms and differing APIs, but this also allowed us to create new a mode for the Hive drones and applications: single process execution of the Hive communication system.

(a) iPhone View Flow (b) iPhone View Grid

Fig. 3. There are three view selection methods on the mobile video player. Both mobile versions support instant switching (left or right) to an adjacent view. Our iPhone version also supports View Flow (a), which is similar to Cover Flow in other iPhone applications, except our version uses video thumbnails. The second mode (b) is the View Grid which lays out all the available views in a grid.

3.3 Mobile Viewing

We have developed multi-view hypermedia viewers for the iPhone and Nokia devices. Both use object visualization for interaction, and provide methods for switching views. The iPhone version is a more complete system due to the simpler developer platform and advanced graphics [6]. Viewing of hypermedia is not an intuitive operation and so we define some requirements our system must fulfill:

Visualization. The problem is that visual annotations cover the regions they follow which in turn might confuse the information the video content conveys. We can conclude that one requirement for a hypermedia viewer is to visualize annotations with a minimum of user distraction in the way they perceive the video information. The Nokia player in Figure 2(b) demonstrates our use of background masks highlighting the players in a minimally obtrusive way (the red is emphasized for demonstration purposes).

Interaction. The dimension of an annotation's sensitive regions must be large enough in respect to their movement to enable users to easily interact with them. The larger selection boxes in Figure 2(a) show the increased target area for interaction. These boxes are only visible when selection mode is activated, so that when viewing the video they are not obscuring content.

Multi-View Video. The novelty of our system is partly defined through the integration of multi-view video content such as for sport events. There are different concepts for how to support the switching of views; Regardless of the method, we require a mechanism to assist users to retain orientation between views: a system enabling an arbitrary switch between views would risk users losing their sense of orientation and might be unable to follow the game properly.

4 Conclusion

We have presented a work-in-progress framework for the creation, delivery and consumption of multi-view hypermedia, with targeted application in sports broad- casts. Our framework connects components created for video capture, authoring and annotation of multi-view video, distributed processing and delivery of images with semantic data, and viewing of multi-view hypermedia on two mobile platforms. We are working on a unified architecture for viewing platforms such that each platform should look and feel the same, and we are developing intuitive mental models for interaction with hypermedia on mobile devices.

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Cheshire: A Design Framework for Alternate Reality Games

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Abstract. Alternate Reality Games (ARG) have come very far in the last ten years. Great works by the likes of Steve Peters, Christy Dena and Jim Miller have pushed the genre forward, but it still lacks some of the tools created for other types of games. The design process for ARGs is, in the best case scenario, complicated. Given the enormous amount of media these kind of games use, things can escalate from complex to utterly impossible in the blink of an eye and sadly, there are currently no tools to help solve this problem or lower its impact in the finished game. This paper proposes Cheshire, a framework to enable categorization of games and alignment of these with defined sets of patterns previously detected in the design of the experience. This tool will help maintain the generated experience as loyal to the original concept as possible, and graphically represent which elements will support it in the best manner.

Keywords: Alternate Reality Games, ARG, Game Design, Digital Narrative.

1 Introduction

Alternate Reality Games have gained much notoriety in the latest years due to their impact as promotional tools for other types of media, but this doesn't mean this is the only way such genre can be enjoyed. Many efforts have been made towards pushing this particular kind of games forward, but the many layers of complexity that crafting this kind of experiences garners makes the task of designing such games a very real challenge.

In this paper we attempt to solve such issue by presenting Cheshire, a framework that allows the definition of core elements and design patterns a given ARG has to align with in order to deliver the kind of experience it's designed to provide.

2 The ARG Design Problem

ARG design is, at best, complicated. The process, even though it has many similarities with regular game design, tends to tilt towards the more difficult part of the spectrum due to the complexity of the media and delivery channels the designers

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have to keep in mind. Besides this obvious difficulty, there are no tools specifically created to support designers in this task. Currently, the tools used aren't anymore customized than Gantt charts and workflows.

The problems mentioned can be pointed as one of the main causes of the long development times ARGs can represent and, to a given extent, to several games disappearing before seeing the light of day (a situation know as meltdown [1]).

3 The Design Framework

3.1 Core Elements

First of all, a set of core interactions and elements has to be described. To construct a proper framework, we'll base our model on MDA [2], where the design process is modeled using three different stages. Even though this framework can't be used directly on ARGs (given MDA's focus on predefining dynamics), the idea of a layered information flow proves to be very useful.

It's important to note that ARGs are generally social experiences, but single player experiences aren't out of the question. Only taking into account the social aspect of it and relegating the flow and *gaming* sensation would transform it in nothing short of a social network or discussion group. The proper introduction of these gaming elements to the public allows for flow and momentum control, modeling the experience. The most basic of these elements is the *narreme* (a term coined by Lev Manovich [5]), which contains important information to advance in the game. This new information generates pieces of media that work as puzzles, obstacles and challenges for the players to overcome, adding a gameplay layer. Finally, these obstacles are overcome, generally in a social manner, completely out of the control of the designer in an emerging fashion; this means the designers can only present the problem, the way to solve it falls on the players' shoulders.

Once the players have passed the challenge presented by a particular piece of media, a new *narreme* is introduced, taking the role of gratification as well as motivation to keep on advancing the game.

Now that the basic elements and their relations have been described, we must mention the behaviors they elicit. These behaviors are:

- *Sense of Movement:* When players start the game or overcome a high impact obstacle, they get a narreme. This element holds two functions, first to gratify the player and second to kick-start the next story element, allowing for the development of characters, situations and events.
- *Obstacles and Challenge:* Media by itself has no meaning beyond presenting information; it's through the existence of challenge that players feel compelled to keep playing. Through media this obstacles are presented to the participants.
- *Emerging Dynamics:* Since ARGs are generally social, the obstacles and challenges must be designed with this in mind. For that reason, the *way* players solve a problem is out of the designers' control, they can only define a starting point (problem) and an ending (solution).

These elements and their relations can be seen on figure 1.

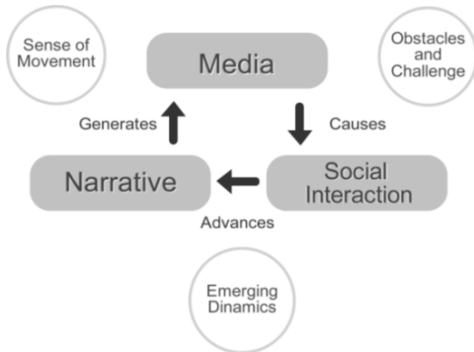

Fig. 1. Core elements and the behaviors they elicit

It's important to notice that the media can be presented in two mayor ways, it can be *unidirectional*, meaning it only goes from the designers to the players or vice versa without an automatic response; this type will be called *passive*. On the other hand, there's media that looks for direct responses to a given interaction by the players. This type will be called *active*.

Each of these two types of media generates a different impact on the general flow of the game. The active media causes a greater apparition of narrative elements, since puzzles in ARGs tend to require lengthy analysis, the fast nature of this media makes it better suited to deliver story elements that advance the plot and don't present big obstacles. On the other hand, passive media gives players enough time to think about the challenges presented and correctly solve the puzzles.

These relationships are displayed on figure 2.

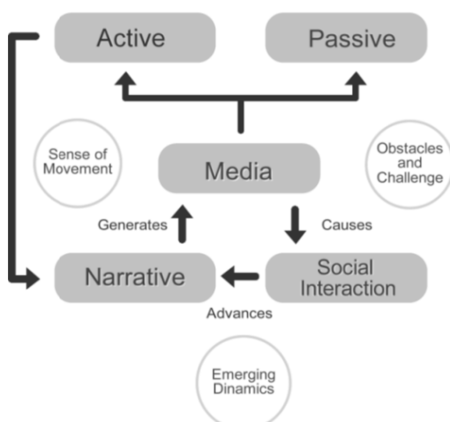

Fig. 2. Differentiation of types of media and their impact in the game flow

3.2 Patterns and Alignment

With the core elements defined, it's possible to align them with a defined set of design patterns. This alignment helps give the designers a general guideline of what patterns to use in the design process to achieve the kind of game they set out to create.

The patterns used were the ones compiled by Christy Dena in [4], which are in turned based on the work displayed in [3]. Even though there are many more game design patterns out there, the work of compiling which ones are particularly useful for ARGs has been done previously and we'll use them as an already analyzed element in our framework.

These patterns are grouped in four categories:

- *Collaboration*: An event or situation inside the game requires interaction and cooperation between players with different skills or, in other case, in a common problem that requires a large number of people working in tandem.
- *Group Activities*: In some games, players do things in rather static groups.
- *Stimulated Social Interaction*: Games played face to face tend to have a high degree of social interaction, be it required by the game or not.
- *Competition*: Despite social interaction tend to be associated with players doing things together; the road to such interactions tends to be in most cases, paved with conflict and competition amongst them.

One important thing to note is that, given the similar characteristics that Collaboration and Group Activities share, we'll merge them, encompassing all patterns of both categories. Why is it useful to merge them? Having only three axes to use in the framework makes the creation of a graphical representation much easier, since we can resemble a Cartesian model with three planes[1].

In this three-plane representation and with the previously described core elements centered on the junction of the three categories, it's possible to orderly list the patterns in each category around the core elements, properly giving a guideline as to which pattern must be more emphasized when creating the elements needed for the game.

Each of the patterns was placed based on their definition and their degree of alignment with each category (for example, Dynamic Alliances is centered in the Group Activities axis, while Conflict and Player Murder are much closer to Competition). In addition to the placement of the patterns, a color code was applied. Having properly aligning the colors with the axes (for a full color version, please refer to footnote 2), it's possible to classify a given game based on the patterns it uses and where in the color spectrum landed. How is this done? It's pretty simple, actually: the moment the design starts, the designers choose which category to focus on; once defined, we choose a specific color and, given the distance relation between the selected point in the spectrum and each given pattern, the emphasis each different pattern requires to achieve the a specific type of game is defined.

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[1] For the sake of space, a full-color, high-definition graphical representation of the framework can be found in `http://alumnos.inf.utfsm.cl/~abaltra/diag.png`

4 Validation

To illustrate the usefulness of Cheshire, two games were designed. The first one, built by a team of students from UTFSM[2] and members of USMGames[3] (Team A), was designed in the lapse of over four weeks and defined a game time of barely over a week. This team did not use Cheshire, only focused its' efforts using Gantt Charts and regular game design techniques.

On the other hand, a second game was designed, this time by a smaller team on a more constricted schedule (Team B). This time, the team used Cheshire to define which patterns to emphasize when crafting the experience and guide the design process. The design took little over two weeks and defined a game time of two weeks.

Both teams were formed by members of the same University with rather similar knowledge of game design and implementation; different topics were used for each game, but the basic literacy of each group on each given subject was roughly the same.

After both design processes ended, some differences are worth noting:

Table 1. Comparison of characteristics of both designed games

	Team A	Team B
Design Team	2 people.	1 person.
Expected Players	Under 100.	Over 150.
Planned game time	One week.	Two weeks.
In-game routes	One entry point with 5 possible paths. All paths must be traversed.	One lineal path.
Actors	None on-site, one administrator sends data to the payers.	At least 4 on-site, one administrator per site and at least 4 users on each web page.
Digital Tools	One website and one mobile app.	Two websites and *at least* one mobile app.
Design time	One week.	Two weeks.

Table 1 shows that the human effort invested by Team B was a lot less than that of Team A, even though the second game was of at least the same (if not higher) complexity.

A point to keep in mind, and that perhaps shows more clearly the contribution of Cheshire is that both games went in completely different directions by the end of their development. Team As' game drifted towards a treasure hunt, even though it was initially going to be a story-driven game while Team Bs' experience stayed close to its' core concept, a character driven adventure with light usage of geolocation.

[2] Universidad Técnica Federico Santa María.

[3] `http://www.usmgames.cl`

5 Conclusions and Future Work

For anyone who's ever designed an ARG, it's clear that it's impossible to create an absolutely generic tool that carries the whole design process. The breadth of such process tends to be of such magnitude that a tool like that would only be useful for a particular game and not for many different experiences. However, the beginning of the experience can be aided by the use of Cheshire, as the proper selection of patterns gives the designers a very useful set of guidelines to which adhere their works to.

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CiVo: Real-Time Visualization of Social Activities by Cartoonized Twitter

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Abstract. We propose a web system called CiVo (City Voice) that is capable of visualizing public conversations on the Internet. It monitors the posting on the Twitter with respect to a set of specific phrases and displays the correspondent movie clips with cartoons on the time line on CiVo when it finds them. It extends the Twitter to a visual social medium that allows people to share what happens in the world at a glance. The main loop of CiVo runs on PHP while monitoring the Twitter using its API and it returns a specific SWF file to the HTTP clients for each GET request. The SWF file always updates its sub-SWFs reflecting the phrases found on the Twitter.

Keywords: Twitter, web services, cartoonization, Action Script, PHP.

1 Introduction

Twitter is the most popular social media in present [3][6]. It permits only short postings and reduces lots of efforts that have been required with conventional web pages for making them flawless and up to date. To further enhance the power of Twitter, visualization of the textual postings in pictorial forms is effective and there have been many interesting works [5][4][1][2]. Most of the works visualize the relation between tweets and the tweeters based on their personal profiles. To understand their topics, however, viewers still need to read the texts. We propose a novel visualization that cartoonizes the Twitter. It finds a set of key phrases and expresses their meanings and nuances in cartoons so the viewers can visually and intuitively share the public interest and events at a glance.

2 How to Cartoonize the Textual Tweets

People can view the CiVo site by following a special Twitter account ”xxCiVoXxx”, that follows back the users so that their tweets appear on the time line of ”xxCiVoXxx”. Fig.1 shows two major modules of the proposed system. One of the modules monitors the time line of ”xxCiVoXxx” using Twitter API and searches a specific set of keywords and generates the background component (”background.xml”

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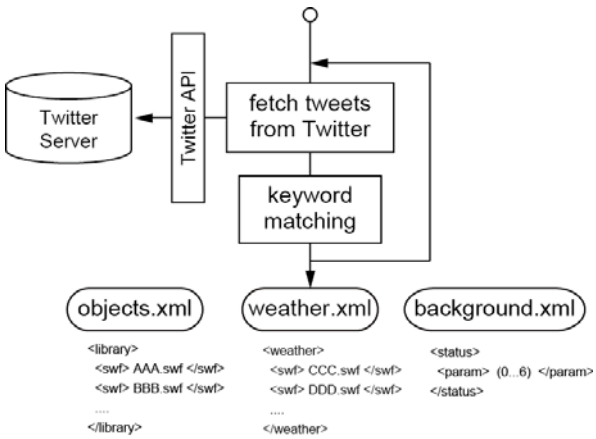
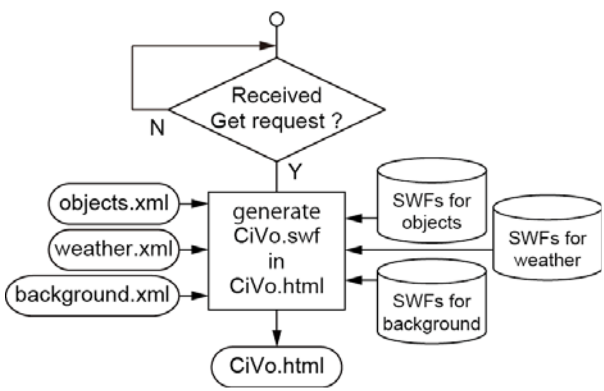
and ”weather.xml”) and the object component (”objects.xml”) of the whole scene in the web page of CiVo. Those XML files hold the hyperlinks to the movie clips (SWFs) correspondent with the keywords that have been tweeted (Fig.1(a)). The other module returns a HTML file ”CiVo.html” responding to each HTTP/GET request that embeds a SWF file ”CiVo.swf” that internally loads sub-SWFs that have already been specified in the XML files as mentioned above (Fig.1(b)). ”CiVo.swf” shows a walking girl on the ground of a small planet that rotates slowly. The ground has no objects until the keywords are tweeted.



(a) Determination of sub-SWFs to be contained in CiVo web page.



(b) Creation of CiVo page.

Fig. 1. The proposed method of tweet cartoonization

An example set of keywords and their correspondent cartoons that have been currently implemented are shown in Fig.2. Those keywords are currently implemented in Japanese (extensible to any languages). During the execution time, the system reloads the pairs of keywords and their correspondent cartoons (SWFs) from a single text file every minute. It allows the service provider to add new sets of keywords and the correspondent cartoons without restarting the system. Fig.3 shows examples of translation from a keyword to the correspondent cartoon.

(a) "bear". (b) "bird". (c) "bricks". (d) "bubble". (e) "building".

(f) "church". (g) "fence". (h) "forest". (i) "ghost". (j) "grass".

(k) "grave". (l) "house". (m) "moon". (n) "anger". (o) "hurry".

(p) "sleep". (q) "star". (r) "sun". (s) "tree".

Fig. 2. Keywords and the correspondent cartoons

(a) Keyword ”moon” gives the cartoon of the moon.

(b) Keyword ”dark” makes the background darker.

Fig. 3. Examples of cartoonization by the proposed method

3 Conclusion

We proposed a web system called CiVo that translated textual conversations on Twitter in the form of cartoons. It enables the viewer to grasp what people talk about at a glance. Future works include installation to public facilities such as train stations.

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Re:Cycle - A Generative Ambient Video Engine

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Abstract. *Re:Cycle* is a visual poem, improvised in real-time by a system of deceptively simple rules relating to luminance and chrominance values in a set of moving image shots. Richly textured natural images of snow, mountains, rivers, and sky slowly unfold in a never-ending sequence that constantly changes. The resulting complex ambient video repudiates the standard cinematic conventions of linear narrative, and draws the viewer into an active creation of meaning for the work.

1 Ambient Video

Ambient Video is video intended to play on the walls in the backgrounds of our lives. In the spirit of Brian Eno's "ambient music", Ambient Video must be "as easy to ignore as it is to notice". [1] Eno's dictum can be expanded to three interrelated criteria that an ambient video art piece must meet. First, it must not require your attention at any time. Second, it must reward your attention with visual interest whenever you do look at it. Finally, because ambient pieces are designed to play repeatedly in our homes, offices and public spaces, they must continue to provide visual pleasure over repeated viewings. The ubiquitous screens in our domestic, corporate and social environments provide rich ground in which ambient imagery can thrive.

2 The Creative Challenge

The viewer's orientation to an ambient video work can be seen as a subtle dance, or to use Cubitt's term, a "dialogue" between the "system-cinema" and the autonomous viewer. [2]. The goal of *Re:Cycle* is to create an ambient work that will run indefinitely, and do so without repeating either shot sequences or specific transitional moments. This increase in playability does come with a price - a loss in aesthetic control over the details of sequencing and transition. One can see this as a tension built into the system. Other artists working in generative visual art have faced a similar set of balances and trade-offs. Lev Manovich's *Soft Cinema* [3] aims to combine the demands of narrative coherence with a recombinant database aesthetic. *77 Million Paintings by Brian Eno* [4] is an extension of his own earlier linear ambient video work into a generative form. *Re:Cycle* is situated somewhere between

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these works. Like *Soft Cinema* it relies on recorded video and representational visuals, not on pure graphic material. At the same time, like *77 Million Paintings*, *Re:Cycle* rejects narrative and is therefore more free to rely on completely random recombination to support re-playability.

The development of *Re:Cycle* has been a dialectical process - the balance between aesthetic control and re-playability has been revisited at every stage. One can frame each significant creative decision an attempt to maximize success across both ends of a continuum:

re-playability <=========> aesthetic control

Re-playability could be increased with a larger database of shots. However, an indiscriminate increase in numbers could undermine aesthetic impact. To avoid this, any additional shots selected would need to be of the same high visual quality as the original set. We limited our choice of transitions in order to protect aesthetic quality. There are a host of video transitional devices: the hard cut, the dissolve, innumerable shape-based wipes, and the more complex transitions such as luminance keyed transitions and chrominance keyed transitions.[1] We decided to forego most of these possible transitions, and restrict ourselves to luminance and chrominance keys precisely because they were more visually complex and therefore more interesting to watch. They have the associated advantage that as the viewer watches them unfold, the flow and the details of the transition are less predictable than dissolves or simple shape-based wipes.

However, the luminance and chrominance keys were not the perfect aesthetic solution for all shots. We used two tactics to increase their aesthetic utility. Shots with very strong regional contrasts simply did not transition well from many of the other shots in our shot database. We removed some of those shots, sacrificing some re-playability because of decreased shot numbers, but increasing our aesthetic impact through the avoidance of a number of poor transitions. Our second tactic was to increase the "feathering" of the edges of the wipes. "Feathering" refers to the softness of the edge of the transition as it proceeded. A sharp transition often produced a feeling of random video noise and visual "busy-ness". A softer transition was slightly less dramatic in some cases, but over the range of random shot transitions tended to be less noisy and more aesthetically pleasing.

3 A Generative Solution

A generative ambient video piece can use simple computational capabilities to continuously vary the sequencing and combinations of the selected ambient shots and visual transitions. Computational variability can further extend the ambient work's ability to use visual pleasure to slow perceived time and privilege reflection and contemplation.

Re:Cycle is a closed generative system, relying on two databases for its operation. The first is a database of ambient video shots, the second is a database of transitions.

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[1] The terminology "wipes", "keys", and "keyed transitions" derives from the earlier language of cinema and analog video production and post-production.

The twenty video clips in the shots database are all visually strong, at least sixty seconds long, and shot in the same general region (the Canadian Rockies). Many contain cyclical and visually interesting motion of clouds or water. The time frame in several of these shots has been manipulated in order to give the motion even more visual interest.

There are four transitions in the transitions database. The luminance transition uses the brightness values within the shot to drive the change from one shot to its successor. The incoming shot will appear first in the brightest sections of the current shot, then in the mid-range brightness areas, and finally in the darkest areas. When the transition is complete, the second shot has replaced the first completely. The other three transitions work in a similar fashion, except they are based on chrominance values (red, blue and green), not brightness. Each of these starts the transition in the areas of the shot with the highest chroma value in the selected color, and continues the transition down through the range of chroma saturation until the transition from one shot to the next is complete.

This engine has the capacity to present an ambient video art work that can run indefinitely, and still provide interesting visuals and transitions. The resultant doubly randomized video stream will generally not repeat particular shot sequencing with any frequency, and will generally provide a different transition for each change. The recombinant aesthetic will play out both temporally and spatially. The random sequencing will provide temporal recombination, while the interplay of random shot and transition selection will drive each shot change with a fresh spatial recombination.

4 Future Work

In addition to collecting a larger number of strong shots for our shot database, we will explore two other strategies: increasing the variety of shot transitions, and incorporating the use of metadata to increase aesthetic impact.

First, one can run any of our transitions in two directions. By incorporating both directions for each of our four transitions, we will increase our effective number of transitions to eight. Secondly, one could use either the current shot, or in the incoming shot as the basis for the transition. The number of possible transitions doubles again, resulting in a database with sixteen possible variations. We increase the re-playability of the piece, with no loss in aesthetic control.

We plan to associate metadata with individual shots, and use the metadata to guide sequencing and transition. This will increase aesthetic control, but it will also require more careful planning, and have a cost in variability and re-playability. The metadata will be used to encourage certain sequences of shots and transitions, and to block others. For example, we have observed that for some shots, certain transitions tend to work well. We've seen that shots that are heavy in red tones throughout respond unpredictably to transitions based on green chrominance values. We could use metadata to tag these shots, and block green chroma transitions. In doing so, we will reduce variability but ensure a higher level of aesthetic quality.

Metadata can also be used to give a level of editorial flow to the sequence. The categorization of shots (e.g., rocks, streams or clouds) can be used to favor sequences that are informally grouped to support semantic or aesthetic connections. Another example might be temporally based sequences that generally progressed from morning to mid-day to dusk, or from spring to summer and winter. All of these metadata applications are appealing because they are an opportunity to increase the coherence of the image flow; however there will be a commensurate loss in overall variability and re-playability. A more varied database of shots will mitigate this problem and allow us to further maximize *Re:Cycle*'s aesthetic impact while maintaining our level of variability and re-playability.

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Tippy the Telepresence Robot

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Abstract. We have built Tippy, a micro telepresence robot that allows a user to remotely project him or herself into another space, move around, and communicate via video and audio. An iPod Touch running Skype provides the robot with wireless video input and output capabilities and handles the movement commands from the remote user. In order to handle the robot's movement without implementing an additional medium, we inserted the control signals visually into the video and detect the signals via light sensors connected to the motor drive system. By optically coupling the mobile device display with the robot's drive-train control, we reduce the amount of software and hardware interfacing required for the end application.

Keywords: telepresence, robot, optic coupling, hardware interfaces, human computer interaction, mobile applications.

1 Introduction

With increasingly powerful mobile devices, a significant amount of processing power is available to portable interactive applications. Numerous existing consumer level accessories such as keyboards, speakers, headsets and other add-ons extend the functionality of devices by providing extra interfaces. However, there is considerable development overhead when trying to interface mobile devices with new hardware. This paper presents Tippy (Fig. 1), a telepresence robot as an example application, which requires a hardware interface between mobile device and custom circuitry and describes the process of implementing a simple optically coupled interface to achieve this.

Fig. 1. Tippy the telepresensce robot

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2 Motivation

Two way video conferencing is now available on devices such as the iPod Touch [1]. The compact form factor and wireless capability of the iTouch make it an ideal platform for constructing an inexpensive telepresence [2] robot similar in functionality to [3], but in a smaller package. There are two ways that the iTouch based robot can be controlled remotely. First, the iTouch can be interfaced directly with the motor drive hardware using an iOS application that communicates with the hardware serial port. The application would have to run in background while the video application is active. Second, a dedicated, separate wireless link (using ZigBee, Bluetooth, or other Radio Frequency technologies) can be implemented on the robot to receive the remote commands and transfer them to the drive hardware.

The first option above is similar to [3], but it is considerably more difficult to directly interface with the iTouch's hardware port. The second option requires extra wireless hardware which adds considerably to the cost of the system. We found an alternative solution through overlaying the control signals directly into the video, and then building an optically coupled hardware interface between the iTouch and the motor control.

3 Existing Work

The concept of optical coupling using a display source is demonstrated in [4] where the average brightness value of a displayed character on a monitor is used to drive audio synthesis and in [5] where a mobile display is used to generate and display a sequence of codes to be transferred to another terminal. The difference between Tippy and these systems is that the optical signal is generated remotely and added as an overlay on top the incoming video signal. This way, the mobile device simply renders the video on screen as it is received and is not aware of the existence of the extra information. Because of this, any device with a front facing camera can be used in place of the iTouch with no additional modifications. Light sensors mounted on the screen detect the overlay signals and a microcontroller translates them into motor drive commands. As a teleconference robot, Tippy is significantly more compact compared to [3] and considerably cheaper (~$350 vs. ~$500).

4 The Tippy System

4.1 Overview

There are two main components of Tippy: the remote user control end and the robot end. The two parts are connected through the Internet via two-way video using Skype, as shown in Fig. 2.

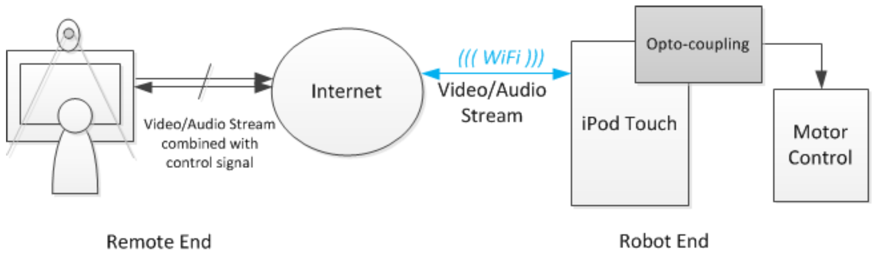

Fig. 2. Tippy system diagram

4.2 Remote User End

For normal two-way video conversation, Skype captures the video stream from a local input capture source (e.g.: a webcam) and transmits it to the remote end. For the Tippy system, in addition to the feed from the capture source, we also send the movement commands through the video. This is achieved through a custom Microsoft DirectShow filter that adds an overlay to the input source. The overlay consists of a black bar that appears at the top of the video image, with four white squares that light up in predefined places depending on the input command.

Using a binary representation with the four squares, up to sixteen discrete commands can be implemented (the current Tippy prototype only uses five). A simple GUI application was written to trigger each command, and the keyboard keys “w, a, s, and d” are mapped to forward, left, back, and right, respectively.

4.3 Robot End

On the robot end, the iTouch displays the video containing the overlay as it is received from Skype. A row of four photo-resistors are mounted on the LCD screen where the overlay appears. The photo-resistors are connected in a voltage divider configuration and the changing voltage is detected by an Arduino [6] microcontroller. Each sensor value is thresholded to produce a binary result. Programmed logic on the microcontroller drives the input pins of an integrated H-bridge motor driver, as shown in Fig. 3.

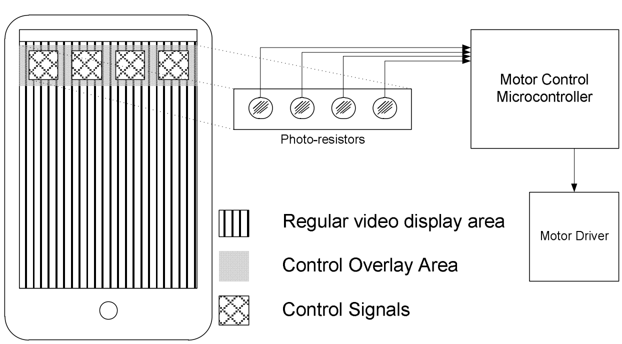

Fig. 3. The Tippy optical hardware interface

To quickly prototype a working system, we used components from the Tamiya [7] wheel and track kit that provide a simple and flexible drivetrain platform. A dual channel motor driver provides bi-directional control of the geared motors driving each track and allows the full spectrum of motion afforded by a tracked vehicle.

5 Future Development

In the first prototype we only implemented four directions of movement. It would be quite easy to extend the number of discrete controls up to sixteen given the current optical hardware and software overlay. More complex movements can be implemented and variable speed control can be added using pulse width modulation control. For the optical interface, it would be possible to add a modulation scheme to provide a larger range of input values.

6 Conclusion

The concept of optic coupling can be used to easily extend the functionality of mobile devices as demonstrated through this project. Using mostly existing hardware and software we were able to quickly implement a low cost telepresence robot with little development overhead. We hope that the methodology employed can be used by others to rapidly prototype and demonstrate new and exciting ideas using mobile devices.

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A Poor Woman's Interactive Remake of the "I Still Remember" Documentary with OpenGL

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Abstract. Making the "I Still Remember" documentary's memory floating bubbles interactive with audience's participation using a near day-to-day OpenGL (aimed at later enhancements with haptics). We describe a simple process of making a passive documentary interactive using available tools and preserving the aesthetic and emotional appeal. Moreover, the good comparison of the linear convention film and its nonlinear narrative version with audiences' body movement involvement may give answers to some of the artists who are still hesitating to adapt their projects to the dramatic developed new technology.

Keywords: interactive documentaries, computer graphics, HCI, OpenGL.

1 Introduction

We briefly review the related work and literature on various topics of interactive cinema, documentary, and our position about it as well as new media and interaction research in cinema, and documentary in general . We then describe the methodology of application of some very common computer graphics tools and techniques to make a passive documentary "I Still Remember" [10] interactive in Section 2 as a work in progress. We then conclude with limitations of our approach and the immediate future work in Section 3.

Interactive cinema. A complete research overview on the evolution of cinema in general, modern digital art (to 2003), and specifically including the interaction aspects are well described in [8]. Some of the interactive elements that make the cinema 4D or 5D include unior bi-directional physical and sensory touch via touch screens, joysticks, Wii-like devices, and force feedback devices, such as haptics, moving seats, or even smell or snow fall (see "Polar Express"). 4D usually entails the virtual cinematic show affecting the real environment of the audience but the audience has no way to interact back, just react. 5D would be bi-directional, primarily with the use of motion capture and tracking, touch-, and haptic-devices. Some recent research on haptics that can be employed for interactivity in cinema is in the book [16] featuring multifaceted research chapters on devices and techniques that translate the interactions in the virtual world into real physical world with force feedback and allow the users to use the same devices to alter the virtual world again. Song et al. positioned about many related aspects in [9].

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Interactive documentary. Everything has been affected by arising new technologies, newspaper, such a NYT changes from paper format to mobile or computer based. Just about the same is happening to the dynamic media and documentary production. The notion of interactive documentary has roots in traditional story telling and narrative and computer-based techniques with user-interaction, interactive TV, and computer games.

The interactive mode in documentary theory appears in the introduction of the *fou*r *mode*s in documentary theory, such as expositional, observational, *interactive*, and self-reflexive, as detailed in [7]. Next, Barfield discusses what interactive documentaries could be back in 2003 and the problem of narrative vs. interaction and interactive story telling with 4 main structures [2]. A very relevant description of technical and non-technical sides of making an interactive archive by a brother of a person with the degrading Usher syndrome (who can't hear or see any longer) who made home-shot family audio/video footage spanning across 20 years [12]. Furthermore, Lachman presents "Diamond Road Online" (DRO) – an experimental interactive documentary system with user interface and recommendation systems to present the documentary stories (in a keyword indexed database) of diamond trade allowing semantic links between clips to make a continuous story off those clips [4]. Another recent article details the production process of the documentary "A Golden Age" in England as an interactive configurable documentary (interactive narrative) and the use of the "ShapeShifting Media" technology with the technical implementation details and the Narrative Structure Language (NSL) [14].

Then there is also a similar shift in education and drama portrayal. A recent book [1] describes drama teaching using computer games with the intent to make a memorable learning experience in a simulated environment including the documentation of the research and practice of the approach. And, in the journal article [11] the authors implement an interactive drama engine (IDE) based on theoretical foundations of narratives and drama as well as practicality and interactivity of 3D first-person fiction/adventure/etc. games where participants can deeply affect the story line unlike in traditional games no documentaries. The most recent items and developments discuss newer web-based and database-driven technologies for digital storytelling [15] such as the Highrise documentary film "Out My Window" [3], and also open-source software systems, such as Korsakow [13] in Java to build one own's documentaries in tree-like structure.

2 Methodology

Augmenting and expanding the "I Still Remember" short film with interaction and projection of the memory bubbles. What could it be and the necessaries of introducing interactive media technology to traditional documentary film making? The research could be a long journey as witnessed by some of the items in Section 1, but we take a small step at a time.

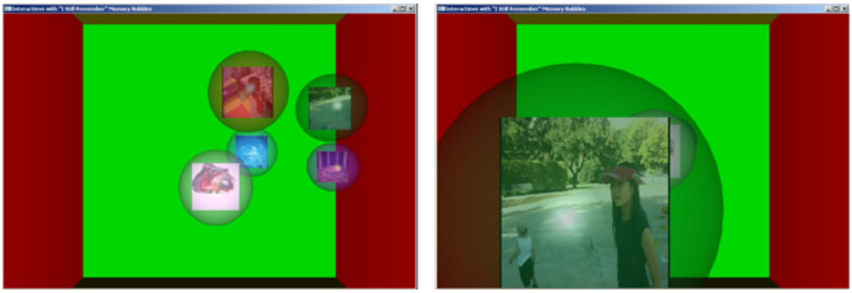
"Mostly, *th*e *memorie*s *ar*e *lik*e *littl*e *picture*s *i*n *m*y *head*, *lik*e *floa*t *aroun*d *i*n *the* *bubbles... So*, *whe*n I *wan*t *to* *se*e *them*, I *searc*h *al*l *thos*e *bubbles... The*n I *go* *int*o *one*, I *ca*n *remembe*r *them...*"

We would like to visualize the idea into a real touchable interactive installation. The prototype is the augmenting the “I Still Remember” short film with interaction and projection of the memory bubbles. This runnable simple program we have developed in OpenGL to demonstrate how the 3D bubbles floating randomly in the space. Each of them will contain a piece of memory, and project the bubbles will on the environment surfaces, such as walls. What makes an interactive installation documentary piece different from a traditional documentary is the aspect of interactivity itself and the audience being able to compose their preferred pathways and storylines selectively, bidirectionally, with ability to go into details of interesting points to them unlike a linear passive progression. In the advanced way, the interaction can be also immersive and bidirectional with haptics and virtual reality techniques. The resulting “artistic high-level algorithm” :

1. The media represent memories of home videos, photos, audio, and animated texts [5].
2. Each bubble has a unique color, which presents the emotion level of memories, such as brightness and sadness.
3. Audience is allowed to interact with the bubbles, and the bubbles’ motion and collision response are to be based on the behavior and gestures of audience. The effects of bubbles could be soap bubble bursting, softbody dynamics, and rigid body sparkling collision. (In this work, we limit this step to interaction by the audience using only mouse clicks in an OpenGL window to bring a bubble of choice or to move a synthetic camera in that environment with a keyboard).

Modeling. We model each bubble object in the first iteration as a translucent sphere with a flat polygon inside, procedurally. The polygon is a 2-sided quad onto which a texture photograph can be mapped, or a text item with or without animation, or more generally a video clip [6], all of which are done via OpenGL. Each bubble is defined by the property of the contained media and the outer color. Of course the bubbles also have a radius and a position. A more advanced ball modeling under consideration in utilization of the softbody objects instead of plain spheres to add realism and tangeability. The amount of bubbles and their content is determined presently via a preset set of content in the code constant, but is planned to be dynamic.

Interaction. The present level of interactivity by the audience is via simple mouse clicks the 2D coordinates of which are then translated to the nearest bubble, which is then “selected” and zooms in slowly onto the viewer with its content gradually taking over the full screen in which the corresponding media content (photograph, text, video clip) is rendered (see Figure 1(b)). Clicking the zoomed-in content makes it recede back to the bubble pool of memories. For the video clip-based bubbles on zoom-in the sound is also activated. The sound may also optionally be activated on textual and photo bubbles if it is present in a form of narration. More advanced interactivity is planned with haptics and camera-marker motion capture or a Wii.



(a) Bubbles Float with Screen Media Inside Them

(b) A Close Up Example of a Selected Bubble with a Video Content Playing

Fig. 1. Example renderings of the Memory Bubbles Containing Videos and Static Photos

Projection. The installation is *planne*d to be projected in a black box or an enclosed room alike. An option is planned for the projection to be stereoscopic. Another projection option is the 180-degree screen VR system that we are considering.

3 Conclusion

We presented our initial "poor woman"'s way approaching an interactive documentary work-in-progress with a widely available OpenGL library and a set of online open available resources to play clips, texts, and images from a passive storyline documentary into making it interactive. The memory bubbles concept came from the content of the original documentary itself of a little girl describing her own memories as floating bubbles she could pick and "see inside" if she wanted to remember something. The working interactive prototype features 5 bubbles with 3 videos and 2 images as illustrated in sample screenshots in Figure 1(a) and in Figure 1(b).

Current limitations. Current limitations that plague interactivity in the documentaries, specifically a profound difficulty to for multiple people to interact with the same documentary piece instance at the same time is problematic (e.g. one would need to support multi-input in a form of multiple mice, keyboards, haptic devices, cameras or motion tracking sensors from more than one individual from the same audience in the same space-time. Our specific documentary's evolution is also impacted bu the general limitations described in the preceding paragraph, but also has its specific limitations related to the technological limits on content quality, dimensions, and the scale that can be played at simultaneously. It is also hardware-dependent. Another aspect is that the bubbles float in 3D space, but the basic mouse interaction is 2D and clicks have to be translated to the bubbles nearest in the z dimension, which sometimes is confusing when x and y are near for two or more bubbles, and the user wants one bubble, but gets another one instead to view.

Future work. "Rich woman"'s augmented and expanded interactive documentary installation immersive and tangible experience will include the following items: 1.

Research on and address the limitations in some way 2. Haptic connectivity 3. Softbody balls 4. Interactive installation 5. Black box and VR projection installation 6. Stereoscopy 7. Database-driven.

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Automated Song Selection System Complying with Emotional Requests

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Abstract. Recently, we have a lot of musical pieces due to a large capacity of storage. However, it would be difficult to select the song with bibliographic data as the capacity of the music database increases. Therefore, we proposed an emotional song selection system. In this study, the Acoustic - Emotion model was composed by relating the acoustic fluctuation features that can explain the time variation of music with the emotional evaluations of music obtained through the subjective evaluation experiments. Based on the model, the emotional evaluations of music were calculated from their acoustic features. Using the proposed system, user can select the song with the adjective words and their degrees.

Keywords: Music, Emotion, Melodic database retrieval technique, Fluctuation features.

1 Introduction

The development of the data processing technology has enabled us to have and carry the portable music player with a large capacity of storage. The song has been selected with bibliographic data; however it would be difficult as capacity of the database increases. Thus, some music retrieval techniques based on human instinct have been studied [1, 2]. It has been known that the mood of the music influences human feelings and behaviors. From these facts, we believe that the emotional song selection system is needed in order to enjoy more entertainment of music. In this paper, we propose the automated song selection system complying with the emotional requests, which is based on “Acoustic - Emotion" model.

Fig.1 shows the general idea of the proposed system. The system previously labels each emotional evaluations of a song by its acoustic features. As users input their requests with the adjectives and their degrees, then the system outputs suitable songs for the requests. The proposed system needs only the degrees of the adjectives, and may be user-intuitive.

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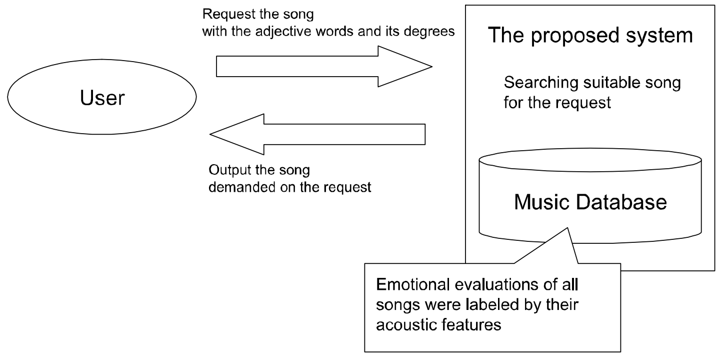

Fig. 1. The general of the proposed system

2 Fluctuation Features

The primary consideration in music should be the temporal variation of sounds. The temporal concept of music has been regarded as the one of the more important factors for music in the field of the cognitive psychology [3]. Then it was used that the fluctuation features that can explain the temporal variation of music as the acoustic features of music.

Melody, rhythm, and harmony are the three major factors for composing music. They are signed and sealed as the structures of both the pitch and volume, and are different among songs. It has been believed that the emotional evaluation of the song can be influenced by their differences. As the acoustic features of music, the thirty six fluctuation features were prepared, which concern the time variation of pitch, volume, and rhythm. They can be extracted from fluctuation spectrums calculated from music, and detailed in our previous works [4].

3 Emotional Evaluation

The emotional evaluations of music were obtained through the subjective evaluation experiments. One hundred and fifty songs were prepared to be evaluated, which were arbitrarily selected from several genres, e.g., Pop, Classical, Jazz, Rock, and so on. Arbitrarily-prescribed phrase in a song was used as the object to be subjectively evaluated, and the evaluations were assumed as the emotional evaluation of the song.

Eight pairs of adjective were prepared for evaluation, and are listed in Table.1. All the prepared songs were evaluated on a scale one to seven for the each adjective based on the Semantic Differential method. Eighteen males and females in their twenties participated in our evaluation, and were asked to listen to and evaluate all the songs in random order.

Table 1. Adjectives for emotional evaluation

Adjective index	Evaluation on a one-to-seven scale
1	Bright - Dark
2	Mellifluence - Harsh
3	Rich - Poor
4	Clear - Murky
5	Agitato - Peaceful
6	Heavy - Light
7	Soft - Hard
8	Thick - Thin

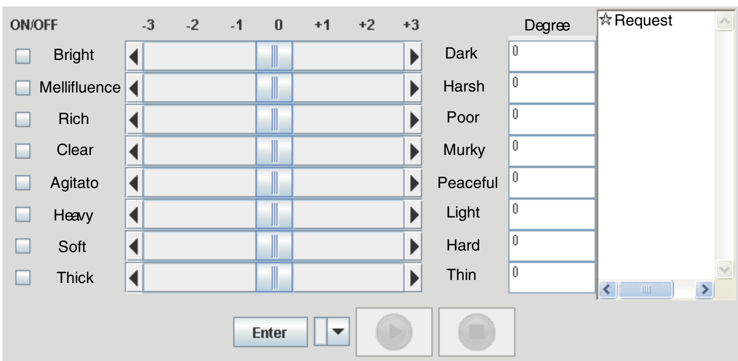

Fig. 2. The Interface of the proposed system

4 Automated Song Selection System Complying with Emotional Requests

Fig.2 shows the interface of the proposed system. As user selects adjectives and the corresponding degrees, the songs complying with the emotional request are outputted.

4.1 Acoustic – Emotion Model

The acoustic – Emotion model was composed by relating the fluctuation features and the emotional evaluations of the song. Then the contributory features for labeling the degrees of the each adjective were selected from the thirty six features using a step wise method, and the linear discriminant function was used as the evaluation function. The estimate space for each adjective was generated by conducting canonical discriminant analysis, where each the explanatory and dependent variables were the selected contributory features and the degrees of each adjective, respectively. The estimate spaces for each adjective were stored in the proposed system, and labeled the emotional evaluation of a song with the acoustic fluctuation features. The effectiveness of the model was validated in our previous works [4].

Table 2. Demonstration results

Request	Selected song
Bright - Dark: +3	*Symphony No.5 in Cminor*
Clear - Murky: -3	/ Ludwig van Beethven
Rich - Poor: -3	*Merry Chrimas, Mr. Lawrence*
Clear - Murky: -3	/ Ryuichi Sakamoto (1983)
Rich - Poor: -3	
Clear - Murky: -3	*SWEET MEMORIES*
Heavy - Light: +3	/ Seiko Matsuda (1983)
Rich - Poor: +1	
Heavy - Light: +3	*Can you Celebrate?*
Soft - Hard: -3	/ Namie Amuro (1997)

4.2 Song Select Demonstration

Using the proposed system, Japanese male in his twenties freely selected songs from his own music database, which stored one hundred songs that were not used in subjective evaluation experiment for constructing Acoustic – Emotion model. The requests and the corresponding selected songs by the proposed system are shown in Table.2. It seems that the selected songs are complied with the requests, and most people may be satisfied with the results.

5 Conclusion

In this paper, we proposed the automated song selection system complying with emotional requests, which was based on the Acoustic – Emotion model. In the proposed system, the emotional evaluations of music are dynamically labeled from their acoustic fluctuation features. Since users can select songs from large storage of music with only adjectives and their degrees.

In the future direction of this study, alleviation of the user's request constraints will be covered with applying the database retrieval techniques. And conducting the BGM attaching experiment, the usability of the proposed system will be verified.

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Bringing Empathy into Play: On the Effects of Empathy in Violent and Nonviolent Video Games

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Abstract. While violent media has adverse effects on cognition, emotion and behavior, prosocial content promotes these variables in a prosocial way. Greater individual levels of empathy as well as increasing the level of empathy in media content typically foster prosocial behavior and reduce aggression. Two experiments replicated game content findings, and also showed that inducing empathy prior to a video game had a positive influence on behavior. However, under certain circumstances, inducing empathy before playing a violent video game may even have negative effects on behavior. As empathy is a common tool in prevention programs, the implications of these findings are discussed.

Keywords: video games, empathy, aggression, prosocial behavior.

1 Prosocial and Antisocial Effects of Video Games

In a recent overview, Anderson and his colleagues [1] confirmed that video game violence exposure is positively related to indicators of aggression. Furthermore, violent video game exposure was also significantly related to lower levels of prosocial (i.e., helping) behavior and a decrease in empathy. Recent studies found that prosocial video games reduce aggressive cognitions [2] and enhance prosocial behavior (cf. [3]). These findings can be explained by the General Learning Model (GLM, [4]), which addresses both negative and positive effects of media use and proposes that games teach something to media users (regardless of content), and that the valence of this content matters. In sum, video games as a medium with the highest level of interactivity appear to provide the ground for both prosocial and antisocial learning.

2 Empathy, Entertainment Media, and Behavioral Consequences

Cohen and Strayer [5] define empathy as ”the ability to understand and share in another’s emotional state or context” (p.988). The perception of the concept of empathy varies from an emotional response to others’ feelings to the cognitive ability to understand these feelings. In addition to these two often-used major components of cognitive and affective empathy, a dimension for empathy in fictional contexts broadens the concept [6]. Empathy is typically associated with positive effects like, for example, a higher willingness to help others but negatively related to aggressive behavior [7]. With regard to exposure to media violence, it has been shown that

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playing violent video games increases physical aggression, but reduces affective empathy [8]. Similar results have been reported regarding identification with aggressive game characters, while shifting the focus towards the victim of violence in the game may have a beneficial effect in terms of decreasing aggressive behavior [9]. Identification with a media or game character may therefore either foster *or* reduce aggressive tendencies depending on the particular content. To date, however, only few studies manipulated the level of empathy in media content and show indeed positive, that is, aggression-reducing, prosocial effects [7].

3 Study 1: Empathy Induction in a Prosocial versus Violent Game

Based on the findings mentioned above, playing a prosocial video game should lead to more prosocial and less antisocial behavior compared to a violent video game. Similarly, reading an empathy-related text should lead to stronger empathetic reactions and more prosocial behavior compared to a neutral text. Regarding the interaction of both factors, it was expected that empathy might compensate for the negative effects of playing a violent video game. All hypotheses were tested with one-sided analyses of variances (ANOVAs). Eighty students (55% females, M_{Age}=23.4) read a bogus newspaper article on the beneficial effect of video games on memory and were offered either no explanation (neutral condition) or this effect was attributed to emotional involvement and empathy in video games (empathy condition). Next, participants used the *Nintendo Wii*® game console to play either the prosocial video game *Trauma Center 2: New blood* or the violent video game *Manhunt 2* for 10 minutes. Participants were then allowed to take a reward for participating, which was placed outside the lab. Finally, they were handed an envelope containing a questionnaire, which completion would be optional and not controlled. This measured their actual prosocial (returning the questionnaire) and antisocial behavior ("stealing" more than one piece) in an externally valid way.

As expected, the violent video game led to less prosocial behavior (*M*=10%) than the prosocial game (*M*=31%; $\chi^2(1)$=5.52, *p*=.02, *d*=0.70). Similarly, *Manhunt 2* led to more antisocial behavior (*M*=1.29, *SD*=1.42) than *Trauma Center* (*M*=0.77, *SD*=0.96; *F(1,76)*=3.47, *p*=.03, η^2=.44). In other words, people playing the prosocial *Trauma Center* were more likely to take just the amount of reward they were allowed and were more likely to deliver the envelope. Hence, prosocial media content was shown to trigger prosocial behavior while violent media content triggered antisocial behavior. However, regarding the newspaper article participants read (empathy-related or neutral), no significant difference was observed for prosocial behavior ($M_{Empathy}$=20.5%; and $M_{Neutral}$=19.5; $\chi^2(1)$=0.01, *p*=.57) or antisocial behavior ($M_{Empathy}$=1.12, *SD*=1.38; and $M_{Neutral}$=0.95, *SD*=1.07; *F*(1,76)=0.27, *p*=.60). When looking at the interaction between game and text, the analyses for antisocial (*F*(1,76)=0.56, *p*=.46) and prosocial behavior (*F*(1,76)=2.39, *p*=.12) were also nonsignificant. However, it seemed that the empathy-stimulating text (compared to neutral) fostered prosocial behavior after the prosocial game (from 25% to 37% helpers), but led to less helping after the violent game (from 16% to 5% helpers).

4 Study 2: Empathy Induction and Playing Perpetrator or Victim

In Study 2 empathy was induced by means of a short clip. It was expected that watching this clip prior to playing a violent video game should increase players' moral concerns and foster their prosocial behavior. In addition, we assumed that the role of the character would play a role: Compared to playing the victim from the previous clip, playing the perpetrator should result in stronger levels of moral concerns in the game. In addition, prosocial behavior was expected to be highest for participants, who had seen the empathy-stimulating clip and played the victim. All hypotheses were tested with one-sided analyses of variances (ANOVA). Eighty students (69% females, M_{Age}=21.8) either watched a neutral (excerpt from *"The Last Emperor")* or an empathy clip (an emotional kidnapping sequence from the movie *"Street Fighter–The Legend of Chun-Li"*). Next, participants played either the victim or the perpetrator from the clip in the corresponding video game *Streetfighter IV* using the Sony PlayStation©3 console for 15 minutes. At the end, participants were remunerated 5 Euros in coins and told that a donation box for a good cause would be placed outside the lab. Whether and how much participants donated were used as indicators of prosocial behavior.

Results for prosocial behavior and moral concerns were in line with our expectations. Participants who had watched the empathy clip donated more often (M=85%) than those who had seen the neutral clip (M=68%; $\chi^2(1)$=3.38, p=.06, d=0.42), however, slightly failing to reach significance. Participants in the empathy clip condition also reported having more moral concerns (M=1.80, SD=0.88) than those in the neutral condition (M=1.35, SD=0.62; F(1,76)=7.75, p=.00, η^2=.09). It appears that a short clip was sufficient to entail changes in the perception of a violent video game and significantly affected people's decision to engage in prosocial behavior.

When looking at the interactions between type of clip and game character, only for those playing the victim, the empathy clip led to an almost significant raise in donating behavior ($\chi^2(1)$=3.58, p=.06, d=0.63). Because experiencing either a victory or a loss may have additionally affected the players, their status as winner or loser was added as an additional variable. This 3-way-interaction was significant with respect to the amount players donated (F(1,72)=4.18, p=.04, η^2=.06). Having previously played the victim led to five times higher donations (M=3.00, SD=1.41) compared to players of the perpetrator (M=0.60, SD=0.34). In contrast to our expectation, it appears that the effects of empathy largely depend on the game character and the game outcome.

5 General Discussion and Concluding Remarks

Study 1 replicated findings (e.g. [1]) that prosocial game content triggered prosocial behavior whereas violent content led to antisocial behavior. With regard to empathy, a fictitious text was not powerful enough to foster prosocial behavior after playing a "good" (i.e., prosocial) game, or to increase detrimental effects after playing a "bad" (i.e., violent) video game. In Study 2, with a stronger induction, however, empathy induced through a video clip had a substantial impact: This clip shown prior to playing a beat 'em up game led to more prosocial behavior and an increase in moral concerns after playing the game. The interaction of clip and game character showed the differential effect empathy induction could have. While empathy induction had the expected effects on player's feelings (i.e., moral concerns), winning in the "bad guy" condition led to even less prosocial behavior. This finding, for example, is in line with earlier findings of higher identification with mean characters, which leads to more violence [9]. However, it is still unexpected as empathy is *generally* promoted as a help-oriented tool aimed at reducing aggression and fostering prosocial behavior [10].

In sum, the present study corroborates a very differential role of empathy in the media context. Further research in this field is urgently needed, as our findings challenge the conventional characterization of the nature of media content. Evidently, simple classifications in either "good" or "bad" forms of entertainment media are overly shortsighted.

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Cross-Platform Social Web Application for Older Adults with HTML 5

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Abstract. Online social networks can potentially play an important role in connecting older adults with family and friends who often live far. However, adoption of social Web services among the elderly is still very limited because the user interfaces are not adapted to them and also because few of their friends use such services. This paper introduces a mobile Web application designed with older adults' characteristics in mind that integrates a popular social network.

Keywords: storytelling, online social networks, user-centered interface design, older adults, html5.

1 Introduction

Older adults may face a reduction in personal contact mainly due to the loss of loved ones, mobility difficulties or geographical separation [10]. To keep in touch, families often use several communication channels such as mail, telephone and, more recently, online social networks. Although the first two are well mastered by older adults, the adoption of the latter is still low due to the complex user interfaces, which were not designed considering older adults' characteristics [10]. Nevertheless, social networks can potentially be a key for fighting loneliness and isolation among older adults, allowing them to stay connected with loved ones who may be physically distant [5].

This paper presents the design and implementation of a storytelling application for older adults, introducing the problems that older adults face in their daily life and their difficulties in using social networking services. The paper also describes the methods that are and have been used to design the application, their results and some details of the implementation.

2 Use of Social Networks by Older Adults

Older adults can find themselves in situations of social exclusion, due to retirement, moving difficulties or simply because they live far from friends and family [10]. A study with US elderly citizens reveals that most retirees are staying at home and one-third of those aged 75 and older live alone [9]. Loneliness may cause severe

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conditions, such as depression and insomnia [10]. This is due to the fact that, as human-beings we need to communicate with each other in order to share our knowledge and experiences [1, 2]. Social exclusion is often aggravated by the onset of health conditions.

The use of ICTs (Information and Communication Technologies) is known to play a fundamental role in the psychological well-being of seniors, by enabling them to socialize, reducing feelings of loneliness and alienation [5]. However, the elderly struggle to adopt new technologies and software. This is partially due to the fact that the current generation of seniors grew up without computers and, therefore, have difficulties in perceiving the value and usefulness ICTs have in their daily activities [7]. But online social networks open up new and exciting opportunities for the social inclusion of older adults. In fact, they are giving more importance to this form of communication, acknowledging their benefits. According to Madden [6], the engagement of older adults in social media services in the US has doubled between April 2009 and May 2010 to 26%. This study points out three main reasons for this increased adoption of social networks by older adults: i) reconnecting with people from their past; ii) seeking out advice a chronic diseases and sharing experience with others; iii) creating a bridge in generational gaps. Thus, older adults seem eager to start using social networking applications to communicate with friends and family but might be reluctant to do so due to the complex design of existing user interfaces. This calls upon careful design of future social Web applications, specifically intended at facilitating social inclusion of seniors.

3 Designing a Social Web Application for Older Adults

We are developing a social Web application for older adults, in which they should be able to communicate with friends and family to share their life-stories or general thoughts and feelings from their daily life. A user-centered design approach is fundamental to gather the needed information to start prototyping the design for such application. For this reason, we conducted informal interviews, observation, and usability tests in a day care center. These techniques were crucial to understand the needs, challenges and to obtain early feedback from the target audience.

3.1 Sharing Life-Stories and Thoughts

Storytelling presents advantages, not only for the storytellers themselves, but also for the story listeners. These stories carry life experiences to the next generations, the story listeners, establishing a bound between the two, providing them with wisdom that might influence their future [1, 2]. A storytelling application for older adults that integrates with online social networks like Facebook, which is the most adopted social network world wide with more than 500 million users [4], has obvious advantages. Thus, the design of our application focuses primarily on the user experience addressing the characteristics of the elderly and leverages the Facebook API to post the user's stories and thoughts as *wall posts*. This enables standard Facebook users to post *comments* on the stories, which potentiates the interaction between the older adults and a large social network of contacts.

3.2 Results of the User-Centered Design Approach

Usability tests with 25 subjects, with an average age of 75, from a day care center showed that older adults struggle to perceive small sized items. Thus, items as text and images should be adapted to the user's ocular characteristics, adopting a size suitable for the user to read or watch the images with minimal effort. With the same usability tests we were able to determine that the minimum usable font size is of 2.8mm so the older adults can read comfortably on mobile devices.

By carrying out informal interviews with the same set of older adults we confirmed findings described in the literature, observing that they get confused when shown large amounts of information, such as more than a message in the same display or even multiple notifications [3, 10]. When presented with many different items to process, older adults distract themselves easily. This might result in a loss of interest to use the application. With these interviews we concluded that it's important to reduce the application's complexity, by introducing only the essential features.

We also observed that all subjects from the day center had to listen or read questions or instructions more than once in order to understand them. Therefore, whenever showing information to older adults, we should always give them the necessary time to understand each piece of information, removing the possibility to use information that automatically disappears from the screen [3].

Older adults have higher rates of illiteracy than any other age bracket [8], hence proper images and sounds must exist to allow the replacement of the written text, so that illiterate seniors are able to use the system. It is relevant for older adults that our application allows them to record their voice or even a video to simplify the input process, removing the need for them to type text. With this information in mind, we know that we will need not only to stimulate the interest from seniors, but also to provide them with a pleasant and easy experience while using a social application. Therefore, our application ensures that the font size is appropriate for older adults, that there are no large amounts of information in each screen (e. g.: only a story each time) and that only the more important functionalities are present. This way they can perform their actions without getting confused with functionalities that they will not use such as events, groups or even external applications.

3.3 Implementation

The fast-paced growth of technology has led to the emergence of a number of different electronic devices. As the variety of devices grew, the technologies used to create software for them also expanded. HTML 5 aims to accelerate development by creating a Web standard that allows developers to create rich web applications that can be written once and that run in multiple devices, allowing users to choose the device that best suits them, considering portability, screen size, input method or even device costs. Because of the older adults' difficulties on adopting new technologies, this is an important feature for them to feel comfortable while trying the application. Thus, HTML 5 was used to implement an elderly-friendly storytelling application that seamlessly integrates with Facebook, enabling older adults to share stories with a potentially large social network of people that may be connected through any platform.

4 Conclusions

Older adults are subject to feelings of loneliness resulting from isolation. Studies also show that older adults are receptive to adopting online social networks as a mean to improve their well-being and connect them with their acquaintances. With this in mind, our work provides a way for seniors to communicate with friends and family helping them to strength relationships and reduce feelings of loneliness. The application was designed to be as intuitive and pleasant as possible, adapting to common impairments and limitations of the older adult. HTML 5 allows the creation of a cross-platform application, giving the users the freedom to choose the device that best fits them.

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Designing a Wearable Vibrotactile Feedforward Wrist Display for Novice Gameplay

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Abstract. As the potential of the video game medium expands, new design challenges come to light. In this paper, we present the design of a wearable vibrotactile feedforward display for novice players. The device, named "The Gauntlet Guide," is designed to provide vibrotactile guidance cues during navigation tasks in a fast-paced, visual- and audio-intensive video game. We report on a preliminary study in which we assessed the reliability, ergonomics and appeal of the display. Our findings support continued research on haptic feedforward as a viable technique for scaffolding the learning curve in modern video game environments and engaging novice players in gameplay.

Keywords: Vibrotactile, feedforward, guidance, tactile wrist display, wearable, haptics, video games, learning curve, navigation, novice players.

1 Introduction

As a maturing medium with a solid foundation in the entertainment industry, the video game is increasingly being embraced outside of entertainment contexts. This raises the issue of *how* to design video games for new purposes (e.g. learning, training) and previously overlooked audiences (e.g. children, women). In this in-progress research, we focus on three central aspects of the video game medium: its expanding audience, increasing sophistication, and multimodal nature. These foci guided us in the design of a prototype for engaging novice players who are unfamiliar with navigating modern game environments. In this paper, we present insights from our design process and report on findings from a preliminary study.

2 Research Problem

The learning curve necessary to engage with increasingly sophisticated game environments can make them inaccessible to novice players [1]. Novice players can expend effort on navigation, which distracts them from main gameplay tasks [2]. A potential solution that has not been adequately explored is feedforward [3]. Feed-forward, contrasted with feedback, is a system response intended to guide future action; only recently has feedforward gained attention. We seek to explore its uncharted potential in the design of our prototype.

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The multimodal aspect of modern game environments lends itself to the use of haptics for feedforward. In a previous study that compared visual and haptic modalities, we found no indication of simultaneous visual and haptic stimuli hampering performance in a pattern-matching task [4]. Moreover, Forsyth and MacLean [5] conducted a study that showed increased performance with and preference for the use of predictive, overlaid haptic cues in dynamic tasks that involved differing path complexity and visibility. These findings suggest that haptic guidance could be well suited to a gaming context, where maintained engagement and agency is crucial. However, this needs to be explored empirically.

A great deal of research has been conducted around the concept of wearable tactile displays (WTD) for navigation [6]. However, only recently has the use of vibrotactile stimuli for presenting discreet secondary information gained attention. Lee and Starner [7] developed a WTD that presents two-dimensional navigation information via directional vibration cues. Their design features a 3x3 array of actuators, which allows for a rich selection of patterns. However, users need to undergo 40 minutes of training to perform at 99% accuracy. Such a design, while rich with regard to information presentation, presents issues for the problem under question in our research because our goal is to support early and consistent gameplay for novice users. In contrast, initial findings from our preliminary study indicated that our simpler design requires at most 10 minutes of training [8]. However, the implications of this are contingent upon our prototype's success in the upcoming full study.

Fig. 1. The Gauntlet Guide coupled with the Wii Wheel. The bottom two photos show how the actuators are covered.

3 The Gauntlet Guide

Our wearable wrist display provides vibrotactile navigation cues via coin type pager motors arranged in the cardinal directions along the wrist. Players receive haptic feedforward information via the display and control their game avatar using the Wii Wheel, the controller that comes with our chosen fast-paced, multimodal video game, Mario Kart Wii (2008). As the novice player learns how to use the device, they are in the process of crafting a mental model of how the device works; we have coupled these elements to support this process, as suggested by the spatial contiguity principle, one of Mayer's multimedia principles for learning.

The directional patterns themselves garnered special consideration during the ideation stage due to our focus on navigation and known stimuli discrimination problems with respect to vibrotactile motion. We considered variations in spatial configuration and motion style. We implemented a novel mounting for the actuators: instead of being laid flat, the actuators are positioned perpendicular to the wrist.

Positive findings from our preliminary study support the continued exploration of this mounting in the full study [8]. Further, we discovered that sequential motion—each actuator in a given direction being triggered in sequence—was preferred. Our "attention-grabbing" play of the first stimulus opposite to the actual sequence was found to be unsuitable. This led us to use the first stimulus in the sequence instead. Finally, given observations of orientation difficulties, the prototype is now worn along the left side of the left wrist, complimenting how the Wii Wheel is held.

3.1 Future Research: Evaluation in Context of Use

In the next phase of this research, we will evaluate our prototype in its intended context of use. We propose a within-subjects study to investigate how augmenting navigation in a fast-paced multimodal game environment with haptic feedforward affects the user experience of novice players. We ask: Is haptically augmented feedforward an effective style of guidance for novice players navigating a fast-paced game environment that commands the attention of visual and auditory modalities?

We will employ a Wizard of Oz setup, involving a human operator enacting computer responses; this approach has been widely validated for HCI studies. The main task will involve playing through three levels of a racing game with each of three feedforward configurations: haptic, visual and none. The comparison of visual and haptic presentation modes draws directly from our previous work comparing light and heat [9] and visual and haptic modes [4]. Game level and feedforward configuration will be counter-balanced to account for carry-over effects.

We will measure performance (task time and errors), satisfaction (in a post-task questionnaire comprised of Likert scale questions drawn from Davis's scale for perceived ease of use with information technology [10]) and engagement (in self-reports using the Game Engagement Questionnaire [11]).

3.2 Contributions

Our goal is to explore the potential of haptic feedforward through a vibrotactile display for guiding novices. We propose three contributions:

1. Knowledge: To discover how augmenting navigation in a sophisticated game environment with haptic feedforward affects the user experience of novice players.
2. Demonstration: To exhibit a proof-of-concept approach through a prototype—the Gauntlet Guide—that seeks to increase the user experience potential of haptics in gaming through a new context of use.
3. Principles: To establish a set of design guidelines for haptic feedforward.

We seek to explore the potential of haptic feedforward, an approach whose value we foresee increasing as the video game medium continues to push the boundaries of technical quality, applications and audience.

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Interactive Ink-and-Wash Drawing

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Abstract. This paper is about the study on an artwork, a Ink-and-Wash Painting that has been expressed through a digital algorithm. Ink-and-Wash Painting were popular during the Chosun era [1] reigned by kings and officials [2]. It is the intention of this paper to study the potential of expressing Ink-and-Wash Painting through interaction, and present a direction that can coincide with modern paintings by developing Ink-and-Wash Painting from a traditional aspect through analyzing the theories and techniques instilled in my work.

Keywords: Interactive drawing, Interactive Ink-and-Wash drawing, Digital Ink-and-Wash Painting, Interactive Four Gracious Plants.

1 Introduction

Oriental painting has pursued its aesthetic value in plant. It has symbolized the beauty and of plant leaves, branches and flowers and their implicit values. As the representative example, the Four Gracious Plants refers to plum, orchid, chrysanthemum and bamboo in oriental painting, The Four Gracious Plants [3] originally referred to the persons who has virtue, nobility and knowledge, used to pay a tribute to four generals with high dignity in the Warring States Period [4]. This word in painting was originated from applying plum, orchid, chrysanthemum and bamboo to the great persons since the Four Gracious plants were regarded as pure, noble and honorable. This implies that the model for human internal ideology is sought from the plants [5]. For this reason, the brushing of the Four Gracious Plants, as attractive materials for the noblemen, has been regarded to reflect the character of a classical scholar and as a means to develop ones personality [3]. When taking a look at Korean history, ancestors have firmly protected our tradition and culture from numerous foreign invasions and handed them down to the present generation. However, entering the brilliant digital era, it is a fact that traditional values and culture are treated as invaluable and thus neglected. Therefore, there is a need to actively utilize and fuse modern media as a means of inheriting and fostering our tradition. The purpose of this dissertation is to make the original meaning of the Ink-and-Wash Painting, the most aesthetic oriental painting, stand out as well as naturally blending it into the lives of modern people by having a different form of expression.

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2 The Four Gracious Plants

One of the most important characteristics of Ink-and-Wash Painting is to draw not a figure but the mind. This idea means that painting expresses the form, but its ultimate goal is to search for the mind through the forms including brushing line and trace of ink. This idea also pictorially represents the attitude to place importance on mind and disregard form. This implies that the Ink-and-Wash Painting is regarded as an art which requires high level of metaphysical philosophy or personality. In order to reinterpret the Ink-and-Wash Painting representing the idea of mental training into digital, the role of digital interface is more important than anything else. The interface that can express the mind, in other words the digital interface to replace the brush, informatizes the expressive behaviors of audience and visualizes its outcome onto the screen for the interactions with them. This paper describes the interactive artwork for two plants among the Four Gracious Plants; bamboo and orchid.

2.1 Bamboo Concept

Based on the concept of this work, the bamboo was painted according to the strength and the length of the breath of a daegum player. Daegum is one of the representative musical instruments that were played in palaces during Chosun Dynasty. Literary men learned how to write or paint, and also, how to play daegum. It was taken as it was believed to cultivate good minds, just like the four gracious plants. In other words, the painting is not drawn on a paper using a brush but drawn by daegum play, that is, according to the strength and the length of the breath of a daegum player. A daegum is hollow inside and therefore the sound resonates from within and comes out of chwigoo. So, the ultra tiny microphone is installed inside chwigoo, so that the computer receives and recognizes the strength and length of the breath of a player, and then classifies them into 5 different sounds. The strength of the breath determines the shading of the ink and the length of the breath determines the length of the bamboos knot [2].

Fig. 1. The artwork as it is drawn according to a performer's play

SuDongpo (1036-1101), the famous Chinese artist, stressed that to paint a bamboo, one has to first grow a bamboo in his mind and paint it only when his mind is aligned with it [6]. The same bamboo can have a different look and feel depending on who has drawn it. Likewise, depending on the painters intention and emotional state, a painting could look or feel different. Just like a hand-drawn picture cannot be repeated or duplicated, any participant can draw a different picture and express his intention as he listens to different performers play.

2.2 Orchid Concept

During the old days in the orient, people used to wipe oriental orchid leaves or painted oriental orchid for mental training by having an oriental orchid always by their side. Once each orchid is wiped off, the things troubling ones mind is forgotten and ones heart is emptied. Through the act of wiping orchid leaves with utmost care, an orchid instilled with ancient philosophical ideas is visualized. Just as God breathed life into human nostrils and created a living life form, an orchid flower with an excellent fragrance is visualized when a breath is breathed into an orchid flower [7].

Fig. 2. (a)The orchid leaf is drawn at the same angle as the bending angle used when the participant rubs the orchid leaf (b)The flower is drawn when the participant smells the flower (c)Complete of drawing

When an orchid leaf is selected and wiped using the thumb and index finger as if sweeping it down, an orchid leaf is drawn one after another inside the digital frame. A bend sensor is attached behind orchid leaves, and the size of an angle made while an orchid leaf is curved appears due to the difference in electrical current through bend sensors. When the angle of the curve communicated through the orchid leaf is big, the orchid leaf in the painting is drawn as curved leaves or leaves blowing in the wind. The user employs rubbing motions to make various designs, through which the user may create a balance between the orchid and the blank space. After drawing the orchid leaf, the flower is drawn. The flower of the orchid is simple, with only one or two bunches. The fragrance is elegant and delicate, and these graceful qualities attract the attention of the viewer. For this reason, the primary interface with the flower is olfactory rather than tactile. When digilog orchid users smell the flower, the flower generates various images according to its strength When the interactive work is finished, a caption or a poem that goes well with the style of the painting is written in the remaining blank space with a stamped red seal. All of these methods communicate that the painting was produced in the same way orchid paintings were painted in the old days. The regularity and creativity of the orchid painting striking a balance, writing a poem and writing which goes well with the blank space, the seal of the artist, and above all, the greatest significance is that interaction was achieved through the act of wiping the orchid leaves with the attitude and spirituality of the person drawing the painting [7][8].

3 Conclusions

Ink-and-Wash Painting representing oriental art is a collection of a diverse range of art that can be enjoyed along with the beauty of poems, calligraphies, and seals within the painting. This is an artwork for examining the spirituality and figurative perception of oriental art, finding and succeeding a modern way of expression which was completed by achieving mutual harmony between analog contents and digital technology. The painting in this artwork should be painted in a leisurely way just like when one drinks tea after tea leaves have been sufficiently soaked. Only then one can feel the deep taste and aroma and experience the slow art. If we appreciate this work in the similar way, we get close to the thoughts and lives of the painters of those times who used to draw the four gracious plants.

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Digital Keepsake Box: Sharing Items and Memories to Enhance Communications among Remote Persons

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Abstract. This study introduces a digital keepsake box that enhances communications among group users, such as family members and friends, who are living at a distance. It allows users to virtually share items that involve common interests and memories. The box also increases awareness of the existence of other users by slightly opening the cover of the box when other users put items in their box. The results of user studies suggest that the digital keepsake box is useful in enhancing remote communications.

Keywords: communication, sharing, interaction in a group, awareness.

1 Introduction

In a face-to-face conversation, we are able to share the same space with others and to sense connection directly. This kind of sense fulfils an important role in maintaining relationships among people. In contrast, people living apart are forced to communicate through remote communication tools such as telephones, instant messengers and social network services (SNSes). In this case, one person sends voice, text and images to another person, and vice versa. There are no interactions in the same space, and the sense of connection with others tends to be lacking. Users are also required to go through many steps to communicate (e.g. logging in, browsing through pages, typing text etc.). These steps are sometimes bothersome for users and may result in fewer opportunities for communication. This study proposes a digital keepsake box to enhance communications among multiple users living at a distance. The box provides a virtual space for sharing items that involve common interests or memories. It is easy to operate, and provides ample opportunities to communicate.

2 Related Works

Real-world-oriented interfaces have been developed to enhance the sense of connection among people living in remote locations. Digital Family Portrait [1] is a photo-frame interface, which indicates the daily activities of a family member living in a remote place. FamilyPlanter [2] sends information regarding the presence and motion of someone to a family member. Peek-A-Drawer [3] is a drawer-based interface, which virtually transmits the contents of one's drawer to family members at

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a distance. Lover's cups [4] are drinking interfaces for a couple in physically different places. These interfaces are designed to be used as a pair. One of the pair sends information to the other, and also receives information from the other. Only the situation of one-to-one interactions is considered, and interactions among three or more users are not supported. The digital keepsake box provides a single space for sharing with multiple users at a distance, and enables one-to-*n* and *n*-to-*n* interactions.

3 Concept of Digital Keepsake Box

The interface proposed in this study adopts the metaphor of a keepsake box which is used to keep favourite items and memories. Every user has his/her own digital keepsake box in which he/she places items for communicating with people living at a distance. The operations of placing items, as well as opening and closing the cover of the box, are simple and familiar. In a traditional keepsake box, the original items placed by a user exist only in his/her box. The digital keepsake box, however, virtually shares those items and presents them as if they are in a single keepsake box, as shown in Fig. 1. This provides a common space for users to interact, and creates opportunities for communication. In addition, the box has a function which implicitly increases the awareness of other users' actions. The covers of all of the boxes in a group open slightly when one of the users puts some items in his/her box. The rest of the users will be aware that somebody else in a group has placed something in his/her box. Figure 2 illustrates the concept of the function.

4 Implementation

Based on the concept of the digital keepsake box, a prototype interface shown in Fig. 3 was implemented. The size of the box is 45 cm × 48 cm × 34 cm. This size allows users to insert large-sized items, such as foods and toys. A 19-inch LCD showing the content inside the box was placed on the bottom of the box. On the back of the cover, a Web camera and a fluorescent lamp were placed for taking pictures. A servomotor that cranks up the cover of the box and microswitches to detect whether the cover is opened or closed were also placed on the edge of the box. The fluorescent lamp, servomotor and microswitches are controlled through a set of Phidgets [5].

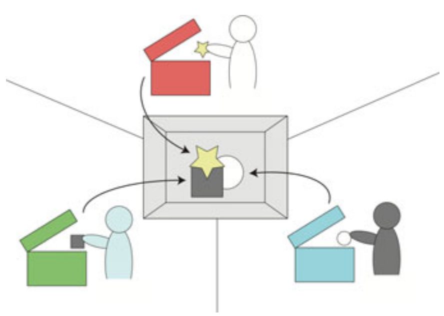

Fig. 1. Virtual sharing of the contents in the digital keepsake box

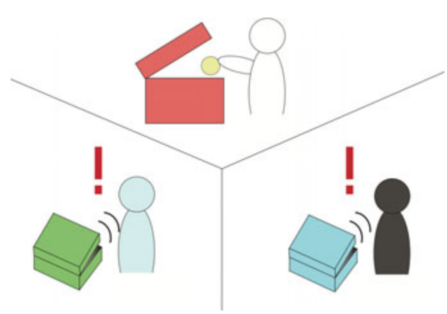

Fig. 2. Function that implicitly increases the awareness of other users' actions

When the cover of the box is closed, a picture of the inside of the box is automatically taken by the Web camera. First, it is determined whether the user has placed items in the box by comparing the colour histograms of the picture taken and the background image. If items exist in the box, the region of the items in the picture is detected by background subtraction. The region without the items is set as transparent using an alpha channel. After image processing, the processed picture is sent to other users' keepsake boxes using TCP/IP.

When a box receives a picture from another user, the plastic bar attached to the servomotor rotates by 90 degrees. It slightly cranks up the cover of the box. The plastic bar returns to the original position when the microswitch detects that the cover has been fully opened by a user.

The LCD on the bottom of the box always shows the contents shared by the users. Figure 4 shows the process of the contents presentation. First, the internal side of the box is drawn in three-dimensional space. The pictures of the items are also placed in the three-dimensional space, such that the oldest picture goes to the back and the newer pictures are layered on the older pictures, similar to a box in the real world. The contents are redrawn when the user puts new items in the box and the box receives a picture from another box.

5 Preliminary User Study

In order to observe how users interact with the digital keepsake box, a preliminary user study was conducted for two groups, each of which consisted of three participants. All of the participants in a group knew each other and had frequently used an SNS. The study consisted of two phases. In Phase I, the participants communicated only with the community pages of Mixi [6], which is one of the popular SNSes in Japan, for six consecutive days. In Phase II, a digital keepsake box was delivered to each participant, and they communicated using the box as well as the SNS community pages. Phase II was also conducted for six consecutive days.

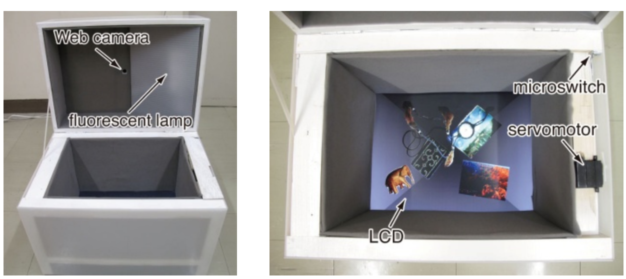

Fig. 3. Appearance of the digital keepsake box prototype

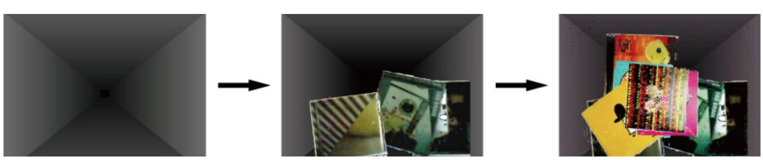

Fig. 4. Presentation of the contents inside the digital keepsake box

The participants in Group A used the boxes to converse in the SNS. The average number of daily comments posted on the community pages was 4.6 comments per parson in Phase I, while the average was 9.3 comments in Phase II. Among all the comments in Phase II, nearly half of the comments concerned the items placed in the boxes. In the interview, some participants commented, ‘I placed something to see how other people react.’ and ‘I tried to start conversations by putting items in the box.’ These results demonstrated that the digital keepsake boxes were used concurrently with the community pages and created opportunities for communications.

Because the three participants in Group B were commonly interested in music, they used the box to share information about their interests (e.g. putting their own favourite CDs in the boxes). In this group, the average numbers of daily comments on the community pages were 1.8 and 1.4 comments per parson in Phases I and II, respectively. No significant difference was observed in terms of the number of comments. One of the participants said, ‘We did not use the community pages so often.’ In addition, only 7% of the comments in Phase II concerned the items in the box. The participants in this group, however, frequently placed items in the box (7.3 items per day) and checked the contents in the box (4.8 times per day per person). The results indicated that Group B communicated simply using the digital keepsake boxes themselves, instead of using them together with the SNS community pages.

6 Conclusion

This paper described a digital keepsake box to enhance communications among group users, such as family members and friends, who are living at a distance. The box provided a virtual space for sharing items involving common interests or memories. A preliminary user study was conducted for two groups to observe how the users interacted with the box. Although the usage of the digital keepsake boxes was different between the groups, the results of the study demonstrated that the boxes were useful for improving communication through an SNS. As future work, the authors will conduct a detailed user study and will also implement functions to maintain the contents inside the box (e.g. taking out some items, and changing the position of items in the box).

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Emotional Intelligent Contents: Expressing User's Own Emotion within Contents

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Abstract. This paper presents an Emotionally Intelligent Contents (EIC) framework. This framework helps to create content that changes its elements (such as textures, color, light and sound) dynamically in response to a user's emotional state. Also, this emotionally intelligent content allows users to add their own emotion characters at run-time. This paper presents an overview of the EIC framework designed to adapt a game environment to a user's emotional state as measured physiologically or through an explicit rating of one's affective state. It will then describe a couple of applications built with this framework.

Keywords: Emotion, Emotional Intelligent Contents, Emotional Characters.

1 Introduction

Emotion stimulates the five senses and helps users to become more immersed in game contents. However, most emotional contents are created by designers beforehand, and as such, users are exposed to pre-designed emotion states, such as sadness or, happiness. These emotional contents cannot be changed dynamically at run-time. In this paper, we propose emotional contents that can go beyond simply appealing pre-defined feelings. These kinds of emotional contents can actively affect the user's own emotion to either intensify or diminish emotional states. This is done by recognizing and analyzing the user's emotional states and accordingly adjusting the elements of the contents in real-time. In this paper, we refer these kinds of contents as emotionally intelligent contents.

Emotionally intelligent contents can be used in various application domains, such as in education, games and clinics. For instance, emotionally intelligent contents used in education may vary in color and sound in order to capture the attention of students who get bored with learning materials. Similarly, a emotionally intelligent contents in a game may change color and sound according to the users' emotional states to attract more users more into the game. In Fig. 1, the image on the right shows a prototype implementation of the emotionally intelligent contents. This emotional game allows users to replace the in-game character with their own characters. Then, the color of the exchanged character can be changed based on the users' emotional states.

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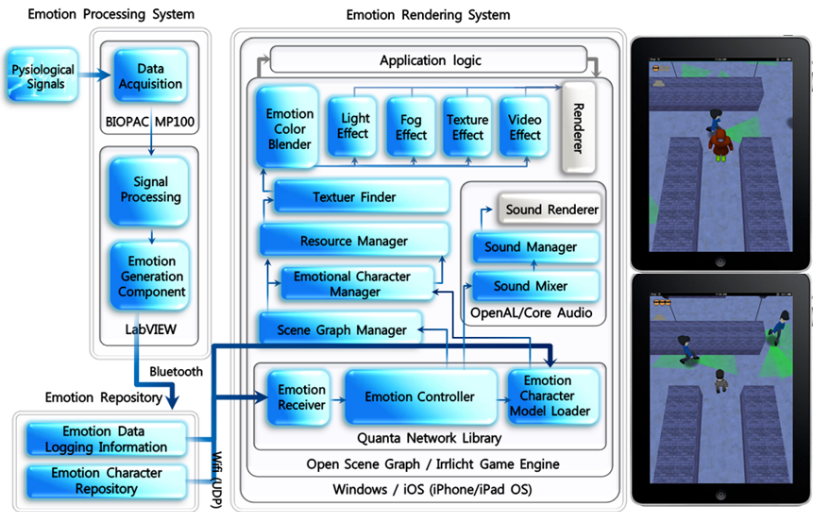

Fig. 1. The system architecture of the Emotion Intelligent Contents Framework (left); The Nocturne Thief game built with the EIC framework (right)

There have been a lot of previous studies that employ users' biofeedback as input data for a game. Neuro Wander [1] used a brain-computer interface for game control. Facial expression [2] and speech [3] were also used for recognizing user's emotions that used for an input to the game. Our work, on the other hand, focuses on providing users with the ability to express or change their emotions so that they become more immersed and engaged into the contents.

This paper presents a framework that allows easy construction of Emotionally Intelligent Contents (EIC). The EIC framework can interpret the emotions of the users and present the newly manipulated contents in response to the current emotional state. This framework allows users to additionally add or replace an emotional object into the content in real-time. These newly added or replaced emotional objects user's emotion or respond to the emotions in real-time as other emotional objects do.

This paper first describes the design and architecture of the Emotionally Intelligent Contents (EIC) framework. It will then present two applications built with the EIC framework, EmOcean and Nocturne Thief, and discuss directions for future research.

2 Design and Implementation

In Fig. 1, the image on the left shows the system architecture of the EIC framework, which is divided into Emotion Processing, Controlling and Rendering modules. The Emotion Processing Module reads users' emotional states via active user input and passive recognition. Users' emotional states can be actively recognized via explicit selection, by users, on a graphical user interface. Passive recognition of emotions is conducted by analyzing physiological signals, such as, PPG (photoplethysmograph), GSR (Galvanic Skin Response) and SKT (skin temperature). For the sake of simplicity, emotional states are divided into 9 different states in a two dimensional space.

When users' emotions are retrieved, they are sent to the Emotion Repository Module, and then read by the Emotion Receiver and Controller. Passive reading of physiological signals is accomplished using the BIOPAC MP100 data acquisition system and the home-brew analyzer software built with National Instruments' LabView. The Emotion Processing module runs only on a desktop computer whereas the Control and Rendering modules run on both desktop and mobile systems. The Control module contains the pre-defined rules that describe how to change the visual and aural properties of the three dimensional contents when a specific emotional state is received.

When the system identifies a user's emotion and the accompanying rule with which to apply the emotional state, it will send this information to the Visual and Aural Rendering modules. The Visual Rendering module is built on top of the open-source three-dimensional game engine called Irrlicht. The Rendering modules contain a number of C++ classes to support alteration of texture maps, animation, video playback, light and fog effects, and so on. The Aural Rendering module written with OpenAL supports alteration of sound play speed (i.e., faster or slower).

In this EIC framework, an emotion character can be added as a new object or can replace an existing object. When the emotional content receives a message containing a URL, it downloads the emotion character from a web site or loads it from local storage to be inserted into the content. Depending on the contents, the emotion character can be a dynamic (i.e., moving or animated) object, such as a person or an animal, or a non-animated object, such as a tree or a rock. Once this new emotion character is added to the 3D environment, the emotion recognized either passively or actively would then change the visual aesthetic features of the character.

When adding or replacing an emotion character, the content must determine whether the character will have first-person view, as in a FPS game, or tethered view. In tethered view, the player can control the character of the content. When this emotion character is added in first-person view content, the content is switched to support tethered view. That is, a virtual camera is attached to the emotion character and the player actually controls the character's movement. If the character is removed from the content, it switches back to first-person view. When this character is inserted in tethered-view, the primary character of the content is replaced. If this character is removed, it will revert to the original character. This mechanism is accomplished by modifying the scene graph structure of the content without affecting the content logic.

3 Applications

The experts in the fashion industry found that feelings of pleasure and states of emotional arousal in people increased as brightness of color and luminosity increased, respectively. We made a color table for nine different emotional state representations based on this finding. In this EIC framework, the texture maps of the emotion objects are masked according to user emotion. Similarly, the tempo of the sound (i.e. fast or slow) also changed depending on the emotional status.

We have built a couple of prototype applications using the EIC framework. EmOcean is a virtual world for Windows and iOS platforms of an ocean environment populated with rocks, fish, coral and sea weed. In the EmOcean environment, a few rocks and fish change their visual properties in response to users' emotions. In addition, the tempo of the background music and sound is adjusted depending on the user's emotional states. Moreover, it is possible to add an emotion character at run-time, which is attached to the virtual camera and expresses the users' emotional status.

The Nocturne Thief (see Fig. 1) open-source game [4] was re-written with an emotionally intelligent environment. The goal of this game is to control the thief character to steal gold bars without getting caught by the guards. We ported this game to iPhone/iPad platforms and make it be more emotionally-aware with the EIC framework. The thief character can be replaced with a user's own emotion character. When the game character is replaced, the emotional avatar changes its color based on the users' emotional states. Since all logistics of user emotion response embedded in the EIC framework, no other game logic is modified.

4 Conclusions and Future Work

Emotionally Intelligent Contents (EICs) manipulate the visual and aural elements of contents in real-time based on users' emotional states. The EIC framework recognizes users' emotional states actively via explicit selection from the GUI or passively by sensing and analyzing physiological signals. Emotion-oriented contents provide enjoyment and cause users to become more immersed in the contents, since the contents respond to their own emotions. We expect that this EIC framework will garner more public attention in the contents industry. In this research, we developed an EIC framework designed for easy construction of such emotionally intelligent contents. The framework also allows for the adding of emotion characters at run-time, which would respond to a user's emotional states. In the future, further experiments will be conducted to determine which elements of the contents would affect the users.

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Exercise Pal Mootchi

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Abstract. Exercise is vital to maintaining good health, but many people neglect to work out regularly or often enough. One reason is the lack of will to take part in physical activities. We believe that interactive technologies can play a role in providing entertaining and implicitly educational mechanisms that will help people pursue healthy physical activities. As an example to our approach we present a mixed reality pet, *Mootchi*, which will provide users with an emotional incentive for exercising, indirectly acting as a persuasive physical trainer. This short paper outlines our prototype implementation and initial findings based on a design critique of *Mootchi*.

Keywords: Personal projection, emotional attachment, mobile interfaces, persuasive educational interfaces.

1 Introduction

Exercising daily is beneficial to everyone's health, but many do not exercise often enough. As media becomes more readily available due to an increase in entertainment products, people spend more time on these devices and participate in less physical activities. We are exploring ways in which interactive educational technology can be used to diminish and hopefully reverse this effect. We hope to see the design of mobile interfaces that implicitly act as educational trainers, persuading users to be physically active. Our current *Mootchi* prototype is an early example for this vision.

The use of interactive technologies to encourage users to exercise is not a new idea, but such devices often require the user to look at a screen, perhaps on a PC or a mobile phone, in order to benefit from the interface. When a user forgets to check the device, the exercise reminder is hidden and can be avoided by an unmotivated user.

In contrast, let us consider a person's relationship with pets. Dogs, for example, who want to go for a walk are hard to ignore. A dog will pester and beg until its owner walks it. The dog is a physical entity with which the owner has a close emotional relationship, a relationship that makes it hard for the owner to neglect the dog's physical needs. *Mootchi* is an attempt to create an implicit educational training system based on emotional persuasion, similarly in essence to the one in the owner-pet relationship. It is a mixed reality pet, projected by the user's mobile phone onto her environment. *Mootchi* is quite emotionally expressive, and its emotional state is directly connected to the amount of physical activity *Mootchi* senses through the phone's accelerometer. When it is unhappy, the user is reminded to walk *Mootchi* until it cheers up again (Fig. 1. a).

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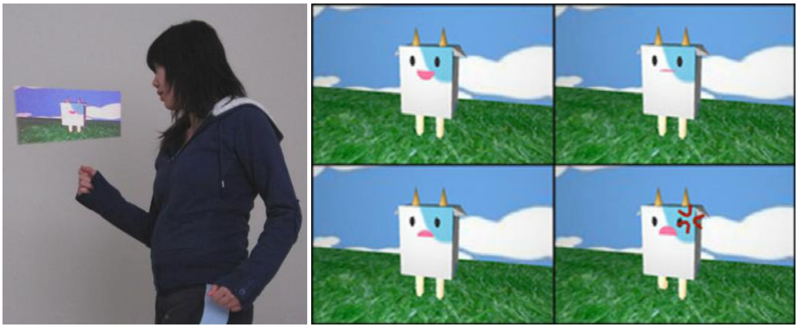

Fig. 1. a. Going for a walk with *Mootchi*. *Mootchi* is projected onto the wall by wearing a portable projector on the user's shoulder. **b.** *Mootchi*'s four moods: happy, neutral, sad, and angry.

Unlike previous virtual pets efforts *Mootchi* does not live on the screen of a mobile phone, but a mixed reality entity projected onto the user's workspace, wall, or any other flat surface in the user's vicinity. In this way, *Mootchi* is an integral and continuous part of the user's physical environment, thus harder to ignore and neglect.

2 Related Work

Lin J. J. et al. [3] uses the growth of a fish running on a mobile phone to keep track of user's exercising progress. Our approach shares many of the concepts with Lin's research, but *Mootchi* attempts to create an emotional bond with the user, in hopes that the commitment is not for the workout per se, but rather for *Mootchi*'s happiness. As *Mootchi* is projected onto the user's workspace, it is also harder to ignore than a mobile device that can be hidden in a pocket or bag.

Dillahunt T. et al. [1] studied how different degrees of emotional ties to a virtual animal can encourage environmentally friendly actions. A Flash-based virtual polar bear and its habitat showed the user that environmentally friendly actions increased the size of the bear's iceberg. This study found that those with a stronger attachment to the animal were more committed to environmentally friendly actions in the short term. Similarly, we hope that the emotional attachment to *Mootchi* will elicit a stronger commitment to perform the physical activity that *Mootchi* craves.

Mootchi is designed as a persuasive social actor, one that users can create an emotional bond with, and can be treated as if it were alive. According to Fogg B. J. [2], social actors give users positive feedback, model a target attitude, or provide social support. *Mootchi* provides positive feedback when the user exercises by becoming happy. When users perceive an application as a social actor, Fogg argues that the application has a higher chance of persuading and motivating users.

Tamagotchi was very well received by children and young adults, and many became attached to it emotionally. Similarly, Nintendo's Pocket Pikachu is a virtual pet living on the screen of a pedometer. The objective is to walk Pikachu in order to gain "watts" to feed it. Our design incorporates the pet attributes these interfaces, but augments it with a stronger relationship with the physical world. *Mootchi* is projected onto the user's environment and thus becomes a mixed reality pet that is more persistent and graspable, and constantly sharing the environment with the user.

Fig. 2. A user browses the web and glances over to check on *Mootchi*

3 Mootchi Prototype

Mootchi was prototyped as an Apple iPod touch app (Fig. 1. b). A MicroVision SHOWXX Laser Pico Projector was used to project it into the user's surroundings. In the short term we hope that *Mootchi*-like interfaces can be designed around mobile phones with built-in projectors (such as the LG Projector Phone).

Mootchi has four moods: happy, neutral, sad, and angry, and its facial expressions show what mood it is currently in. When the user is sitting to work or watch TV for example, the projector can be placed on a desk projecting *Mootchi* onto a nearby wall so she will see *Mootchi* at all times (Fig. 2). The user may also choose to wear the projector on her shoulder or calf while walking with *Mootchi* so she does not have to look at the iPod touch to check *Mootchi*'s current mood while exercising.

4 Preliminary Design Critique and Results

We asked two students from our lab to play with *Mootchi* as part of a preliminary design critique. *Mootchi* was projected onto a wall next to a laptop (Fig. 2), and the participants were told that walking *Mootchi* would make it happy. Due to time constraints, *Mootchi*'s mood changed more rapidly than it normally would. In the first phase, the participants browsed the internet, classified as an activity that is not extremely engaging. The participants were asked to refrain from watch any videos. In the second phase, the participants watched a short movie as a more engaging task.

In the first phase of the design critique, both participants noticed *Mootchi*'s mood changes quickly, and proceeded to walk *Mootchi* until it became happy again. However, in the second phase, both resorted to shaking the iPod touch to simulate the effects of walking so they can continue to watch the movie without interruption. One of the participants reflected that *Mootchi*'s mood changes were so subtle that during the movie-watching phase, the mood changes went unnoticed at times.

Although both participants liked *Mootchi*, they both said they would turn it off or ignore it when doing a task that involves concentration. Neither of them liked the idea of using the projector while walking. One said that she would feel embarrassed if others saw that she did not take good care of it.

A participant said she was guilted into walking *Mootchi*, and was definitely motivated by it. She felt obligated to keep it happy. The other participant was not motivated to walk around for *Mootchi*'s happiness, and would walk *Mootchi* only as an excuse to procrastinate. He suggested letting *Mootchi* evolve as the user exercises. If the exercising goal was not met, then it should devolve or even die. He believes that this may increase users' attachment to *Mootchi*.

5 Conclusion

The participants' awareness of *Mootchi*'s mood changes during the first phase compared to the second enforces our perception of the lower/higher engagement requirement for the tasks chosen. When *Mootchi* becomes an integral part of the user's living space, its presence may diminish because it does not have attention-grabbing animations. Giving *Mootchi* flashier animations may alleviate this problem.

The suggestion that *Mootchi* will be able to affect the user more if it can grow and die is a valid point. Evolution is a large part of the Tamagotchi gameplay, and the virtual pet's mortality gives an incentive for players to care for it properly.

Both of the participants enjoyed playing with *Mootchi*, though only one was motivated to go for a walk to make it happy. Because of the different reactions to *Mootchi*'s needs, a more intensive study should be conducted to confirm our results.

Mootchi is a mixed reality pet that attempts to encourage users to perform physical activities such as walking or jogging by using both emotional attachment and physical integration with the user's environment. By becoming a social actor, *Mootchi* creates an emotional bond with the user so the user will care about *Mootchi*'s happiness. We believe that *Mootchi*, once some of the current prototype's limitations are resolved, has great potential to urge people to remain physically active, and to become an exercising companion and educational tool for a healthy lifestyle for everyone.

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Exploring the Concept of Third Space within Networked Social Media

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Abstract. Third Space is thinking differently of the significance and meanings of space progressing beyond the inadequacy of dualism, as in mental and physical space. The discourse on Third space emerges to set aside the 'either/or' manner of binary categorizing to encompass 'both/and also' logic that allows an 'Other' set of options. The online social networking is the newest thing in creating connectivity and the identities. This paper is an attempt to comprehend and recognize the dynamics of the concept of Third space through the online social networking realm.

Keywords: Social Space, Third Space, Social Networks, Hybridity, Difference, Radical Openness.

1 Introduction

Space is a fundamental area of study in many disciplines. Plato stressed that matter and space are the same and Aristotelian world is a plenum (space filled with matter). Descartes has rejected both Aristotelian and anti-Aristotelian thoughts on space, instead defined the material substance within the three dimensional spatial extension [8]. Kant's [5] notion of space is neither Aristotelian nor Cartesian, but a priori, which shifted the discourse of space from philosophy to science. Heidegger [2] was the first to introduce the notion that the existence is spatial. Norberg-Schulz [7] believed that the human interest in space appeared from the need to comprehend the environmental relations that surround him, to give meanings and order to the events and actions.

The noticeable dynamism in the spatial discussion is its dualism and privileging one over the other. According to Henri Lefebvre [6], the philosophical space is given precedence over the social and physical space. The space between the philosophical epistemologies and the physical or the social space is the space that was overlooked, disregarded and not conceptualized. The Third Space is this overlooked and disregarded space, a space that includes both the philosophical and social/physical and also the space that is 'in between'. The intention of this research is to examine the epistemologies of the 'in between' space or the 'third space' and its dynamisms as a space of radical openness and critical enquiry. This enquiry will be positioning the

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modern networked social media within the discourse of Third space and the phenomenon of being virtually connected on a social space; a platform of immense interactivity and communication of information.

2 Objective

The broad objective of this study is to clarify the spatiality of the networked social media and understand the spatial concept of Third space in relation to the modern communication media. At this point in this research, the primary objective is to establish the concept of Third space and its trajectories. Thus, form a foundation to study the second stage which would enquire into the materialization of social connections and their diffusion leading to the hypothetical position of the relationship between third space and networked social media.

3 Concept of Third Space

Exploring the conceptualization of the Third space begins with Lefebvre's [6] dialogue on space. He, with his discussions on the lived and conceived, the real and the imagined, analyses the discourse on space as a three-part dialectic between everyday practices and perceptions, representations or theories of space and the spatial imaginary of the time. Edward Soja is another prominent figure in highlighting the importance of Third space by familiarizing the terminology 'Thirdspace'. Soja's [9] 'Thirdspace' is tentative and flexible to capture the constant shifts in ideas, thoughts and events and meanings. "For me this space of radical openness is a margin- a profound edge. The focus was on both center and the margin understanding the contradiction on both spaces" says bell hooks [3]. Homi K. Bhabha's [1] Third space is a space of difference and hybridity. The significance of the hybridity is not to be able to trace the two original moments from where the Third space emerged but rather understanding the hybridity as the Third space, which enables other spaces to emerge. Gayatri Spivak's [11] Third space will define both center and the margin, but still operates as a space of radical resistance. Anthony Vidler's [12] 'The Third Typology' and Jane Jacobs's [4] City earmarked another approach to the Third space in urban environment.

Over the years, there materialized a shift in our knowledge of space as well as the spatial practices itself. The new spaces such as the spaces created over the internet, web camera telecasts, chat rooms with video/audio chatting, blogging and most recently the online social networking. Are these incomprehensible, imaginative yet so networked and interactive spaces contradicting the existing knowledge and conceptualization of Third space? These new developments would be briefly examined by trying to place the networked social media within the Third space criteria.

4 Understanding Third Space in Networked Social Media

Understanding Third Space leads us towards a discussion examining the spaces of new modernity, the spaces of actions, interactions, and concepts and theories. Online social networking (Facebook, MySpace, Twitter etc.) consisted of individuals, connected through a telecommunication network, interacting on one platform, which could be customized yet universally defining similar functions, ambiguous yet with one clear intention – connectivity; with an immense amount of information exchanged, shared, declared and stored. The tangibility is the visuality on an interface; intangibility is the connection that provides the access to interact with others. The spatiality is diverse, different and essentially rapid.

Let us examine the dynamics of Third Space and understand the paradigm changes with regards to the social networking realm. *a) Third space clarifies the binaries in the discourse of space* - By existing as connected to yet independent of the existing spaces, Third space explains the binaries, says. Bhabha[1]. Examining the social networking platforms, the differences are noticeable on a common platform, interacting, sharing information and uploading new knowledge both written and visual. It is the 'in between' space, where it is continually transforming in accordance with the dynamics of the cultural interactions. *b) Third space is counter-hegemonic* - Social networks clearly projects the ideologies and supremacies related to information and its sharing, managing and storing. These platforms could act as authoritarian custodians of the social interactions of the people within/out of the realm of the network by dictating the behavior pattern within the site while simultaneously promoting the virtues of social connectivity though the market place. Facebook, a prominent social media platform, advocates that having a Facebook account as the only sustainable way of managing your friendships. *d) Third space is both imaginative and real* - This is a resemblance to the mirror; the reflection is on the mirror where the person is not. It is both imaginative and real concurrently, thus accommodating both, the person before the mirror looking in and the person reflected in the mirror looking out, the reflection and the real. On the social media platforms there exist the projection, the person on the mirror, the person who was a reflection yet not in attendance, and on the other side is physical self looking at the reflected self. *e) Third space is a space of negotiation, contestation, and rearticulating* - The networked social media through its interactive platforms created spaces of voices, which contest, negotiate and rearticulate the social issues, political suppression, censorship, injustice etc. The protests following the Iranian Election in 2009, Iranian government has prevented the reporting of atrocities happening within, however, people started using social network sites, as a way of broadcasting the happenings.

It could be understood that networked social media, though demonstrate strong indicators of being able to be positioned within the Third space discourse, it is still an ambiguous project with several problematic evolving. Both the Third space and the networked social media are conceptually and critically underdeveloped, which impede further developments such as understanding the dynamics critically.

5 Conclusion and Future Work

Social networking spaces has produced a space that operates with a hegemonic parameters, yet accumulates different values in a form of being a collective social force, thus emerging beyond the binary vision towards the Third space. Describing third space Soja [10] says that it is not an alternative concept but a space where issues were raised and discussed without privileging any party and actions. Potentially the positioning of networked social media among the conceptualizations of Third space offers for new knowledge on spatiality

The next step in this study is to examine the multiplicity in connectivity, where we would examine the users of networked social media to analyze the magnitude of connectivity. The succeeding study would be the establishment of the multiple interaction space which would be a further study of the extent of the connectivity and development of the argument. In the final phase we would decisively maintain our hypothetical position, which would be to establish that multiple interaction space as the third space.

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Game Information Dynamics

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Abstract. This paper is concerned with game information dynamics. Information and information kinetic energy are derived using existing models. Based on Einstein's special relativity theory, it is suggested that when the velocity of information particles is slightly smaller than the speed of light, our mental concentration increases enormously.

Keywords: Information Dynamics, Energy, Relativity Theory, Emotion.

1 Introduction

A central problem in game research has been to obtain the relationship between information of game outcome and game length (or time), e.g. [4, 5]. Here information of game outcome represents the data, which is the certainty of the game outcome. A natural extension is to obtain, e.g., information velocity and information acceleration. Recently, game information dynamic models have been proposed based on fluid mechanics ([2]). In the models, information is mathematically expressed as an analytical function of the game length (or time).

The two models are expressed, respectively, by

$$\text{Model 1: } \xi = \eta^n, \tag{1}$$

and

$$\text{Model 2: } \xi = [\sin(\pi/2 \cdot \eta)]^n, \tag{2}$$

where ξ is non-dimensional information of game outcome, η non-dimensional game length (or time), and n a positive real number parameter. The value of the parameter n might depend on fairness of the game, strength of the two opponents, and strength difference between the two opponents. Information dynamics may be discussed using these models. Information kinetic energy, for example, can be obtained by using Model 1 or Model 2, following the definition in physics. It is considered that game information is closely related to emotions of observers or players ([3]).

The main purpose of the present paper is to clarify how information and information kinetic energy depend on game length, using previously proposed game information dynamic models ([2]).

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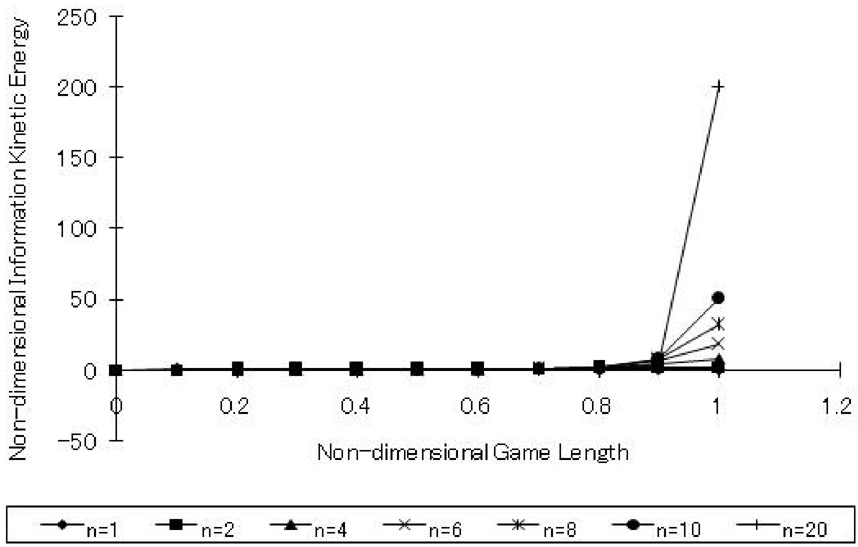

Fig. 1. Non-dimensional information kinetic energy E_k against non-dimensional game length η for Model 1

2 Information Dynamics

Game information dynamics are, e.g., information, information momentum, information force and information energy, in relation to game length or time during a game. If information particles have mass in our brain (or informatical world) and flow exactly the same as fluid particles in the physical world, it is possible to discuss information dynamics. We have observed fair similarities between information momentum, information force and information kinetic energy with respect to game length. Therefore, in the present study we consider only information kinetic energy. We assume that information particles flow as electromagnetic particles (photons) or electrochemical particles in the informatical world and form a homogeneous information fluid.

Since Model 1 is expressed by (1), non-dimensional information velocity (first derivative) is

$$d\xi / d\eta = n\, \eta^{n-1}. \quad (3)$$

Since Model 2 is expressed by (2) the non-dimensional information velocity is derived as

$$d\xi / d\eta = n \cdot \pi/2[\sin(\pi/2 \cdot \eta)]^{n-1} \cdot \cos(\pi/2 \cdot \eta). \quad (4)$$

Non-dimensional information kinetic energy E_k is defined as

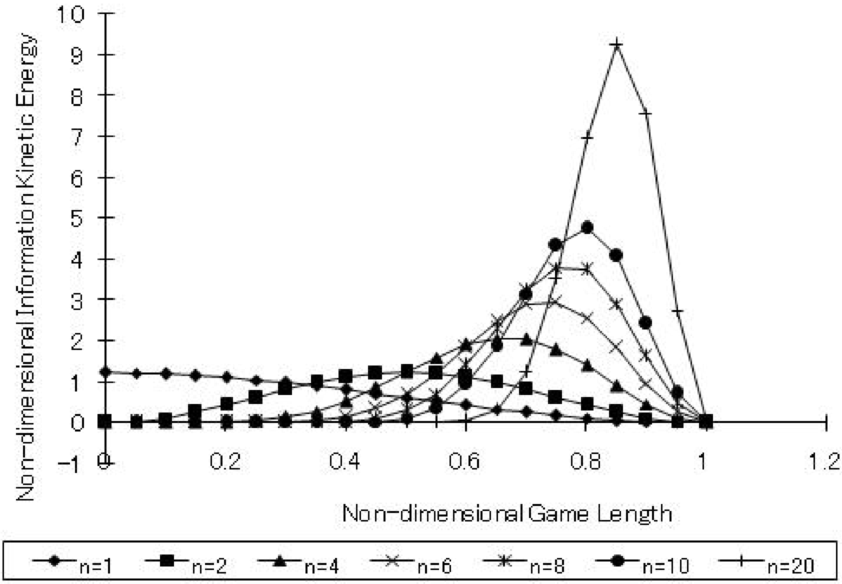

Fig. 2. Non-dimensional information kinetic energy E_k against non-dimensional game length η for Model 2

$$E_k = 1/2 \cdot \varphi \cdot (d\xi/d\eta)^2. \tag{5}$$

Under the assumption of a homogeneous information fluid, non-dimensional information mass $\varphi = 1$, and thus (5) becomes

$$E_k = 1/2 \cdot (d\xi/d\eta)^2. \tag{6}$$

This particular case has been considered. It is possible to calculate the value of E_k by substituting either (3) or (4) into (6).

Figure 1 shows how non-dimensional information kinetic energy depends on non-dimensional game length η for Model 1.

Figure 2 shows how non-dimensional information kinetic energy E_k depends on non-dimensional game length η for Model 2. When $n \geq 2$, E_k increases with increasing η, takes a peak value and becomes zero at the end. However, the larger the value of n, the greater the peak value of E_k as well as the value of η at which E_k takes the peak value. When $n \leq 1$, E_k decreases from an initial positive value to zero with increasing η.

3 Discussion and Conclusion

The slowing of time in a moving inertial frame with constant velocity v, has been derived by Einstein([1]) as follows,

$$\Delta t = \Delta t_0[1 - (v/c)^2]^{1/2}, \quad (7)$$

where Δt is the elapsed time on the first inertial frame with velocity v, as seen by an observer on the second inertial frame, and Δt_0 the elapsed time for the observer on the second inertial frame. This denotes that the greater the velocity v is, the slower time proceeds on the first inertial frame, and vice versa.

Let us consider the case that the information particles (the first inertial frame) move with a constant velocity v, relative to our body (the second inertial frame) fixed to the earth. Assuming again that motion of information particles reflects our emotions, when $v \leq c$, we may feel as if time stops, for the elapsed time on the information particles, corresponding to the first inertial frame with velocity v, becomes nearly equal to zero, as to be detected by the observer on the second inertial frame. For example, when an event proceeds on the first frame with constant velocity v, the elapsed time on the first inertial frame is shorter than that on the second inertial frame. This means that the time on the first inertial frame proceeds slower than that on the second inertial frame, so that our cognitive sensor fixed to our body (the second inertial frame) perceives the event, being compacted within a shorter time. This may be the reason why our mental concentration increases with increasing information particle velocity v. It is inferred that when $v \leq c$, our mental concentration increases enormously, and thus we can possess very high potential to overcome any problem or difficulty. Under this situation, a player equipped with high mental concentration in games such as Chess, Shogi, Go, Base Ball or Soccer can choose the best move or play.

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Interactive Communion Tabletop

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Abstract. Interactivity, the most prominent characteristic of digital media paradigm, generally means a relationship in the communication between human and human, human and machine, or media and media interacting each other. This work is interactive art and is produced to prepare a foundation for closer communication between human and human based on technology.

Keywords: Interactive ivy, Interactive design, Communion hand, Digital media art.

1 Introduction

The paradigm in technological development moved from sensibility, communion and communication in its value standard. In other words, it becomes more important whether the user can feel comfort and respond sensibly to it through digital. Digital technology opens a new horizon of sense with the advent of new technology that experiences new senses never felt before and recognizes the organic combinations or information of sensors. Through this, the foundation for closer communication between machine and human being or human to human has been laid. Therefore, the non-verbal interactions in this work provides the basis to intentionally extend the knowledge about interactions, nurture behavioral pattern and actively utilize the communication. In addition, the social interactions with strange others can deliver the meaning to others through body language and understand and sympathize each other through the message extracted by others.

2 Concept

Interactivity, which is implemented by digital technology, provides feedback on actual situation in real time and takes on an aspect with more instant commitment through human body. At this moment, the body of a spectator functions as body interface and sometimes it becomes just a tool of the work running the work. When a spectator realizes instinctively that his/her body is changing with the image of the work while he/she does specific exercise with his/her own body, or fully understands the instruction to run the work, he/she could be aware of any situations controlled by dynamic objects, spectators, and any intangible immaterial interface, that is, hidden

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computer or other devices with the whole body. The distance occurred by the relationship between such interfaces forms a structure of situation and such structure based on spectators is generated from an external space with regular experience.

This work is meaningful to get the way to try to get rid of the wall about strangers and forge closer relationship. A wall is an actual visible presence, but in the work, the wall means mental wall in people's mind, disconnection against exterior intercourse. The wall with cold property interrupts between the outside and the inside completely. So we need to learn many approaches to break down the invisible mental wall and try communication with each other. When you put your hands on the table carefully as if you express your heart, virtual trunks and leaves of ivy are out from your fingertips and go toward the wall crossing each other. The trunks from each hand get tangled for communication and safely get to the wall freely and convert the existing cold wall with a sense of alienation into the wall of communication.

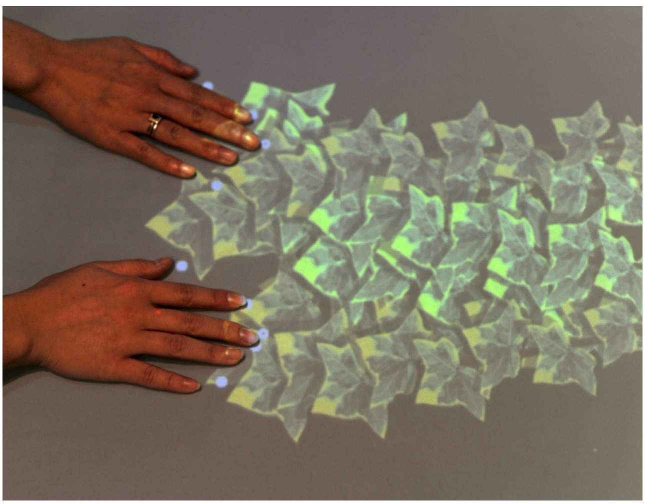

Fig. 1. Hand Feature Detection

3 System Process

Hand Ivy is composed of an interactive tabletop and a vertical screen to represent the climbing of ivy. Because of using two displays, we should adjust the resolution of two screens and calibrate them to make sure that there is no loose connection between them. Those processes which is adjusting the resolution and calibrating them are performed in the software.

3.1 Hand Feature Detection

Hand features, such as width, height, fingertips and palm center, are used to represent the user's characteristics by passing down the characteristics to the ivy leaves. Then the leaves are generated with the received information like the ratio of the width to height of hand. There are five vines of ivy from each fingertip and the fingertips are the roots of each vine. So we need to know where the fingertips are.

When user puts his or her hand on the interactive tabletop as shown in the Fig.1, the system takes its shadow using a camera. Then we extract the region of interest, after making the binary image from the acquired image from the camera. At the first, the region is applied to the morphological process to detect the palm center and a skeleton of each finger as you can see in the Fig.1. Then find the tips of skeleton of the opposite direction to the palm center for each finger to detect the fingertips. If the system has some trouble during the procedure, it determines that the shadow on the tabletop comes from unknown object instead of user's hand.

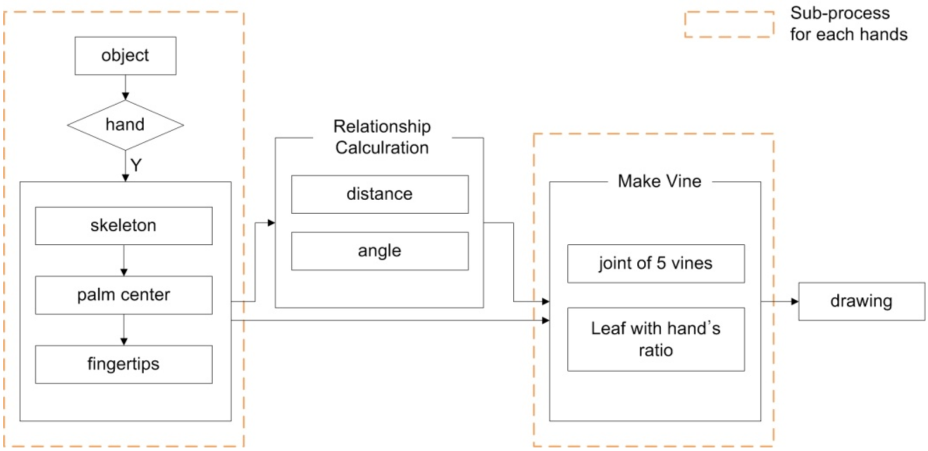

Fig. 2. Diagram

3.2 The Relationship between Users from Hand Features

The twisted vines imply the communicating and breathing together between the users by their hands on the interactive tabletop. It means that they are more intimate when they put their hands closer or toward each other. We inferred their closeness by considering the distance and the angle between their hands using the hand feature. Their intimacy is expressed graphically on the screen with the vines and its connection.

In modern society, we are able to communicate more freely taking advantage of the media development in IT era including digital media and communication devices. However, as the communication becomes freer and expanded, it becomes more difficult to build communicative relationship because of increased indirect communication. Direct encounter, gesture and non-verbal emotional exchange might lead to true communication, even though it is not verbally done.

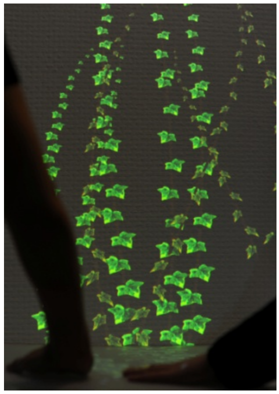

Fig. 3. The way to get the user's hand

4 Conclusions

Human beings maintain their life through the relationships with others, and the desire to build relationships and communicate with others is one of the basic natures of human beings. However, all of us living in this modern era build our own wall and boundary to make a physical space isolated from outside due to environmental factors or others. Therefore, I intended to construct a media art that can soften the cold wall blocking communications with warmth through sensible approach.

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Lifelogging for Hidden Minds: Interacting Unconsciously

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Abstract. In this paper, we propose a conceptual design of an entertainment system, which would utilize a combination of lifelogging and bio-signal measuring techniques for capturing unconscious communication flow coming from a user. We expect this system could interpret the user's unconsciousness and generate an emotionally rich feedback framed in a narrative, which would be tailored according to the universal symbolic patterns. This concept aims to explore a new area of entertainment computing. The discussed system looks promising to proceed with future work.

Keywords: Unconsciousness, Symbol, Bio-signal, Emotion, Lifelogging, Entertainment, Narrative, Interaction.

1 Introduction

According to [4], human to human interaction is always induced by both levels of cognition: conscious level (e.g., knowledge) and un- or subconscious level (e.g. emotions). As illustrated in Figure 1, traditionally for interaction with products, people manipulate products based on explicit mental models that is built by their consciousness [3]. Products, in turn, provide a feedback that is enclosed in logical messages intended for users' conscious understanding [4]. Affective Computing has addressed the importance of emotion in interaction between user and products [5]. To make the next step in enhancement of user experience, we intend to bring user-product interaction to a high-dimensional level of human minds: unconsciousness. Therefore, we propose a concept of entertainment system that allows users to interact with it unconsciously.

To achieve this goal, it is proposed to utilize physiological data from users to detect implicit traces of unconscious behaviors. On the other hand, the system would provide a feedback, which could reach users' unconsciousness. According to Jung [1], universal symbolic content (e.g. Mandala) could be one of the communicative media that might get in touch with human's unconsciousness. The system aims at offering users experience, which enables both consciousness and unconsciousness to be unified and mutually enhancing. Moreover the system would present to users an opportunity of sharing emotional experience with other users, thus improving human-to-human communication.

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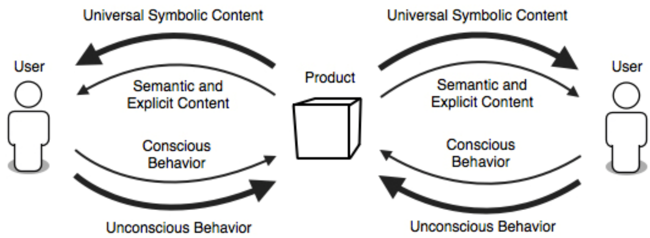

Fig. 1. Human-product interaction: traditional (thin line) and new approaches (bold line)

2 The Concept of a System for Unconsciousness Interaction

There are obviously two main challenges in the design of such a system. The first challenge is to access and interpret user's unconsciousness. We see an opportunity to overcome this challenge by recording physiological signals, which exhibit traces of human unconsciousness. The second challenge is to generate a feedback, which could reach users' unconsciousness. Universal symbolic content seems to be a good media type for this purpose, which would be able to reach human unconsciousness. Therefore, the correlation among psychological status, physiological status, and universal symbolic contents should be further clarified.

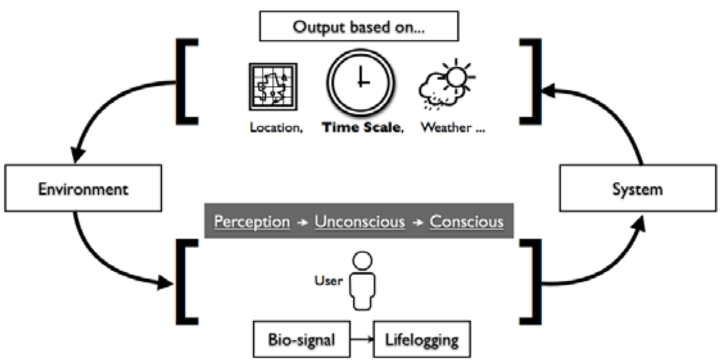

Fig. 2. The conceptual design of the entertainment system based on Kansei Mediation interaction model

As shown in Figure 2, this system would consist of a wearable lifelogging device, which would include sensors for both recording user's physiological signals and user's environment. The lifelogging device would selectively collect snapshots of the user's environment only at the moments of time that for some reason important for the user, even if the user consciously does not think that a moment is important. The selection of the moment to make a snapshot of reality (including photo or video, sound, location, etc.) would be automated based on the physiological signals of the user obtained from the sensors. The system then is able to analyze these materials and generate interpretation of them. Based on the mapping between physiological status and universal symbolic content, the system would generate a symbolic pattern. This feedback can be woven into the context of everyday life and be implemented in various applications. The reaction of the system would be merged into the background of the environment that will not grab users' full attention, but can be perceived unconsciously.

2.1 Lifelogging and Bio-Signal Components

We see a good opportunity for application of the lifelogging to enable people to exposure their unconsciousness triggered by first-person experience. Lifelogging applications use different kinds of sensors, which can be considered as an objective source of information about the environment, comparing to humans perception. Therefore the lifelogging will allow capturing the data from the environment as stimuli that influence a user's psychological status. However, the key issue is to choose a proper moment to trigger this process. Our answer to this is measuring physiological signals. Therefore, this device will also monitor a user's physiological status as a reference to observe implicit psychological status of the user.

According to Rauterberg [6], the human unconscious is represented by the genetic reproduction system, the peripheral nervous system (PNS) and the central nervous system (CNS). These three distinct systems contribute to unconscious information processing. Within each of them it is possible to find certain subsystems, which have direct relation to emotional feelings. Therefore it is proposed to use physiological aspects of human emotions for an interpretation of the human unconscious. This idea would be a starting point in the design of an entertainment system, which is able to understand human unconsciousness. Quantified physiological signals of human body would serve as an input data for the system and would provide an insight into the current state of mind of the user.

There is a number of physiological metrics, which are used to infer information regarding emotional state of a person, for example, galvanic skin resistance, respiration, temperature, and heart rate [2]. These metrics are promising for monitoring non-conscious activities because they cannot be easily controlled. Taking into account that the lifelogging component of the system, which requires information about the current psychological state of the user, is wearable, bio-sensors for measurement of physiological signals have to be non-intrusive and wearable as well. The data obtained from bio-sensors would allow automatically trigger lifelogging at the points of time, which have significant relevance for human's unconsciousness.

2.2 Narratives and Other Media as Feedback

As a potential application of an entertainment system, we intend to represent user's unconsciousness via generating a narrative that consists of lifelogging snapshots and universal symbolic contents. Since one might not be aware of when and where the snapshots were taken by the lifelogging device, this would consequently arouse their curiosity. "Curiosity is a state in which one's interest is heightened, leading to exploration" [7]. Especially when this concept is put into the context of everyday routine, which might be boring to some of us, the narratives could extract unconscious experience that would surprise us. So the concept of the system by itself might provoke curiosity, but it is important to enable the system to convey the implicit emotional feelings to the users. Depending on how the system organizes the story and on the ingredients, which the system adds to the narratives, the emotional reaction would vary. Previous research has exemplified how to lead users to the emotions of boredom and curiosity [7], which reveals the potential of using narratives for conveying emotions.

3 Conclusion and Future Work

We consider the proposed concept of an entertainment system as a promising direction for future research, which would lead to an unconscious mode of human and product interaction. However this ambitious goal poses a number of research questions: (1) Mapping of physiological signals and psychological states of users; (2) Mapping of psychological states of users and universal symbolic content; (3) Practical application of the system in entertainment.

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Maritime City: Using Games Technology to Train Social Workers – Some Initial Results

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Abstract. Maritime City is an educational tool for training Healthcare professionals, currently targeted towards Social Workers. It has its roots in the serious games area and is developed in a commercial game engine. This paper presents some initial results from testing the game with in-practice Social Workers in the context of child protection, with the aim to show equivalence between this approach and more traditional methods. The testing found that the game was realistic (apart from in some areas, which has provided new directions for the research) and also showed that there are many areas of the game experience that impact on the learning in ways similar to that of traditional role-play.

Keywords: Games technology, health, social work, serious game.

1 Introduction

Games Technology has, over the past 20 years, become more and more popular for use in training and education. Examples range from the use of Brain Training style games in primary and secondary education in Scotland [1] through to the US military, which have invested heavily in games for training [2]. This paper aims to show how Maritime City can help with one aspect of training, that of preparing for situations that are unfamiliar.

In the Social Work field in the UK, there is a set of standards that define a Social Worker role - the National Occupational Standards for Social Work [3]. However, there is an issue with students having access to "real world" training scenarios. This is of such concern that the 2009 Social Work Task Force report identified it as one of the top three issues facing Social Work education in the UK, saying:

"*Practice Placements: that new arrangements be put in place to provide sufficient high quality practice placements, which are properly supervised and assessed, for all social work students.*" [4]

This makes a very clear statement to educators in this field – you must make sure that your students *all* get some form of placement to help them prepare for real life practice. As this is not always possible, a popular and widely used alternative to some placement activities is role-play. However, role-play has some drawbacks, a point made by Woodhouse:

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"McHardy and Allan…have reported that 44% of students have negative feelings about the use of role play, with a further 29% 'sitting on the fence'…" [5]

Although a small example, this shows that students have some resistance to role-play; furthermore, Woodhouse raises other issues with role-play including safety and the danger of the activity going off course and becoming unfocused.

1.1 Maritime City

Maritime City is a training environment built using games technology that aims to help solve some of these issues.

The game is designed using the Source game engine, created by Valve Corporation [6]. This was chosen as it has excellent facial animation features which is important as Dolgoff et al mention when discussing the imposition of values when Social Workers deal with clients:

"Covert messages about value, such as body language, facial expressions, and tone of voice, are often more powerful than overt ones" [7]

The ability to read these emotional states is, as Dolgoff et al. mention, crucial for anyone training to be a Social Worker. They need to understand the state of their client but also reflect on their practice in order to improve their own communication skills in both verbal and non-verbal forms.

1.2 Scenario Overview

The first scenario developed in Maritime City is loosely based on the Baby Peter Connelly (Baby P) case. In this particular case, the child was deemed at risk but was not removed from the situation [8]. This resulted in the child continuing to be abused and eventually resulted in the child's death.

In the game, the player takes control of a Social Worker named Brendan. He has been asked to investigate a disturbance at a local house where there is a lady called Elli living with her two young children, Tara and Liam.

The scenario is designed to mirror the pertinent aspects of the Baby P case and encourage the player to reflect on their practice. The game encourages players to investigate a range of approaches for each part of the scenario.

2 The Experiment

The game was tested with a group (n=10) of in-practice (i.e. qualified, practicing Social Workers) as part of a child protection module being studied as part of a Masters degree. They were asked to play the game and then complete a role-play, both on the same scenario.

The experiment was designed to ensure that none of the class were unfairly advantaged or disadvantaged by undertaking the experiment. All members were fully informed of their rights and responsibilities and were free to leave at any time.

The surveys were designed to have a balance of Open-ended and Likert-scale (using a higher-is-better scale) questions in order to provide a variety of data.

The general purpose of the experiment is to test whether it is possible to show *equivalence* between educational games such as Maritime City and more traditional teaching methods such as role-play.

3 Results

Results based on the post-game survey had a number of interesting findings. The first question asked the player to rate how realistic they found the characters; a majority (37.5%) answered "Very realistic".

The next question asked players how easy they found the game to use (the player moves with the keyboard and "looks" with the mouse). The majority of the responses said that they found it easy to use but there were 37.5% of responses saying that they *did not* find it easy to use.

The players also felt that the game was successful at communicating the lesson content, with 62.5% of respondents rating it "Quite effective" (the second highest option).

The free text options gave more detail to the situation. When asked how they would approach the situation if they had to do it again, respondents wanted a joint visit (n=2), to call the Police (n=2), or to use different language and tone of voice (n=2). When asked which things they thought Brendan did well, there were common themes of risk assessment (n=4), the choice of questions (n=3) and the fact he decided to call for assistance (n=3). All of these are vital jumping-off points for discussion and tie directly into the underlying learning areas for the session.

Another element that threw up some surprising results regarded the question on what risks the player identified from the scenario. The reason this is surprising is because the scenario was never designed to have overt risks, but the players identified a lot more than just the obvious ones in the game (e.g. broken bottles). For instance, some respondents (n=2) pointed out that Luke was either drunk or under the influence of narcotics, despite this never being mentioned in the speech in the game. This shows that the character behavior alone is enough to communicate some traits.

Finally, when asked to provide feedback on the game generally, there were a number of responses that revolved around a very specific area on the realism of the environment and characters – the cleanliness and state of the environment and characters. The house was deemed to be too tidy, too well kept, not realistic enough from the outside (the brickwork was too clean and the garden too well maintained). The characters themselves were also criticized for being too clean and well kept, something that the players felt was not a true reflection of what they see in practice.

4 Conclusions

Maritime City has only been used in small-scale tests so far but the initial results from these tests are pleasing. The scenario given for people to use has got good feedback and there are a number of issues raised by the testing group that have direct implications for development of the product.

The most interesting thing, however, has been the realization that Maritime City can bring about the same areas of discussion as, say, a role-play session. The areas students identified that they wished to discuss further after playing the game (such as the risk factors for the characters, or the environment) was something that was hoped would occur. Although a small testing group it appears it would be possible to use games such as Maritime City to foster debate around issues in much the same way as role-play does currently. Obviously, there needs to be a lot more testing and further analysis of the results to help fully substantiate this claim but it is a good starting point.

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Opportunity of Accelerating User eXperience (UX) Technologies on Embedded Systems

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Abstract. An important class of features centered on recognition (i.e. the ability to reconize images, speech, gestures, etc) is rapidly becoming available on UX (user eXperience) devices. This requires high performance computing to support recognition with low-latency, low power and high throughput. In this paper, we investigate the UX technologies and find opportunity to accelerate the UX technology on embedded systems.

Keywords: User eXperience, Recognition, Hardware Accelerator, Multi-Processor System-on-Chip (MPSoC), Embedded System.

1 Introduction

As user interacts more with devices such as game platforms, smart phones, smart TVs, entertainment equipments in automobile etc., the enhancing personalized experience became challenging to enable more natural modes of input-output as compared to traditional devices. For instance, various devises that enable selecting or moving object on electronic devices adopting infra-red rays or eye tracking methods without touching devices were introduced. A glove like mouse is already in the market and a 3D air mouse for open space usage is also available, enhancing user experience. Accordingly, game companies are pursuing realistic game interfaces and other conventional companies also are trying to adopt these devices for efficient presentation and education. Clearly, these usage models highlight that the enhancing user experience is gaining significant momentum and such workload need to be analyzed and characterized for embedded systems in terms of performance, costs, and power. In this paper, we first investigate current UX technologies which are promised to bring forth a new spectrum of novel usage models for computing devices in the field of game, entertainment, automotive and medical applications. Then, we discuss an opportunity of accelerating UX technologies for embedded systems by proposing processor architecture based on multi-processor system-on-chip (MPSoC).

The rest of this article is organized as follows. We first describe three different types of motion capture methods and introduce the corresponding UX devices in section 2. We discuss the opportunity to accelerate the UX technologies on embedded systems and propose the architecture of UX processor adopting application specific hardware accelerators along with CPUs in section 3. Finally, we conclude in section 4 by outlining the direction for future works on this topic.

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2 User eXperience (UX) Technologies

2.1 Optical Motion Capture Systems for Human Body

Optical motion capture systems use video cameras to track the motion of markers attached to the particular location of a human body. A passive type of marker uses infrared (IR) LEDs mounted around camera lens. An active type of marker utilizes IR light emitted by the LEDs rather than light reflected from markers avoiding several problems that often plague passive optical systems, including swapping of markers, noisy or missing data and false reflections. The centers of the marker images are extracted from the various camera views using triangulation to compute their frame-to-frame positions in 3D space. These systems use a skeleton which is driven by the tracked marker positions as they are captured and the captured skeleton moves around the human's skeleton, which moves the mesh that makes up the skin of the human. Recently, optical motion capturing without using markers are introduced which recognizes gesture and movement of human based on image processing. Fraunhofer’s iPointer Presenter enables touch-less operation of a computer through gestures by using two infrared cameras to register a user’s finger movements with millimeter precision [1]. At the same time software interprets the recoded data as hand gestures and assigns them to predefined computer commands. Microsoft’s Kinect is a controller-free gaming experience for video game platform which enables users to control and interact with the game platform without the need to touch a controller, using gestures and spoken commands. The Kinect is a single sensor bar that contains two depth sensors, and a standard RGB camera. The Kinect also features a built-in microphone that allows voice-activated commands when applicable, and the vocal feature does pop up in games [2].

2.2 Magnetic Motion Capture Systems for Human Body

Magnetic motion capture system utilizes sensors placed on the body to measure the low-frequency magnetic field generated by a transmitter source. It is useful to detect hidden objects and provides low cost system compared with the optical motion capture system. However, magnetic motion capture system is not free from electrical wiring due to the shielded cable and is sensitive to the environment in measuring the magnetic field of the objects. A magnetic motion capture system measuring movement of hands and a body simultaneously was introduced [3]. The transmitter for a hand is placed at the same position as the one of a sensor attached on a forearm. A PC for capturing data is connected to two LIBERTY™ systems through USB interfaces, and to the MotionStar Wireless™ system via the Ethernet cable. They evaluated the system by measuring a folk dance and demonstrated that the proposed system can digitize the hands and the body movement accurately.

2.3 Mechanical Motion Capture Systems for Human Body

Mechanical motion capture systems measure the human’s joint motion using potentiometer and slider. This method is not affected by typical problems of optical and magnetic based systems providing absolute measurement and supports high sampling frequency of motion. However, it has a limitation on natural motion capture due to the attached mechanical devices on the body. Chording glove is a kind of hand input device to measure human-hand postures so that the user can intuitively interact with synthetic objects in a virtual environment in a natural way [4]. The keys of a chord keyboard are mounted on the fingers of a glove. A chord can be made by pressing the fingers against any surface. Shift buttons placed on the index finger enable the glove to enter the full ASCII character set. The chording glove is designed as a text input device for wearable computers and virtual environments. Haptic workstation is a fully integrated simulation system providing right and left whole-hand force feedback, immersive 3D viewing, and easy to use CAD model manipulation [5].

2.4 Gaze Tracking Systems

In addition to the whole body capture systems, a gaze tracking system measures point of view or relative movement of eye. With gaze tracking system, users can intuitively interact with application platforms thanks to similar operation protocol with a convention computer mouse. Also, its throughput is very high compared to that of the hand operation based conventional input devices. Heo et al. proposed a realistic game system using a multi-modal interface, including gaze tracking, hand gesture recognition and bio-signal analysis [6]. In order to unify the gaze tracking device and the head mounted display, a near infrared LED illuminator and one camera are attached below the head mounted display.

3 Accelerating UX Technology on Embedded Systems

Enhancing user experience has become of significant interest for the usage models such as realist game, mobile devices, wearable computers, and medical instruments etc. to provide natural user interfaces. In order to achieve these usage models, employing heterogeneous motion capture systems together is a suitable approach to provide high-accuracy and to compensate for the limitation of the different motion capture schemes. This heterogeneous UX device is required to keep the following things in key focus: 1) need to ensure that it is user friendly adoptable, 2) need to ensure that it is extremely efficient in terms of low power, low cost and high performance, 3) need to satisfy the application apace (accuracy, execution time, and throughput) and 4) need to provide a general-purpose programming environment for different application developers.

Heterogeneous multi-processor System-on-Chip (MPSoC) is attracted by computing intensive applications due to its capability of drawing strengths of different processors to improve the overall performance. Usually, the computing intensive tasks are mapped to the accelerator processors and the rest of the tasks are mapped to the CPUs in a heterogeneous MPSoC. Researchers have been exploring the integration of domain-specific hardware accelerators in order to improve performance and power efficiency for a class of special purpose applications and application-specific accelerators have been developed for image processing, security, and communication.

Fig. 1 illustrates the proposed highly efficient UX processor architecture suitable for a large-scale motion capture system based on the heterogeneous MPSoC architecture that integrates low-power CPU cores along with application specific accelerators. In order to provide a low-cost energy efficient architecture, we adopt multiple small cores (e.g. Intel Atom or ARM core). This UX processor consisting of multiple small cores connected through an on-die system interconnect to an integrated memory controller to attach to the main memory. In order to accelerate the UX execution time, we explored the potential of integrating application-specific hardware accelerators for the key primitives of UX devices. All of these accelerators should be key primitives in such motion capture algorithms and be reusable across a wide range of UX workloads for heterogeneous sensors. This heterogeneous architecture is advantageous because it provides significant performance improvement and energy efficiency that is inherent with integrated hardware accelerators as compared to general purpose CPUs.

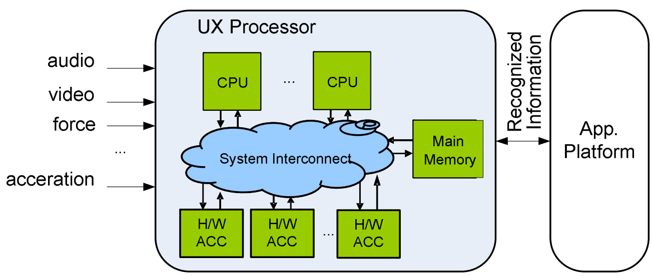

Fig. 1. Architecture of UX processor

4 Conclusions and Future Works

In this paper, we investigated motion capture systems for UX devices and presented an opportunity to accelerate the UX technology on embedded systems by proposing the processor architecture based on MPSoC. With emerging UX based applications on game console and smart devices, we plan to continue studying additional workloads and further refining our processor architecture with the right set of accelerators and associated architectural supports. We also plan to simulate the hardware accelerators proposed along with RISC cores in a SoC platform to study the interaction between hardware and software components. We expect that accelerating UX technology on embedded systems will bring forth a new spectrum of novel usage models for entertainment platforms.

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Randomness + Structure = Clutter: A Procedural Object Placement Generator

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Abstract. *Clutter* is the random yet structured placement of objects in a room. We describe a procedural clutter generator that achieves believable, varied, and controllable object placement using a hierarchical colored Petri net capable of expressing any computable set of object placement constraints.

1 Introduction

The demand for game content has increased to the point that its creation by artists and designers has become one of the more time-consuming and costly parts of game development. *Procedural content generation* is the term used for computer generation of game content (see, for example, Roden and Parberry [1] and Nelson and Mateas [2]). In addition to taking some of the fiscal and temporal burden from game developers, real-time procedural content generation can increase a game's replayability by the incorporation of the generators into the game itself.

We use the term *clutter* to refer to non-architectural room contents. There has been little previous work on clutter generation. Howard and Broughton [3] offer a method in which the major pieces of furniture are added by hand and the miscellaneous objects are added by a genetic algorithm. Tutenel *et al.* [4] offer a more complete solution using a constraint solver that requires a set of tagged bounding boxes for each object.

Doran and Parberry [5] list a set of five criteria important to any procedural content generation system: *novelty*, *structure*, *interest*, *speed* and *controllability*. We present in the paper a procedural clutter generator that we have designed to maximize controllability but not at the cost of the other four criteria. We argue that our generator produces interesting room clutter, and demonstrate this with an implementation of the generator available online for the reader to test for themselves [6] using any standard web browser. We also argue that our generator is flexible enough that a designer can control the output to produce appropriate clutter for different types of rooms.

2 Anchors, Objects and Collisions

A cluttered room does not usually contain a completely random jumble of objects. There are almost always patterns in the way that things are laid out, for example,

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certain objects or sets of objects tend to be grouped in specific areas of a room. Objects usually appear in either the corners, spaced regularly but not perfectly along the edges, in a rough grid in the center of the room, or in a specific but logical relation to other objects in the room.

We capture this intuition with the concept of an *anchor point*, which marks a place at which an object can be (approximately) located. Throughout the rest of this paper our examples will be in 2D for ease of discussion, but the principles are the same in 3D. In 2D the anchors, as mentioned above, would be placed in the corners, spaced along the edges, and spread out in a grid in the center of the room. The spacing along the edges and the size of the grid depend on the room type. The placement of these initial anchor points may be done procedurally or by the designer.

Each object placed by our clutter generator also has a set of anchor points for further objects. For example, a table may have anchor points for the chairs around it and points on top for the place settings, center piece, and other clutter.

To avoid having all the objects sit in perfect alignment with each other, objects being placed have a Gaussian displacement in both position and orientation about the normal of the surface the object is on, specified by the standard deviations.

It is very likely that randomly-placed objects will end up colliding. If an object collides with another, we simply generate new random displacements for its position and orientation, repeating if necessary up to some small number of attempts. If this fails, it is often safe to throw the object away. However, some items that are important for gameplay could fail to generate. In this case, we suggest that another random room layout be generated, again up to some small number of attempts. If that fails, it is likely that the constraints should be redesigned.

3 Petri Nets

Petri nets date from 1939 [7] and have since been applied to a wide range of applications including distributed computing [8] and manufacturing [9]. There are many great resources on the basics of Petri nets, so we will avoid repeating that information here. The Petri nets we use are a variation on colored, hierarchical Petri nets with inhibitor edges. The inclusion of inhibitor edges is needed to make the Petri net Turing-complete (see Peterson [10]).

Tokens in standard Petri nets are indistinguishable. Conversely, in *colored* Petri nets the tokens carry extra information. We use this to store the information needed to place objects in the room. While it may seem natural for tokens to represent objects, this approach quickly runs into problems. Instead, each token will carry either zero or one anchor points. Generic tokens, with no anchor point, can be added manually to the initial net or be created at run time. Tokens with anchor points can only be created at run time.

Colored Petri nets also add extra semantics to the transitions to handle this extra information. In our implementation, this leads to three significant differences over standard Petri nets.

First, the relation between the incoming and outgoing edges of transitions must be made explicit. For each incoming edge, the user must specify which outgoing edge will get the token or that the token is to be discarded. Similarly, for each outgoing edge, there is the possibility of making a new generic token, or taking whatever is coming from one of the incoming edges.

Second, for each incoming edge the user can specify which types of tokens to allow on that edge. This is handled by attaching a non-unique name to each anchor point and then checking those names when deciding if the transition is ready to fire.

Third and finally, each incoming edge can create an object at the anchor point represented by the token it is working with. That token is then replaced by a set of new tokens representing the anchor points on the new object.

While running, one live transition is picked randomly to fire. To control how often things happen more precisely, a probability is attached to each transition representing how likely it is to fire if picked. This defaults to 1 which means it *will* fire if picked.

The pages of hierarchical Petri nets make running the net somewhat difficult. To avoid that, we instead unroll the net into a single page. To provide the widest range of possibilities, each place and transition is assigned a *scope*. A local scope means that places and transitions with the same name on different pages are considered different, while a global scope would mean they are the same and should be combined when the net is unrolled. To make sure that the unrolling works we also introduce *links*, a subtype of places. Links are treated like any other place but they cannot have generic tokens and can only be locally scoped. All page calls connect places in the current page to links in the called page, which are merged when that page call is unrolled.

4 Implementation

We implemented a prototype of our system in 2D in Java. The room and the initial anchor points were prepared by hand, but the system is designed to be used alongside a room generator. Figure 1 shows some of the generated rooms. (The reader is invited to visit Taylor and Parberry [6] for higher resolution images or to try the generator for themselves.)

The list of objects and the Petri net are stored in XML files. The system takes these inputs plus the room with the initial anchor points. It then unrolls the Petri net, creates a token for each anchor point, and feeds those into the starting place in the net. Execution consists of making a list of live transitions and firing one randomly. This continues until there are no live transitions.

Judging our approach by the criteria mentioned in the Introduction, we claim that our content is novel in that the room contents are unpredictable, yet there is structure in the way the contents are laid out. As evidence, we provide the pictures in Figure 1. Our approach is comparable in speed to that of Tutenel *et al.* [4], and the Turing-completeness of Petri nets offers better controllability. The approach used by Howard and Broughton [3] is designed for a specific subset of clutter generation and so suffers in both categories.

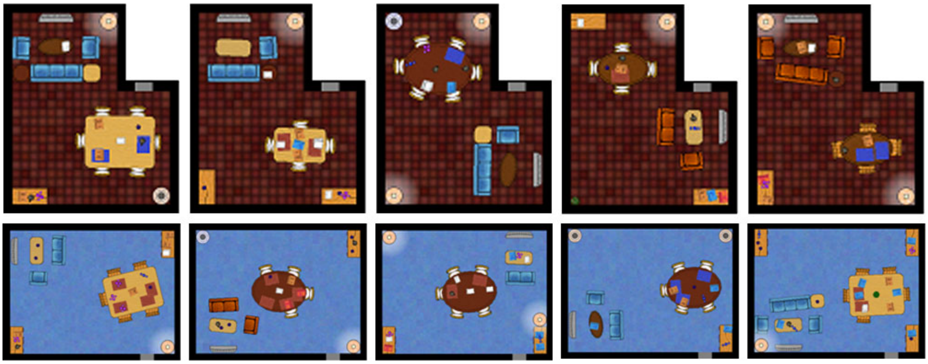

Fig. 1. Ten rooms generated with our system using the same Petri net and object set

5 Conclusions and Further Work

This paper introduces a procedural clutter generator based on hierarchical, colored Petri nets that can express any arbitrary computable set of constraints between objects. It remains to construct a graphical user interface for the designer. This interface should ideally output XML scripts that can be read by our generator.

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Toward a Framework for Prototyping Physical Interfaces in Multiplayer Gaming: TwinSpace Experiences

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Abstract. We reflect on our experiences using an experimental platform for rapidly prototyping physical control configurations for multiplayer games. We describe how the architecture permits novel forms of collaborative play through the combination and configuration of basic tangible/physical building blocks, the deep integration between physical and virtual objects, and flexibility in how physical and virtual spaces are mapped onto each other. We also identify three important limitations of the architecture that became apparent through our prototyping efforts.

1 Introduction

One of the main challenges in designing physical interfaces is the generation of usable prototypes (Greenberg & Fitchett, 2001). This problem is especially pronounced in gaming, where physical interactions may need to be rapid, fluid, tightly synchronized, and readily interpreted by other players. Our goal is to build a platform to support the rapid design and implementation of novel physical interfaces for mixed-reality multiplayer games. We repurposed the TwinSpace framework for mixed-presence collaborative work (Reilly et al., 2010) as this platform to understand how elements of its design meet and fall short of this goal. We designed three games with this system: a shopping simulation, a scavenger hunt, and a mixed-reality card game. Due to space constraints, we describe only the scavenger hunt game. Our experiences revealed three problems that toolkits for prototyping games with physical interfaces need to address: first, the management of connection protocols and interconnections between components of the overall game; second, the translation layer between input/output components that may report/present information in different ways, and third, a common naming mechanism suitable for rapid prototyping. At the same time, our work validates the utility in this design space of three of TwinSpace's main features: its ability to deeply intertwine real and virtual objects, to define how real and virtual spaces are mapped onto each other, and to combine and configure heterogeneous collections of sensors and devices.

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2 The Case for a Framework

Infrastructure support for designing collaborative games involving physical interaction includes toolkits for designing physical interfaces, toolkits providing middleware support for confederated devices, and the content and game engines themselves. The basic problem with the current state of affairs is that these supports are disconnected. Input and middleware toolkits do not explicitly tie into content back-ends (e.g. an MMORPG engine), nor do they provide any support in specifying the mappings between the virtual world, the physical world, and the physical and virtual devices that inhabit these spaces.

Yet, game designers and researchers need to explore how to translate physical interactions into game actions, and how to manifest game events in the physical world. This calls for a software framework that is flexible and powerful enough to facilitate exploration of the many possible mappings between physical and virtual. Physical interfaces reflect and enforce collaborative gaming styles (Mandryk et al., 2002), as does the (relative) physical location of the players themselves (Benford et al., 2006). Because physical controls and mixed-presence configurations influence collaborative behaviour, a framework should support ways for researchers, designers and possibly gamers to define device configurations and real-virtual mappings.

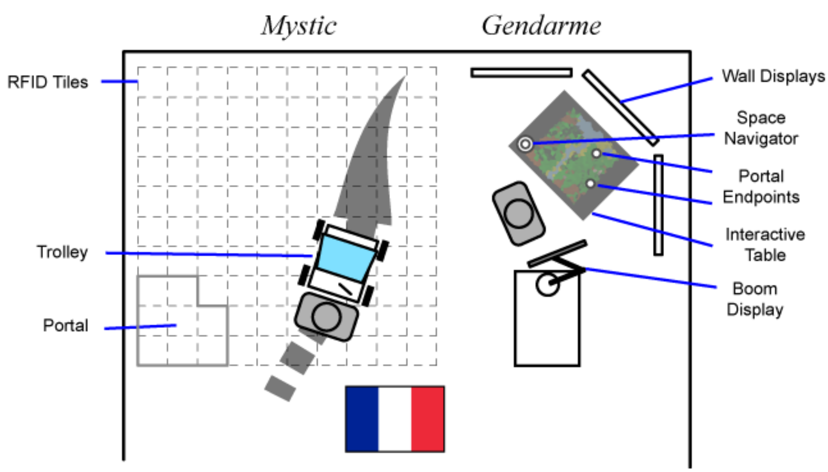

Fig. 1. Or de l'Acadie, French side. The Mystic collects riches using the trolley interface. The Gendarme seeks out desireable locations and guides the Mystic using a set of physical interfaces.

We have built a generic framework for prototyping collaborative mixed reality environments, including games, called TwinSpace (Reilly et al. (2010)). TwinSpace offers a range of methods for defining how a physical interface operates, in terms of the game space, the physical environment, and its relation to other game interfaces. One way this is achieved is by deeply interconnecting real and virtual spaces. For example, events generated by digital infrastructure in a physical space—such as sensor or input device events—can be published and reported in the virtual space. Likewise, events in the virtual space—such as an avatar entering a region, or a new player joining a game—can be published in the physical world. Further, TwinSpace offers facilities to define spatial and structural correspondence between physical and virtual spaces (for example, regions of a physical room can be mapped to regions in the virtual space). Finally, TwinSpace permits the definition and connection of heterogeneous clients (basic first-person mouse+keyboard clients, kiosks, instrumented spaces, etc.) to a shared game environment.

3 Using the Framework: Benefits and Limitations

In order to discuss our experiences, we briefly describe one of our game prototypes here. Or de l'Acadie is a game set in an abandoned 18th Century French colonial fort. Two pairs (French and British sides) compete for valuables distributed throughout the fort, with the goal to collect the most valuables.

Each British player controls a single Soldier using keyboard controls. Players are not collocated, and can communicate with each other only when their soldiers are within earshot. Each Soldier is equipped with a static top-down map of the fort, and can collect a limited number of riches before needing to return to a location at the edge of the fort to stash them.

The French side consists of a Mi'kmaq mystic (the "Mystic"), and a deceased French soldier (the "Gendarme"). The French team is physically collocated (Figure 1), and uses a range of physical controls to locate and collect the valuables. While the 'living' players (French and British) are constrained by the laws of physics, the Gendarme moves freely through walls and in the air, but is unable to collect valuables. Instead, he communicates with the Mystic who collects them.

The Mystic pushes a cart, and does not need to periodically stow the riches like the British Soldiers do, but as a result he cannot move quickly, or climb stairs. Luckily, the Gendarme can transport the Mystic to any location in the fort by creating a portal between the Mystic's current location and the desired destination. The game is described in more detail in Reilly et al. (2010).

Mixed reality games combine virtual and physical to create a fused game space. This *asymmetry* between the worlds and players' experiences of them provides interesting design opportunities. For example, interfaces can be tailored to promote advantageous multi-role strategies of gameplay. The flexibility of TwinSpace proved invaluable during our design process: by allowing us to easily connect, and re-map physical interfaces with game entities, it gave us the ability to explore novel combinations and mappings rapidly.

The framework allowed us to move quickly between quite different overall game designs for Or de l'Acadie. Three key design changes were made that impacted the game scenario. The first was to define two players for the French side: the Gendarme, whose interface consisted of the table, wall displays and SpaceNavigator, and the Mystic, whose interface consisted of the trolley. TwinSpace allowed us to decouple the trolley from the immersive view very easily. The second was to provide a single interface for controlling the Gendarme's position (the SpaceNavigator), using the tabletop only as a dynamic view of the fort and as an interface for placing portal endpoints. Moving portal endpoints sent a message to the game server to reconfigure the in-game portal accordingly. Finally, as an all-seeing ghost, we allowed the Gendarme to see what the Mystic sees, in order to help him locate riches. The existing report of position and orientation given by the trolley for the first design was quickly remapped to control the home position of the Gendarme's boom display in the final design. Rotating the display on the boom causes the orientation of the camera to change relative to the Mystic's perspective (accomplished using a MotionNode sensor). Similarly, the existing report of position and orientation given by the trolley was remapped to control the home position of the Gendarme's boom display.

When using the framework we also identified three required improvements:

Timely and Appropriate Communication between Components. For example, our games made use of a moderate number of sensors (~10), but even so we would sometimes experience synchronization or message latency issues. While generally imperceptible with a small number of interfaces, scalability was an issue.

Translation Layers between Interconnected Components. When combining components in novel ways, we frequently encountered format mismatches. While TwinSpace currently provides some mapping capacity to apply basic transforms, it was sometimes not sophisticated enough.

Consistent Naming of Entities. During prototyping quick hacks were often written that hard-coded device or virtual object IDs to test quickly, because the mapping component did not provide an interface to define IDs globally or to query object IDs based on desired attributes.

4 Conclusion

TwinSpace provides key features that facilitate the development of collaborative gaming prototypes employing physical interfaces. By providing many options for connectivity between physical and virtual while simultaneously centralizing mapping details, and by supporting heterogeneous gaming interfaces, TwinSpace allowed us to specify and reconfigure interfaces and gaming scenarios as a team in an iterative, exploratory fashion. Our prototypes have combined multiple interface elements, yielding interfaces tailored for unique forms of collaborative gameplay. Our experiences also highlight some important current limitations of the framework that will need to be addressed in order to provide more complete support for these prototyping activities.

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RTFX: On-Set Previs with UnrealEngine3

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Abstract. This paper discusses on-set previsualization with distributed motion capture, virtual camera and asset control, and real-time rendering using a video game engine. Our test harness, RTFX, demonstrates the feasibility and usefulness of a system that couples Epic Games' UnrealEngine3 with the Houdini 3D animation kit by Side Effects Software and a passive motion capture system by Vicon.

Keywords: previsualization, real-time rendering, virtual production.

1 Introduction

Previsualization (previs) tools employ 3D modeling and animation software to prototype film sequences before production begins. These tools allow creative and technical issues to be explored early in the production pipeline, improving film quality while reducing costs and human error [1], [2]. *On-set* previs and virtual production tools augment the camera feed with rudimentary special effects and virtual sets, providing real-time feedback to the production cast and crew [3], [4]. These tools have been integrated with motion capture (mocap) and green screening to create elaborate virtual worlds and characters for several productions such as *Avatar* [5].

Using the UnrealEngine3 video game engine, we have developed an on-set previs tool called RTFX that provides real-time visualization of mocap, virtual cameras and 3D effects (including particle systems). These features allow actors to interact with virtual assets and trigger special effects in the virtual set. The tool also combines distributed mocap and effects streams into a single visualization. These features enable us to demonstrate the viability of several novel applications:

1. **Detailed special effects and virtual asset previs with integrated mocap.** This improves the quality of feedback to the director concerning actor-asset relationships in the virtual set, e.g., when an actor triggers a startling explosion special effect, do they turn their head in the correct direction?
2. **Distributed mocap.** Traditional systems require all the actors to work in the same volume at the same time, so these systems are subject to scheduling conflicts and volume limitations, e.g., *Beowulf*, the largest volume on record, limited the virtual set to 21 actors [6]. RTFX connects to multiple mocap servers, each with their own recording volume, then combines the data from each server in real-time to generate a common virtual set.

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3. **Distributed visualization.** RTFX supports previs from several configurable virtual cameras, enabling the director to explore the virtual set with a variety of camera parameters, including those calibrated to actual equipment. Also, mapping these cameras to actor headsets ensures coherent action across multiple mocap volumes.
4. **Distributed skeletal control.** RTFX supports distributed control of individual skeletons. This enables large, sophisticated meshes to be animated by a mixture of sources (both mocap and programmatic). For example, the mocap bones from two humans could control a dragon's wings and body, while an external program coordinates the motion of the dragon's head with fire-breathing special effects.

2 Previous Work

Several video game engines have been used to control virtual assets and render real-time previs. Industrial Light & Magic used an Unreal engine to plan camera sequences for the movie *Artificial Intelligence* [7]: the mouse, keyboard and joystick movements that normally control video game character motion were harnessed to control camera sequences within the virtual set.

Nitsche's [8] experiments with camera controlling interfaces and puppetry also use an Unreal engine. This system captures hand-controlled puppet-based motion and projects it into the virtual set. Mazalek [9] proposes a similar system called TUI3D (Tangible User Interface for real-time 3D) that controls animated characters through real-time puppet interaction. TUI3D acquires joint position and orientation data from puppet sensors, and then passes this data into a custom Unreal2004 tool that provides enhanced scripting and game controls for animation. Also, Mazalek et al. extended TUI3D with a wearable interface for real-time avatar control [10].

Nitsche [8] and Mazalek [9] also identify a potential limitation for video game engine-based real-time previs. To optimize in-game frame rates and detail levels, these engines provide limited animation control and normally favour pre-fabricated sequences over live animation. But since movie action tends to be non-deterministic and non-repetitive, animating these sequences requires a resource-intensive approach that cannot take advantage of the underlying engine optimizations.

3 Observations

We demonstrate the practicality of a game engine-rendered previs system by measuring frame rate under different workloads, and then justify the results from the context of the RTFX architecture (Figure 1). Note that frame rates below 24 fps (the minimum film frame rate) may produce undesirable flickering and hesitation.

The first test measured the relationship between mocap complexity (actor count and distribution) and frame rate. In particular, we recorded frame rate during visualizations of one through twenty-one mocap actors. The experiment was repeated with three distributions of actors: local (all actors in one mocap volume), remote (all actors in a remote volume), and distributed (half local actors, half remote).

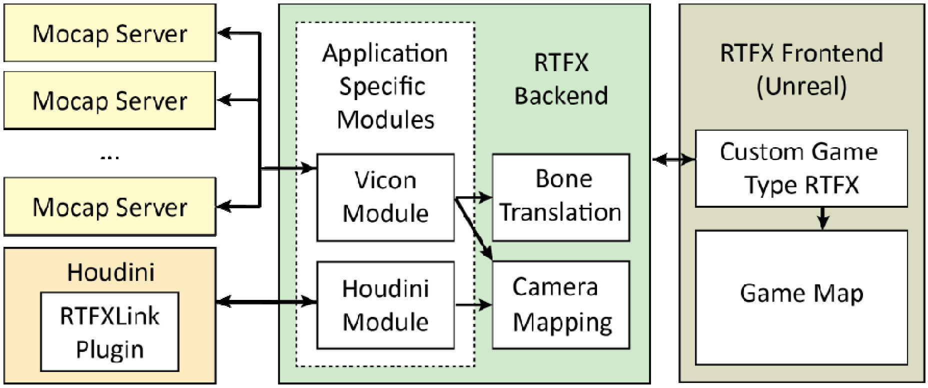

Fig. 1. RTFX architecture

Figure 2 shows that frame rate decreases as the number of mocap actors increases, and visual performance degrades with more than seven local, four distributed or three remote actors (frame rate falls below 24 fps). The architectural cause of this trend is the RTFX backend: for every frame, and for every bone in the mocap volume, a serial call to the mocap server is executed. Parallelizing the calls improves the curves.

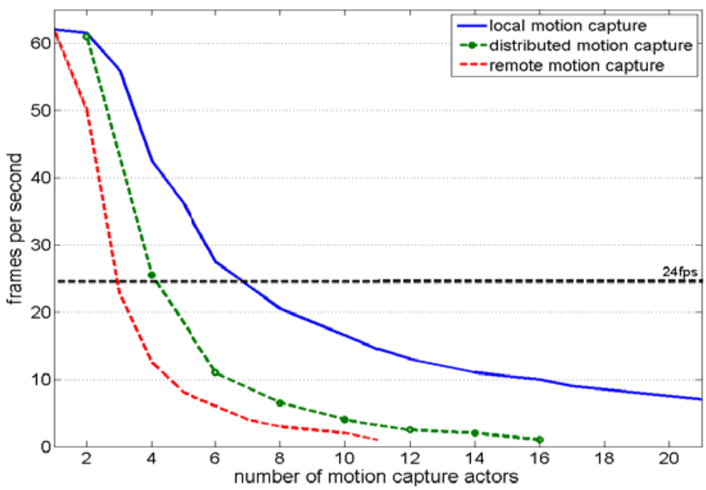

Fig. 2. Relationship between mocap complexity and frame rate for three actor distributions: local, remote and distributed

The second test measured the effect of virtual set (game map) detail level on frame rate while visualizing mocap. Two detail levels of virtual sets were used: basic (untextured floor plane and light) and complex (Epic's FoliageMap: a jungle scene with particle systems, lighting effects and hundreds of animated assets). We observed that set detail level has only a small effect on performance compared to the number of actors: on average the complex set's frame rate was only 2 fps lower than that of the basic set.

Finally, we tested the effect of virtual cameras on performance. RTFX supports three camera types: static (fixed position), motion capture, and Houdini. The frame rate of each camera was recorded within basic and complex virtual sets. No observable difference was recorded: all experiments ran at 62 fps. This result was expected since camera simulation requires much less network communication than mocap visualization.

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Serious Questionnaires in Playful Social Network Applications

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Abstract. Conducting surveys is a costly and time-consuming process. We developed a playful questionnaire that addresses the issue of motivation for voluntary participation. In addition, distributing playful questionnaires on Facebook gives access to basic user data, which may allow employing some of them as quality control questions or simply help to lessen the number of questions.

Keywords: questionnaire, human subject survey, game, social networks, social media, Facebook, playful applications.

1 Introduction

As social media experiences an unparalleled growth, it inspires studies that aim at better understanding the patterns of behavior inside social networks.

Social network tools and application, are playing a strategic role in helping to create bonds among virtual friends and consequently with the network itself [1]. Facebook, the leading social network site and a virtual socializing spot for more than 550 million users [2], gained grounds partly by hosting more than 20 million applications that kept users attached to the Facebook. Most popular are social network games that managed to attract more than dozens of millions of active players per month [3], [4].

Although the most successful games gained their noteworthy number of players by offering flexible never-lose game play (*Farmville*[1], *Café World*[2]), there are many win-lose games like *Brain Buddies*[3], *Diamond Dash*[4], *Quiz Monster*[5] [5] that attract millions of active participants in spite of their classic result-oriented game mechanics. Moreover, there are numbers of serious applications, including opinion-mining games, discussed in the section 2, that also have a classic game set-up that gained their niche in the Facebook application environment.

In addition, one of the strongest advantages of using Facebook is the opportunity that it gives to access user's basic information like age, gender, location, marital status, educational background, etc., since studies show that overwhelming majority of Facebook users enter valid demographical information about themselves [7].

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[1] http://apps.facebook.com/Farmville
[2] http://apps.facebook.com/Cafeworld
[3] http://apps.facebook.com/Brainbuddies/
[4] http://apps.facebook.com/Diamonddash/
[5] http://apps.facebook.com/Quizmonster/

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2 Related Work

Variety of studies has shown the potential of using playful elements for research purposes. For example, Bernhaupt [8] attempted to improve the process of cultural probing by joining it with classical table card games. Participants perceived the process of probing as a natural part of the card game, which altogether encouraged more active involvement of participants.

Castranova [9] put forward that MMORPG video games are amenable to controlled social experimentations. He observed that various human interactions like coordination of actions, etc., can be studies in MMORPG game environment.

In addition, there is a variety of games with the purpose that outsource serious tasks to the crowd. *GWAP*[6] is a classical example of massive human computation effort at common sense tagging.

Furthermore, social networks are also efficient platforms for experiments with serious tasks. Human computation experiments with the collection of a common sense data through games on a Taiwanese social network reported adequate quality level of obtained data [10]. Similarly, *Phrase Detectives*[7] [11] motivates Facebook users to annotate various texts by rewarding them with points and levels. Simultaneously, the integration with Facebook allows promoting the game among wider number of users by enabling friends invitations and reporting the results of players on their news feeds. Another playful application, a serious game called *Sentiment Quiz*[8], integrated into Facebook collects emotional responses of players to a vast list of English terms in order to compare them with the results obtained through controlled experiments. Finally, an application named *My Personality*[9], run by psychology department of Cambridge University for scientific purposes, reaches more than 100 000 active users per month and so far accumulated input from four million users in total [6]. This permits to conclude that Facebook may serve as a productive environment for dissemination of serious surveys of other types, provided that they are presented in formats that are appropriate for this domain of social networks: give users some useful outcomes and/or contain entertaining elements.

3 Playful Questionnaire

The projects discussed in the previous sections permit to posit a successful integration of serious surveys into a playful social network environment. While scoring systems are not applicable for non-competitive one-time-use survey applications, introducing rich graphics, playful metaphors, and rewarding outcomes at the end (i.e. playful personality reading report) may increase the appeal of the questionnaires to a greater number of Facebook users.

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[6] `http://gwap.com`

[7] `https://apps.facebook.com/phrasedetectives/`

[8] `https://apps.facebook.com/sentiment-quiz/`

[9] `http://apps.facebook.com/Mypersonality/`

We created a playful questionnaire called *Bake Your Personality*[10] where users answer four “serious” questions in a step-by-step manner (Picture 1). The questions are asked using a metaphorical concept of a cooking process and of choosing ingredients for a final product (a cake). Each question represents a stage of ingredient selection or amount adjustment process; and answers are represented by visual items that users interact with. When translated to traditional questionnaire format, our questionnaire contains the equivalents of two single-choice questions (age and gender - to verify the reliability of results by comparing with actual Facebook profile data), one multiple-choice question on preferred game genres (with a strict limit of 3 answers), and the necessity to rate selected game genres in terms of their importance to the user. When necessary, the answers to past questions can provide content for the following ones and thus allow more sophisticated approach to the opinion mining. Once all answers are given, the players “bake” their unique cakes, and receive a personality description based on the “ingredients” they used. The anticipation of the outcome (personality reading report) motivates players to give thoughtful answers and thus increases our chances of receiving good quality input data.

Fig. 1. A screenshot of the *Bake your Personality* playful questionnaire

The visual design of the questionnaire is created following the established visual style of most social network games: simple one with colorful objects that make part of our daily life and provide realistic interaction patterns (taking and placing various items). We intended to appeal to a general feminine social network gaming audience, which consequently influenced the selected visual style and inspired the metaphorical concept of the cooking process.

[10] http://apps.facebook.com/hcompgames/

4 Conclusions

The benefit of the free-style metaphorical questionnaire is that it provides the freedom of designing questions and answers that fit the needs of the researchers.

In addition, distributing questionnaires on social platforms such as Facebook provides a good opportunity of establishing a quality control by asking questions that can be verified through the access to the personal profile of the users; and in likewise manner help to cut on certain questions, the answers to which can be accessed through the Facebook profile of the user.

The next steps in this research will include experiments and analysis to verify the effectiveness of playful questionnaire concept in terms of the rate of participation and quality of data, including the degree of bias introduced by the playful elements. Also, more studies with regards to the appeal to different groups of users are needed. This would potentially allow for the creation of a well-defined framework of content construction (both visually and conceptually) depending on the profiles of segmented groups.

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Tangible Interaction on Tabletops for Elderly People

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Abstract. The urge to improve the life of older adults grows as this segment of society expands. Computers have an enormous potential to benefit the lives of older adults, however, the unawareness or disregard of their characteristics, renders technology, many times, impossible to use. Peripherals are a common obstacle when learning to operate computers, because the most common ones do not directly map the input in the user interface. It has been argued that touch- and gesture-based user interfaces, due to their direct mapping of input, can reduce the obstacles that older adults face, when using the computer. To assess this, this paper presents a project that uses a multi-touch tabletop system as a gaming platform for older adults. Specifically, it reports on the low-fidelity prototype that was built to test whether tangible objects can be used. Conclusions regarding the viability of tangible objects for that purpose are also drawn.

Keywords: Tangible objects, Tabletop, Games for elderly, Natural User Interface, Human-Computer Interaction.

1 Introduction

Population is getting older at an accelerated pace and should reach historical levels in the next years. Recent projections foresee that by 2060, 30% of the European population will be 65 years or older [1]. This demographic change is shaping a new society with fewer young people and an ever-growing number of older adults [2]. This setting urges one to reflect on the needs of elders, in order to discover how to improve their quality of life in a society built for younger people.

The aging process is responsible for changes in the perception, cognitive and motor systems [3]. Nevertheless, if properly stimulated, it is possible to slow down or decrease the effects of certain changes in these systems. It is therefore relevant to create stimulation tools that are adequate for older adults.

Moreover, studies [4,5,6] have shown that digital games can help maintaining and improving cognitive abilities, psychomotor skills, and social interaction.

The project that backdrops this paper, consists of a tabletop gaming system that aims to stimulate both the cognitive and motor systems of older adults. The specificities of this target audience, led one to devote special care into the design of

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the user interface, and on creating a system that interfered as little as possible with older adults' habits and traditions. This paper focuses on tangible objects used on tabletops and how they can be used to stimulate older adults.

2 The Tabletop as a Platform for Older Adults to Play games

Despite the growing number of older adults, technology is still designed for younger users. Even though older adults are receptive to technology, in most situations it is avoided because it is either not understood or because it ignores the characteristics of older adults and is therefore extremely difficult to use [7].

Natural User Interfaces (NUI) consist of interfaces that rely on natural interaction [8] to offer a direct mapping between the input device and the application. Touch-based technologies and NUIs may be presented as replacement for the keyboard and mouse as the computer's main input without having a significant learning curve associated [9].

The tabletop, a table sized touch-based user interface, can remove the barrier that keeps older adults from starting to use computers [10,11,12].

Apart from the advantages offered by these user interfaces, tabletops can be used by multiple users, enabling collaborative work or collaborative games.

This project was aimed at understanding how tangible objects can be used to improve the quality of life of older adults by providing a better and richer experience when in contact with digital games and by enabling the user to interact with the application using real objects. In order to do it, the authors decided to observe how older adults interacted with the tabletop and how tangible objects could be used as opposed to using images displayed on the tabletop's surface. A low-fidelity prototype to enable these observations was made.

3 Game Prototype

This prototype aimed to understand how the elders interacted with the table while playing the game and to see whether tangible objects could be used in the game, and if so, how and in which situations. The prototype was based on the Air Hockey game [13] and consists of throwing a puck to the other player's goal, as shown in Fig. 1.

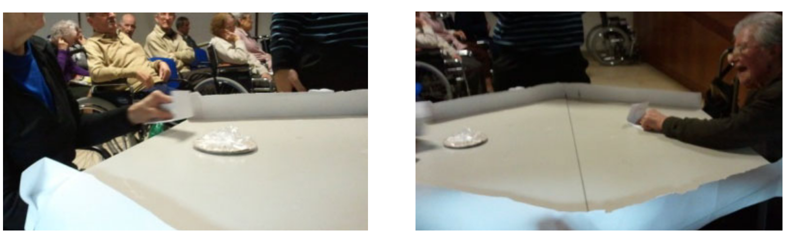

Fig. 1. Participants of the usability test playing with the game prototype

This type of game should benefit older adults, as it requires a certain level of cognitive reasoning to deal with the reflection of the moving object when it hits the edges of the table and gross motor skills to interact with said object using hands or a tangible object.

Older adults felt an increasing motivation while playing the game. During the game, players were asked to use a tangible object instead of their hands. As a result, users tended to respect the game rules. By contrast, when not using the tangible object, users used both arms and tended to break the rules more often.

4 Conclusions

The observations showed that tangible objects cannot be used efficiently and with precision when the players actively use them. However, they have shown that tangible objects could be used to enforce the rules of the game. Moreover, players who had a greater motor decline were more prone to moving their arm energetically without being told to. This indicates that the use of tangible objects is likely to promote gross motor skills stimulation.

On the other hand, this test indicated that tangible objects should be seen as a proof-by-possession type of object rather than a gameplay type, as their usage on devices that have dead areas or poor object motion tracking may cause an unsatisfactory user experience.

5 Future Work

The studies conducted and described in this paper indicate that tangible objects may be a viable option to stimulate cognitive function and motor skills on elderly people. Further conclusions could be drawn if a high-fidelity prototype was used with the final users.

Different prototypes and ideas should also be tested, such as variations of the game, or even different types altogether. A high-fidelity prototype is planned and will integrate the results gathered through software testing on the tabletop and of prototype testing with the elderly people.

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The Cursor as an Artistic Expression in *Jeddah*

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Abstract. The paper discusses *Jeddah*, an interactive artwork that experiments with the relation between cursor and background art. In addition to being functional, the cursor is also cast as an element of artistic expression. It is exaggerated in shape, scale, color and motion to blend in with the background art, and is constantly transforming in response to the art world. This is done to enhance the mood and experience of spatial exploration of *Jeddah*'s world.

Keywords: Cursor transformation, cursor aesthetics, spatial exploration, experimental artwork.

1 Introduction

Jeddah portrays an historic neighborhood in Saudi Arabia, with buildings that were once beautiful, now decaying or demolished. It places the user in the first person perspective, to unfold the narrative through spatial exploration. To complement the artwork, an expressive cursor blends and interacts with the background's artwork, exaggerated in shape, scale, color and motion, transforming with its changing position [1]. The background art consists of stylized real photographs that mimic media forms such as collage and water-colored paintings. This is done to establish a dream-like mood, metaphor and character [2], [3].

2 *Jeddah*'s Expressive Cursor

Jeddah's aesthetic approach to interface design adopts Shamonsky's [4] position that the ease-of-use in today's functionally designed interfaces takes away the excitement of interaction with an artifact. The aesthetic approach encourages the user to sensually engage with the interface itself, as opposed to the user purely focusing on the task at hand. Interfaces can also become actors in the narrative, acting as extensions of the user, like a gun becoming an extension of the user's hand in first-person shooter games [5], [6], [7], [8], [9]. In *Jeddah*, the cursor serves as a functional and guidance tool, as well as one of artistic expression. The expressive cursor melts into the textures and attitudes of the story world, while also guiding the user by hinting the consequences of a click, thereby breaking the norm of point-and-click [1].

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2.1 Cursor as Functional Tool

The cursor indicates possible actions when rolling over hotspots, while the nature of the highlight indicates how the action fits with space. For example, upon rolling over electrical wires in the scene, the cursor changes to a hand to grab the wires and transport to another location. When flight is possible, it gracefully transforms from the initial breathing spiral to a winged figure with its own sense of function and narrative impact.

Fig. 1. The cursor transforms into a rotating star (left) or a hand (right) to indicate action

Fig. 2. The cursor gracefully transforms from a butterfly (left) to a winged figure and finally a rotating star (right)

2.2 Cursor as Guidance Tool

The cursor acts as a guide throughout the work by signaling possible actions. It transforms in shape, scale, color and motion to foreshadow the consequence of the click. When arriving at a forking path, hovering the cursor on different areas gives an impression of the destination ahead. This effect was achieved by layering several backgrounds, and changing their transparency values in response to the cursor's position. Pointing the cursor towards the sky transforms it into a butterfly to indicate flight, while pointing it towards the land transforms the landscape into a mirage or desert.

Fig. 3. The position of the cursor on the screen foreshadows the eventful consequence of clicking in that direction by changing the entire background to emphasize the sky, the desert land, or a mirage

2.3 Cursor as Artistic Expression

The cursor's design complements the artwork and narrative of *Jeddah*. Its scale is initially exaggerated so that it covers the whole screen at times; yet, it is also translucent, blending within the story world. It expands and rotates to imitate a breathing motion, changing shape to mimic the actions which it represents, acting as an extension of the user. Other moving objects in the scenes serve to complement the artistic composition and advance an ongoing narrative. The cursor is transformed by the actions of these objects that include: mist, wires, nightmarish figures, and calligraphic poetry floating in the air.

Fig. 4. The cursor is an artistic element that complements the background. It is seen as a rotating spiral (left), or a breathing spirit attacked by a nightmarish figure (right).

3 Discussion

This paper suggests the use of cursor as an aesthetic as well as functional device in interactive artworks. It outlines the concepts behind the creation of *Jeddah's* cursor, treated as both a functional guide and an expressive actor. Through the use of expressive treatments, the cursor enhances the experience of narrative, mood and spatial exploration in *Jeddah*'s interactive artwork.

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The Role of Movies and Telephony in the History of Communication Media

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Abstract. Various types of new communication media have recently emerged such as e-mails, blogs, and social networks. We try to investigate this recent trend in communication in this paper based on the long history of human communications. Further, we want to elucidate that this trend could be interpreted as a shift from logical to emotional communications. We simultaneously want to clarify that this recent trend has its origins in the invention of movies and telephony in the late 19th century.

Keywords: Communications, media history, movies, telephony.

1 Introduction

New communication media as e-mails, blogs [1], and social networks [2] in the area of communications have recently emerged and have rapidly been changing the way we communicate. The influence of social networks such as Twitter [3] and Facebook [4] has especially been significant. The main characteristic of these new media is that people exchange short messages with other people in their small communities to inform others of their daily activities. Most of these messages do not contain any significant information but still work well to give people the feeling of "being connected."

The emergence of digital games in the area of entertainment has similarly been changing the people's behaviors. People used to enjoy entertainment before the era of digital games to forget the negative aspects of their daily toil and ease stress. However, people do not currently enjoy playing games for specific purposes but only for fun.

The basic trend behind these recent phenomena has been that our behaviors have been becoming increasingly more dependent on emotion rather than logic. Most of the messages exchanged through e-mails, Twitter, and Facebook have been short fragments of text and have mostly contained emotional and not logical information. Also, people enjoy playing games because these have a strong impact on the emotional aspect of their brains rather than the logical.

The question therefore is: "What has initiated such change?" In our long history of humanity, philosophers have been trying to define what the most specific human capability is and their conclusion has been that logical thinking and behavior represent the most specific human capability. This originated with the ancient Greek

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philosopher Plato [7], who tried to classify the basic factors of human behaviors into *logos* and *pathos*. He also tried to place emphasis on logos declaring pathos to be something that was less intelligent in human beings.

We attempt to identify this recent trend in communications in this paper as well as in other areas of our everyday lives as a shift from logical to emotional thinking, or in other words, from logos to pathos based on our investigations into the long history of human communications.

2 The History of Communication Media

Let us look at the long history of human communications. It is obvious that one of the principal inventions in human history was the invention of written characters dated at around 4,000 B.C. Of course, we already had verbal languages before this invention. Nevertheless, people tended to convey emotional rather than logical information through their everyday use of language in the form of spoken messages. With the invention of written characters, they first had a way of expressing logical messages. However, it took a long time before they got to know the difference between logical and emotional messages. It could be said that Plato was the first to clearly identify the importance of people's logical way of thinking.

Nonetheless, it again required a long and gradual process before people actually learned how to express themselves logically. Only a few people such as philosophers, mathematicians, and physicists could express their thoughts/concepts logically. Most people still lived lives of emotion. But finally the invention of printing technology came by Gutenberg in 15th century came. This invention made it easier for people to access printed documents and to understand logical messages and they thus began to think more logically. In this sense, the invention of printing technology is an extremely innovative invention in human history.

The invention of movies was achieved by the Lumiere brothers in the late 19th century and telephony was invented by Alexander Graham Bell during the same period. These two inventions are usually not as well recognized or evaluated in the history of communications and media compared with the invention of written characters and printing technologies. However, these two inventions were actually the next stage in tremendous innovations and comparable to the preceding discoveries. The main reason for this is that these media again initiated the trend in human behaviors back to being emotion dependent after the long years of a logic-dependent culture in the Western world.

The main characteristic in telephony is that people can exchange emotional verbal messages and bridge the gap of distance. Before telephony, text mail (snail mail) could mainly convey logical messages but made it difficult to convey emotional meanings. With the emergence of telephony, people could retain the feeling of being connected by engaging in verbal and emotional communications even though they were separated by distance. The influence this invention had was so forceful that it again drew people back from logical communications using printed text to the emotional communications that had existed in the era before Gutenburg.

The invention of movies had the same influence on people's behaviors. Again, people before the invention of movies received information mainly in the form of written messages, which meant that they were used to receiving logical messages. However, the invention of movies changed the whole situation. The effect of images, especially moving images, were so strong that people were very easily exposed to the virtual world where people experienced the development of emotional storytelling.

It is very important to recognize the huge and significant influences created by these two new media that were invented in the late 19th century. As previously stated, the invention of printing technology initiated the shift from emotional to logical thinking. On the other hand, the invention of movies and telephony again initiated a reverse shift from logical to emotional thinking. Actually, the recent tendency of people's behavior toward emotional rather than logical behavior has been initiated by these two inventions. It is interesting and important to know that these inventions were achieved almost at the same time in the late 19th century. After that, the influence of these two new media gradually penetrated into our society.

3 Trend Behind New Communication Media

The era of networks arrived in the late 20th and early 21st centuries. In the late 20th century, e-mails appeared and blogs and social networks such as Twitter and Facebook have emerged in the early 21st century. It has become far easier for people separated by distance to exchange messages through these media. What is interesting here is that communications using these media are based on the exchange of text messages. As explained in Chapter 2, written messages basically convey logical messages. Despite this, it is noteworthy that the messages exchanged using these new media, especially in social networks, are usually very short, which makes it more difficult to convey logical meaning.

This fact was not very well recognized in the early days of e-mails. However, then text messaging with mobile phones became popular. As it is difficult to send long messages with mobile phones, people usually send short messages consisting of one or two sentences. The messages exchanged on mobile phones in such cases are not logical but emotional. This reminds us of short poems such as 'Haiku' or 'Waka' that are traditional forms of Japanese poetry.

It is interesting to point out the similarity in communications based on social networks to the communications done by exchanging Waka (short poems) almost a thousand years ago in Japan. It was customary at that time for nobles throughout Japan to communicate by exchanging Waka. It should be emphasized that although these Waka communications were done by exchanging written messages, the information exchanged in these communications was emotional.

What then is the effect of movies in our everyday lives? Movies represent one of the major sources of entertainment in people's everyday lives. It has become far easier to create fantastic scenes that were difficult to create in the early days of movies especially with the advance in computer-graphics technologies. Many scenes in recent movies tend to appeal directly to our emotions by only showing us dynamic images instead of including explanatory narrations and explanatory dialogues.

Another good example is games. People, especially youths, are eager to continuously play games. Most games are only for enjoyment. Actual humanoid characters can easily be generated due to the development of computer-graphics technologies. Also, people can gain enjoyment from the development of interactive stories by controlling these realistic characters and interacting with other characters or monsters due to the development of interactive technologies. The brain functions that work when people are enjoying games are undeniably emotional.

The authors believe that the tendency of human behavior to shift from logical to emotional was initiated by the invention of movies and telephony. This gradually changed the basic way we think and behave. New communication media such as e-mails, blogs, social networks, and games have only accelerated this trend as have digital games.

4 Conclusion

The authors explained the phenomenon of the recent trend in communications focusing on such new media as e-mails, blogs, and social networks. The methodology we adopted was not only to observe the recent trend but also to try to learn about communications from our long history with it. What we found is that behind this recent tendency there is actually a more fundamental trend from logical to emotional thinking. We also found that this is a reverse movement to that people have tried to adopt during their long history from emotional to logical thinking, which was initiated by the invention of written characters, by great Western philosophers such as Plato and Descartes, and by the invention of printing technologies. We also indicated that this reverse trend was initiated by the invention of movies and telephony in the late 19th century. New technologies such as the Internet and computer graphics have only accelerated this trend.

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To Virtualize or Not? The Importance of Physical and Virtual Components in Augmented Reality Board Games

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Abstract. Whereas traditional games have employed entirely physical interfaces, computer games provide a generally virtual alternative. Motivated by interest in supporting conventional gameplay in the computer environment, we investigate the benefits of game interaction techniques based on gestures applied to tangible objects, comparing the user experience with that resulting from more virtualized interaction. Our study is applied in the context of a German-style board game, Settlers of Catan. Significant findings indicate a preference for tangible components for complex interaction tasks.

Keywords: Augmented Reality, Tangible User Interfaces, Augmented Gaming, Multi-user Interaction.

1 Introduction

Computer games can be extremely powerful and dynamic, simulating complex physical environments, modeling situations that are impossible in real-life, and taking on the role of either moderator, intelligent opponent, or both. Moreover, the computer can automate repetitive, mundane tasks such as shuffling, point-counting, and memorizing rules, factors that may detract from the enjoyment of certain game genres such as board games. Due to these capabilities, we are interested to see if the gaming experience of social board games may be improved with computer augmentation. We hope to discover new game design techniques that will appeal to wider audiences.

2 Related Work

As an alternative to both traditional board games and purely computer-focused video games, hybrid board/video games offer the potential to enhance the social gaming experience of the physical world with the benefits of computer augmentation. This is typically achieved by a tangible user interface (TUI) paradigm, which couples physical game pieces to the computer through some sensing mechanism. Using these pieces as input devices that afford manipulation, spatial reasoning skills can be exercised while parallel operation and collaboration is supported between single and multiple users (Fitzmaurice, Ishii, & Buxton, 1995). In addition, augmented or mixed

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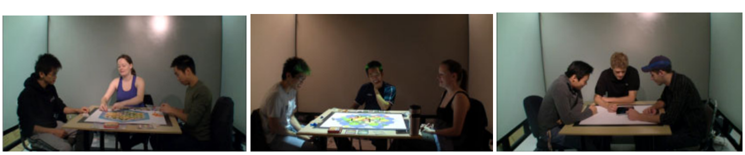
reality techniques can provide real world interaction in a more integrated manner than can a pure video game. Typically, graphics are projected into the same space where the tangible interfaces are used, e.g., on a table. The combined interaction-display format of tangible user interfaces with augmented reality, or Tangible Augmented Reality (TAR) (Billinghurst & Kato, 2002), enhances face-to-face communications of multi-player games, while allowing players to interact in a natural manner. This idea of merging pre-existing, everyday knowledge with digital interaction techniques arises from the Reality-Based Interaction (RBI) framework, which provides techniques for analyzing and comparing components used for this style of interaction (Jacob, et al., 2008).

3 Experiments

Within this RBI framework, we designed a TAR system to investigate the important question of whether tangible or digital components are preferred in social gaming situations. In general, we believe tangible components will be favored due to their affordances for natural interaction. Our hypothesis is that non-strategic (or “set”) actions such as game setup and piece sorting will favor automation through virtualization. Moreover, for situations where strategy or multi-player interaction is required, we expect that tangible objects will be preferred due to their assistance with planning through spatialization (Kirsh & Maglio, 1994) (Patten & Ishii, 2000) and support of parallel actions between multiple people (Fitzmaurice, Ishii, & Buxton, 1995). To test this hypothesis, we designed a Settlers of Catan TAR prototype that facilitates the use of tangible objects in addition to automating and assisting players on low-cognition tasks. Traditionally, Settlers is a multi-player strategy board game that involves cooperation, negotiation, and logic.

3.1 Settlers of Catan Prototype

The comparison study for Settlers of Catan is presented on the classic board game version, our developed TAR version, and a digitized version on the Apple iPad. As we move from the classic to the digitized version, the number of tangible components decreases as the amount of automation and rule enforcement increases. Fewer rules are enforced when tangible components are present to accommodate rich object manipulation techniques. For tasks where no tangible handle is available, computer automation and rule enforcement are used to guide and inform the player of the actions available.



(a) (b) (c)

Fig. 1. Settlers of Catan Classic, TAR, and Digital mode

3.2 Design

The experiment comprised the three conditions as described above. Our subject pool consisted of nine participants, two female and seven male, ranging from 23 to 30 years of age. The participants were randomly assigned to one of three groups of three players. The groups were presented with every condition, with each group experiencing the conditions in a different order. A modified Latin square was used where each condition appeared in every slot of the ordering. The post-test questionnaire was completed immediately after each gameplay session. Once all three conditions were complete, players were asked to choose what they considered to be the best overall condition. The post-test questionnaire was comprised of questions from FUGA's Game Experience and Social Presence in Gaming Questionnaire (GEQ and SPGQ) (de Kort, IJsselsteijn, & Poels, 2007) (IJsselsteijn, et al., 2008) and O'Brien's User Engagement Scale (O'Brien, 2010).

4 Results and Analysis

The questionnaire was comprised of two high level categories: personal game experience and social experience. These reflect the single-user experience and between-player experience, respectively. One or more questions make up each of the listed sections in both personal and social game experience. The responses within each category were averaged to form the associated mean score, as shown in Table 1, separated by subject and condition for analysis. As seen, the TAR condition was rated the highest most frequently in the questionnaire. In general, players found tangible components essential for negotiation and resource trading and preferred automatic, organized board setup.

Table 1. Mean score averaged over all subjects

Questionnaire Results			
Section	Mean		
	Classic	Digital	TAR
Personal Game Experience			
Perceived Usability	3.04	2.11	3.59
Aesthetics	3.94	3.56	4.28
Focused Attention	3.67	2.89	4.44
Sensory and Imag. Immersion	3.78	2.94	3.83
Endurability	4.33	2.83	4.50
Negative Affect	2.78	1.78	3.00
Positive Affect	4.17	3.28	4.50
Social Experience			
Empathy	3.33	3.19	3.83
Negative Feelings	3.37	3.22	2.96
Behavioural Involvement	3.85	3.26	3.89

5 Conclusion

The study described in this paper tested different implementations of Settlers of Catan to determine the appropriateness of digitizing various physical elements commonly used in board games. Our approach in this regard is to retain tangible components used for making strategic choices while digitizing pieces used for simple, mundane tasks such as the ones required for board setup. These qualities resulted in the TAR condition being the highest rated in many portions of the survey and unanimously chosen by players as their favorite. Preference of tangible components over digital equivalents for complex interaction tasks such as card trading was demonstrated by the significant differences between the virtual and tangible (identical in both classic and TAR) conditions in many areas of the questionnaire.

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Using Game Engines in Mixed Reality Installations

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Abstract. In mixed reality installations we have to integrate a variety of technologies such as virtual reality, augmented reality, animated virtual agents and robotic agents. In this paper we describe some of our explorations with a game engine as the driving software for mixed reality installations.

Keywords: Mixed reality, virtual reality, CAVE, game engine.

1 Introduction

In a mixed reality installation, a variety of technologies is integrated such as virtual reality, augmented reality, and animated virtual agents and robotic agents. One of the main challenges is how to design and implement a mixed reality installation that integrates a heterogeneous array of sensors and actuators, immersive interactive environments into aware system that will engage the user, providing a meaningful experience.

In this paper we address the problems of building a CAVE environment in mixed reality installations, and share our experience in using a game engine as the driver for the CAVE, and in interfacing the game engine with sensors, actuators and input devices.

2 Game Engines for the CAVE

A CAVE system is usually a projection based virtual reality environment, consisting of a room in which the walls, ceiling and floor surround a viewer with projected images [1]. Building realistic virtual environments is a complex, expensive and time consuming process. Although virtual environment development toolkits are available, many just provide a subset of the tools needed to build complete virtual worlds. One alternative is the reuse of computer game technology. The current generation of computer games presents realistic virtual worlds featuring user-friendly interaction and the simulation of the real world. A number of computer game engines provide tools, documentation and source code, either with the game itself or separately available, so the end-users can create new content.

CryEngine [2] supports a number of features that are useful for creating immersive and realistic games and virtual environments, the necessary development tools are

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integrated with the engine itself, including CryEngine Sandbox world editing system. Advantages to using the CryEngine include the fact that the engine produces very high quality graphics and visuals. Disadvantages with this engine include that it has high demands on supporting hardware requirements for the high visual and audio components.

In previous work we introduced the CryEngine automatic Virtual Environment (CryVE), a CAVE system based on the game engine CryEngine2 [3]. The software architecture uses the multiplayer features of a CryEngine computer game to build the projections in the different sides of the installation. Instances of the game are started on all computers in the system, connected to each other through a network hub, with one of them acting as a server (master) while the rest are game clients (slaves). The server controls the interactive, "in-game" action (walking, jumping, flying, etc.) while the clients provide the extra "cameras" that complete the peripheral view required by the CAVE, by aligning and synchronizing themselves to the pose and motion of the master, effectively enlarging its field of view. Finally each computer renders its piece of the virtual world to the corresponding projection screen (Fig.1 shows the CryVE system architecture). A more detailed description of the design and implementation of CryVE can be found in [4].

Fig. 1. CryVE system architecture (taken from [cite journal paper])

3 Use cases

Next we describe some of our explorations with the utilizing game engines in mixed reality installations.

3.1 The ALICE Project and Cultural Computing

The ALICE installation [5] uses mixed reality as a new medium for edutainment and entertainment, and consists of six consecutive stages, using a variety of technologies such as virtual reality, augmented reality, animated virtual agents and robotic agents. One of the stages in the ALICE project is based on the book chapter where Alice adjusts her size based on eating and drinking. It is associated with the concept of space: a CAVE system is used to be able to manipulate the relative size of the users in comparison to the environment. The virtual room is projected on a five sided CAVE, the bottle features touch and tilt sensors to detect drinking and the cookie box is equipped with a microphone that allows detecting the visitor's chewing sounds when eating the cookie. The implementation of interaction with the game engine is done with XML messaging.

Fig. 2. In the ALICE installation [2, 3], the "Eat me, Drink me" stage is implemented in a CAVE system

3.2 A Virtual Museum Tour

We developed a conceptual design of a Virtual Museum Exhibition that showcased historic events from the Netherlands [6]. The virtual environment resembled a medieval settlement, a virtual world that recreated sixteenth century Holland. For this, a medieval game map was modified by adding dynamic interactions that could be selected by the visitors. Visitors of the museum can use a portable controller in combination with CryVE to have an immersive experience. The handheld device is used as an interface for exploring the virtual world.

Fig. 3. A tour in the Virtual Museum (left) Impression of the Virtual Garden(right)

3.3 Virtual Garden with Tangible Interfaces

The Virtual Garden project is an attempt to aid a common person in designing his or her garden, without requiring the user to be proficient with computers. A CryEngine driven CAVE is used to create a convincing virtual environment. The user can explore and manipulate this environment through a tangible interface, which is basically a miniature representation of the virtual environment. The physical objects of the interface are fitted with pattern markers which determinate the position and rotation of the object from the video stream and are transferred to an XML file where each of the objects is a child with three attributes (xpos, ypos, rotation).

4 Discussions and Future Work

We have developed different implementations of mixed reality environments with the CryVE system. The presented solutions are using the same software architecture for synchronization of the projection but different ways for interaction with the virtual world have to be developed. In each of the mixed reality installations we have to integrate different sensors, actuators and input devices. Interaction with hardware is implemented by means of XML packet exchange.

With the CryVE system we have gained a platform for easy development of virtual environments, the future challenge is to develop a platform which will easily integrate different inputs from the mixed reality environment. Problems which have to be solved are synchronization of the frame buffers, integration of different input devices and flexibility in incorporation of different sensors, actuators and input/output devices.

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1st Workshop on Game Development and Model-Driven Software Development

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Abstract. This workshop brings together game development professionals and experts of model-driven software development (MDSD). MDSD can improve the way software is developed by providing a higher level of abstraction and model-to-model transformation respectively model-to-text generation by automated tools. With this workshop, we want to identify how game development can benefit from MDSD. Thereby, the workshop focuses on a strong collaboration of both expert groups to determine the chances, challenges, and boundaries of introducing MDSD to the game domain.

Keywords: Game Development, Model-Driven Software Development, Model-Driven Game Development.

1 Relevance of Workshop Topic

Games are highly interactive media applications within a hard to define common scope. Developed in multidisciplinary teams, they combine the artistic challenges of multimedia productions with the engineering challenges of IT-productions [4]. Hence, we face ambitious demands regarding the overall development process. However, the growing complexity and scale were not encountered by refined game development methods for many years [5]. Only recently, agile project management methods like Scrum were applied successfully in several productions [7, 8, 9].

In the last decade, MDSD has successfully made the transition from the academic sphere to industrial-grade software development and it provides many advantages [6] game development could benefit from. Key features of a system are formally described on a higher level of abstraction (the problem domain), omitting distracting details like the technical realization on a distinct platform (the solution domain). This allows for a better integration of domain experts (e.g. game designers, game writers, concept artists) in the development process. Using model-to-model transformation or model-to-text generation, the transition from problem space to solution space can be automated, which is more efficient and less error-prone than the manual implementation in a third generation

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language. Moreover, often grounding on a common game engine, games feature characteristics of software product lines, while product-line engineering is an explicit application field of MDSD [6]. That is why we think that game development and MDSD should get in touch.

2 Workshop Objective

The workshop's main objective is to bring together researchers and industry professionals of both fields to identify if and how the game development process could benefit from MDSD. Thereby, we want to initialize a dialogue that holds on and evolves far beyond the boundaries of the workshop, creating an information transfer both communities benefit from.

2.1 Proposed Form and Schedule

In order to accomplish the described objective, we plan to provide a full day workshop that is divided into four sections, with a distinct sub-goal each.

Why Should We Care? During the first section, two keynotes introduce MDSD respectively the game development process. With the keynote speakers moderating the discussion of this section, the goal is to create a common understanding of the advantages and boundaries of MDSD as well as the existing and forthcoming challenges in game development that can be addressed by MDSD.

Position Papers: In the second section, selected researchers and industry professionals present their experiences and opinions on model-driven game development, covering theories, techniques, tools, infrastructure, and boundaries of MDSD. Based on these presentations as well as the results of the first section, the participants should identify one or more exemplary sub-domains and describe requirements for corresponding DSLs in different working groups.

Finding the Right Abstraction: The central aspect of defining a DSL is to find the right abstraction that completely describes the domain from the target group's perspective. Hence, in the third section of the workshop, we introduce a framework that describes how a DSL can be defined cooperatively by domain experts (game development professionals) and language engineers (MDSD experts). Afterwards, the participants are asked to apply this framework, designing DSLs for the former identified sub-domains.

Open Discussion: In the final section, the different DSL designs of the working groups are presented and optimized. We believe that the DSL results can be used as a foundation of upcoming project and research cooperation between the participants. We want to close the workshop with an organized summary of lessons learned.

2.2 Expected Workshop Outcome

First, as our list of potential participants with confirmed interest also points out, there is a strong request in the game development community to get in touch with MDSD. Therefore, the website of the workshop will feature a list with contact information of all participants. The position papers will be published in the proceedings of the workshop. The achieved results of the workshop are going to be published in form of a technical report on the website. This report will also feature all open issues for future work. Participants with similar research and development interests can connect and collaborate on solving these issues.

3 Bio Information of Workshop Leaders

Robert Walter received a diploma in Software Engineering and a Master of Science in Computer Science. In his Ph.D. studies, he examines the game development process with a focus on the creation and processing of narrative game content, develops concepts for domain-specific languages (DSLs)[1], and tools for an improved integration of all stakeholders—from game writers over artists and voice actors to localization studios—into the game development process [3]. The goal is to find patterns that reduce development time, effort, complexity, and costs.

Maic Masuch holds the chair of Media Technology and Entertainment Computing at the Faculty of Engineering, Department of Computer Science and Cognitive Science at the University of Duisburg-Essen. He received his Ph.D. with a dissertation on computer animation at the University of Magdeburg and, in 2002, became Germany's first Professor for Computer Games. He founded two companies, researches in the field of game design and game development for over twelve years, and is one of the pioneers of German video game research.

Ed Merks leads the Eclipse Modeling Framework project as well as the top-level Eclipse Modeling project. He is a coauthor of the authoritative book "EMF: Eclipse Modeling Framework" [1] which is published as a second expanded edition. He is an elected member of the Eclipse Foundation Board of Directors and has been recognized by the Eclipse Community Awards as Top Ambassador, Top Committer, and Top Newcomer Evangelist. Ed is currently interested in all aspects of Eclipse modeling and its application and is well recognized for his dedication to the Eclipse community, posting literally thousands of newsgroup answers each year. He spent 16 years at IBM, achieving the level of Senior Technical Staff Member after completing his Ph.D. at Simon Fraser University. He is a partner of itemis AG. His experience in modeling technology spans 25 years.

4 Potential Workshop Participants

We received confirmed expression of interest from the following experts: ***Andrew Brownsword*** (Former Chief Architect at EA BlackBox), ***Paul Martin*** (Director of

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[1] "[A DSL is] a computer programming language of limited expressiveness focused on a particular domain." [2].

Technology at Slant Six Games), ***Markus Völter*** (independent researcher, consultant and coach, itemis AG), ***Karsten Thoms*** (Software Architect and Coach, itemis AG), ***José A. Carsí*** and ***Emanuel Montero*** (Associate Professor and Ph.D. student, Software Engineering and Information Systems Research Group, Universidad Politécnica de Valencia), ***Daniel Volk*** (Ravensburger Digital GmbH), ***Sonja Maier*** (Bundeswehr University Munich).

Amongst others, we are also in contact with Richard Dansky (Central Clancy Writer, Ubisoft), Mike Acton (Engine Director, Insomniac Games), and Jeff Ward (Toolsmith/Programmer Fire Hose Games). In the moment, we suggest a total number of 20 people joining the workshop.

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How Does an Interactive Story Feel Like? Theory and Measurement of the User Experience

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Abstract. This workshop is dedicated to discussing the user experience of an emerging new type of entertainment computing: Interactive stories. Technology development in Interactive Storytelling (IS) has made substantial progress recently, but theory and empirical studies on the user perspective have not received much attention in the entertainment computing community so far. The workshop introduces a measurement toolkit for testing user experiences in IS prototypes and stimulates discussion on conceptual as well as methodological issues in user-focused research on IS.

Keywords: Interactive storytelling, user experience, methods, measurement.

1 Workshop Background and Objectives

Research and development on Interactive Storytelling (IS) is about to bring out systems and media that provide novel modes of entertainment, learning, and other experiences [1]. Departing from existing media, such as adventure video games, and synthesizing diverse streams of technology, including as artificial intelligence, 3D real-time imaging and/or speech recognition, the vision of Interactive Storytelling is to facilitate user experiences that combine immersion in fictional stories with perceptions of agency and the situation dynamics of improvisation theatre. Conceptually, IS emerges as one pathway towards next generation entertainment computing [2]. So far, various demonstrators have been developed that illustrate how this vision of new entertainment media could be implemented technically in the future (e.g., the “Façade” system [3] or the “Madam Bovary” system [1]).

While technology development in IS has made substantial progress, the audience perspective has received less attention in the entertainment computing community. System creators certainly have implicit or explicit assumptions about how users will experience their interactive story; however, not much theoretical or empirical knowledge has been developed in this regard [4]. The workshop is intended to stimulate a focused discussion on the user perspective: How will using such media

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will ‘feel like’? Which modes of enjoyment does or can Interactive Storytelling facilitate? These questions need to be addressed with more rigor, because the user perspective can offer important inputs to make reasonable design decisions and to strategies for bringing IS systems to mass entertainment markets.

More specifically, the workshop splits the user perspective issue into two key elements. One is theoretical reflection. We want to debate with colleagues interested in Interactive Storytelling on how to describe, model, and theorize the enjoyable and potentially less enjoyable dimensions of IS experiences. Related questions are:

- Which concepts from research on conventional entertainment media can or should be applied to Interactive Storytelling? Are, for instance, the flow concept or the notion of suspense viable tools to model IS-based entertainment?
- Which kind of stories or narrative building blocks promise to ‘work well’ in Interactive media? Can user-centered models of fun help to define strategies of generating appealing content for Interactive Stories?
- How does the user experience in IS (probably) differ from existing entertainment experiences? What makes the conceptual difference between IS and, for example, an adventure video game or a “World of Warcraft” © experience?

The second key element of the workshop is the empirical measurement of the user experience in IS. We introduce a standardized measurement toolkit, which has been developed by the IRIS network of excellence (http://iris.scm.tees.ac.uk/). This toolkit is based on theoretical foundations, expert interviews, and benchmarking studies conducted with different media and prototypes of Interactive Storytelling. Its purpose is to provide an easy-to-handle application for system creators that allows conducting rapid user studies with new prototypes and comparing a system’s performance with data obtained from other systems [5] [6]. The toolkit comes as a set of self-report measures to be applied immediately after users finish exposure to an Interactive Story. It includes scales on various dimensions of the user experience, including fundamental issues such as perceived usability and character believability, affective-motivational processes such as efficacy, suspense and curiosity, and evaluative dimensions such as user satisfaction and enjoyment. Moreover, flexible components are included that can be customized for specific study purposes. Benchmarking data are available, for example, for the “Façade” system [3] and allow comparing results from new studies with data obtained from published reference systems. The measurement toolkit is available as a software application that enables mostly automatized data collection and analysis.

The workshop serves to make interested IS researchers familiar with the measurement toolkit, to demonstrate its application in prototyping studies and to illustrate how findings from testing one’s own IS prototype can be compared to data from reference systems. In addition, methodological issues related to the user experience will be discussed with participants. Key questions are

- Which cognitive, affective, and motivational processes need to be addressed in empirical studies on IS system users? Does the current IRIS measurement toolkit cover all relevant facets?
- In addition to self-report measures, which other methods of user research are promising for future studies in IS?
- How can data from user tracking – such as user decisions' on story progress or users' individual style of handling the system's interface – be exploited for understanding the enjoyment of IS?

2 Workshop Activity Plan

The workshop is planned as a half-day event (4 hours). It mostly relies on impulse presentations and discussion rounds that involve participants as experts in entertainment computing and Interactive Storytelling. The workshop agenda is envisioned as follows:

(1) Introduction of workshop objectives and participants (20 min)
(2) Theoretical issues: Impulse presentation by workshop organizers on conceptual issues in IS user experiences (see above), statements by workshop participants (60 min)
(3) Short break (10 min)
(4) Introduction of the IRIS measurement toolkit: Presentation and demonstration by workshop organizers, questions and answers (60 min)
(5) Discussion: Methodological issues in IS user research (see above) (45 min)
(6) Short break (15 min)
(7) Conclusion: Summary by Workshop Organizers, discussion of next steps (incl. collaboration perspectives among participants, new project ideas with focus on user studies) (30 min)

3 Workshop Organizers

The workshop is organized by a research team of the IRIS network of excellence. They are responsible for user research within the network and lead a thematic work package in IRIS. The conceptual and methodological issues addressed in the workshop have been elaborated by the organizers both within the past 2+ years of IRIS project work and in preceding projects on media psychology and entertainment computing.

Christian Roth is junior project manager for the IRIS user studies work package at the Center for Advanced Media Research Amsterdam (CAMeRA). He has been involved as key personnel in research and development of the of the IRIS measurement toolkit that is foundational for the workshop. Thematic key publications are [5] [6] [7].

Peter Vorderer is professor of communication science at Mannheim university and responsible senior researcher for user studies in the IRIS network. He has published extensively on numerous topics in media entertainment, particularly related to new media technologies. Thematic key publications are [8] [9].

Christoph Klimmt is professor of communication science at Hanover University of Music, Drama, and Media, and managing researcher for user studies at the IRIS network. He specializes in research on user responses to video games and empirical methods of media effects studies. Thematic key publications are [7] [10].

Ivar Vermeulen is assistant professor at Department of Communication Science, VU University Amsterdam. He specializes in experimental communication studies and methods analysis. Thematic key publications are [5] [6].

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Open Software and Art: A Tutorial

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Abstract. The tutorial is devoted mainly to PhD students, researchers, educators, and artists who are interested to learn, practice, and reflect about software tools for creativity and art. In this work, we chose to focus on open source software and its intersection with art. This choice is motivated by significant related work in open source software and art and available software for art like Processing, Arduino, and Scratch. Four research questions will shape the discussion: 1) Development or use of software? 2) Who are the stakeholders? 3) How to evaluate art and technology works? 4) Are there feelings beyond creativity and amusement one should aim at when designing art and technology expressions?

Keywords: Art and Technology, Open Source Software, Creativity, Arduino, Processing, Scratch.

1 Introduction

The general research question that shapes our tutorial is: How can we increase knowledge about the intersection between software and art? This question has guided the work of researchers, artists, and technologist in the last 40 years [3], [8], [4]. Given that software is getting increased power on the way people experience art and culture, increased knowledge about the intersection of software and art benefits cultural industries, which produce media for publishing, museums, and entertainment. More specifically, increased knowledge about software and art provides both better technology platforms for cultural industries and better conceptual models for decision makers. Knowledge about software tools for creativity and art is important for artists, engineers, students, educators, and researchers in art and technology [11] [13] [16]. In the proposed tutorial, we chose to focus on open source software and its intersection with art and available software for art like Processing, Arduino, and Scratch. Moreover, we will describe examples of artistic expressions based on these technologies.

This proposal has the following structure. Section 2 provides information about the tutorial implementation and the teacher. Section 3 provides the background literature which addresses issues related to software and art. Section 4 presents four main research questions that will shape the tutorial. Section 5 gives a conclusive summary.

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2 Information about the Tutorial and the Teacher

The tutorial is devoted mainly to PhD students and researchers in art and technology. Educators and artists who are interested to learn, practice, and reflect about software tools for creativity and art are also invited. We aim at twelve to twenty participants.

The tutorial will last one full day and it will be organized as a combination of a learning session and hands-on applied sessions. The learning session consists of lectures by the teacher on the theme presented in this proposal. In addition, there will be three small hands-on applied creative sessions in which the participants will be able to experiment with Scratch [10], Arduino [5], and Processing [6].

Participants will have to bring their laptop (Windows, Linux, or Mac). It is an advantage if the participants have already installed the three tools, but this is not mandatory. No practical programming knowledge is required. Participants will be able to work in small groups and to improvise presentations. Pictures will be used as a mean to record and reflect about the creative activities. The ArTe blog [14] links to a set of reusable resources, among which three master level and a PhD course in the field of software and art. The blog also documents a set of creative workshops that have been offered by the same teacher and her group during the last years. This documentation includes pictures, videos, and code fragments to be reused.

In this tutorial, we chose to focus on open source software (OSS) and its intersection with art. This choice is motivated by significant related work in OSS and art and available OSS for art like Processing [11], [6], Arduino [5], and Scratch [10].

Letizia Jaccheri is a professor at NTNU, Norway. She has twenty years' experience of teaching and researching and she has been involved in the supervision of more than 12 PhD students. Concerning the theme of software and art, she teaches three master level (one theory based and two practice based [9] and a PhD level course. She has published book chapters and papers and has given presentations at several universities in Europe. Her motivation for developing this tutorial is to test the bulk of knowledge and practical learning methods with an International audience. Lastly the aim is to connect to the ICEC community.

3 Background

Artists need software technology for creating and evolving their artwork [16]. Theoreticians aim at understanding the consequences of software to art practices [7]. Technologists see the contact with artists as a source for innovation [8]. Computer science researchers recognize the importance of new media art as a legitimate research field [12]. Tools for creativity are a subject of study within computer science research. 'New media artists realize their desire for personal expression with powerful development environments that support animation, music, or video editing tools' [13].

The inner joy of creation has often been identified as an attribute of the open source software developer culture, bringing it, according to Castells [2] close to the world of art. Castells anticipates art as a growing area of the Internet, stating that 'open source art is the new frontier of artistic creation'. For Castells, the Internet not only serves as a means for distribution of artifacts, but also serves as a platform for a process that aims to create new artistic artifacts.

A software system is open source if its code is available to everybody for inspection, use, and modification. Users of OSS are not paying customers but software co-developers. Use and further release of modified version of an OSS system are regulated by a license. OSS is much more than the possibility to change the code. OSS projects are associated with communities of users and developers. The degree of activeness of the community is crucial for an OSS project. Each user of an active community is not isolated but part of a community. Members of each community are connected and help each other via mailing lists, forum and IRC channels.

4 Research Questions

There are at least four questions to stimulate reflection on the relationship between computing and art.

RQ1: Development or use? In the computing world, the relation with art is mostly visible in the subfield of Human Computer Interaction. The novelty of our work is that we look at the intersection of software engineering and art [16]. While HCI is concerned with the use of computer systems, software engineering is concerned with the development and evolution of software. We will point to events in which the users have been empowered to be the producers of fragments of OSS code while developers, artists, and researchers act as enablers and observers during the events. Developers and artists are themselves actors of the creative process that has the purpose of designing the events and producing the artifact that serve as components to the event.

RQ2: Who are the stakeholders? In previous work [15], [16], we have identified the importance of a stakeholder model. The work reported in this tutorial goes a step further by giving concrete examples of art and software projects and the involvement of the different stakeholders. In the tutorial we will discuss how the roles of artist, researcher, developer, audience are important to be able to plan and reflect about art and software projects. At the same time, these roles are not fixed and each person can play in the context of the same project or of different projects different roles.

RQ3: How to evaluate works in this intersection? Evaluation methods of user experience require a search for a balance between the research goal and the artistic goal. The criteria for successful art events can be different from the criteria for successful research. While artists may see evaluation activities as disturbing, evaluation activities have to be integrated in a way they become acceptable from an aesthetics point of view.

RQ4: Are there feelings beyond creativity and amusement we should look at? An important dimension is the role of creativity in the intersection of software and art. A superficial view of the intersection may lead to a model that categories artists as creative and engineers and researchers as analytical. ‘Creativity is often thought of as a trait exclusive to artists and primarily an individual activity’ [1]. Another interesting point of our work is that we dare to give words to other emotional states rather than playfulness and creativity when describing the relations between users and technology. In our cases we will describe romantic, contemplative, and boring situations.

5 Conclusions

A full day tutorial will be organized as a combination of a learning session and hands-on applied sessions with OSS tools for creativity. The learning sessions will be grounded in both related literature and the research experience of the teacher. The hands-on sessions will have the goal to let the participants experiment with software tools for creativity and to work in small groups of participants. This will enable the participants to get to know each other in a creative and motivating atmosphere. Our experience with similar creative sessions, especially with the Scratch tool, tells that participants will be able to create and share their contributions.

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Beyond Badges – Gamification for the Real World

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Abstract. Gamification is simple common sense - why not apply decades of games industry design and experience to non-game businesses and software in order to attract users, improve engagement, and build loyalty and community? But the concept of gamification is mired in confusion - does it mean simply stapling a game to non-game software? "decorating" web sites with a thin veneer of game-like graphics and mechanics? Badges and leaderboards? Or is it something more subtle and powerful - thinking like a game designer in uncovering the real challenges, rewards and engagement loops in any interactive situation (and what situations in real life are not interactive in some way or another?) and building on those to make real world tasks more intuitive, engaging and fun? In this talk, we will deconstruct the concept of gamification, illustrate some of the key principles of real world gamification, and look at a few simple examples of how those principles are being applied.

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Playing Digital Games Will Make You a Better Human Being

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Abstract. The negative stereotypes about the effects of playing computer or video games are a rich source of material for mass media; we hear less often about the positive aspects of digital game play. In her talk, Regan Mandryk will address five prevalent negative stereotypes, debunking common myths on how playing digital games makes you: 1) fat and lazy, 2) stupid, 3) unable to focus, 4) socially isolated, and 5) emotionally stunted. Drawing from her own research and the research of other academics who study digital games, Dr. Mandryk will leave you itching to go play games so that you can become a smarter, fitter, better-focused individual with a great emotional connection to your circle of friends.

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