Giorgio De Michelis
Francesco Tisato
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Arts and Technology

Third International Conference, ArtsIT 2013
Milan, Italy, March 2013
Revised Selected Papers

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Preface

The Third International ICST Conference on Arts and Technology (ArtsIT 2013) was held at the University of Milano Bicocca in Italy, during March 21–23, 2013.

It was organized with support from CREATE-NET, the European Alliance for Innovation, the University of Milano Bicocca and Hangar Bicocca (Italy). The presented papers cover a wide range of topics.

The venue for the conference was the new University District of Bicocca in the northern end of Milan, where both the campus of the new University of Milano Bicocca and Hangar Bicocca are located. Hangar Bicocca is a recently established Museum of Contemporary Art, hosting the *Seven Heavenly Palaces* by Anselm Kiefer.

The theme for ArtsIT 2013 theme was "Working for the artists," intended to underline the interaction between technologists and artists: this interaction is necessary not only to avoid an art conditioned by technology, but also to promote the use of ICT to augment the expressive potential of artists.

The conference included three keynote speeches by Antonio Camurri (University of Genova), Andrea Lissoni (Hangar Bicocca), and Klaus Obermaier, an independent media artist and choreographer. The conference scientific program included five thematic sessions consisting of 19 high-quality papers. The sessions are titled: (1) Art and Technology in Action; (2) Music and Technology in Action; (3) Reflecting on Art and Technology; (4) Understanding the Artistic Practice, and (5) At the Boundaries. The papers were selected out of 31 submissions from 14 countries by a Program Committee consisting of 42 members.

A new Special Session called "Exhibition," hosted by Hangar Bicocca, was organized to allow artists to present, de vivo or in video, their augmented installations / performances. We received 31 submissions from 11 countries for this session, of which only ten were presented at the conference, after being selected by a multi disciplinary committee consisting of eight members.

Also, ongoing projects and studies were presented at the poster session organized at the end of the first day.

The Gala Dinner was held on March 22 at Dopolavoro Bicocca, the restaurant at Hangar Bicocca.

We would like to thank the Organizing Committee members, the Program Committee members, and all the authors and reviewers who contributed immensely toward the success of this event. Also, on behalf of the Organizing Committee and the Steering Committee of ArtsIT 2013, we would like to thank our sponsoring institutions EAI, CREATE-NET, University of Milano-Bicocca, and Hangar Bicocca.

March 2013

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Giorgio De Michelis

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Subway: Activist Performance through Mediation

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Abstract. Subway is a participatory multi-located activist art project. It builds on the mediation of a dance performance by breaking a video apart into its image frames; creating a photo app in Android to re-use these frames as guides for a frame-by-frame reenactment; and finally reassembling the collected images into a new video. Through the affordances of digital and mobile media, it allowed participants in New York and Teheran to create a shared dance performance as digital activist art.

Keywords: Digital Performance, Activism, Mobile Technology, Dance, Participation.

1 Introduction

This paper describes the participatory art project *Subway* that used cell phone technology to combine different forms of mediated performances in Iran and the United States into a shared dance piece. Based on a collaboration between performance artist Ava Ansari and digital designer Andrew Quitmeyer at the Digital World and Image Group, *Subway* involved numerous performers in Iran, New York, and Atlanta who contributed in an asynchronous dance performance with the help of an Android cell phone application.

The goal of this collaboration was not to add technology to an artistic practice but to build on an existing performance art and create a new responding piece that uses the technology as a transformational tool.

1.1 Building on Technological Affordances

Communication technology has been credited to support powers for social change in various forms. Because communication is so important in shaping a political climate, repressive regimes often aim to control it in the form of state-run TV stations or censorship of press. However, digital communication channels such as cell phones and online media can be difficult to control. Their flexibility adaptability force some local powers that want to suppress any activist communication to switch off certain services completely. This shut-down behavior by authority against new media has

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been observed in many protest situations from San Francisco subway stations [1] to the Arab Spring [2]. However, how significant digital media's role in these movements really was is debated. "When Wael Ghonim, a major figure in cyberactivism in Egypt, stated in an interview with CNN days before the ouster of Hosni Mubarak, 'If you want to free a society just give them internet access' (Khamis and Vaughn, 2011, p. 1) he was probably exaggerating" [3].

Without denying the important role of those technologies in activism, the goal in the project presented here was not to form a general communication channel. Providing "access" creates the possibility for communication and collaboration but those opportunities itself still need further facilitation to evolve, a discursive framework. These channels by themselves are not artistic expressions, because they allow expression of countless perspectives. For example, mobile phones are used by political activists representing opposing intentions at the same time. While they support conversation, they do so technologically and without any regard of the context. They contain a rhetoric logic in their functionality – but how this logic is applied remains open. To design channels that foster conversation as participatory art practice a framework is needed [4]. Thus, the goal of the here presented work was more specific: How can mobile technologies and digital media be utilized to create participatory artistic political expression?

This calls for a project design that builds on the affordances of mobile devices as facilitators for such a political artistic engagement. Among the particular qualities of these technologies is their ubiquitous presence, availability of shared technological platforms across boundaries, and wide-spread accessibility. These technologies also support various modes of interaction and documentation: they capture images, videos and sounds, while including additional information such as GPS data, time stamps, and personal tags. Therefore, these features laid out the technological and design space for our project.

1.2 Evolution

Men and (especially) women are prohibited from dancing in public in Iran. Their expressive freedom is severely limited by this rule. So when Iranian performance artist Ava Ansari moved to New York City she recorded a dance performance as a response to this restriction. In the work, titled "Dancing by Myself in Public," she dances freely, un-announced, and uninterrupted in New York's Times Square subway station. In her homeland, this behavior would be very dangerous and most likely penalized with fines or imprisonment.

Ava's video formed the basis for a collaboration with the *Digital World and Image Group* (DWIG) at the Georgia Institute of Technology. Starting in Fall 2011, with an online meeting between the group and Ansari, Andrew Quitmeyer and other students designed various digital responses to Ava's performance. These included abstractions of the dancing movements, telepresence concepts, as well as projections on bodies and on location. All of them were presented back to Ansari for feedback to inform any re-iterations of the idea. Quitmeyer's design evolved as the basis for the final project, named *Subway* after the location of the initial dance. It grew from Ansari's comment that her original desire was to share her performance with others living in Iran, but that such a practice remained dangerous. The target of the collaboration was to build this connection without explicitly breaking any rules or endangering any participant. The method was to deploy digital technology to transform the notion of dancing itself.

Fig. 1. Still from Ava Ansari's "Dancing by Myself in Public" (2011)

1.3 Concept

Quitmeyer suggested an application where participants would re-create Ansari's original dance through a series of discrete poses. Each frame from the video of her dance would be abstracted and used as a visual overlay in a custom photo-taking app. Pairs of participants in Iran would take the app out into public areas and capture images of themselves aligning to the overlays in static poses. The pictures would be returned and re-assembled to re-form Ava's original dance moves but set frame-by-frame in Iran. Incorporating Ansari's feedback, the same approach was used to include entirely new "freestyle" poses from Iranian artists as notations for dancers in the US – a feature that was included but will not be the focus of this paper.

Subway, thus, deals with the mediation of dance but transforms the role of the media from a uni-directional online video to a bi-directional photographic exchange. It also plays on the ubiquity of cell phones – even in Iran – because the performers could stage their pose as an inconspicuous snap shot typical among friends who feed images like these regularly into their Facebook, Flickr, or Twitter accounts. These shots have become familiar moments of the connected and digital literate urban lifestyle.

Finally, it builds on an Open Source philosophy as the custom application was produced in the Android system, which allows for easy publication and code sharing. This was important for the project, because participating performers in Iran had to remain anonymous to avoid possible retribution, so the distribution, installation, and de-installation of the software had to be simple and sidestep more limited, centralized, and monitored formats.

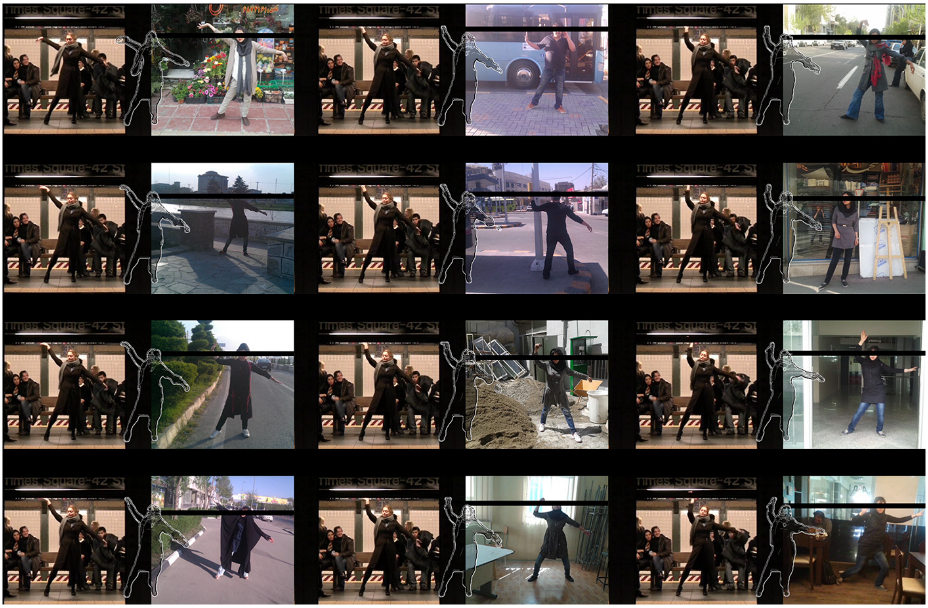

Fig. 2. Stills from the final artifact illustrating the concept. The performance is remediated via a digital arbitrator.

2 *Subway* App: Design, Methodology, and Implementation

A fully functional app had to be designed to bring Andrew's suggested concept to life. The implementation of this design in an effective, yet safe manner would need to deal with several given and some unforeseen constraints.

2.1 Pose Generation

The only record of Ava's original performance in the New York City subway, was a web-hosted Vimeo video originally created by Jian Yi.[1] The original recording was inaccessible. With Ava and Jian Yi's permission, Andrew downloaded a high-quality copy from Vimeo, and used this as the basis for generating the abstracted poses. He brought the video into Adobe After Effects CS5, and traced the contours of Ava's dancing body. This practice enabled him to carefully segment Ava's image from the background in each frame. Images of these poses from each frame could be used to match bodily movements for the re-enactment. However, photographic representation of a dancing woman could lead to charges of possessing "pornographic material." Thus, the visual design of our poses had to deal with opposing constraints: Distorted enough to get by the arbitrary authoritarian distinction of "pornography" while identifiable enough for participants to correctly align themselves.

[1] "Dancing by myself in public," Ava Ansari and Jian Yi. `http://vimeo.com/34677426`

Fig. 3. Stylized poses to meet the conflicting criteria of relate-ability and distortion

The resulting design takes the photographic poses, and processes them as layers of styles intended to abstract the bodily form. Each of these abstracted poses is saved as a semi-transparent .png file with a label including the original frame number.

2.2 Application Development

Platform and Technology

A custom Android app was developed to enable the distributed performance. The Android platform was selected for its open-source nature. Whatever art piece we created, we intended to release it as freely as possible. Even more important in selecting Android was its relatively broader means of distribution. Like Apple's iOS, Android has central repositories for sharing applications: Google Play or the Amazon Appstore for Android. But the platform also permits independent distribution and installation. One can use the compiled programs on Android devices as zipped .apk files in many different ways. This ability was essential to our design.

The Android app itself builds off a simple camera app featuring a viewfinder and snapshot button. On top of this, users can enter their anonymous user number into the app, and their assigned target poses will overlay the video preview. Finally, it also includes the mode-selection button letting the user quickly switch from the "Match" –style performance to the less conspicuous "Freestyle"-mode. This app was designed to work for any camera-enabled Android device including tablets and phones (compatible with Android 1.6 and higher), and thus needed to restrict the aspect ratio for the varying embedded cameras in order for the final results to correctly match-up.

Distribution Design

The app was created with various deployment and retrieval methods in mind since Internet connections in Iran can be sketchy and state-run censorship sometimes block standard methods of distribution. Hence, we designed it to compress down to 9.6MB, making it small enough to fit under the common 10MB attachment limit for emails. In the worst case of complete internet cut-off, it also permitted participants to copy the app onto inexpensive thumb drives for physical distribution. After participants installed the application on their mobile device, they would collect their assigned poses. Then, they returned the generated images in a similar fashion, uploading to servers, emailing, or physically mailing the data back to Georgia Tech. In the end of this particular instance of the project, using several large Gmail accounts seemed to work best to discretely channel information back and forth.

Image Allocation Design

Another key factor to the app's distribution was the allocation of groups of frames to specific, yet anonymous individuals. Hundreds of frames needed to be re-posed. As a result, we could not expect every participant to collect every single pose but had to find a way to split the involvement. For privacy and security reasons, we also could not follow the traditional digital app design where users would sign-up to a centralized service that intelligently assigns specific frames to specific individuals. In many ways we needed the opposite of a viral social media platform. We settled on the design of a redundant app containing all possible poses, but assigning a chosen few to specific individuals. Technically, every copy of the program contained all 1000+ frames needed for the project. Participants entered a user number, which defined a specific set of random frames for them to perform. Anonymous users distributing the apps amongst themselves, then simply needed to keep track of what user numbers had been completed, and which still needed performers. In this way, highly-participative interactors could fulfill as many frames as they wished (by choosing more user-numbers and unlocking more frames), and participants who were unable to fulfill their allotted frames could have their anonymous user-number re-performed by others. All this would be possible largely independent from each other. Using this method about 98% of the total frames were enacted and returned for recompilation at Georgia Tech. There was only a 5% overlap of data. Ultimately, the design was effective to engage contributors and the distribution as inconspicuous as possible.

Interaction Design

Although the project did not break the underlying rule directly – it did not call for a public flash mob dance performances, for example – the underlying intent of the project was still subversive. Thus, the interaction design had to be adjusted.

Fig. 4. a) Members of the Digital World and Image Group testing the performance of an early version of the *Subway* app. b) Close-up view of "at-home" testing.

Once the app was in an early state, we prototyped the entire process, simulating distribution, use, and data return, with the group at Georgia Tech. One key factor we discovered was that the size of the overlay directly affects the distance between the participant pair. The further apart a pair stood while directing and aligning bodies to templates, the more noticeable they were in a crowd. Thus Andrew worked to maximize the size of the visual overlay within the bounds of the performance on the screen. In these early tests, a concern was brought forth by Ansari about the potential hypocrisy of forcing the Iranian participants to only match her performance. While the pose-by-pose participation in the dance was a key concept of *Subway*, it remained directed only from the original "Dancing by myself in public" video to its re-enactment. The re-enactment frame-by-frame is a new form, different from the first dance and not a mere re-creation. However, the artistic creative contribution of the Iranian performers needed to be clearer supported. Therefore we added an additional "freestyle" mode to the application, which removes the overlay, and lets participants pose in any manner they wish. Ansari will use collected "freestyle" images to inform a second dance in in the US. The goal is to mediate a dialog between the participants in both countries. The final outcome of the project, thus, is twofold: the continuous dance re-assembled from the individual images following the original movement; and a collection of freestyle postures of anonymous Iranians in public places that will guide a new dance performance in the US.

2.3 International Performance

The entire performance of *Subway* spans two countries and features actors in very different, specialized roles. "Dancing by Myself in Public" was originally produced 2011. The design, implementation, and re-iterations of the *Subway* project were conducted in 2012. The Iranian participants and performers collected the necessary frames over a period of approximately 10 weeks. Those were assembled to form the final product of this stage: a 4-minute video of the collected frames and documenting the creation process. This video is a trace of the actual event that was realized through the participation of performances in New York, Iran, and in technology.

Fig. 5. Sample stills of the Iranian performers posing in public for the dance re-enactment

3 Conclusion

A key element of *Subway* was the use of technology not as addition or amplifier of existent art practice, but as a transformative force in a collaborative art piece. To achieve this, the project combines different forms of performance. Ansari's original dance in the Times Square station exemplifies a form of cultural performance, defined by McKenzie as “the living, embodied expression of cultural traditions and transformations” [5]. Exactly this option is not available to the Iranian participants. That is, why the cell phone application acts as a form of technological performance, for which McKenzie emphasizes the computer’s role, as “[t]he computer not only performs, it helps produce performances of other products and materials” [5]. In the case of *Subway*, the technological performance is achieved by the design, implementation, and usage of the Android app. The performance of this app is to be understood as the necessary hinge that combines the different dance representations to a new result. It deconstructs the video, uses the resulting elements as creative cells, and reconstructs the results into a new moving image piece. Auslander has questioned whether “live performance is a specifically human activity” [6]. The role of media as a connection between the Iranian and US American performers demonstrates a form of asynchronous live-ness that defines the *Subway* project. Through this particular design, it manages to criticize restrictive practices and foster the dialog between artists in both countries. Ultimately, the project harnesses both, the expression of human performers and of mobile devices to achieve a participatory political artwork.

Acknowledgments. This project was dedicated to, and made possible only through the courageous help of numerous, anonymous Iranian performers. Additional help was given from Molly Kleimann, Jian Yi, Kitty Quitmeyer, Taeyoon Choi, and the members of the Digital World and Image Group.

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Exhibiting Poetry in Public Places Using a Network of Scattered QR Codes

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Abstract. Our goal was to remove poetry from its usual setting, exhibit it in public places and let the unsuspecting citizen engage with it in a way that he is unaccustomed to. We thus came up with codepoetry, a poetry game in the city. A large number of QR barcodes, spray painted on walls around central Athens using a large metallic stencil, tempt passers-by into scanning them using a smartphone in order to reveal a random poem from a curated online collection to which participating modern Greek writers and members of the public have contributed. The experience is further enhanced by allowing visitors to leave comments underneath the verses. The public context in combination with the use of smartphones and the feeling of playful discovery, helps familiarize the audience with poetry and demystifies this form of expression.

Keywords: Quick Response code, QR, poetry, street game, smartphone, mobile, scanner.

1 Introduction

Even though there is a number of people that read and write poetry in Greece, the vast majority are left with a distorted impression of this literary medium emanating from their school days. Poets are commonly beatified and poetry is often associated with beauty, rhyme, wordplay or esotericism rather than a wide range of emotions, imagery and style in tune with the times. The academic experience of many and the prevalence of prosaic approaches to reality leaves most with little appetite or aptitude to experience a poem, let alone create one.

Our primary goal was to reconcile the public with poetry by raising its awareness and to promote a reflective dialogue with space. To achieve that, we decided to showcase verses in an original way on public surfaces. In other words, we wanted to take poetry out of its traditional setting and into places where people don't expect it to exist. To achieve that on a relatively big scale we combined smartphones, Quick Response (QR) codes and the internet to create a distributed game of poetry in the city. Scattered QR codes invite you to discover the poetry hidden in unexpected places and with the help of a smartphone the scanned QR leads you straight to a random poem from the constantly updated,

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curated, online collection. To further enhance the experience we allowed visitors to leave comments underneath each poem or to send a message directly to its author, even anonymously.

Realizing that the QR code contains a poem, before its actual content is read, is enough to change, even temporarily, the lay impression about poetry. Combining the elements of discovery and decryption along with two seemingly incompatible concepts such as poetry and technology, takes members of the public by surprise and positively predisposes them to the random poem that they are served, making its reading more likely. From web page analytics and various forms of feedback from the public one can conclude with some certainty that our effort has somewhat reconciled the unsuspecting receiver with this form of expression.

2 Poetry in Public Spaces

In antiquity, when oral traditions were strong, poetry was used to strengthen communal ties, teach moral values, relieve people from sufferings and even combat oppression. At that time poetry was at the center of public life. With the advent of written tradition, poetry was gradually displaced to a more private sphere. There have been few attempts to place poetry again more prominently in the public realm. Some of these are examined below.

2.1 Poetry on Public Transport

Starting in 1986 some of the advertising space on carriages of the London Underground was reclaimed and short poems fitting in small carriage panels have been displayed. Judith Chernaik first came up with the idea and along with her small team continues to choose the verses that will go up. They make their choices for a wide range of passengers, selecting poems from antiquity, new voices from English-speaking countries around the world, as well as translations. The endeavour has been praised extensively and has been extended to London buses. Perhaps unsurprisingly, it has been adopted by cities around the world such as Dublin, Paris, New York, Vienna, Stockholm, Helsinki, Barcelona, Moscow, St. Petersburg and, most recently, Shanghai and Warsaw [1]. As the creators themselves have noted "Poetry thrives on paradox, and the poems seemed to take a new life when they were removed from books and set among the adverts" [2]. The best poems have been printed on paperback (now in its 11^{th} edition) with the ninth edition of the collection selling an impressive 250,000 copies [3]. On some occasions, such as in Paris, open competitions were held offering to display the winning poems on public transport panels.

In our native Athens, in 2011 and for a whole month, the National Book Centre of Greece (under the auspices of the Ministry of Education) decorated the insides of trains, buses and other means of transport with verses of Odysseas Elytis, Greece's Nobel prize laureate, in order to celebrate the 100^{th} anniversary since his birth as part of world poetry day.

2.2 Poetry on Walls

Since 1992, in the Dutch city of Leiden, a small group of artists started the project Dicht op de Muur (Poetry on the Wall) where they paint poems from all languages on walls in the city center. They are usually painted along the building fronts and the type and style of the lettering is chosen so as to match the poem. For example, painter Jan Willem Bruins said he chose letters that resembled bird beaks when painting a poem about the voice of birds [4]. The poems are accompanied by plaques with translations in English and Dutch and once again the reaction has been so positive that it has been emulated in other Dutch cities. In 2004 the Dutch embassy in the capital of Bulgaria launched a similar project [5] and other cities have done so as well.

Similar efforts have taken place in Toronto where the city's Poet Laureate launched the "Poetry is Public is Poetry" city-wide initiative to transform public spaces into "an illuminating forum for the written word"[6].

3 Our Approach

Poetry adds a layer of codification on top of language. We attempted to introduce yet another layer by encrypting poems using technology before placing them in public view.

3.1 Choice of Physical Materials

Quick Responce Codes. In order to encode the poems we chose Quick Response (QR) codes. QR codes were developed by Denso Wave, a subsidiary of the Japanese car manufacturer Toyota [7], in 1994 to track vehicle parts during the manufacturing process. Despite their industrial origin, they are becoming increasingly popular in the developed world for consumer goods tracking, entertainment and transport ticketing, marketing, in-store product labelling, digital content downloads, etc [8].

QR codes have certain characteristics that make their use in our project most suitable. Firstly, they are widely adopted as they are an open ISO standard and Denso has chosen not to exercise their patent rights. Secondly, QR codes can be easily scanned. The rise of smartphones has provided fertile ground for the technology to flourish as people effectively carry a personal barcode scanner with them. All widely used mobile platforms (Android, iOS & Windows Phone) offer applications allowing scanning. Thirdly, their great storage capacity and high redundancy allows for strong error correction capabilities (decoding is still possible with up to 30% QR code damage). This is particularly important in our case as the QR impressions were going to be exposed to the elements of nature and resistance to decay was needed. Finally, coupling the QR code scanner with a smartphone makes the use of QR codes particularly attractive. The code itself contains metadata enabling the phones to respond differently to each content type. This way, a website address is passed to the web browser, an audio file link opens the media player and so on.

Fig. 1. The QR code containing the link to the online collection

Fig. 2. Spray painting the QR code using a metallic stencil

We used one of the many online services in order to generate the specific QR code for our project. We chose to encode the QR content with high error correction (level H) in order to maximize immunity to damage and enable robust reading. Even though a QR code can easily store a very long poem, we chose not to encode poems into the QR code itself. Instead, we encrypted a link to the project's page (www.codepoetry.gr) where a dynamically chosen poem is served to the visitor. If we wanted to encode the poems directly into the QR code we would need to prepare a QR stencil for each poem, an impractical act especially in metal (more on this in section 3.2).

Finally, we placed below the QR code the phrase "THIS IS A POEM" and above it, its Greek equivalent, in order to hint at the contents of the QR code and to ease the possible reservations of a suspicious public as to its purpose. Figure 1 shows the resulting QR code.

Stencil and Spray. We originally started by printing out the QR codes on stickers of varying sizes and applying them on surfaces around the city. The short lifespan of stickers along with the greater cost of printing, led us to switch to mainly stencil and spray. Figure 2 shows the application of paint on the metallic QR stencil.

We used free and open source software [9] in order to convert the image of the QR code into a vector-based stencil pattern suitable for laser cutting (see [10] for more details on this conversion). Cheaper alternatives to metal such as plastic, wood and paper were rejected as metal makes cleaning and reusing possible. After spraying over the stencil around 40 times a strong corrosive is applied to scrape off the paint with metallic brushes and resume painting.

As of September 2012 we have put up more than 500 QR stamps in central Athens and some busy peripheral neighbourhoods. We applied most of these in popular, central locations where people go shopping or out at night.

Fig. 3. Using a smartphone to decode the QR code after it has been spray-painted on a wall

Fig. 4. A poem displayed on the smartphone after scanning the QR

3.2 Choice of Software Platform

As mentioned in section 3.1, instead of encoding poems inside the QR code we encoded a web address which leads the visitor to a web service delivering poems. For content delivery we chose Wordpress [11], the free and open source website platform and optimized it for touch interfaces by installing a mobile theme on top [12]. As soon as someone scans the QR code (Fig. 3) the mobile phone detects the URL embedded within it and offers to launch the browser automatically. We found that the experience is so seamless that most people believe the poem is embedded into the QR code itself.

As figure 1 shows, we did not include the web site address in plain text for passers-by that did not own a smartphone or did not know what a QR code is. We felt that the specific sequence of first discovering what the enigmatic signs on the walls are and only then decrypting their poetic content, was of tantamount importance. While visitors using their smartphone get a random poem from codepoetry's collection (Fig. 3 and 4), visitors using a desktop computer are redirected to an "about page" with background information on the game instead. Because, we want the site to be discovered and used mainly from mobile devices, we have disallowed indexing by search engines. After all, there are plenty of online anthologies. This was about delivering poetic content to an new audience in an original way.

We felt that each poem should take centre stage on the display screen and as the mobile screenshot in figure 4 shows, the page is designed to be minimalistic. We did not want the reader to be distracted and we therefore placed our project's banner and all relevant information underneath the poem. If the reader remains curious he can read on and learn more after giving the poem a chance.

The ability to deliver dynamic content enables us to add and remove poems as we see fit. This allows for an evolving collection as well as the temporary introduction of a poetic theme to commemorate a historic event or poet. Furthermore, we get to enhance the experience by delivering a random poem each time a QR code is scanned. Randomness is a vital element as it enhances the sense of uniqueness. Each scan of the QR reveals a different poem.

Finally, our decision to dynamically serve the content as a web service has the advantage of permiting interactivity. Visitors to the page may choose to respond to the poem they have just read by leaving a comment underneath it, even anonymously, or send a personal message to the contributing author.

3.3 Choice of Content

While traditional publishing routes often focus on established names in poetry, the nature of our project led us towards contemporary and emerging poets. Having greater affinity for city culture and technology, they contributed poems enthusiastically. Wanting to encourage interactivity between poets and their audience, we made the decision to include only living writers.

What is more, we let the door open to unpublished poets and as a result about 20% of poems in the collection have been contributed by members of the public. The only submission rule is that they must have written the poem themselves and it must either be in Greek or in English. Once we receive a poem we make a personal judgement whether to include it in the collection.

4 Results

The reaction from people to our effort has been very positive and supportive and we assess that with various means.

With about 300 surviving QR stamps across the city we are now getting on average 100 visitors daily, with the average visit lasting a minute and a half. The average number of pages per visit is 2.5. Of these, on average, about 80% are direct hits resulting from scanning the QR code with a mobile phone and 20% come from social networks, newspapers [13,14], blogs [15,16] or other referrals. We expect these numbers to grow as smartphone penetration and QR code recognition rate increases (see section 5).

Because smartphones are particularly popular among the younger generation, who are also more likely to know of QR codes, it is natural that our project has had a greater impact on younger people, a group that would otherwise be less likely to count poetry readers among its ranks. Modern technology and its popular incarnation, the powerful smartphone, has worked like a trojan horse in getting contentemporary poetry known to a young audience.

Allowing, after some vetting, works of unpublished authors to appear on the site has also been quite successful as we receive new material every week, although we try to maintain the percentage to about 20%.

The enthousiasm of the general public is also expressed on the web page by means of positive comments that are submitted regularly underneath each poem. Additionally, as we've made writing directly to poets possible, members of the public have often expressed their admiration for the poems and the medium their authors chose to showcase them. Furthermore, a number of readers has approached us for technical advice as they want to emulate the effort in their city.

5 Future Work and Discussion

We expect traffic to increase as our network of QR stencils and as smartphone penetration rates grow. Export.gov estimates that mobile phone penetration in Greece is at 25% while WIRED magazine puts it at 35% [17,18]. Furthermore, QR code technology is relatively at its infancy. The Pan-European average of people that report using their smartphones for scanning QR codes is at 14.1% [19].

Encouraging people to engage more actively with poetry and public space is one of the mandates of our project. To achieve that we want to give voice to a much greater number of poets. To make that possible, we plan to setup a crowdsourced process for curating the online collection by enlisting volunteer editors. This way we also reduce the bias of the current setup and we prolong the viability of a project with an escalating workload. To further assist us with the latter, we plan to make our QR code stickers freely available on our web site in a printer friendly format.

Realizing the momentum and potential of our project, we decided to expand to other countries. We will soon host international versions of codepoetry and visitors are going to be forwarded to poems written in their language based on their IP address. Embracing the principles of free culture and the free software movement, we plan to setup instructional documents outlining our approach (technical tutorials, printer-ready codepoetry stickers and general advice) to help foreign teams spread poetry in their city.

The dynamic nature of the platform leaves a lot of room for exploration with regards to means of content delivery. Presently, the web page contains text only, but we have been exploring the possibility of including richer material. Audio such as read verses can be easily added to the service and we have been considering the use of augmented reality (AR) technology.

Principles of our technique could also be used to create poetry-based "treasure hunts" in a city. In such a game, a few unique QR codes contain poems, location-specific audio content as well as hints about the location of the next step constituting a poetic tour of a city.

Taking advantage of new media and the city's concrete canvas, we hope efforts such as the above help poetry regain its public voice and enter the civic landscape more dynamically.

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The Soundwalker in the Street: Location-Based Audio Walks and the Poetic Re-imagination of Space

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Abstract. The development of mobile and location-based technologies intensifies media use in public space. Media theorist Eric Kluitenberg emphasizes this emerging trend, as he notes that the city becomes an intensified mediatized space where the modus operandi is carried out almost without thinking. The aim of this article is to show, with the use of location-based audio walks as case studies, how this intensive hybridization of space on the contrary is able to provide new possibilities to engage with space. The power of location-based audio walks is its aesthetic and poetic potential of layering new information over a physical space, while revealing the stories, memories and history of specific physical locations. In doing so, these audio walks can be seen as a poetic act: they draw together human involvement and invite engagement with reality to such an extent that it enters consciousness and it re-imagines space poetically.

Keywords: Hybrid Space, Poetics, Locative Media, Audio Walks, Augmented Reality, Postphenomenology.

1 Introduction

From the moment I plug in my headphones, Farid Boukakar starts to talk. He grew up here in the Transvaal neighbourhood; a part of The Hague I would never have gone to if it weren't for this GPS audio tour called *De Tapes* (2006). While standing at the corner of the Hobbema Square, the city reveals itself. I discover the beauty, rivalry and gossip of Farid's hood. My pace and route define what I hear and piece by piece the stories of the Transvaal quarter and its people come to life. *De Tapes* uses a personal digital assistant (PDA), which is part of the broad ecology of locative media. The term 'locative media' refers to the trend of the integration of location awareness in mobile devices. The development of location-based technologies intensifies media use in public space. As a result, the way people move through space has radically altered in the last decade. How people walk through the city with the use of these locative media changes the way they perceive their surroundings as well as the way they experience their relationship with reality and the world. Media theorist Eric Kluitenberg emphasizes this emerging trend, as he notes that the city becomes an

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intensified mediatized space where the modus operandi is carried out almost without thinking: “customary patterns of spatial behavior, sometimes established over centuries have been obliterated in little more than ten years with the mass-adoption of mobile phone technology”[1]. The question that should concern us, according to Kluitenberg, “is how this new sensibility for an increasingly hybridized spatial multiplicity can be intensified, to such an extent that it can enter consciousness, that it can be re-imagined, poetically – possibly reconstructed or reconfigured”[1].

The aim of this article is to answer Kluitenberg’s call, by showing that this new modus operandi enters consciousness not only when the system is down. On the contrary, this intensive hybridization provides new possibilities to engage with space. In doing so, it is able to re-imagine space poetically. In addition, this article aims to provide a theoretical framework for developers who want to create engaging locative media application and poetic experiences.

2 Poetics of Hybrid Space

The relationship between physical and digital space changes with the intensive use and integration of media networks in ‘real’ places. Kluitenberg’s call towards theorists starts with this intensive hybridization of space. In this article I will refer to hybrid space as the technological blurring of spatial borders with social and communicational interactions, as well as the intertwined aesthetics, cultural and imaginary elements and experience of space. Hybrid space is thus a variety of flows, entities and relationships defined by its dynamics and multiplicity. Having established hybrid space as a multiple entity, it raises questions concerning the density and structure of these flows, because, as Kluitenberg mentions as well, space itself has always been multiple. In addition, virtuality has always been part of it. One can say that space and virtuality have always been hybrid entities in relationship to each other [3]. However, the density of technologies in space intensifies and reveals a greater amount of connections and relationships. It shows that the multiplicity of hybrid space consists of a dynamic flux of connections and relationships. Hybrid space is thus constantly constructed and reconstructed within this dynamic flux.

Within this complex network of relations, I will further investigate the role of memory and engagement, since these elements play a significant part in the experience of space. In addition, Kluitenberg’s call evolves around the trend of disengagement with surrounding space and the lack of modern technologies to enter consciousness while the operator is still on. Kluitenberg searches for a new sort of involvement with space that is able to re-imagine, reconstruct and reconfigure space poetically. He refers back to the concept of poetic imagination of space, coined by the French philosopher Gaston Bachelard [2], because this involves a certain engagement and performativity not only with physical space, but with the aesthetics of imagination as well. The experience of space is thus not merely based on physical objects, but is an exploration of the soul and shaped by memories, thoughts and dreams. The key idea taken from Bachelard is that space itself is performative and plays an active role in the network of relationships of hybrid space. While walking, traveling and interacting with space, it connects and shapes one's memory and in doing so, it can be seen as a poetic act [2]. Bachelard uses phenomenology to understand in what ways space shapes imagination and enters individual consciousness. He refers to this process as poetic imagination, in which the poetic act shows how this imagination enters consciousness [2].

2.1 Mediated Engagement

How then can this new modus operandi enter consciousness in such a way that it re-imagines space poetically while the operator is still on? Dutch philosopher Peter-Paul Verbeek offers a suitable framework to answer this question. His postphenomenology[1] finds its foundation in the multiplicity of relations. It is based on the work of Don Ihde, who centers on the manner in which human beings deal with concrete technological artifacts, and the praxes and interpretations that are made possible by them; Bruno Latour, who understands artifacts as well as humans as active actors in human life and actions;[4] and Albert Borgmann, who focuses on the way technological devices involve engagement, while at the same time these artifacts engage its users as well [5]. This engagement is made possible by actions and shapes human existence.

Peter-Paul Verbeek provides a framework for understanding the role of artifacts in the practice and experience of human beings. This postphenomenological perspective focuses on the mediating role of technology, where reality arises in a network of relations, as do the human beings who encounter it. Verbeek develops a diagram that translates the most important concepts from the existential and hermeneutic perspectives of technology into a postphenomenological vocabulary. This vocabulary consists of three elements for each dimension, these are: the point of departure for analysis; the most relevant human-artifact relations; and the terminology to describe the characteristics of each dimension of mediation.

I will use this vocabulary in my analysis of location-based audio walks because it makes a thorough investigation of specific technologies possible. In addition, it provides a framework to describe technologies not only in terms of their functionality but also as mediating the relation between human beings and their world [4]. The key concept in his approach is thus mediation, as mediation helps to show that technologies actively shape the character of the human-world relations. I will use this postphenomenological framework and vocabulary as methodology for the individual ethnografic analysis of location-based audio walks.

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[1] Verbeek focuses within his framework on the role of aesthetics [4]. However, I will use the terminology of poetics, because the idea of aesthetics in general leans towards visual dominance. In addition, it excludes the role of imagination, memory and dreams within the overall experience.

Table 1. Postphenomenological Vocabulary by Verbeek [4]

Hermeneutic	**Existential**
Experience	Existence
How reality appears to humans	How humans appear in their world
Perception (microperception)	Action
Interpretation	Involvement (effort and focal engagement): - with the artifacts themselves - with the context of the artifacts - with what artifacts make available
Transformation	Translation
Amplification	Invitation
Reduction	Inhibition
Constitution of objectivity	Constitution of subjectivity
Most Relevant Human-Artifact Relations	
Embodiment relations	Embodiment relations
Hermeneutic relations	Alterity relations
Point of departure	
Artifacts mediate perception and context of interpretation (Macro perception)	Artifacts mediate action and context of existence
Experience takes shape as perception interpreted within a context of meaning	Existence takes shape as action involved in a context of existence

3 Location-Based Audio Walks

Technologies like location-based media mediate behavior and perception of space. The significance of these media is the integration of location-based technologies like GPS in mobile technologies. This makes it possible to create specific context for physical locations, as well as to locate one's presence in space. Within the multiplicity of hybrid space, locative media create dynamic relationships between media objects, its users and the physical surroundings [1]. An important characteristic of location-based applications is thus the creation of a doubled perception of space. I will focus this research on location-based audio walks, an artistic niche within the locative media ecology. Audio walks are generally associated with museum and city tours where they replace a human tour guide. However, this research will look at tours that specifically use location-based technologies, create a narrative and are audio dominant. I will refer to them as location-based audio walks. These audio dominant walks involve an embodied experience and move away from the visual dominance of augmented and mixed realities. Audio plays an important role within the overall experience of urban space. The power of location-based audio walks is therefore its aesthetic and poetic potential of layering new information over a physical space, while revealing the stories, memories and history of specific physical locations. In doing so, it provides the technological potential of engagement with the surrounding space.

The blurring of the line between public and private space when talking about location-based audio walks involves private listening in public space. People spend a substantial portion of their time in public space listening to music on their headphones. Media theorist Michael Bull's notion regarding the acoustic bubble in public space should therefore be taken into account [6]. It shows that while wearing headphones, one experiences a single individual spatial experience, which at the same time destroys the perception of external space and location. This brings about that it does not provide the opportunities for hearing space. The acoustics of architecture get shut off with the boundary between the smaller private and larger public acoustic arena, created by the use of headphones connected to portable audio devices [7]. Having taken this into account, I consider these individual listening practices part of my analysis because the aim of location-based audio walks is to provide an enclosed listening experience within public space.

There is, however, a difference in the experience of space between audio that is exclusively created for a specific location and general music tracks heard in the exact same place. The hybridity of the aural experience mediated by mobile music players intensifies when the connection to the physical surroundings is more direct. Whenever the audio heard is linked to the physical location, it is possible to establish an embodied hybrid experience of space that goes beyond a privatized bubble. Audio guides, soundwalks and location-based audio walks are examples of applications that provide information and audio for specific locations. These media do not only offer the chance of a re-integration of the everyday environment into listening, but they also provide an immersive and embodied experience of this environment.

Within this wide variety of applications, this article will use three case studies for further analysis. They are all based in the Netherlands: *De Tapes,* an interactive GPS audio tour for the Transvaal quarter in The Hague by Dick de Ruijter; *iWhisper*, an audio tour platform in Utrecht developed by Monobanda; and *Westergas GPS tour: Ontploffingsgevaar, kolen & cokes* (danger of explosion, coals and coke), an mobile story using the 7scenes platform and developed by UPlabs in Amsterdam. I experienced and analyzed these audio tours between November 2010 and March 2011. All three are audio dominant, use location-based technologies for interaction and are created by different developers with different platforms.

4 Poetic Re-imagination of Space

The location-based audio walks described above mediate the human-world relationship from a hermeneutic and existential perspective. How does this relate to Eric Kluitenberg's call for the poetics of hybrid space? And how then does this mediation lead to a poetic re-imagination of space? Location-based audio walks are, with reference to Albert Borgmann, engaging products: "Engaging products are present to human beings in ways that are neither entirely ready-to-hand nor entirely present-at-hand. While a ready-to-hand artifact completely withdraws from the relation it makes possible between humans and world, an engaging artifact remains explicitly present in that relation, but without demanding so much involvement that it becomes present-at-hand" [4]. This engagement leads to an embodied relation with the artifact: the PDA of *De Tapes* and the iPhone of *Westergas GPS tour* and *iWhisper.*

These pocket size devices are part of everyday life and invite a variety of uses. The different uses also invite different ways of being involved with the device and with one's surroundings. The structure of this kind of mediation involves amplification and reduction, meaning that certain interpretations of reality are excluded (reduction), while others are promoted (amplification). Location-based audio walks move the machinery of the device and often even the device itself to the background. One's geographical position is registered by the device and is used as interface. The result is that the use of location-based audio walks is fully embodied; the device literally becomes an extension of the senses, as the physical location of one's body defines what one hears when walking one of these audio walks. The involvement with the device and the machinery itself is reduced and moves to the background, while at the same time these technologies amplify the embodied relationship.

Verbeek's framework provides two points of departure for the existential perspective. The first is the idea that artifacts mediate action and context of existence, and the second is that existence takes shape as action involved in a context of existence [4]. The existential dimension relates to the involvement or engagement with the artifact itself, the context or surroundings of the artifact, and that what it makes available. The involvement with the artifact itself is reduced to the technology of the device. In the case of location-based audio walks, it relates to the involvement with the location-based technology of the PDA and iPhone and how this involvement influences actions and behavior. The physical location and the context of the surrounding becomes an integrated element of the artifact and the interaction with the artifact itself. From an existential perspective the way in which humans are present in reality is through their actions. Verbeek gives notion of this by stating that "these actions, on their turn, help to shape the ways in which humans can be involved with reality; their involvement can have the form of 'engagement' or consumption'" [5]. This involvement with reality takes form in the involvement with the technological device itself, as well as with the context of the artifact and the commodities it makes available.

In the case of location-based audio walks, the commodities that are made available turn the involvement of reality from a consumptive practice into a form of engagement with reality. First of all, the location-based technologies of the PDA and the iPhone, as used in the cases, evoke a new form of engagement with the surrounding space. When I was walking these different routes they directly linked to the existing poetic imagination of a certain physical location and created an aural experience within the context of the location. In doing so, they amplified the poetic experience of the surrounding space with the imagination and memory of the location. The surrounding world is present through the embodied experience of space consisting of the interactivity of the location-based technologies, the audio through the headphones, the story told, and its connection to the physical space. One of the most important elements in this mediation is thus what the device makes available. In the case of *De Tapes,* this relates to the cultural awareness of surrounding space due to the fictional and realistic narrative of Farid, who tells his story with a comical flare. Meanwhile, the *Westergas GPS tour* shows how people worked at the factory sixty years ago, and provides a realistic historical layer on top of the surrounding space. It brings the personal and historical stories of a certain place to life. In addition, *iWhisper* creates a fictional historical experience, based on certain historical happenings. The dialogues around the Dom Square are fictional, however, situated as realistic.

In each of these cases the involvement, in particular the poetic involvement with the physical location, is mediated through the location-based technologies. The user is present in the surrounding space, and while walking around or standing still listening to these stories, one relates to and is present in ones own personal and public surrounding world. The connection between the embodied experience mediated by the audio walks is directly linked to the physical location, as well as to one's own memories, dreams, histories and ideas, not only related to that certain location, but in general. My knowledge of the multicultural society, the history of the Westergas factory and the history of the Dom Square are also part of this experience. At the same time, each of these case studies makes different use of audio and establishes in different ways an aural augmented reality. They amplify the aural experience through headphones, and in doing so they reduce the sounds of the city itself. They mediate the experience, and the way the world is present as a fully embodied relation with the presented audio, the surrounding and the device.

The reason for being present in space is thus not functional in nature but poetic: it is to experience the audio walk. The action and the way people appear in their world, with the use of location-based audio walks, is therefore an act on its own. The technology invites the user to walk around and inhabit its surrounding. In doing so, it creates a certain involvement with the surrounding space, which is similar to Borgmann's notion of focal practice: "[These] technologies do not alienate humans from reality, but help shape their relationship with it. In doing so, they amplify specific forms of engagement with reality and reduce others. Technologies are the link between humans and their world" [5]. Location-based audio walks engage one in the surrounding space. One is present in one's world by one's footsteps, one's pace, one's route and connection to the surrounding. The action of walking around involves the experience of the city, one's own experience and the memories presented by the narrative of the walk. They do not have to break down to enter consciousness.

5 Conclusion

Location-based audio walks show how an intensified mediatized space is capable to reconstruct, reshape and re-imagine hybrid space poetically. These location-based audio walks are able to engage and connect to the dreams, memories and imagination of its listeners as well as the urban space around it. They are engaging products that mediate the overall dynamic experience of the human-world relationship within the complex multiplicity of hybrid space.

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How to Outreach the External World from a Museum: The Case of the Marsili's Spirit App

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Abstract. A well known critical success factor for any institution (including museums) is its outreach. Outreach, in fact, concerns how wholly unknown people can be connected and attracted by a given institution. Hence, a successful communication strategy includes outreach activities, which very often involve the use of digital technologies. In fact, digital literacy is progressively increasing and, hence, providing a universal language that can be utilized to decode any information that comes from very far. Virtual reality applications have flourished in museums, for example, showing in videos how past cultures lived and prospered. Augmented reality techniques are being utilized to help visitors imagine the appearance of ancient landscapes on site (e.g., the Colosseum at the Roman Empire time), mixing archaeological remains with superimposed graphical representations. Much more can be done, however, taking advantage of the multimodal interactions that can be realized with the use of modern technologies. Among the many possible choices, *gamification* techniques, for example, are emerging as a viable instrument to incentive people to accomplish given tasks. As such, we here describe how we exploited such paradigm to outreach the exterior of a museum. In particular, we here describe the design and implementation of a smartphone app, available on the iPhone App Store since July 2012, whose scope is that of ferrying visitors from the outside to the inside of five of the main cultural attractions of Bologna, Italy. All this has been achieved providing new and additional (also artistic) content, thus departing from any traditional museum guide paradigm.

Keywords: Gamification, Mobile Apps, Museums, Marsili, Bologna.

1 Introduction

While Italy remains one of the most visited countries of the world (it ranks at the fifth place overall in 2011 with over 45M international arrivals), as well as one of the countries that detains most of the artistic and cultural heritage artifacts that have been

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produced by humanity, no Italian museum, inexplicably, reached any of the top twenty positions in terms of number of visitors [1], [2]. These numbers substantially do not change when also considering specialized exhibitions, that have seen Brazil, Japan, Russia and China at the top (e.g., the most visited one was The Magical World of Escher in Rio de Janeiro, Brazil) [3]. Now, although the reasons at the basis of such phenomenon may be several and articulated, including the fact that many museums, being realized in ancient buildings, cannot accommodate more than a given amount of daily visitors, we cannot forget that an ongoing process is changing the way in which visitors experience museums and exhibitions. In fact, museums should not be considered only containers of art and knowledge, more dedicated to the preservation of their treasures than to the presentation of the messages that they carry, but sites where artifacts communicate and interact with visitors, in both traditional (e.g., tour guides) and modern ways (e.g., digital reconstructions) [4]. Referring to the latter, a number of different techniques have flourished to bring ancient times closer to today's world. Such techniques include innovative graphical and interaction mechanisms, but also new means of communication, such as social networks.

A general trend exists where the use of technology is exploited to create a tight link between an artifact and its visitor. When reading the story of the end of Pompeii through Plinius' *tweets* on the "Day in Pompeii" website, a visitor is unconsciously dragged into the past, but with the utilization of an easily comprehensible language [5]. In this way, not only Plinius' words, but also his feelings, are transferred to those that understand the pathos expressed by a rapid succession of alarming *tweets*. Now, far from thinking that the establishment of any tight link between a visitor and an exhibit exclusively needs the use of advanced technology at all times, we observe that also digital interfaces can play an important role in such domain.

Clearly, any technology cannot be successful without a deep understanding of the environment where it will be used. The Italian context, as many others in Europe, comprises a plethora of museums and institutions that are immersed in historical settings, where often the surroundings are themselves part of the general experience that a visitor enjoys. Considering such scenario, and the fact that many travelers visit Italy all year round, we can understand that the problem becomes that of convincing any wandering tourists to enter and explore the institutions they meet along their way. The outreach of a museum can be improved, being aware that it requires effective communication strategies [6]. This means that the stories behind any artifact or exhibit within a museum should be both interesting and appealing to any visitor that moves outside (i.e., out of the comfort zone).

All this can be done, the moment that a common language exists to communicate with all. While no universally spoken language exists since the Tower of Babel, the widespread dissemination of technology has put in place an incredible tool capable of reaching most people, if not all, through common means (e.g., smartphone, computer, etc.) [7]. For example, it is now natural for many tourists to *google* for any attraction or to search for any type of guide when reaching a new place, typically using a smartphone. In such scenario, we considered the opportunity of extending such behavior, with the creation of an iPhone app, *Marsili's Spirit*, that does not implement a traditional museum guide, but acts as a bridge towards a few of the main attractions of Bologna [8].

Now, before providing here some more information concerning our specific app, we should anticipate how we designed such bridge. In fact, we have been inspired by a recently defined application creation paradigm, known as *gamification*, which is now often used to shepherd users to engage in desired behaviors [9]. Unquestionably, games represent a unifying language, as they can be understood and played by most, if not universally by all. For this reason, more and more applications have seen a widespread use of gaming elements (e.g., incentives, competitions, tasks, etc.) to the point that the term *gamification* has been coined to generally describe them all. As we shall see in the following, *gamification* practices, commonly understood as nontraditional challenges and rewards, are here tenuously reinterpreted with the creation of mechanisms that feed rewarding information based on geo-locations.

Anticipating how *Marsili's Spirit* works, we begin explaining its purpose and its reason of birth. In fact, three centuries ago Count Luigi Ferdinando Marsili, a soldier and a scientist, founded the Institute of Sciences and Arts in Bologna. This event is currently being celebrated by the local University and by all those Bolognese Museums (i.e., four museums and a church) that today preserve the historical, scientific and military legacy of Count Marsili. In fact, Count Marsili's personal goal was that of re-shaping and rejuvenating his hometown's University, promoting its attractiveness to the most established and promising scholars of that time through the creation of a new Institute, the *Istituto delle Scienze e delle Arti*, and a legacy that comprised many and many artifacts, of very different nature, collected during his military campaigns. In such scenario and influenced by the magnetism of Count Marsili's story, we aimed at revitalizing his timeless spirit, putting together, in a unique mix, geo-location services, an artistic comic strip, photos of Greek statues, modern paintings, a museum guide, Turkish music and the Count's message to posterity. All this artistic content has been put to good use, utilizing technical means, to arise the curiosity and, hence, the attraction that visitors could feel for all of the involved institutions. In fact, while walking around the city center of Bologna, a user of our app is encouraged to reach any of the five museums, as the artistic information it contains can be accessed only when walking on those premises.

From the technical point of view, our contribution has been that of dealing with geo-localization. The challenge here has been that of contrasting GPS inaccuracies (inevitable with smartphone GPSs), which would have jeopardized a consistent behavior of our app: two successive GPS readings could place a static visitor at two different locations, meters and meters away one from the other (effect of urban canyons). Hence, with the implementation of a naïve localization scheme, only based on the current GPS location, the app could have detected itself, in the most extreme case, alternatively near and far from a museum (with its behavior oscillating accordingly). In order to deal with such problem we devised an algorithm, based on the use of two concentric circles, that delimit the positions where a user enters/exits a given site: a user reaches a site only when entering the inner circle and exits it when leaving the outer one (the difference between the radii of the two circles creates a safeguard against any possible GPS inaccuracies). This mechanism guarantees a consistent app behavior also inside the museum buildings, locations where smartphone GPSs experience the most severe positioning errors.

The remainder of this paper is organized as follows. In Section 2 we will provide more information regarding Count Marsili and the legacy that he left to the city of Bologna. In Section 3 we describe some of the most relevant *gamification* experiences in the context of a museum and move on to *Marsili's Spirit*, highlighting its innovative aspects and differences with respect to the state of the art. We finally conclude with Section 4.

2 The Marsili Legacy

As anticipated, Count Luigi Ferdinando Marsili was a soldier and a scientist, as well as a visionary and a philanthropist that greatly cared about his hometown, Bologna, and its local University. For this reason, when realizing that Bologna was losing its central role for European culture, as the brightest scholars and scientists of that time were more attracted by other cities (e.g., London and Paris were more open to new ideas and new people), Count Marsili decided to spend his time and resources striving to revitalize the Bolognese academic community. His project was partially carried out enriching the University of Bologna of collections of any kind, amounting to books, instruments, models, antiquities, fossils, etc. Such collections were accumulated during his many trips, due to both his many military campaigns around Europe as a Habsburgic army commander and to his scientific explorations, which were driven by his personal interest for astronomy and oceanography (Count Marsili is considered the founding father of modern oceanography). However, Marsili also wanted to motivate the local society by other means, with the establishment of the local *Istituto delle Scienze e delle Arti*, which, following the example set by other prestigious academies (e.g., the English Royal Society), would serve as a gathering place for the best European minds and, as such, as an important stimulus for the local University. Certainly ahead of his time, he saw within the progress and sharing of knowledge the engine of human prosperity. Whether Count Marsili's project ended being successful or not at his time is hard to say. However, beyond any doubt, he left an important legacy to all the generations of Bolognese students and inhabitants, through the collections he donated to the University and that are now owned and displayed by the main city museums, and through his spirit, which has kept alive throughout the past three centuries thanks to the existence of his Institute. His motto was *Nihil Mihi*, nothing is for me, and he kept his word leaving everything he had to his hometown. It is because of this extraordinary story of life, of generosity and of knowledge that the museums of Bologna decided to celebrate Count Marsili, beyond the celebrations that would be held for the three hundred years since the creation of the local *Instituto*. In the following we will describe how all this was interpreted with an app whose role has been that of leading tourists and visitors to Marsili's sites.

3 Marsili's Spirit

Before moving on to describe *Marsili's Spirit*, we discuss a few examples of how *gamification* has been utilized within museums [10], [11], [12], [13]. Museums, in fact, have abundantly used *gamification* as a way of: (a) teaching concepts, and, (b) revealing artifacts. The former use has been particularly exploited throughout science and technology museums, as games often offer a suitable way of teaching concepts that would be otherwise hard to grasp. However, *gamification* is pervasively reaching all types of museum contexts, for its high potential in capturing attention and transferring information to visitors. An example is given by the companion game to the exhibition - *Denaro e Bellezza* - held in 2011 in Palazzo Strozzi, Florence [10]. Such installation, played from a set of touchscreens, taught visitors how money and goods flowed in Europe during the Renaissance time, through the implementation of a monopoly-like game where each visitor could impersonate a different character (e.g., a Florentine merchant, etc.). While playing, a visitor could earn or lose virtual money and learn how business was run. Another scope that *gamification* has often served is that of a mediator between a visitor and a hidden artifact. Often, in fact, the display of an exhibit is not possible, for various reasons (e.g., it is being restored or borrowed by other institutions). Hence, in such cases, the only way of presenting an exhibit is through its digital representation. However, more and more frequently museum curators opt for installations where visitors can interact and play with hidden artifacts rather than only viewing their digital representations. An example is given by the *Mercator Atlas Robot* installation where visitors could explore a book and its beautiful maps, Mercator's Atlas 1630 print, utilizing gestural interactions [11]. Without such solution the book would have remained inaccessible. Now, it is clear that *gamification* paradigms have been thoroughly experimented within the walls of a museum. The same cannot, instead, be said for the outside world that is usually considered out of the jurisdiction of a museum. We aimed at including the outside context, as that is where potential visitors can be found. Our smartphone app, hence, has been conceived as a ferry that could take new visitors to any of the five involved institutions, breaching the walls that separate those sites from the outside world. This has been achieved designing and implementing a geo-localized app that behaves according to its location of use. In fact, the app executes differently if run in Bologna (i.e., within 5 km from the city center), or outside the city center. When in Bologna, any content that is related to one of the Marsilian sites becomes available only when entering its immediate surroundings. This means that, while on Bolognese grounds, a visitor that is out of an institution's range, say Palazzo Poggi, can only see an advertisement flyer (i.e., a representative image with a caption) related to that institution. When inside, instead, all the content related to that site becomes available. Hence, a tourist can access all the information that the app offers only visiting all of the Marsilian locations. This was done: (a) devising an interface that behaves depending on its location of use, and, (b) designing and implementing a mechanism that efficiently and reliably decides whether a visitor has reached a given museum or not. In Figure 1 we show the graphical interface of our app that is location dependent. In particular, after a few moments spent on the initial landing page (leftmost part of Figure 1), the app presents itself as in the central part of Figure 1. On that form it is possible to individuate six different buttons, five related to the five Marsilian institutions (i.e., Palazzo Poggi, Medievale, Archeologico, Accademia, S. Domenico) and a sixth one (i.e., Marsili's Spirit) that leads to a general information page. While in Bologna, one of the five buttons becomes orange (rightmost part of Figure 1) the

Fig. 1. Left: landing page. Center: initial page. Right: app interface at Palazzo Poggi.

moment that the localization mechanism detects that the smartphone has reached one of the five Marsilian sites (Palazzo Poggi in this case). The question now moves to how an efficient localization mechanism could be put in place. GPS inaccuracies, in fact, could jeopardize the correct individuation of a smartphone's location: for example, the smartphone is detected inside a museum at some moment in time and outside just a second later. Such unreliable behavior would prevent a user from utilizing our app, as it would be acting in an unstable way (e.g., the orange button in the rightmost part of Figure 1 would turn on and off, continuously). We solved such problem, as follows. First of all, we assumed that GPS errors could be high, but always within a limit, also when experiencing harsh conditions (e.g., urban canyons) [14]. We then chose a safeguard distance equal to 150 m, as such value can adequately deal with those situations where a smartphone falls out of satellite coverage (e.g., inside a museum). Hence, we drew two concentric circles for each site, a first one with a radius equal to 50 m and a second one with a radius equal to 200 m. The inner circle represents an entrance gate to a museum: when inside that circle, the app detects that the site has been reached. That same gate, however, is not used as an exit, as it is the outer circle that represents the exit gate. In this way, when a smartphone enters a site, it becomes impossible, or at least very unlikely, that a GPS error positions the smartphone outside of the outer circle (over 150 m away). Same behavior when leaving a museum: once outside of the outer circle the inner circle it too far to be reached and hence the app behaves stabily. Now, remaining faithful to the *gamification* strategy, Marsili's Spirit has been provided with new and original content (also artistic) that served as an incentive and reward to those who visited each of the given sites. In fact, the design team truly committed to Count Marsili's legacy, endowing the app with novel and interesting content, hence departing from the typical museum guide paradigm. Let us consider one example, for the sake of brevity. When visiting Palazzo Poggi (the venue of the *Istituto delle Scienze e delle Arti*, the site that stores most of the printed treasures that Marsili collected), a user discovers a novel and original motion comics (i.e., comic dialogues are animated) that depicts Marsili's hunt for ancient volumes in Buda, during the city siege. In particular, in the leftmost part of Figure 2 we find the cover page, showing an original drawing of Marsili and the title, "Buda 1686". In the central part of Figure 2 Count Marsili is represented while running across Buda's ruins, whereas in the rightmost part he is depicted while saving a volume from destruction.

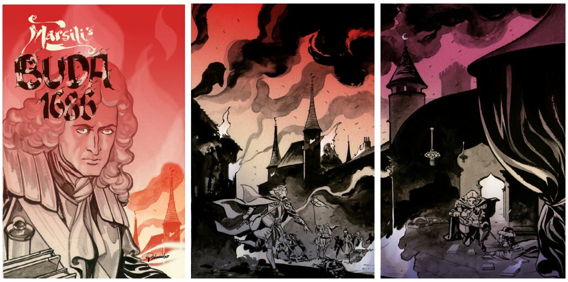

Fig. 2. Motion comics at Palazzo Poggi (left: title, center: Count Marsili in Buda, right: Count Marsili saves ancient volumes from destruction). Courtesy of Giuseppe Palumbo.

Figure 3 reveals how the story ends. In its rightmost part we see Count Marsili asking for help, as fire is endangering the library that he discovered during the siege. In the central part he is represented while arriving in Bologna, with the treasures collected during the Hungary military campaign. The story happily ends with the third illustration (rightmost part of Figure 3), where students and scholars are shown inside the Palazzo Poggi library, studying the volumes that Count Marsili saved.

Fig. 3. Motion comics at Palazzo Poggi (left: Marsili calling for help, center: Marsili in Bologna, right: the volumes Count Marsili saved enrich Palazzo Poggi's library). Courtesy of Giuseppe Palumbo.

A similar mechanism works at each of the five sites. At the Museo Civico Medievale, the app displays a high definition version of Ottoman warrior prints. At the Accademia delle Belle Arti it is possible to browse the exclusive paintings realized by a few leading Bolognese artists. At the Museo Archeologico, a museum guide is provided in the form of a timeline for the Etruscan, Egyptian, Greek and Roman periods. Of great poetic and emotional value is the message that Count Marsili donates to posterity, once the church of S. Domenico is reached. Concluding, the Marsili's Spirit app provides new stimuli to visit the city of Bologna, based on the simple idea of putting modern technologies at the service of culture and society [15].

4 Conclusion

We here presented Marsili's Spirit, an app that has been realized for five museums and churches of the city of Bologna, Italy, in occasion of the celebrations of the third hundred years since the creation of the local *Istituto delle Scienze e delle Arti*. The app implements a *gamification* paradigm, where artistic and rewarding content becomes available only when close to any of the involved institutions. Available on the Apple App Store, it has been downloaded, to this date, by hundreds of visitors.

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Exploiting Latest Technologies for RF Sounding's Evolution

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Abstract. In this paper we present the most recent technological innovations introduced into the artistic installation we called *RF Sounding*, keep on maintaining our fundamental goals: creating an artistic installation that can be used for educational purposes as well. Indeed we have been inspired by the impossible human dream of flying that we reasoned on the acoustic dimension. We decided to make the inaudible, audible by a translation in the audio bandwidth of signals coming from cellular networks. We thus want to provide the user, entering the specifically defined area, with awareness of radio frequency signals characterizing the cellular networks band. With respect to the prototype presented in previous papers we finally exploit the information coming from a spectrum analyser, thus taking into account also the whole uplink, and position data acquired from a Microsoft Kinect in order to realize localization inside the equipped area, without the need for the users to wear an active device.

Keywords: RF propagation, audio, localization, sound spatialization.

1 Introduction and Motivations

Starting from the industrial revolution, technology has become a core aspect of many artistic expressions that have been collected into the term Multimedia Art [1]. Making an overview of the concepts and varieties of expressions related to this term is something beyond our purposes and thus we focus on the main aspects of our work. RF Sounding is an artistic installation inspired by the limitation of human senses, that can also be exploited for educational purposes. Indeed it is substantially based on the translation into the audible bandwidth of radio frequency (RF) signals coming from cellular networks and the exploitation of a localization system to implement sound spatialization (see [10] for an exhaustive list of possible algorithms). This open platform and its parameters (e.g. amplitude, frequency, position) can be exploited as an interesting opportunity for modern music composers which will be called to introduce a proper signal processing on revealed RF signals. This way, users are able to play their own compositions through their mobile phones by doing common actions (e.g switching on and off the phone, making a call, using internet, sending an SMS) and the result is dependent on constrains set by the artist that configured the system. The possibility of listening to RF signals allows the users to increase their

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awareness of the spectral occupancy and emitted powers of phenomen aarising while using the services of a certain cellular network. Concerning the idea of translating radio frequencies into the audible range, it is worth noting that our procedure in somehow different to the widespread concept of auditory display and its subtype called sonification, [2]. Indeed while auditory display is based on the use of sound to communicate and non-speech audio is used in sonification to represent information, the procedure used in RF Sounding is a mere translation (with proper adjustments that will be discussed later) of RFs in the range of audibility. Nevertheless, in recent years, there has been a rapid increase in research related to the various ways in which sound can encode meaning, [3]. Even if we try to maintain a proportion between RFs power and sound amplitude, our procedure does not yet belong to this area of research, although it is necessary to objectively evaluate the quality of the user's experience through the development of proper quality metrics, as it happens for images and videos [4]. The use of cellular networks in artistic expression is not a novelty. Golan Levin's *DialTones* performance is one of the earliest concerts which used mobile devices as part of the performance [5]. Authors of [6] use accelerometric and GPS data coming from the recent smart phones to generate sounds. Many other examples could be proposed but, to the best of authors' knowledge, the direct exploitation of RF signals emitted and received by a cellular phone is a completely new topic. Artists and art researchers have been also investigating the interface of media arts, in an attempt to reveal forms which engage audiences, e.g. [7,8,9]. While some of these works can be used as a platform for other artistic expressions, none has actually an educational purpose as well. RF Sounding is also intended to be used as an open learning environment where students, researchers and common users can increase their knowledge of the strength of the power emitted by their cellular phones with respect to the electromagnetic fields produced in the environment, [10]. The paper is organized as follows: project's evolution and its new underlying technologies are presented in section 2, the translation procedure is described in section 3, details about implementation and overall environment are given in section 4, results and conclusions are presented in sections 5 and 6.

2 New System Overview

The general project for RF Sounding, see figure 1, assumes a scenario comprising a circular area that is accessible through two entrances and is equipped with a wireless sensor network (WSN), an antenna gathering signals in the neighbourhood and loudspeakers to diffuse spatialized sound. Outside the area, a spectrum analyser and a processing unit are in charge of analysing and processing RFs' and positions' data, figure 2. In previous works, [10,11,12,13] we proposed and developed a prototype of the project by using a simple GSM engine tracing only a limited set of channels (*Siemens TC35* [14]), the localization algorithm was achieved through a collaborative target and sound spatialization was simplified in stereophony. The nodes of the WSN we used for localization are the *Crossbow Crickets* [15]. In this paper we make a step ahead with respect to the prototype previously presented, indeed the TC35 is replaced by a spectrum

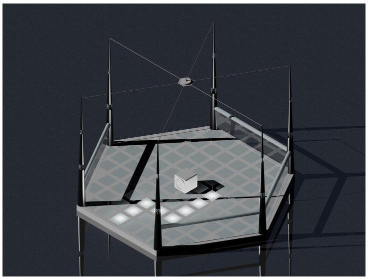


Fig. 1. Axonometric view of the equipped area

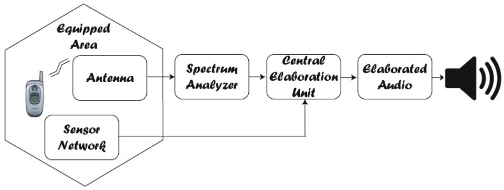


Fig. 2. RF Sounding: old configuration general functioning

analyser and localization is realized by the use of a Microsoft Kinect, [16]. In this way we faced two important issues of our project: exploitation of uplink and downlink channels and passive localization. Moreover two different processing units are connected respectively to the spectrum analyser and to the Kinect, this allows to increase remoteness and system flexibility which in turn could widespread uses' applications. The spectrum analyser we used is an Agilent HP 8592B and it can be connected to an elaboration unit through a IEEE 488 interface commonly called GPIB (General Purpose Interface Bus) interface, [17]. Free Windows utilities that help making and recording research-quality measurements with GPIB-based electronic test equipment are available on the internet. An application written in C-language has been developed to read data from the device. In this way we could trace all the possible activities of RF signals happening within a certain frequency range even if some approximations and omissions have to be done due to the variations' rapidity. Anyway it is worth noting that with the described setting a user that enters the installation area bringing his switched off mobile phone perceives a low intensity acoustic signal that can be associated to RF signals emitted by far sources such as Base Stations (BSs) or other Mobile Terminals (MTs). On the other hand if the user inside the equipped area switches on his cellphone, he will sense a much higher acoustic signal due to the cellular procedures the MT and BS will carry on starting from handshaking, [18]. Microsoft Kinect's impact has extended toward researchers and practitioners in computer science electronic engineering and robotics due to its wide availability and low cost. Depth cameras are a rich source of information for indoor localization and Kinect sensor provides a valid alternative to other available sensors, such as the Cricket Indoor Localization system we used in previous prototypes, in particular due to its high performance compared to the price and the easiness of use. The availability of an SDK has pushed a lot of experiments and applications by researchers and followers.

3 From Radio to Audio

Basing on ITU Radio Regulations, [19] the radio spectrum comprises frequencies in the interval $[3.0, 300 \cdot 10^9]$ KHz. The bandwidth defined by such an interval is so widespread that we were obliged to focus our interests toward a subset of the radio frequency range, that is the one characterizing cellular communications (GSM and UMTS) and WiFi. It follows that with respect to [10] we take into account also the bandwidth between [2400, 2483.5] MHz. Radio frequencies for the considered standards are subdivided as represented in figure 3 where frequencies' gaps are also pointed out. Since the human auditory system is able to

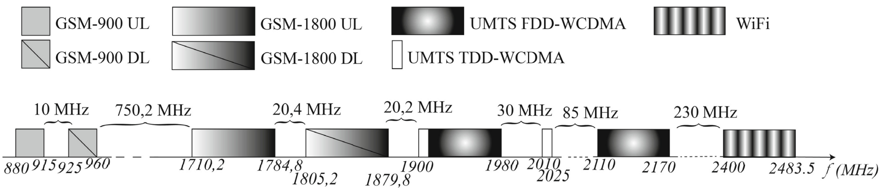


Fig. 3. Frequency allocation

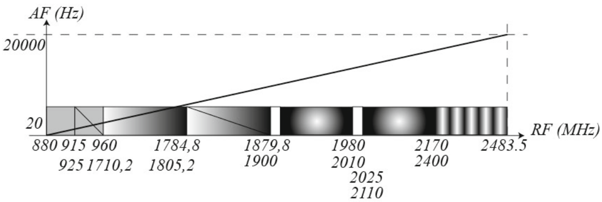


Fig. 4. Assumed relation between AFs and RFs

sense a range of frequencies between 20 Hz and 20000 Hz, the bandwidth offered by just one of the previous RF standards exceeds the audible range by some orders of magnitude. Moreover it appears to the authors that the easiest way to make a conversion is by linear relationships and this causes the need of an approximation of the gaps between each RF band. Indeed, in order to not loose audible bandwidth, we decided to count out the gaps and to establish a linear correspondence between audio frequencies (AFs) and RFs as shown in figure 4. A similar linear relationship was established between RFs powers and sounds amplitudes.

4 Design Environment and Open Sound Control

In order to connect all the devices involved, with the main purpose of increasing system's flexibility and opportunities, we assumed the configuration shown in figure 5. For all the connections, with the exception of the IEEE 488, we used the Open Sound Control (OSC) protocol for communication between the devices involved. OSC is a transport-independent protocol [20] and its format can be used by many software and programming environments for artistic expressions such as Processing [21], PureData [22], Cycling '74 Max [23], etc.; it also allows applications running on different environments and different physical machines to communicate with each other by sending/receiving commands and data. To implement sound synthesis and elaboration as well as sound spatialization we used Max 5 [23], a visual programming language for music and multimedia. Max is based on data-flows: Max programs (called *patches*) are made by arranging and connecting building-blocks of *objects* within a *patcher*, or visual canvas. Basing on figure 5, Laptop 1 is in charge of providing Max with data taken from the spectrum analyser. This is achieved by an application that sends proper commands to the device. Received data are treated with some filters and transposed into AFs. The result is packed into OSC messages and sent toward Laptop 3, that is, Laptop 1 acts as an OSC client which can easily communicate over LANs/WLANs. The application we developed uses ieee-488 libraries to control the spectrum analyzer and a modified version of libraries described in [24] to create an OSC client. Laptot 2 acts in a similar manner with respect to the Kinect; it hosts SynapsE [25], a software that allows to easily interface with the Kinect through the possibility of generating and receiving OSC messages. In particular, through SynapsE, we ask (every 2 seconds) Kinect to provide positions' data that are sent toward the server. Finally Laptop 3 acts as an OSC server receiving OSC messages coming from the network. It is equipped with Max 5 and, for our purpose of communication through OSC, we exploit the use of two Max object: *udpsend* to instruct Kinect to track user's *torso*, figure 6 and *udpreceive*, that allows to receive OSC messages through UDP ports, both from our application on Laptop 1 and SynapsE on Laptop 2.

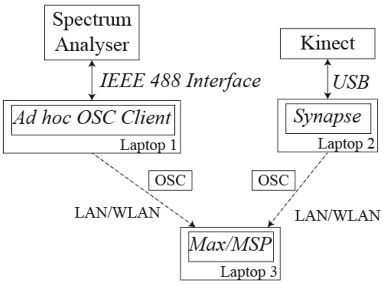


Fig. 5. Logical overview

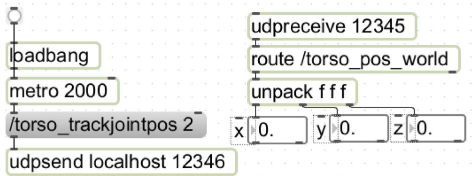


Fig. 6. Max patch used to communicate with Microsoft Kinect

5 Results

We set up a room equipped with all previously presented devices. In order to test the correct functioning of our prototype we used a Max's patch developed for educational purposes, which exploits a simple sum of sinusoids obtained by a 'simple' translation of RFs, see figure 7. Keep on maintaining educational purposes, as a first step toward exploitation of localization data, we set up a virtual border, under the spectrum analyser's antenna, where the users have to enter in

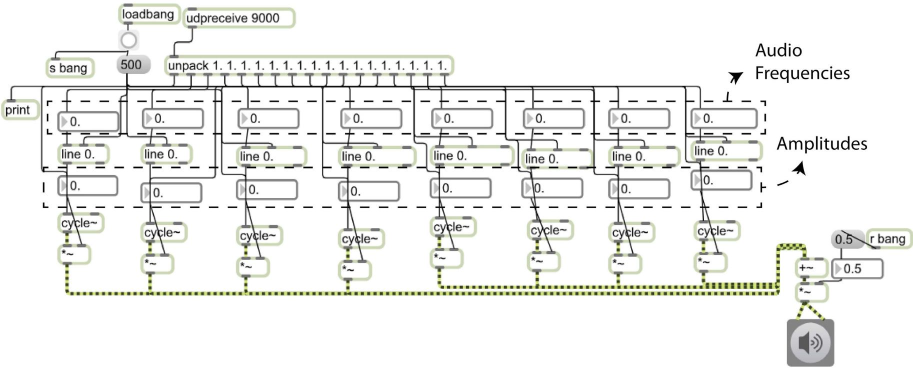
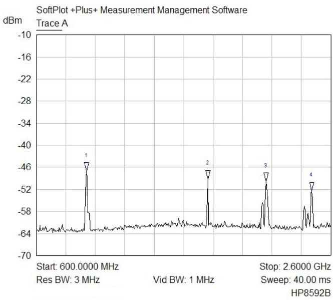
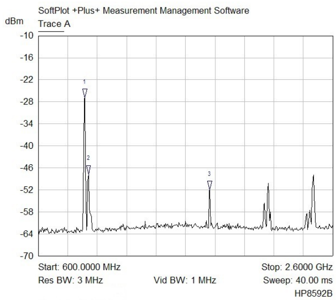


Fig. 7. Max patch used for educational purposes



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Trace A	940.0000 MHz	-47.12 dBm	GSM DownLink
2 ∇	Trace A	1.7650 GHz	-49.25 dBm	GSM UpLink
3 ∇	Trace A	2.1600 GHz	-49.89 dBm	UMTS Activity
4 ∇	Trace A	2.4700 GHz	-52.45 dBm	WiFi Activity

Fig. 8. Background RFs (plot obtained by Laptop 1 from the spectrum analyzer)



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Trace A	915.0000 MHz	-26.93 dBm	GSM UL (Incoming call)
2 ∇	Trace A	940.0000 MHz	-47.71 dBm	GSM DL (Incoming call)
3 ∇	Trace A	1.7650 GHz	-51.95 dBm	GSM UL (Incoming call)

Fig. 9. Additional frequency introduced at the switch on of a cellphone and handshaking frequency when making a call

order to trigger the beginning of the experience. This way the RF listener (the antenna) and the audio listener (the user) are sharing the same reference point. If the user exits the virtual border, a simple audio spatialization algorithm is applied to follow his movements inside the room. On the other hand if two or more users are in the room, the system does not apply any spatialization to keep the virtual border the reference point for the users interested in appreciating merely the translation effects. We asked the users entering the area to make the following actions: getting inside with offline cellphones, switching on their cellphones, making a call or receiving a call or sending an SMS. Users gathering the specified area could appreciate a background sound coming from the active BSs in the defined area as well as from WiFi signalling, figure 8. When a cellphone is switched on the users could listen to a more loud and fast fading out sound due to the procedure of handshaking, [10], moreover when making a call the sensed sound appears to overcome the background one and rapidly change toward a frequency whose corresponding sinusoid lasts, with high loudness, for the duration of the whole call. Users could also appreciate the differences of RF power levels, and subsequently audio intensities, in a comparison between a common GSM/UMTS call and a call set up with VoIP using WiFi; the latter are lower, especially in uplink. 9 shows the effects of these procedures (obtained by using a *max hold* function). Some RF procedures are so fast to not being appreciable by human ears. For this reason we developed a control algorithm on Laptop 1, fig. 5, that slows down their effects as to make them perceptible by the human auditory system, thus overcoming human limitations also in the time domain.

6 Conclusions

In this paper we presented the technological advances we carried on for RF Sounding project. In particular we focused on the new opportunities introduced by the use of a spectrum analyser and a Microsoft Kinect. Indeed while the first allows to take into account the whole amount of RF channels (downlink and uplink), the second permits to achieve a more precise user's positioning thus increasing the reality of the user's perspective and opening the way to a variety of artistic opportunities. Future works are mainly concerned with the exploitation of Microsoft Kinect potentialities, in particular concerning the opportunity of differentiating more than one user's position inside the equipped area and exploiting facial expressions to change the emitted sound accordingly. Moreover a study on quality metrics will be carried on.

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Giving Robots a "Voice": A Kineto-Acoustic Project

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Abstract. In this paper we present a kineto-acoustic project based on soccer robots. The movements of robots, determined by the needs of a soccer game, are transformed into a piece of music. Therefore, the robots are equipped with microphones, speakers, and custom-designed audio modules. The amplification of microphones and speakers is adjusted to create constantly varying feedback effects. These effects evolve from the relative positions and motions of the robots. Furthermore, data from control computers are utilized for the musical sound modulation. As the sequence of movements is not deterministic the resulting musical structure is unique in each performance.

Keywords: sound art, live electronic music, audio signal processing, robotics.

1 Introduction

The development of human-machine interaction is becoming increasingly important. Extensive research exists e.g. in the field of neuroscience with the goal to emulate human-like behavior and communication for autonomous robots. This is particularly the case in areas such as service robotics, health care, and search & rescue. Enhanced acceptance of these technologies among potential users has to be established, to take on the role as a helpful partner. However, it is also observed that users develop emotional ties to robots that behave independently and intelligently. It seems like the existence of quasi-human behavior also suggests the presence of human feelings. The resulting conflicts and misunderstandings are the basis for the musical and theatrical art project *RoboMusicTheatre* with robots and humans, which will be implemented progressively over the coming years. The project *MID SIZE ROBO SOCCER MUSIC* will expand one scenic idea to an independent kineto-acoustic project for a prestigious international art festival[1]. The foundation for the sound structure is provided by

[1] Festival *Inhuman Music - Music by Accident, Animals and Machines*, taking place from 21st to 24th February 2013 in Haus der Kulturen der Welt in Berlin.

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autonomous behaviors, team coordination, and dynamics of the robotic systems. Therefore, the performance is realized by two robotic soccer teams, which generate acoustic feedback loops.

The paper is structured as follows. Section 2 describes the artwork and the concept of the kineto-acoustic robotic performance. The following sections state technical details of the realization. The audio processing and the development of the needed hardware are presented in Section 3. Subsequently, key characteristics of the applied robotic technology are identified and described. The paper concludes with a discussion and outlook to future work.

2 Artistic Concept

Every sound is the result of motion. The sounds and tones generated by our everyday high-tech environment may be largely irrelevant, often annoying, and the same time inescapable. Nevertheless, sound is the objective of every motion in acoustic arts. However, the type of tone generator is immaterial.

Links exists between sound and motion at an even more fundamental level, for instance with electro-acoustic feedback. In this case, the frequency of the feedback is determined by the distance between microphone and speaker, the resonances in the room, and all devices in the electro-acoustic chain [1].

With this in mind, we developed the idea of using robots of the *Middle Size League* of the *RoboCup* initiative [7] to generate a polyphonic texture of sound. The emerging sound is audibly linked to the motions of the robots, seeming to give them a "voice" while moving as independent players across the soccer field.

The robots are equipped with microphones, speakers, and a custom-designed audio module to form this "robotic voice". The robot motions and individual positions lead to varying feedback effects due to the microphone amplification. Additionally, other data from the robot computers are evaluated for the sound modulation. One example is the distance to other robots in conjunction with the speed of movement. Thus, the movements of robots, determined by the flow of a soccer game, are transformed into a piece of music. Due to the unique motion flow, the sound cannot arise in any other manner and will be different in each performance.

3 Sound Processing Technology

The application of networks for sound production, musical composition, and performance has a long tradition in experimental music and sound art. Related examples are the *League of Automatic Music Composers* [1] of the late 1970s or the contemporary laptop orchestras [2]. While these are still based on a traditional ensemble of individual human musicians, an ongoing evolution of concepts and pieces of art exists, where humans are only partially involved or totally absent. Without human musicians or organizers, different ways to structure music and sound production are necessary. One of the main principles of self-organization in nature is the feedback loop, which has become popular in technology based music and sound art for many decades [3]. Even some of the basic components of sound production use a feedback structure e.g., oscillators and filters.

Self-organized systems based on autonomous agents utilize feedback-loops to create emergent behavior. If the resulting actions incorporate audible effects, the acoustical output and the corresponding behavior like motion patterns might be regarded as speech, musical gestures, or structures.

In order to create a musical structure and to form an ensemble out of the team of machines, we developed a distributed system for sound processing based on portable audio modules and a structure for communication.

3.1 Hardware Architecture of the Audio Modules

Each mobile robot is equipped with an audio module, which can receive, process, and send audio signals or control data. The audio modules work autonomously but are connected to the hosting platform to allow reception of allocentric position and velocity. In addition, there is a main audio processing unit which can send and receive control data from the audio modules of all mobile robots.

The main component of the audio module is a single-board computer (BeagleBoard xM [4]) with a 1 GHz ARM CPU. A small electret microphone capsule perceives the sound of the environment. The microphone is connected to a built-in audio input via a pre-amplifier. This pre-amplifier includes an adjustable noise gate which helps to separate the sound of the other robots from the background noise. After being processed by the software running on the board, the audio signal gets amplified and dispensed by the speaker.

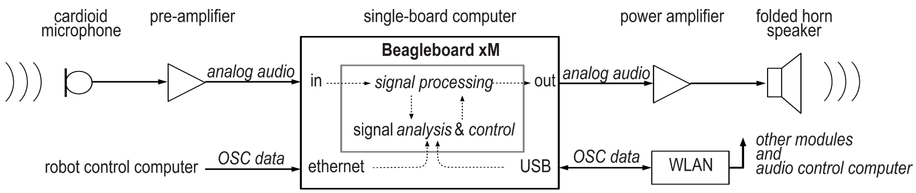

Fig. 1. Hardware architecture of the developed audio module

The directivity patterns of both, the microphone (cardioid) and the speaker (folded horn), were chosen to minimize the probability of direct feedback between audio output and input of the module itself. For the same reason microphone and speaker are aligned to opposite directions. The horn shape of the speakers can be regarded as a social and aesthetical reference to the megaphones and Vuvuzelas common for football games spectators in stadiums. In order to receive context information from the hosting mobile robot an Ethernet connection is used. All audio modules are able to share features of the sound analysis and context information of the hosting platform with the central audio process via wireless network. These data are transferred using the Open Sound Control (OSC) [5] protocol.

3.2 Signal Processing Software and Communication

The signal processing software is written in SuperCollider (SC) [6], a programming language and run-time environment for sound synthesis, signal processing, algorithmic musical composition, and live-coding. The SC-environment consists of two components: The *server* to perform the audio signal processing and the *language* that controls processes on the server. The server is able to communicate with other instances of SC or other software on remote machines using the OSC protocol. Fig. 2 outlines the structure of the developed signal processing for this project. The audio processing of the different parts is realized as follows:

- **Preprocessing:** Due to the noisy environment the incoming raw signal has to be filtered to eliminate the noise using band-pass filters and noise-gates. We automatically adjust the level and the spectrum of the processed input signal to suppress direct feedback.
- **Feature Extraction:** Sound features have to be extracted, like amplitude (envelope follower), fundamental pitch (autocorrelation pitch follower), spectral shape (spectral centroid, spectral flatness, spectral percentile), etc. These features are communicated to the other audio modules and form the basis to adapt distributed sound processing.
- **Dynamics:** In order to create an audible response dynamically to the audio input within the context of the environment, the received features are used for the selection and the control of the available sound processing algorithms.

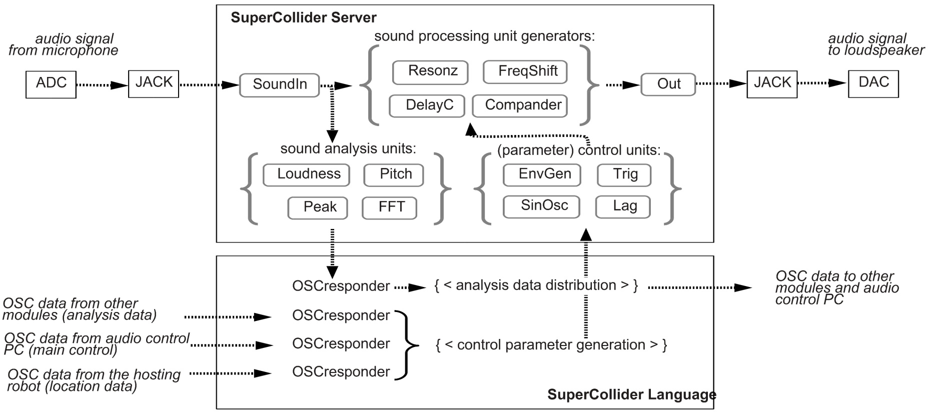

Fig. 2. Structure of the signal processing software SC

This framework allows the transformation of environment dynamics into an acoustic performance. In order to realize the dynamics, which result in artificial composition, autonomous mobile components are needed.

4 Robot Technology

The concept of the project with the goal of a polyphonic sound structure demands sophisticated technological requirements for the underlying mobile platform.

- **Autonomous System Behavior:** The technology should feature a human independent (autonomous) operation.
- **Team Coordination:** Music typically consists of an interference of multiple sounds. Therefore, the applied technology should provide multiple interacting system components (agents) to synthesis this.
- **Mobility:** The dynamic of the sound structure is based on vibrant distance changes. Therefore, mobility is a key requirement of the platform.

A RoboCup MSL team of autonomous mobile robots meets these requirements. The robot size of 52x52x80cm and the ability to carry sufficient payload allows attachment of the described audio modules. Additionally, the 12x18m field size provides ideal conditions for the feedback generation with respect to the wave length of audible sound.

Two MSL teams, namely Tech United [8] from the Technical University of Eindhoven and Carpe Noctem [9] from the University of Kassel provide the robots for the performance (Fig. 3). Beside the available MSL platforms, a MSL soccer game provides a well-established setup for the project. Such a game features the dynamic game flow needed for the sound composition of the project. Both teams annually participate in MSL competitions and provide the expertise for the technical infrastructure. Following, a short excerpt of the robotic technology relevant to the stated requirements is given. More details can be found in [10] and [11].

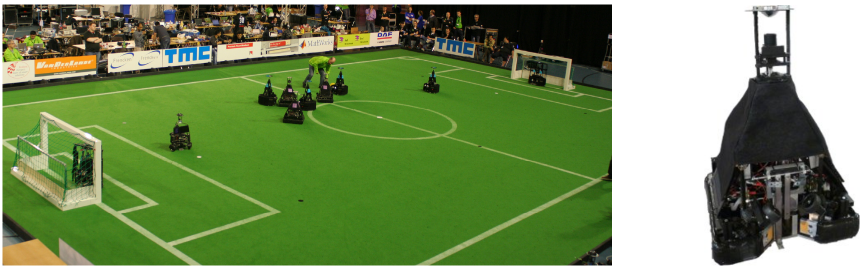

Fig. 3. Left: Typical situation in a MSL game (Tech United versus Carpe Noctem). Right: MSL robot from Carpe Noctem [9].

4.1 Autonomous System Behavior

A characteristic of autonomous mobile robots is their ability to move and act independently in their environment. In case of soccer robots the relevant context of the environment is characterized by positions and velocities of the robots, the ball, the teammates, and the obstacles. As these quantities are real valued, the number of possible states is apart from precision limitations infinite. This fact makes it impossible to model all situations explicitly. Even the simulation of a wide variety of situations is too computational expensive to cover the search space sufficiently with current computers.

Therefore, we need team behavior, which is able to generalize and is usually realized by techniques known from control theory. Their goal is to converge to a global control target, like approaching the ball or to score a goal. A control cycle in this case is divided in three parts. First, sensing the environment e.g., by a camera and extracting high-level information to specify the current situation. Second, selecting the robots behavior, this includes the team coordination process. Third, the chosen motion command has to be transformed to low-level actions like motor velocities to execute the selected behavior.

As the global system – including own and opponent team dynamics – is too complex, we cannot use a model in order to prove convergence. Thus, the flow of a soccer match can be assumed as a chaotic system with some fix points. Practically this means that two similar situations with equal appearance mostly result in different outcomes. This is even true without the incorporation of learning or randomized behavior. In a MSL soccer game, e.g. fix points are manifested by the half-time.

However, to reach the goal to give the robot a “voice” this behavior is beneficial, as we can achieve highly complex team dynamics and unforeseen situations. Combined with the dynamics of the sound generation as described in Section 3, the generated sound structure appears as an expression of musical creativity formed by the robots.

4.2 Team Coordination

In order to enforce a convergent strategy, we realize the plan and behavior selection step by a strategy description that allows modeling from a global perspective. Therefore, we use ***A*** ***L****anguage for* ***I****nteractive* ***C****ooperative* ***A****gents* (ALICA) [12]. The language describes tasks for an arbitrary number of robots within a plan. A plan consists of a set of states connected by transitions similar to a state machine. Every state can in turn include a plan or an atomic behavior, like *kick* or *move to point*. For each transition a condition has to be specified that triggers a state-switch if evaluated as true. ALICA achieves synchronization either explicitly by synchronized transitions, or implicitly based on the underlying common knowledge base, which is in case of the Carpe Noctem robots the knowledge of active states of the other robots and the situation specified in the world model. As the world model shares not only local information of the robot itself but the common belief of the world state, synchronous transition triggering can be achieved.

The communication between the different robot processes is realized by using the ***R****obot* ***O****perating* ***S****ystem* (ROS) [13]. It provides a middleware for inter-process communication, build chain, and tool support for debugging of robot platforms. Thus, ROS supports the challenging task to maintain robots.

Using this framework we specified a plan structure for playing soccer with the control target to score goals. Furthermore, it determines regulations for the chaotic game flow as described in Section 4.1 and therefore the dynamics of the resulting sound structure.

4.3 Mobility

The stated autonomy results in position changes, which form the foundation of the envisioned dynamic polyphonic sound structure. Therefore a high degree of mobility supports the dynamics in this sound structure and is an essential part of the projects realization. As velocity and agility are inherent elements in MSL competitions, a lot of effort is spent from the community to realize and optimize drive systems of the used robots. The technology of omnidirectional drives [14], realized with multiple (typically three to four) omnidirectional wheels (see Fig. 3), has been established as a quasi-standard in MSL RoboCup to improve robots maneuverability [8] [9] [14].

The wheel consists of a series of rollers attached to its lateral surface that are perpendicular to the rolling direction. This allows an almost frictionless translation in direction of the rotational axis of the wheel.

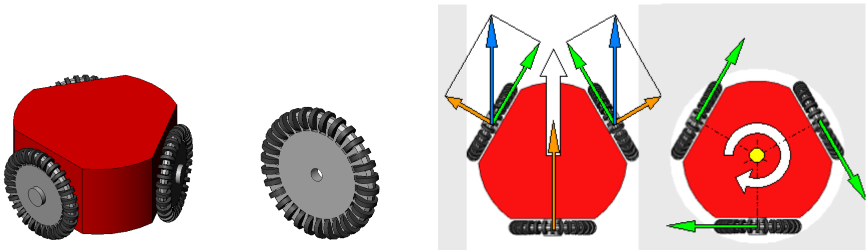

Fig. 4. Left: omnidirectional drive system in 120° configuration. Middle: Model of an omni wheel used in the omnidirectional drive system. Right: Omni drive with different global movements (white arrows) and the needed wheel velocities (green: propulsion velocity, orange: slide velocity, and blue: effective velocity) [15]

Each wheel velocity is individually controlled. The combination of all wheel velocities defines the global robot movement dependent on its geometry. For some illustrative robot movements (white arrows) the required wheel velocities (green arrows) are depicted in Fig.5. A detailed description of the control mechanisms is presented in [14] [10]. Using such a drive mechanism allows the robot to move in arbitrary directions and independently rotate. This results in a drive system that allows very agile movements and enables the dynamic position changes required for the polyphonic sound generation in this project.

5 Conclusion

This paper presents a kineto-acoustic project that encourages the reflection about emotional ties in an autonomous setting (see video [16]). Mobile autonomous soccer robots and distributed polyphonic sound processing are the two technologies to realize the artwork. The sound processing units mounted on a Middle Size League robot are equipped with a microphone and a speaker. The distances between the robots and their velocities determine the modulation and amplitude of various acoustic feedback loops. Other data can be evaluated for sound processing.

The resulting polyphonic "voices" of the robots build a texture of sound. This has a structure that can be appreciated as a form of avant-garde electronic music. Usually, these kinds of artworks have human creators and inherently bear human expression. The listener of the presented performance may infer expressive musical values in this music, even though it was autonomously generated by technology.

In this performance sound originates from motion. In future work we plan to investigate the reverse order. Therefore, transformations have to be identified that determine the movements to generate specific sounds. The goal is to allow robots to generate musical structures, sounds, and tones in the same autonomous fashion they solve soccer tasks. This would take us beyond music into the area of choreography.

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Assistive Synchronised Music Improvisation

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Abstract. The second stage of a project to develop a tool for assistive musical improvisation is described. Building on the findings from preliminary participatory workshops with a group of adult learners with mobility issues, a pattern based musical-model is defined. Employing a synchronised pattern-based approach to music generation a prototype 'instrument' has been realised that brings together key assistive and musical features that were identified as desirable. Using an example combination of joystick and force-sensor controls, the system offers the performer a combination of rule and skill-based performance behaviours to maintain both a sense of ownership and control.

Keywords: Accessibility, disability, music, improvisation, technology.

1 Introduction

Group-based activities can greatly increase an individual's sense of social inclusion and music-making through improvisation can enhance this further through additional self-expression on the part of the participant. Community Music practitioners will often work with groups of individuals who can benefit from such collective music happenings but who are, for one reason or another, faced with barriers to participation. There may be physical reasons why it is difficult for an individual to engage with playing a traditional instrument, or cognitive challenges that might make the process of comprehending common music conventions difficult (key, meter, harmony etc.). Factors such as the cost of taking music lessons or purchasing an instrument can affect an individual's choices as can the ability to master and retain the technical information to produce satisfactory musical outcomes. Community Music workshops will tend to focus on using methods and instruments that help alleviate some of these challenges and barriers.

There is no one philosophy here, but improvisation can be key in overcoming these barriers as everyone can have something to contribute. Stevens [1] describes techniques for encouraging and enabling improvised music for mixed abilities and Moser and McKay [2] address similar themes whilst also taking into account other factors including how to setup the environment, warming-up and using technology. Improvised game-play can be used as a vehicle for introducing people to music making, indeed Stevens' Sustain, Click and One-Two are all examples of game-like exercises and in this same way Lewis [3] and Nankivell [4] suggest similar musical games

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including Hocket, Add-On, Name Game and Six Chords. Of these, Add-On is an approach that is particularly rewarding as it follows a familiar musical structuring system that is both easy to comprehend and commonplace in many musical styles. A short repeating pattern or 'groove' is established by one player while the rest of the group simply listen. After a short while, one of the remaining group members adds a layer to this initial idea and the process is repeated until, layer-by-layer, a complete musical texture is achieved; this might be quite complex rhythmically, harmonically and melodically by its conclusion. Key here is the notion of very simple musical offerings gradually coming together to create bigger and more complex outcomes; the individual becoming part of the group regardless of ability.

It was this same layering game of Add-On that Challis and Smith [5] used to explore the potential for assistive technology in enabling users with mobility issues to take part in community music workshops. A series of three workshops was employed to allow the researchers to engage with the group as observer participants. Initially this involved joining in with the group in typical musical activities followed by two technology-assisted workshops to enable a more varied repertoire to emerge.

2 Findings of the Tools for Improvisation Project

The findings of these workshops are deliberately condensed here and can be further supported by other work by Challis [6-8] in this same area of assistive music technology. It should be noted that the individuals who contributed to the workshops had differing mobility issues rather than sensory or cognitive challenges. With this in mind, the group had relatively fixed ideas of the type of musical interaction they enjoyed but had challenges in working with conventional instruments; In particular, two members of the group had specific issues with dexterity such that individual finger movement was observed to be noticeably difficult.

Synchronisation: The ability to have musical phrases synchronized in time was immediately identified as being important; without this the group would quickly lose the beat and the layering process would become confused. It was acknowledged that this was quite significantly influenced by the make-up of the group, most of whom had head-related traumas that, amongst other challenges, presented mobility issues. The level of effort and articulation and effort required to repeatedly carry out, for example, percussive exercises was obviously demanding in terms of maintaining rhythmic cohesion. A simple MIDI-clock system was used to test this theory with very positive results.

Skill/rule-Based Behaviours: Earlier work in this same area [5] had already suggested that Malloch et al's model for Performance Behaviours [9] had considerable relevance within the field of assistive music technology but that additional consideration needed to be given in terms of understanding the key labels of skill, rule and model. Where skill would ordinarily suggest that the performer is responsible for the entire lifespan of each note, the same may not be true for someone with clear physical barriers. As such, employing rule-based behaviours for the latter performer may be considered to involve more skill than for someone with no physical barriers. With this in mind, it was seen that aiming to introduce performance behaviours that lie somewhere between skill and rule would be advantageous; being able to further adapt these actions around the individual's needs could enhance this further.

Pattern Generation: Observation and participant feedback clearly showed that the group were most comfortable working with repeating rhythmic and harmonic patterns to build up layers. This was particularly true where the performer had substantial control over the generation of the patterns. It was also shown that synchronisation of the patterns was of considerable help to the group though it should also be acknowledged that, if the performer missed the beat when triggering a pattern, the musical events would be generated in time with the rest of the group whilst remaining off-beat. This helped maintain a skill-based element to the flow and control of the music. It was also clear that, though abstract approaches to improvisation are frequently employed in a community music setting, the group were keen to work with mainstream song-like structures employing chord progressions and meter-led percussion beats.

Ownership: As suggested by Healey [10], a sense of ownership remains significant to the participant who is perhaps using assistive means. Pressing a switch to release a pre-arranged and quite comprehensive stream of music may not be as meaningful as, for example, pressing a switch again and again to control the way in which the notes flow. Some level of control and skill is introduced into the process.

Ease of Use: In simple terms, participants appreciated control devices that are intuitive to use, perhaps offering bigger musical outcomes than are suggested by the user's input so long as the previously identified sense of ownership is not eroded. There is a fine balance of relationships here as ownership is in part affected by the notion of skill-based performance behaviours which may well dictate the extent to which an interaction can be regarded as being easy or not.

3 Musical Design

The first stage of the Tools for Improvisation project concluded that this collection of features could be brought together within a system that employs a grid-like system for controlling the triggering and control of musical patterns. This was based on the success of using a similar interface in the workshop with very positive results. In principle, one or more grid-controllers could be used in conjunction with an additional input mechanism to enable expressive control. This would enable the performer to trigger and manipulate sound expressively whilst also still requiring some level of skill. This would be particularly true if small melodic units could be navigated and triggered to create more complete patterns and progressions. Using small scale testing of different approaches, the musical scope for such a system has been more clearly defined, leading in turn to a working prototype. Before discussing the design of the interface to the system it is first important to understand the rationale behind the musical model that it enables.

3.1 Musical Patterns

Modern music makes much use of repeated phrases to create layers. Indeed, the term loop is now very much established within the vocabulary of music composition and analysis; a contemporary take on the more traditional notion of the ostinato. Certain components of popular music can be deconstructed into repetitive loop like phrases. Take a drum beat for example, a complete drum part might be broken down into a series of short phrases which are repeated for substantial passages, perhaps punctuated by slight adaptations or fills to underline the structure. The basic starting pattern itself may be further broken down into constituent repeating parts for individual drums: a pattern of high-hats, a rhythmic backbone from the kick, a back-beat from the snare and so on. Given a starting palette of complementary patterns, a player might pick and choose individual beats to join together, building longer bars and phrases by moving between much smaller musical units. This is the basic concept that is used behind the musical model of the improvisation tool; the performer has access to a virtual array of nine such patterns that can be combined to create either rhythmic or harmonic patterns.

3.2 Creating Rhythmic Patterns

For the rhythmic palette, a player can access beat-long fragments that focus on key drum voices. A pattern might be, for example, mainly focused on the kick-drum such that if played repeatedly, this emphasis of the rhythm would remain firmly with this particular drum; it would ‘feel’ like a kick-drum rhythm. Contrasting patterns might focus on other drums and percussion instruments (snare or toms for example) and again, repeated play of these would have similar results, creating a rhythm that is focused purely on the single drum. However, if the player chooses to move between patterns, the overall feel can be made to oscillate between two or more drum-focused patterns (see Figures 1 and 2). Using this approach, a familiar drum beat can be deconstructed into its constituent beat-long patterns, these become part of the palette which is then filled with a number of variation patterns. The performer can reconstruct the original beat but can also build variations and adaptations by choosing alternate phrases. This is contrast to current commercial technologies (e.g. Kaossilator) where the system essentially enables the performer to join together bars into phrases rather than beats into bars.

Fig. 1. Example patterns on a kick and snare drum

Fig. 2. Simple beat based joining of patterns in Figure 1

This can be achieved by simply timing when to move from one pattern to another though, as will be described in Section 4, additional parameters can be altered to further increase the variety of the patterns and fills that can be created. Importantly, a performer should be able to move from one pattern to another between beats if needs be. This way, a larger phrase might be constructed using whole and part-beats (see Figure 3).

Fig. 3. A more complex phrase, built with the same patterns as Figure 1 but moving from pattern to pattern within the beat

3.3 Creating Melodic and Harmonic Patterns

In a similar fashion to building rhythmic patterns, melodic ideas can be built from palettes of pitch-based units. These can be based on single pitches, with repeating rhythms, and also from groups of pitches that share a diatonic relationship, again with repeating rhythms. The player can build musical ideas based on repeated single pitches or bring together a sequence of units to create an arpeggiated pattern, where the notes are taken up and down chord voicings. Again, the extent to which additional variety and expression can be introduced is governed by the interface design and the limits and needs of the user. Though there are technologies that enable these arpeggiated approaches, they typically involve the input of a base chord shape by way of a conventional keyboard; the approach being explored here, removes this requirement as diatonically related chords are mapped out within the grid.

3.4 Instrument Design and Implementation

For the purposes of the prototype design, the grid-size has been limited to three by three such that the initial palette will offer nine rhythmic or harmonic patterns for the user to improvise with. There are various ways in which a grid like this might be conceived and accessed, including a physical grid of switches or pressure pads, a touch-pad, a virtual grid based on the movement of sensors such as accelerometers and gyroscopes, or through the use of a joystick; the following interface is just one example of how this can be achieved. The switches and pads will offer additional visual cues and feedback as to where and how to interact as the grid will be apparent within the device. The joystick approach will require some additional skill to control though there is some feedback in the position of the joystick lever itself; similar is true of the touch-pad where the position of the finger is the cue. The virtual approaches may introduce more uncertainty and required skill without additional feedback.

The purpose of the prototype has been to demonstrate that the musical model can work rather than to demonstrate the appropriateness of any specific interaction method. For this initial version, two methods have been explored, a grid of force-sensitive pads (Figure 4) and a combination of stay-put and centring joysticks (Figure 5). Depending on the mode of play (rhythm or pitch), pressing one of the pads will begin the pattern associated with that specific grid position. Maintaining pressure will allow that pattern to cycle round to create a repeating phrase whilst changing pressure will increase and decrease the volume. Patterns can be joined together by moving from pad to pad to access the different phrases and silence can be achieved by simply not pressing a pad. MIDI clock messages are available such that other devices can be synchronised to the main tempo though individual events are not delayed in any way to quantise around the beat. So, if a player triggers a pattern on a beat it will be in tempo, if the same pattern is triggered slightly behind the beat, it will also be in tempo but always behind the beat until retriggered. This meets the requirement of needing skill to remain in beat whilst triggering and moving between individual patterns.

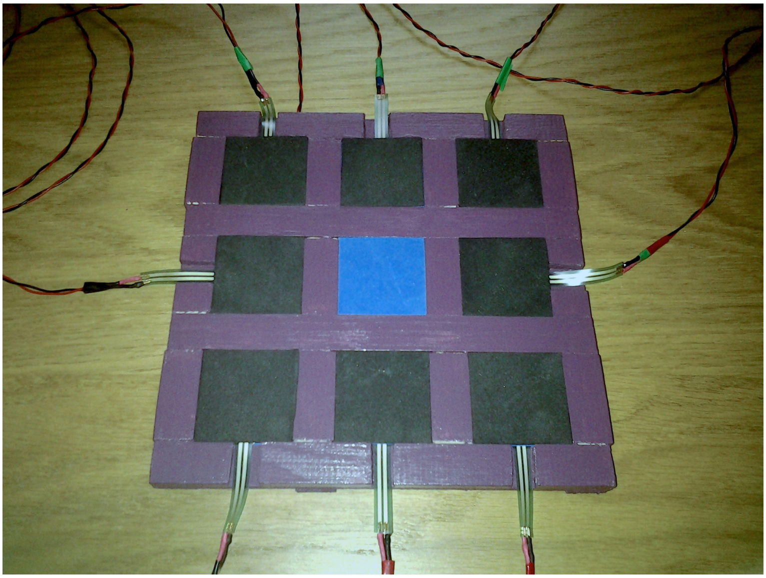

Fig. 4. Interface: force-sensor component

Although quite complex patterns can be achieved by using the pads alone, additional variation can be introduced by using a joystick. This, again, offers nine positions that correspond to a three by three grid (centre, up, up-right, right, down-right, down, down-right, left, up-left). When playback is rhythm-based, the joystick allows different combinations of drums, cymbals and percussion to be included within the main patterns being triggered by the pads. For example, one position might offer a basic drum-snare combination, whilst another will use similar rhythms but with an added hi-hat pattern or perhaps hand-percussion or possibly both. There is an element of learning-through-play involved with the performer finding his or her way around the patterns and permutations on offer and this very much suits the intended application of the controller within improvised music.

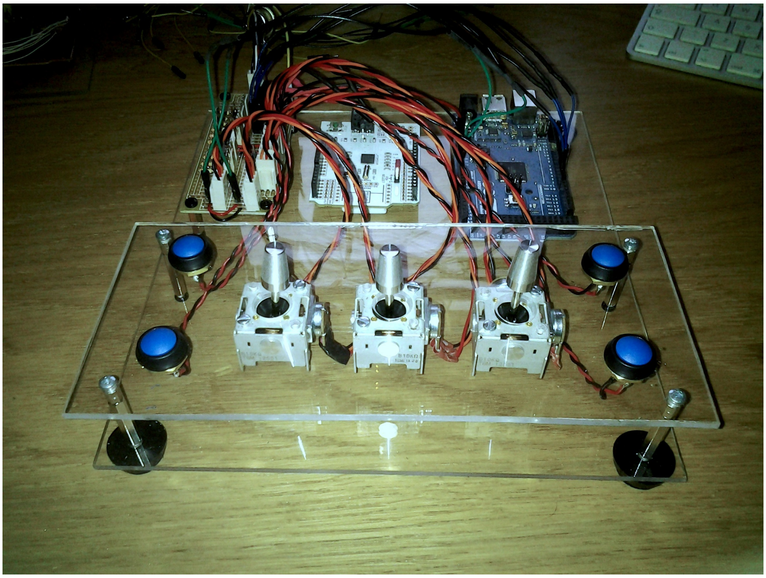

Fig. 5. Interface: stay-put and centring joysticks

When the controller is being used for pitch-based playback, the joystick dictates the root note for the current musical pattern. This allows simple patterns to be moved diatonically from one harmonic position to another, following a chord progression for example. The pitch-based patterns are organized such that vertical or arpeggiated phrases can be achieved alongside more horizontal phrases. Though the system has been initially built using the combination of a grid of force-sensitive pads and a joystick, both offer a 'grid'-based frame of reference. With this in mind, it is wholly possible that a similar interaction may be achieved using two joysticks alone, or two sets of pads and preliminary experiments with two joysticks suggests that this could be particularly effective although the expressive element can be lacking. It should be noted that the joysticks being used within the system are relatively small (3cm x 3cm) as the cost of larger stay-put joysticks has proven to be prohibitively expensive at this stage; initial indications are that larger joysticks will clearly benefit some of the users from the original workshops. It is also acknowledged that a compositional element could be introduced into the system such that patterns could be created and stored by the performer; currently the prototype is only working with a limited set of pre-programmed example patterns.

4 Conclusion

The second stage of the Improvising Tools Project has concluded with the development of a working prototype for enabling group based improvisation. Using an example combination of force-sensitive pads and joysticks, performers are able to trigger and move between a palette of rhythmic or pitch-based patterns to create longer and potentially quite complex phrases. The system employs a balance of skill-based and rule-based performance behaviours to maintain a sense of control and ownership on the part of the improviser. MIDI clock messages are available such that the system can act as a master unit whereby other devices can be synchronized and kept in relative tempo.

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Neuroaesthetic Resonance

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Abstract. *Neuroaesthetic Resonance* evolved from a mature body of research investigating 'Aesthetic Resonance'. Music Making, Digital Painting, Robotic control and Video Game control via movement alone is catalyst of the work where motivated fun through ludic engagement is core. Innovation of apparatus and methods in non-formal rehabilitation via matching digital media plasticity to human performance plasticity are foci. System adaptions according to abilities offer a generic solution. Performance art learning (stage and interactive installations – where solo and multiple 'actors' participated) is a thread in the work. A published patent and commercial product resulted alongside intervention models for in-action and on-action reflections, actions, and evaluations. This paper addresses the issues of innate aesthetic value by philosophically and contextually questioning 'what is art' and 'artistic value'.

Keywords: Aesthetics, Rehabilitation, Neuroplasticity, Aesthetic Resonance.

1 Introduction

SoundScapes is a mature body of research that transcends semiotic domains, disciplines, activity, and role, e.g. art/artist, game/player, learning/teacher, healthcare/therapist/facilitator, and ICT/designer/creator/programmer. Incorporating the concepts of Ludic Engagement Design (LEDA), ArtAbilitation, and GameAbilitation - (all originally coined by the author) – the research has evolved to be a multifaceted entity that is questioned from many perspectives. In this paper the 'art' elements are in focus such that Art and ICT are combined to offer a supplement in traditional intervention in healthcare. Through this work a challenge is posit to traditional interpretations and the question of what is art and its value. By introducing Neuroaesthetics to the author's prior research on Aesthetic Resonance a contribution to contemporary thinking of aesthetic value is also posit. Thus, empirical aesthetics are argued from the context of empowered creative expression in healthcare and similarly healthcare potentials are questioned of creative expression. However, to ascertain such claims and for arguments to be valid first-hand experience is a pre-requisite in line with aesthetic value and the 'Acquaintance Principle' in aesthetic theory [1] i.e. where "judgments of aesthetic value, unlike judgments of moral knowledge, must be based on first-hand experience of their objects and are not, except within very narrow limits, transmissible from one person to another' (p. 233) (see also e.g. [2] [3] [4] [5]).

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Following an introduction of the concept, a focus is on presenting a questioning of the work's aesthetic worth. To be clear, the claim of aesthetic value is not focused solely on the media production (music, image...) resulting from the interactions.

Other issues are prevalent and available for those with knowledge of the situation and acquaintance with which to assess innate aesthetic value, for example: -

- the process of creation (i.e. the participant's manipulation of digital data by movement),
- the empowering through design (designing the environment, the system, and available parameters for change), and
- the facilitating of the interactions (i.e. the process of 'in-action' reflections and evaluations leading to subsequent improvised actions to optimize motivation, interest, and engagement, thus maintaining Flow state [6] [7] [8].

1.1 Background and Concept

The research began in the mid nineteen eighties utilizing opportunities through technology advancements and the author's engineering education, artist background, and experiences with domestic disability. A main focus has been human performance and expression through studying potentials of residual gesture of a disabled participant resulting in a 'self-created' aesthetic/play experience. Non-invasive sensors capture gesture information that is mapped to multimedia to stimulate subsequent gestural responses. This is more recently referred to as an interactive Virtual Reality Environment. Alternative channeling of brain plasticity sensing is targeted as a means for supplementing traditional intervention in therapy and rehabilitation.

Participants have purposefully spanned ability and age profiles in order to generalize findings across semiotic domains. Most of the author's studies have involved adults who are diagnosed as acquired brain injured (ABI) as well as profoundly multiple learning disabled (PMLD). Improvised audio-visual collage creation and manipulation results from interactions with content matched to a user preference (e.g. digital music composition, digital painting, robotic lighting manipulation, virtual reality, video games…). Feedback is direct and immediate to match input that is selectable according to a participant's profile.

The design is for motivating and maintaining a 'fun, enjoyable, and pleasurable' aesthetic experience that is dynamic and challenging of the participant's abilities rather than a more passive traditional therapeutic training experience that may be mundane and boring through repetition.

In SoundScapes facilitator influence and active involvement is acknowledged as an optional and improvised prerequisite. Thus, the facilitator has knowledge of the goal of the sessions, the design of the system to attain those goals, and the parameters of change that the session design makes available as presets. Knowledge of the participant profile is also needed for an optimal session. SoundScapes (as ArtAbilitation) is acknowledged as a movement [9] (p. 177) targeting non-formal human performance alternative therapy and (re)habilitation through creative expression and ludic engagement, these being design parameters.

The basis of the work is recursive reflection of research across and between performance art (stage shows, interactive installations, workshops etc.) and (re)habilitation. The stage shows have two focused strategies (1) where the author directs, produces and performs alongside ‘actors’ with impairment having mixed abilities where dance, music, was performed to audiences (2) the author’s solo performances (also author directed and produced) to audiences.

In all cases much was learnt to influence and evolve Neuroaesthetic Resonance. For example how representations and identities of the self can transcend via the media of performance. Similarly, much was learned from the authors’ creation of interactive installations at leading Museums of Modern Art where specially organized workshops for disabled groups was arranged for the museum’s ‘dark days’ (mostly Mondays) where the usually public areas are closed and only the administration staff are working. Standout instances are recalled from one such installation (COIL: Circle of Interactive Light, continuously exhibited at three MoMA and a Radisson Centre over two years 1998-9). These examples are recalled of the author’s observation sessions from a hidden location of visitors attending the COIL, the first is during public opening times and the second is from the closed workshops on the ‘dark days’.

The first example recalls how a class of school children entered without their teacher and quickly, upon exploring the virtual interactive space (VIS), understood the interactive areas with one assuming the role of leader instructing the others to ‘perform’ to his instructions. The second is where a group of high-functioning wheelchair participants were speeding around in a formation to challenge themselves creatively and to indicate how they understood the VIS potentials. The concept is based upon design, intervention and evaluation of an innate participant experience referred to as Aesthetic Resonance [10] [11] [12] [13]. Evaluating the concept intervention to date has mostly been expert evaluations and thus the advances in brain imagery can offer greater insight and needed clinical evidence. This approach gives opportunities to explore aesthetic value of the work. In line with this an introduction to the neural aspects of Aesthetic Resonance in SoundScapes is presented in [14].

2 Neuroaesthetics/Neuroesthetics

Neuroesthetics (or neuroaesthetics) is a relatively recent sub-discipline of empirical aesthetics. Empirical aesthetics takes a scientific approach to the study of aesthetic perceptions of art and music. Neuroesthetics received its formal definition in 2002 as the scientific study of the neural bases for the contemplation and creation of a work of art. [15]

It is not the purpose of this paper to introduce Neuroaesthetics in detail, as there is a readily growing body of publications. The advances in brain imaging technologies e.g. magnetic resonance imaging (fMRI), magneto encephalography (MEG), and positron emission tomography (PET), increasingly enable analyze of human responses to experiencing stimuli. Such analysis can greatly assist the design of adaptive virtual environments where selection of input and display apparatus is flexibly mixed and matched to content according to the participant profile and responses. In other words, through understanding inner human reaction design improvements to the 'system of empowerment' can be made. The conceptual framework is focused around offering a variety of means to stimulate alternative channels of Neuroplasticity such that typical association between afferent sensing and the person's movement is diverted around damaged areas of the brain. So for example auditory feedback triggered via side-to-side movement gives a feedback sense of balance and body proprioception that can assist when such sensitizing in the brain is damaged (for examples of this technique see Brooks 2004: Humanics). The potentiating of alternative synaptic pathways in this way achieves associations that are conceptualized to evolve to thus contribute to the person's improved functionality via brain plasticity (alternative sensitizing/channeling). Over time the challenge (externally i.e. sensing parameters and mapped content) is incremented according to the motion learning (kinetic chain action-responses) to maintain and optimize the motivation. In this way the state of Flow [6] is targeted such that any conscious limitations maybe subdued through the interaction evoking an experience that is highly stimulating in many ways. Neuroplasticity is used in this case to refer to the ability of the brain and nervous system to change structurally and functionally as a result of input from the environment [16]. This capacity can be at various levels, ranging from cellular changes involved in learning, to large-scale changes involved in cortical remapping in response to injury. The most widely recognized forms of plasticity are learning, memory, and recovery from brain damage. Participants with impairments in line with these attributes are the main foci of designing the interactive environments, otherwise referred to as Virtual Interactive Space (VIS) [10] [11] [14]. Contemporary artists challenge traditional ontology through dematerialization of the object, by not being fixated on a medium, and through not seeking to produce objects of aesthetic interest. This is as artistic value can sometimes reside in something other than its physical appearance, with which one must be in direct perceptual contact to appreciate its specific aesthetic value [17]. For further see Acquaintance Principle and related [1] [2] [18] [19] [20] [21] [22]. The next sections relate art and aesthetics to VIS.

3 Evolution of Neuroaesthetic Resonance

Aesthetics is much broader than the field of the arts, however, confusingly; traditional art theories try to give 'necessary and sufficient conditions' before labeling a piece of work as art or assigning aesthetic value [23]. Evolving from the author's prior empirical work investigating Aesthetic Resonance and Aesthetic Resonant Environments [10] [24], SoundScapes/ArtAbilitation explores the underlying conditions that contribute to aesthetic experience, as well as aesthetic behaviors, using scientific methods. Thus, participant's capacities to express/articulate aesthetic judgments, create, and to receive/respond to aesthetic stimuli are assessed as related performance conditions.

Expression Theory evolved during the Romanticism movement of the nineteenth century to challenge the prior 'imitation theory' by moving from the objective oriented outer world to a subject oriented inner perception of the mind. This is fitting as the concept focused on thoughts and ideas, feelings, and cognitive faculties to evoke the human audience's emotions. Thus, through this focus on the subjective mind, the 'expression theory' is said by its advocates to be inclusive of both the artist and the audience, with innate power enabling an articulation of the communicative and educative power of the mind [23]. Other aesthetic theories, such as attributed to Collingwood and previously Croce [25], similarly relate the mind and its function, expression of emotions, and intuition. Additionally, Collingwood's theory posited that artworks act as a vehicle for people's learning, thus, the artist becomes an educator and the artwork becomes some kind of educational vehicle. In context to this body of work, the terms 'artist' and 'audience', 'learning' and 'educator' can be interpreted as applying to different entities as outlined in the research.

Reflecting these points is that innate to 'Contemporary Art Theory' is a departure from the traditional elements of artist, artwork, audience, and 'artworld' institutions and instead are tensions between normalcy, i.e. being within certain limits that define the range of normal functioning, and creativity. It acts as a guidepost for understanding contemporary art. Thus, a modern-day perspective, in this case 'non-formal', is underlined by a broader interpretation of what art is and the assigned aesthetic value. Interpretation, understanding and meaning of contemporary art form is typically associated to hermeneutic analysis. Via this model, SoundScapes discloses the 'different' world of the participant that is accentuated via its alternative form. It also presents the struggle associated with this disclosure and the inherent radical tension between the participant and that specific world of significance. In a SoundScapes environment, embedded meaning is subject of disclosure through being the feature of the 'installation' experience. According to Heidegger's reflections, SoundScapes seemingly fits being referred to as art, however, not all 'experts' agree through possibly carrying their traditional art history/education baggage and thus unable to perceive the form. This is despite that, in SoundScapes, disclosure, via the medium of a participant's creative expression, "shines forth" brilliantly in beauty [31]. Central to this is the questioning of the inner perception of the mind linked to experiences of the 'art expression' - thus the design of inquiry includes neurological conditions.

4 Discussion and Conclusions

This work challenges philosophical theories of "what is art" from a position built upon an aesthetic belief evolved inductively from practical experiences where participants with impairment are empowered to articulate creatively via profile-specific ICT.

For some people, impairment is a sensitive subject; however, there is much to learn from this alternative, inclusive, and access-focused approach. This is especially so as it is not an artwork created for entertainment or audience, it is a contemporary form that can be interpreted as a personalized installation that was originally conceived as a non-formal supplement for traditional therapy/(re)habilitation/learning intervention. It is in line with how engagement with art in the modern world is different than in the past before the digital / information / knowledge, and creative revolutions.

Building upon this position of aesthetic belief, it is posited that through SoundScapes/ArtAbilitation (including GameAbilitation) acting as a vehicle for 'non-formal learning' [31] creativity and play contribute to stimulate an individual's potential brain plasticity. This is through afferent efferent neural feedback loop closure via the sensorimotor stimulation of alternative channelling (coding) of what is sensed externally compared to what is registered and acted upon internally. However, quantifying progress to define clinical evidence is problematic as development is not readily apparent, especially in transfer to daily living benefit (ADL).

Nuance of progress is typically at the micro level. Thus, video cameras are used in sessions to enable micro-genetic analysis of such nuances to assist investigation of microdevelopment [32]. In addition, software tools that assist analysis through collating and organizing statistically significant time patterns in sequences of behaviors are available to assess participant responses.

According to The International Association of Empirical Aesthetics (IAEA), the field of Aesthetics typically involves psychologists. Increasingly, there is evidence of wider interest including sociologists, musicologists, philosophers, and researchers who specialize in the study of painting, sculpture, literature, film, museum visitor behavior, and so forth.

The term 'Aesthetic Resonance' is similarly referred to across divergent fields as detailed in [14]. Thus, it is no surprise that the growing field of Neuroaesthetics is also attracting scholars from many disciplines including neuroscientists, art historians, artists, and psychologists.

The imaging techniques such as previously cited permit association of brain areas to sensorial stimuli (visual, tactile, auditory, etc.), the planning and execution of motor processes, and/or the perception of determined emotional stimuli.

However, investigations, while questioning the effect on the brain of the aesthetic or the artwork, rarely explore the potentials in substantiating applied empirical research where creative expression is used in healthcare.

This needs to be addressed as Neuroaesthetics uses the techniques of neuroscience in order to explain and understand the aesthetic experiences at the neurological level. In line with the above, inquiring to the possibilities of alternative rechanneling of neuro-pathways of stimuli via the related discipline of Neuroplasticity are posited as a rich line of enquiry.

Such transdisciplinary collaborations are positioned in this paper to assess the potential of afferent efferent neural feedback loop closure via Virtual Interactive Space (VIS) where sensor-based adaptive environments with responsive multimedia are used in healthcare [10] [11] [14]. It is in this way that the ArtAbilitation movement and transdisciplinary research platform Ludic Engagement Designs for All (LEDA) and GameAbilitation have evolved from the SoundScapes body of work.

A central thread of this paper emphasizes disagreement in line with [33] i.e. that for an entity to be art it has to have perceptual resemblance to other works that are previously judged as art, i.e. to be assigned 'necessary and sufficient conditions'. Author agreement is instead of an opposing position by [34] stating how perceptual resemblance is not necessary for something to be art and/or have aesthetic value [17].

The paper closes by quoting Zeki (2009) who states of Neuroaesthetics: -

… neuroscientists would do well to exploit what artists, who have explored the potentials and capacities of the visual brain with their own methods, have to tell us in their works. Because all art obeys the laws of the visual brain, it is not uncommon for art to reveal these laws to us, often surprising us with the visually unexpected. Paul Klee was right when he said, "Art does not represent the visual world, it makes things visible." // It is only by understanding the neural laws that dictate human activity in all spheres - in law, morality, religion and even economics and politics, no less than in art - that we can ever hope to achieve a more proper understanding of the nature of man.

In line with this quotation, a closing reflection is that the research is responsible for apparatus and method questioned from the sphere of healthcare where human activity/ performance is central [36]. Given the background, it therefore offers a viable route to explore alternative art and aesthetic value in this specific context. The questioning empirical contextual aesthetics of empowered creative expression in healthcare, contemporary thinking and traditional interpretations of aesthetic value of ArtsIT is challenged by introducing the neurological affective relationships [10] [14]. Introducing Neuroaesthetics to the author's prior research on Aesthetic Resonance and its innate conditions strengthens this approach. However, further research is needed to fully determine 'necessary and sufficient conditions' to align aesthetic/art value and to understand more fully whether the catalyst evolves from the creative process, the designing of the empowerment, and/or the facilitation of interactions. However, a resolute outcome is the need for first-hand experience to validate any meaningful judgment toward determining the work's innate aesthetic and art meaning. A vehicle with which to question and to augment understanding of the neural laws that dictate human activity and to challenge these laws as strategies to supplement traditional intervention in therapy and (re)habilitation was targeted.

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Digital-Foley and Live Performance

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Abstract. Using a series of reflective case-studies, the role of the Foley artist is reconsidered alongside technological innovations in both digital sound-manipulation and physical computing. A variety of approaches to electronic sound-production and control are described along with first-hand reflections on the expressivity and control that are offered by each within a context of live drama. In redefining digital-Foley, design considerations are outlined that could enhance the connectivity between the sound-artist and the sonic-landscapes they create.

Keywords: Technology, theatre, drama, liveness, sound, music, Foley.

1 Introduction

The term Foley is most commonly associated with its current modern application within the film industry. In this context it is the creation of sound effects for a film which takes place as part of the post-production process. As such, while the effect may be created 'live' in the studio, not only is it a response to pre-recorded material, the sounds themselves will ultimately be captured, edited, re-mixed, and synchronised with the visual stimuli. However, the role of creating sounds to accompany a dramatic work is not limited to the filmic medium, nor is it dependent on the ability to synchronise recorded sound with the moving image.

Although sound could not be separated from its source before the invention of sound recording, since the time of ancient Greece, theatre makers have created contraptions to simulate sounds. Heron of Alexandria invented a machine to replicate thunder which consisted of a metal box, containing a set of staggered metal shelves, and a trapdoor, above which a set of brass balls were placed. Opening the trapdoor released the balls, which would crash onto the shelves and come to rest on a tin sheet at the bottom of the box. The 'Onomastikon' also mentions that the sound of thunder was created by means of, 'bags full of pebble-stones poured into a brazen vessel' [1].

Another technique for making thunder was invented in 1708 by John Dennis who designed it for use in his play 'Appius and Virginia'. Dennis used a sheet of copper suspended by wires. The effect was created by holding the copper sheet at the edge and shaking it vigorously; the harder it is shaken the louder the effect. The thunder-sheet, like many other Foley devices, remained in use throughout the nineteenth and early twentieth century, and until the technology to record and replay sound was

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invented their live manipulation was standard practice not only in the theatre, but also in the broadcast of radio drama.

As a blind medium, radio is entirely dependent on aural signs to communicate the setting in which the drama unfolds as well as the people who populate it and the objects they use. Because the Foley artist's contribution was central and essential in the performance of radio drama the medium is often credited with establishing the artistic credentials of this type of accompaniment. Mott asserts: 'The art of sound effects began when radio and film were first struggling for recognition…the use of sound effects has evolved from the early days of radio to the art form it is today' [2]. While Mott's assertion does not fully take into account the extent to which this evolution was initiated and maintained in the Theatre, the importance of the Foley artist in the production of Radio Drama is unquestionable. Mott then goes on to cite the benefits of late twentieth century recording technology:

"Therein lies the tremendous advantage that effects on tape have over effects that are done live. With taped effects, you will hear the same sound in the exact same manner every time it is played. With live effects, there are never any guarantees. This is especially true of creating sounds that require a certain amount of pressure or friction to produce a desired effect." (ibid, 121)

While the consistency of recorded sound over live sound is undeniable, the transition did carry some penalties. One of these was the loss of the live interaction between Foley artist and performer. Whereas the live creation of sounds allow the Foley artist to respond intuitively to the ebb, flow, and rhythm of the piece, when working with recorded sound during the live event the Foley artist is reduced to an operator who simply sets the volume and presses the play button at the correct cue. This was a small price to pay considering the benefits in terms of dependability and efficiency. Indeed as Mott points out '…manual effects require the use of hands or feet. Inasmuch as sound effects artists are merely human, he or she can perform just so many effects at a given time' (ibid, 124).

This description of the live Foley artist is an important reminder that they were performers, playing an orchestra of sound objects to create sonic response to actions or events. The notion of performance is key within this and analogies can be drawn between musicians (as performers) and Foley artists as performers. Both employ skill-based performance behaviours where the sound produced is directly related to the performers own actions with physical gestures mapping onto sonic outcomes. Both also operate with a certain level of uncertainty, the potential to miss-hit or under-play a particular note or sound but, equally, the facility to quickly adjust and fine-tune the outcome to make amends. In music, this offers the performer scope to react and adjust to the sound of other instruments within improvised music and in Foley it offers the performer similar scope to react and adjust to events unfolding in a live environment.

The following paper describes a practice-as-research based approach to understanding how interactive techniques can be used to more effectively open up the digital domain to the Foley artist. Based on personal experiences of using innovative technologies for sound control in theatre productions, three central case-studies are presented that demonstrate the potential for digital-Foley in live performance. In analyzing and reflecting upon these initial attempts, this paper outlines the principles and possibilities of a process which allows forms of connectivity between the performer, the Foley artist, and the sounds they produce.

2 Reflections on Practice

2.1 Case Study 1: Crash

In 2001 Dean worked as sound designer on an adaptation of J.G. Ballard's novel Crash (1973). In addition to triggering a range of pre-recorded sound clips, a number of more experimental approaches were adopted, three of which are of particular relevance to this paper. Firstly, the director (David Ian Rabey) made the decision to have Dean and his 'instruments' visible to the audience rather than placing him behind a screen or in the lighting box. This positioning not only enabled the audience to see the sound designer and his kit (a visual representation of turning conventions inside-out that chimed with the expressionistic production values of the play), it also allowed the sound designer a close, panoramic view of the audience and performers.

Secondly, as a way of rendering the sounds of car engines in a non-naturalistic way Dean experimented with a Theremin during rehearsals. The Theremin was connected to a guitar effects processor into which he programmed four effects that mimicked the growl and pulse of a car engine. The speeds of the oscillations were controlled by a 'wah-wah' pedal which Dean operated with his right hand while playing the Theremin with his left. In the citation below Rabey describes the effect this created and the performative interplay between Dean and the actors:

"The expressionistic choreography and physical 'score' of the production incorporated many careful actions (some mimed, some not) of sculpting, grooming, tracing, delineating, dancing, caressing, puppeteering, mirroring, [and] countertension... They were further developed in response to… non-musical sound cues… designed to follow, rather than dictate, performers' movements, extending the improvisatory dimension of the soundscape. Rob Dean introduced a Theremin into rehearsals, with which he could suggest the acceleration of cars into a non-naturalistic way, accompanying the performers' 'driving' movements by observing and mimicking their tempo of moves with movement of his own hand within the sonic orbit of the Theremin." [3]

Thirdly, Dean designed and built two Foley devices. One was a contraption which reproduced the sound and impact of a car crash by causing a mid-air collision between two oil drums suspended above the audience (for a full description of this see [3]). The other was a large sheet of plate iron hung from the ceiling by a thin wire like an inflexible thunder sheet. When the metal was struck with a timpani mallet it would make a sound like a dull gong, however Dean used it to create a more visceral sonic effect. He attached four long shards of aluminum to the fingers of a leather work glove. By delicately stroking these sharply tipped 'Kruegeresque' digits along the metal plate Dean created '...the sort of noise conventionally described as 'putting one's teeth on edge'' (ibid, 45). The sound was captured by a floor mic beneath the iron plate and played-back through four speakers arranged around the audience to create a quadraphonic effect.

When the actors performed physical representations of the character Vaughan inflicting harm on himself by scratching themselves and picking at imaginary scabs

Dean would mimic the speed, trajectory, intensity, and rhythm of their movements with the aluminum scrapers. The sound had a clear physical effect on the audience, causing them to wince, groan, and cover their ears. While some of the performers could not bear the sound, others build up a certain degree of tolerance and through the rehearsal process intuitively learnt which movements produced the effects that caused the most discomfort to others. These performers became directly complicit in this act of sonic torture and would maintain direct eye contact with Dean in order to effectively play the metallic instrument by proxy.

2.2 Case Study 2: Dead by Dawn

In February 2009, Challis and Dean collaborated on Dead by Dawn; a stage play based on Sam Rami's 'Evil Dead' films. While performance techniques, lighting states, make-up and hidden trapdoors all contributed to the effectiveness of the production, the sonic material and the manner in which it was manipulated played a central role. The production was designed to include live sound manipulation by a small group of musicians/Foley artists with the aim of creating a cinematic soundtrack within a theatrical environment and combining performance elements of Foley with the digital manipulation of sounds.

The production required a complex palette of sonic events and landscapes that could reinforce the rapidly moving onstage action. After exploring different combinations of sounds and scenes in rehearsal the script was annotated with preliminary sound cues. In this rudimentary score each combination of sonic states was positioned within the narrative structure and given specific names; these included low-fear, mid-fear, full-on-fear, vortex, sinking stomach, slam, and chainsaw. On a practical level this enabled Challis and Dean to establish certain signals which would cue sounds to start, stop, build, peak and fade. However, these prompts were rarely indicated by a particular line of dialogue, instead they would often occur in quick succession during an action sequence and/or require subtle, often continuous variation. Consequently it was virtually impossible to cue them in the usual way as the timing and parameters of the sound depended upon a direct connection between performers and musicians. In order to facilitate and accelerate this interplay Dean assumed the role of a conductor. With a range of hand gestures moments of sustain, changes in volume, and specific sounds effects could all be cued and communicated.

The musicians were positioned on a balcony from which they could see both the stage and the conductor. This viewpoint enabled them to quickly become familiar with the dialogue, movements and effects that prompted certain sounds and sonic states. Once these visual markers had been learnt the musicians were able to mould their sonic accompaniment around them. As such the action on stage was not shackled to a fixed sonic composition thereby granting the performers' a level of autonomy as the musicians could respond to variations in duration and delivery. During some moments a kind of emotive circuit was created; the sound of an evil force approaching produced a response of terror from a performer, this caused the musicians to intensify the sound, which in turn prompted the performer to heighten their response and so on. This relationship continued to evolve throughout the rehearsals and performances.

In a sense it is the inevitable result of having two live elements existing within the same frame. With each run, the connection between the events on stage and the sonic accompaniment became stronger. However, due to the improvised nature of the sound this never became entirely standardized and the more familiar the musicians were with the parameters the freer they were to experiment within them. Two examples which illustrate the opportunities this approach created were a chainsaw attack and the suggestion of evil voices plaguing the main character.

Rather than using conventional control methods Challis adopted an alternative approach to sound control thereby enhancing his ability to match and react to the characters' actions. A sound-controller designed by Challis [4] was adapted and re-configured to work with specific sound-sets. The Octonic is an array of eight infra-red sensors that allows the performer to trigger a sound by breaking one or more of the beams. Moving within a beam can alter the parameters of the sound depending on how the system is set up. For both the chainsaw effect and the random voices, the sound set was placed within a specifically designed software 'instrument'. Six of the beams triggered the individual sounds, with movement within a beam controlling volume for expressive control; the remaining two beams controlled overall pitch and granularity. The chainsaw sequence was performed using backlighting to create an action sequence in silhouette. The sound for the chainsaw was derived from recordings of two motorbike engines and various mechanical grinders to simulate the chainsaw hitting flesh and bone. By placing a hand into one of the motorbike beams, an idling state could be suggested with a motor simply ticking over. Natural movements of the hand trying to stay still contributed to this undulating state through constant but subtle volume changes. A rapid gesture down into the beam instantly increased volume. Using another hand in the pitch-beam gave the impression of revving the chainsaw. This could be done subtly with minor hand adjustments or dramatically at the point of attack at which point 'sliding' into the adjacent beams provided various grinding impact sounds.

The sequence was particularly effective from the audience's perspective who responded with clear enthusiasm for the onstage horror. From the musicians' perspective, being connected to every component of the sound made the overall experience closer to that of playing an instrument. From the start of the sound to its conclusion, they needed to exercise judgment and skill in terms of adjusting the sound-state to complete the intended illusion. Having proximity sensors contributed greatly to this effect by picking up even the slightest movement. Another key benefit was the ability to quickly 'slide' between and across multiples beams, creating complex blends and textures. Similarly, the flexible connection between actors' bodies and the musicians' performance allowed the sonic and the visual to interact. Or to put it another way a two way relationship was created; the actor did not just respond to the sounds, the sounds also responded to the actor.

The same system was used to control the off-stage voices experienced by the main character as he struggles with his own state of mind. In contrast to the chainsaw which was a continuous sound effect for the duration of the sequence, the off-stage voices were intermittent. Processed animal sounds were placed across a stereo field such that each of the six beams corresponded to spatial locations. This allowed

Challis to trigger a sound in a particular location with one hand whilst altering its pitch, dynamic level and granularity with the other. The sequences were semi-improvised; Challis would 'place' a voice and the actor would spin round to look towards that location, however this 'placement' and the order of sounds changed each performance. This cat-and-mouse sequence would become more and more frenetic until the actor was ultimately overwhelmed by the voices now coming from all around him. As with the previous chainsaw sequence, it was clear that ability to move rapidly between sounds by sliding between beams was a very powerful technique. Again, the constant monitoring of the hand's motion afforded great subtlety and variation in a most intuitive way, allowing delicate 'twittering' between voices at the beams' extremities whilst offering dramatic bursts across voices in much closer proximity.

2.3 Case Study 3: An Evening with the Grand Guignol

A suite of three short horror plays, An evening with the Grand Guignol was directed by Richard Hand and performed to a theatre audience at the Aberystwyth Horror Film Festival in 2009. As with Dead by Dawn, live sound-design was employed to create a 'cinematic' soundtrack with sound performers working in close partnership with the cast. In contrast, there was less requirement for spot-effects and more requirement for ambient soundscapes which would often blur the boundaries between music and eerie stage atmosphere. The performers had previously worked with Hand on similar productions for live radio and were familiar with the way in which sound and music might need to cycle round for unset periods of time whilst still reacting subtly to on-stage action. Again, use was made of pre-prepared sound-sets that would belong to key sequences but these generally required sounds to be gradually layered to create an organically changing soundscape. It was not envisaged that complex technologies would be required as it was entirely possible to support the onstage actions using conventional triggers (such as buttons and faders). However, there were clear opportunities where the introduction of uncertainty into the interaction would have sharpened the relationship between the onstage actions and matching sounds. Most notably within these was the production of a heart-beat pulse in the opening sequences which was achieved by sliding a fader rapidly up and down. This method did work but the physical action did not map well onto the resultant sound which was heavily amplified through a sub-woofer such that the audience could feel the sound. In hindsight a more effective approach could have been achieved using a force-sensitive device such that squeezing an object in a clenched fist would control the sound. The sound set for An evening with the Grand Guignol has been revisited to test out this alternate approach and the relationship between performer and sound object is much more connected using this alternate method of triggering and control. A similar pressure-based approach to interaction was also retested on some of the sound sets that were used to create the organic eerie atmospheres. In the original version, drones and sound effects were controlled using buttons and faders whilst in the retest the same sounds were controlled using force-sensors thereby enabling triggering and expressivity to be achieved using the same device. As with the heart-beat test, the overall control of the sound was more apparent with the performer feeling more involved with the emerging soundscape.

3 Design

The three case studies suggest ways in which interactive and novel technologies might be used to harness physical movement for the purposes of digital-Foley. In the same way that contrasting performance behaviours can be seen as significant in the design of digital instruments [5], [6] they can be seen as equally significant within a context of digital-Foley. At one extreme, there are model-based behaviours that have deterministic outcomes where sounds are triggered and allowed to run their course (for instance, the sound designer who edits and applies sound to prerecorded imagery). Further across the continuum there are rule-based behaviours where the triggered sounds have scope for some level of change. This introduces a degree of random uncertainty within the sound in the way that computer games often require. Lastly there are skill-based behaviours. Smalley [7] suggests that sounds can be described by their spectromorphology or how the spectrum changes over time. With this in mind, skill-based performance behaviours will enable the performer to have more comprehensive control over the spectromorphic shape of the sounds they are creating. As such, technology that offers skill-based performance behaviours will be of significant value within a context of digital-Foley. How might this work in practice though? What would make for a more immersive interactive environment within a context of digital-Foley?

The basic remit of the next work-in-progress builds upon the techniques and technologies explored in previous theatrical productions and collaborations. However, for this project Challis and Dean are producing a live radio drama that incorporates digital sound effects and music, the parameters of which will be manipulated by the performers and Foley artists. In order to further explore the possibilities created by the integration of digital technology, this production will experiment with a range of sonic triggers (such as accelerometers, gyroscopes, tilt switches, proximity sensors, and micro controllers). By bending, stretching, hitting, and squeezing parts of the body the actors and Foley artists can trigger sounds and manipulate sonic parameters through direct physical contact or via more intuitive interactions.

It was observed that freedom to move quickly across numerous sound sources can be of great use, particularly if this can be achieved by intuitive and instinctive gestures. It was also identified that the natural uncertainty of small movement introduced subtle degrees of variation to certain sounds thereby adding further nuance to the skill-based performance interaction. Added to this, it was also identified that a multi-parametric approach to sound manipulation can be used to achieve complex sound transformations. Also, Norman [8] would encourage designers to consider the affordances that the interaction might offer us, such that the action required has an intuitive mapping to the sonic outcomes being achieved.

Of the technologies explored within the case studies, those that offered touch-free interaction appeared to bring an engaging dynamic into the performance element; the lack of haptic feedback introducing levels of uncertainty that appeared to feed into the delicacy of the performance. Though infra-red technology was used in the case studies, the same effect could be achieved in a number of different ways. Indeed alternate approaches could also effectively free the performer from being tied to a specific location by the physical apparatus. As identified earlier though, there will also be occasions where sudden triggering of sounds will still be required. Touch-free approaches are less effective in these contexts than physical buttons and switches where the natural haptic feedback of the device offers confirmation of closure. Force sensors make a useful alternative to conventional switches enabling sudden triggering of sounds (with tactile feedback confirming the action) but with the added benefit of velocity sensitivity.

4 Conclusion

As technology develops, established practices, procedures, and skills become redundant once they are superseded by more efficient processes. Sometimes these changes are so sudden and significant they earn the title ‘Revolution’. Like the Industrial Revolution before it the digital revolution has transfigured the way in which we ‘work’ sonic material, reducing the level of manual interaction required and opening new possibilities for the physical manipulation of sound. In this respect, physical computing can enable the Foley artist to work with digitised ‘concrete’ sounds whilst also maintaining a sense of tangibility, but the way in which these relationships can be most effectively exploited is still unclear. It is the exploration of these possibilities that lies at the heart of the project we have termed ‘digital-Foley and live performance’.

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Towards Novel Relationships between the Virtual and the Real in Augmented Reality

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Abstract. In Augmented Reality (AR), virtual and real content coexist in the same physical environment. However, in order to create AR, solely adding virtual content to a real space does not suffice. In this paper we argue that an augmentation *adds* and *relates* something virtual to something real. Subsequently, we discuss both existing and promising future relationships between the virtual and the real. We explore what AR is and what it could possibly include from a technology-independent and conceptual point of view. By comparing our take on AR with common manifestations of AR, we identify possible directions for future research and AR (art) works, such as the use of non-visual modalities and the design of novel interactions between the virtual and the real.

Keywords: Augmented Reality, Augmentation, Real, Virtual, Media Art, Mixed Reality, Modalities, Multi-Modal, Senses, Interaction.

1 Introduction

In Augmented Reality (AR), virtual and real content coexist in a real, physical environment (cf. [1,2]). Something similar happens when we turn on the radio and hear the newsreader speaking. However, the sound of a radio — in combination with the sounds of our surroundings — is generally not experienced as an augmentation of the environment. It is this observation that motivates our research into the nature of AR. Aiming at a better understanding of AR and its potential for media art, we explore what AR is and what it can encompass. We discuss current understandings of AR and explore alternative notions of the paradigm.

Our investigation into the characteristics of AR is driven by our personal interest in better understanding the qualities and potential manifestations of AR (including the artistic ones). We are furthermore interested in the possibilities of addressing other senses, not just the visual. We believe that the conventional definitions of AR are too limiting and we are curious about alternative forms of combining the virtual and the real. Our research intends to foster experiments, artworks, exchange and discussion rather than stating fixed results.

We are interested in the concept of augmenting the real with the virtual; technological aspects of AR fall out of the scope of this paper.

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The paper has five sections. Section 1 gives a short introduction. Section 2 defines augmentation and argues that AR requires a relationship between the virtual and the real. Section 3 identifies both existing and promising future relationships. Section 4 discusses our view of augmentation and compares it to existing understandings. Section 5 concludes the paper and points out possible future directions.

2 Augmentation

In AR, virtual content is superimposed, overlaid, projected onto or added otherwise to our real environment. As a consequence virtual and real content appear to coexist in the same physical space (cf. [1,2]). This common view is shared and spread by acknowledged AR researchers. Milgram et al. discuss AR in terms of the much-cited Reality-Virtuality continuum [10,11]. The continuum describes the realm of Mixed Reality (MR) environments "in which real world and virtual world objects are presented together within a single display" [10]. The continuum ranges from purely virtual environments to entirely real environments. Augmented reality is placed within this continuum and describes an otherwise real environment that is augmented by virtual objects. Similarly, Azuma's widespread survey [1, p. 2] summarizes AR as a field that "allows the user to see the real world, with virtual objects superimposed upon or composited with the real world."

AR has become an emerging academic field since the late 1990s. It is frequently discussed in the context of technologies and techniques that enable or support the augmentation of the physical world with the virtual, such as tracking or calibration techniques (cf. [16]). Another trend in AR research is the focus on visual augmentations, such as the integration of 3D graphics in the real world (see, e.g., [1,10,11,16]). However, we can also interpret AR as a more general concept of augmenting the real with the virtual.

Adding ≠ Augmenting. When interested in augmenting the environment, the common notions of AR can be misleading. One might assume that adding virtual content to the environment augments the environment. However, this is not true in general: virtual content *can* augment the environment, but not necessarily does so.

The example of the radio has illustrated that the presence of virtual content in our environment does not necessarily mean that the environment becomes augmented. Examples for sonic environments where augmentation does take place are Janet Cardiff's audio walks and Cilia Erens' sound walks. Cardiff's walks date back to 1991 and are designed for a certain walking route. While navigating the space, the listener is presented with instructions such as "Go towards the brownish green garbage can. Then there's a trail off to your right. Take the trail, it's overgrown a bit. There's an eaten-out dead tree. Looks like ants" [3]. Besides spoken content, one gets to listen to edited mixes of pre-recorded sounds, which blend in with the already present sounds of the surroundings. The virtual soundscapes mimic the existing physical one "in order to create a new world as a seamless combination of the two" [3]. Similarly, Cilia Erens, who introduced her sound walks in the Netherlands in 1987, superimposes virtual worlds onto the real one. In contrast to Cardiff, she forgoes spoken content and uses largely unprocessed everyday sounds. Yet, the effect is similar [4]: "a new reality within existing realms, a form of 'augmented reality'." Why is that? Unlike with traditional radio, the real and the virtual do not just coexist in the same space but also relate to each other. The pre-recorded sounds used by Erens and Cardiff are designed to mix with the sounds present in the environment. Furthermore, Cardiff's spoken comments refer to what you see around you and Erens' work invites you to make connections between the added sound and what you see. In contrast, the sounds played by a traditional radio are generally not related to the environments in which they are played back; they are *independent* content (and are usually experienced that way).[1]

By acknowledging a necessary relationship between the real and the virtual, we can sharpen our understanding of AR. Augmentation is the result of the relationship(s) between the virtual and the real and not just the addition of the virtual.

3 Relationships between the Virtual and the Real

Technically speaking, the realization that the virtual and the real have to be related is not new. In 2002, MacIntyre [8, p. 1] writes "The relationships between the physical and virtual worlds is what makes Mixed Reality applications different from other interactive 3D applications." Looser et al. [7, p. 22] refer to MacIntyre when they point out that "Creating content for Mixed Reality (MR) and specifically Augmented Reality (AR) applications requires the definition of the relationship between real world and virtual world." Hampshire et al. [5, p. 409] make a similar reference to MacIntyre: "Designing content for MR is driven by the need to define and fuse the relationship between entities in physical world and virtual world." New media theorist Manovich [9, p. 225] notes: "In contrast [to a typical VR system], a typical AR system adds information that is directly related to the user's immediate physical space."

The fact that the relationship between the virtual and real is a defining characteristic of AR applications is clearly acknowledged. However, looking at what relations between the virtual and real are commonly defined, we are surprised: while we can discover manifold relationships in existing AR works and applications, AR research commonly reduces the topic to *registering* real and virtual objects with each other. This is most prominently the case in Azuma et al.'s widespread definition [1,2]. It states that an AR system "combines real and virtual objects in a real environment; runs interactively, and in real time; and registers (aligns) real

[1] Another difference is that the audio/sound walks invite the listener to navigate the space. While this doubtlessly is an important factor for the experience of the work, it is not required for the augmentation.

and virtual objects with each other" [2, p. 34]. Furthermore, research on AR almost exclusively addresses the relationships between the real and the virtual in a technical context. In the following, we address the topic from a conceptual point of view and explore the various relationships we can find, perceive and imagine.

Spatial Relationships. The most dominant manifestation of virtual-real relationships in AR is a *spatial* relationship between virtual and real entities. As virtual objects and real objects are aligned with respect to each other, we perceive the spatial (three-dimensional) relationships between them (e.g., a virtual pen might seem to lay on top of a table and to the left of a glass). Here the virtual objects relate to the surrounding space in the sense that they are *part of/integrated in* the environment.

Content-Based Relationships. Typically, the virtual is not only integrated in the environment spatially but also relates to it on the content level. This can be achieved by specifically creating the content with respect to the real or by presenting content that is *already* related to a specific environment, location or object. Common examples are applications that inform us *about* an environment/object or *annotate* it. For instance, information about a painting, building or monument can be presented virtually at that particular site.

Temporal Relationships. AR often builds on temporal relationships. For example, images can be presented (e.g., superimposed) at the spot where they were taken years ago or sounds can be played back where they were recorded earlier. Here, AR builds on a relationship between the past and the present.

Transformation. A popular approach in site-specific AR is the *modification* of the appearance of real world objects by means of the virtual. Here the virtual seems to *transform* the real. As a consequence, real objects appear differently and gain virtual (often temporary) properties. Although this is not limited to site-specific art, it is especially well known in this context. A whole building can, for example, serve as a canvas for 3D artworks which appear to dynamically transform the underlying architecture in real-time (see, e.g., [14]).

Translation. More and more applications of AR do not *simulate* additional objects but aim at *revealing* what usually is unperceivable. A well-known example is a hand-held Geiger counter, which produces audible clicks that correspond to the amount of radiation. Here the relationship between the virtual and the real is a *translation* from something real we cannot perceive to something virtual we can perceive.

Replacement and Removal. We are often surrounded by a saturated (visual) environment. Hence it comes as no surprise that AR artists have looked into ways of *removing* things as well. A good example is Julian Olivers Artvertiser: a mobile augmented reality project that removes advertisements and *replaces* them by art [12].

Complementation. We can imagine scenarios, where the virtual *complements* the real and vice versa. For this to happen successfully, often both, the virtual and the real, are specifically designed in a way that leaves out certain aspects in order to be filled in by the other. This happens for example in the field of Augmented Prototyping. Here digital images are projected on physical models, resulting in a mixed virtual-real prototype [15].

Influence and Interaction. Developments in AR increasingly focus on interaction between a user and an AR system (cf. [2,16]). However, interaction between a real user and virtual content not necessarily contributes to the augmentation. What we are looking for in AR are relationships between the virtual content and that what it augments.

In line with this, an often neglected aspect is the interaction between the environment and the virtual content. Influences between virtual and real entities can model existing influences, e.g., a real ventilator might move virtual leaves. The need for such behavior has been pointed out by MacIntyre [8, p.3], who suggests using "*physical laws* (i.e. gravity, inertia) when real and virtual *objects interact.*" However, the virtual does not require us to stick to behaviors and reactions that we would expect from real objects. On the contrary, it would be interesting to explore influences and interactions that are impossible to realize between real objects but which are nevertheless believable.

We can take the idea of influence between the virtual and real one step further and imagine bidirectional influences between virtual and real entities. Once the virtual is not only influenced by something real but also influences the real in return, we can speak of true interaction between the virtual and real.

An artwork which demonstrates that real objects can interact with virtual content in novel ways is *Radioscape* by Edwin van der Heide [6]. The installation makes use of several radio transmitters that are distributed over a part of a city, each transmitting one layer of a meta-composition. By navigating through the city with a custom developed receiver, a listener can pick up several signals at a time. The volume of the single layers depends on one's distance to the corresponding transmitters. Due to the chosen wavelength, buildings become conductors and resonators for the transmitted signals. The physical environment is excited by and responds to the transmitted radio waves, ultimately influencing what one hears.

Also the often-desired interaction between an audience/user and an augmented environment can be realized by establishing influential relationships between physical and virtual objects. Once physical objects influence virtual ones, the audience can interact with the augmented environment, simply by interacting with physical objects.

Composed Relationships. With regard to AR art, artists and designers can compose their own, novel, possibly more abstract relationships between virtual content and the environment. It is then up to the audience to discover these.

4 Discussion

We have presented a conception of AR that applies to those combinations of the virtual and the real where a relationship between the two exists. Our view of AR differs therefore from widespread understandings of AR. In the following, we compare our notion with existing views.

The Virtual. In contrast to generally accepted views such as those introduced by Milgram et al. [10,11] and Azuma et al. [1,2], our definition is more comprehensive with respect to what we consider virtual content. Firstly, it does not limit the virtual to virtual *objects*. Furthermore, we do not require computer-generated or digital content but also accept analog forms of the virtual. Looking at definitions as well as applications, AR is often restricted to the sense of sight (cf. [16]). Opposed to these trends, our definition does not require nor promote visual augmentations of the environment.

The Real. Our take on AR is also more encompassing with respect to what can be augmented. We do not limit possible targets of the augmentation to our (visual) environment. In our opinion it is 'something real' that gets augmented. This 'real' can range from an environment to objects to processes or activities. Consequently, our conception of AR includes participatory works of art in which virtual content is added and related to the behavior of a 'real audience'. This happens for example in David Rokeby's *Very Nervous System* [13]: when a participant moves in front of the camera, his or her movement gets augmented with sound. It is interesting to note that spectators of this interaction between the participant and virtual content are confronted with a typical AR scenario: something real (the participant's actions) is related to/augmented with virtual content.

Just like the virtual is not limited to visual content, we cannot only augment 'what we see'. For example, Cardiff's audio walks [3] relate to both, what we see and what we hear.

Relating the Virtual and the Real. Compared to common definitions, our notion of AR is less restrictive regarding how the virtual and real can be combined. We require a relationship between the virtual and the real (the virtual can relate to the real, the real can relate to the virtual or they can relate to each other). However, unlike Azuma et al. [1,2], we do not consider the (real-time) registration of virtual and real objects a requirement.

Our main objection to such a definition is that augmentation can be achieved without registration. If we consider non-visual modalities, examples are not far to seek: the above mentioned audio/sound walks [3,4] accomplish an integration of virtual content by mimicking the sonic nature of the surroundings — aligning virtual and real sound sources is not necessary. Hence, we see registration as only one of the ways by which virtual content can be related to the real environment and require 'a relationship' rather than registration.

Opposed to common trends, we do not consider interaction between a user and the added content decisive for AR. Instead, we emphasize the importance of interaction between the virtual and that what it augments. However, artworks like David Rokebys *Very Nervous System* [13] illustrate that these different types of interaction are not necessarily in conflict: interaction between an audience and virtual content can act as the relationship between the virtual and that what it augments.

Considering the identified relationships between the virtual and the real, we do not claim that we have presented an exhaustive list. Often several relationships are present in the same AR scenario. Therefore the identified relationships should not be understood as mutually exclusive categories.

Concluding our discussion, we want to return to the example of the radio. While we have argued that the sounds of a radio do usually not augment the environment, we can now envision scenarios where this is the case. Simply singing or dancing along with the radio, the virtual and real are combined and related. This reminds us, that the virtual does not always have to be added to the real: the other way around is also possible.

5 Conclusion and Future Directions

Starting out from common understandings of AR, we have developed an encompassing, technology-independent, sense-independent and conceptual view of augmentation. We have pointed out that it does not suffice to combine the virtual and real in order to create AR and have argued that a relationship between the virtual and the real is required. Compared to common definitions, our conception of AR is much broader. Therefore, it suggests many possible forms of AR that have received little attention in AR research and in practice so far.

Possible future directions include the exploration and design of novel relationships between the virtual and the real, e.g., in the form of interaction between both. With respect to this, we think of art and AR as two disciplines that can contribute to and inform each other. The presented overview of existing and possible future relationships can serve as a basis for designing future AR works as well as contribute to future classifications and characterizations of AR.

Interesting fields for future research and practice are furthermore *non-visual*, *cross-modal* and *multi-modal* AR. Up to now the most common form of AR is based on virtual visual content that primarily relates to what we see. Similarly, we have shown that sound can augment the sonic environment. What about alternative possible combinations of modalities? How could visual content augment what we hear, sound augment what we smell, or touch relate to what we hear? We expect that this sparsely explored field offers various possibilities to combine and relate the virtual and the real in novel ways.

We have argued that AR can not only augment the environment. We wonder whether it is also possible to augment moods or feelings. And what about augmented thoughts? Considering this suggests the more general question of whether AR is bound to real space. These considerations pose interesting issues for future investigations into the meaning, impact and possibilities of AR.

Regarding the continuation of this work, we plan on developing a framework that allows us to classify AR scenarios by specifying the virtual, the real and their relationship. Furthermore, we want to address topics that have only been touched upon briefly, such as possible interactions between the virtual and the real that are impossible to realize between real objects.

We hope this research will foster AR works in which the virtual and real no longer merely 'appear to coexist in the same space' (cf. [1,2,6]) but enter an active dialog.

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Interactive Multimedia Installations: Towards a Model for Preservation

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Abstract. Interactive Multimedia Installations (IMIs) are invaluable for the history of art and culture, for media technology and for other disciplines involved in the scientific research and the areas of application. Despite their importance, Interactive Multimedia Installations show some weaknesses that threaten their chance to be preserved long enough to be studied or replicated: (1) they show a complexity that cannot be oversimplified; (2) they are highly refractory to preservation. Moreover, they show an alarmingly short life expectancy compared to other cultural materials, such as audio-video carriers, let alone paper documents, paintings and sculptures. This paper presents the main problems related to the preservation of Interactive Multimedia Installations , and proposes the core of a possible solution.

Keywords: preservation, methodology, interaction, multimedia.

1 Introduction

The concept that multimedia refers to something more than juxtaposition of multiple media was introduced during the digital-machine driven revolution of the last six decades, where the term “medium” is not to be intended etymologically (otherwise, anything providing a multi-sensory stimulation would be multimedia, which is not the present technological-related meaning). In [14], the “new media” are configured according to two levels: a computer level (including data structures, file formats, functions and variables) and a cultural level (a classic novel, a favourite picture). These levels will prove useful in the conceptual model presented in Sec. 4. Just as the meaning of the term multimedia needs to be agreed upon, here the term ’interaction’ holds a technological-related meaning – and in this case the definition matches the etymology. As human beings, our experience of the world is basically inter-active and, in this sense, a condition we are most familiar with. The novelty of the concept resides in that, due to unprecedented computational power, *machines* are able to support interaction.

G. De Michelis et al. (Eds.): ArtsIT 2013, LNICST 116, pp. 81–88, 2013.

More precisely, they support real-time multimodal interaction, with increasingly sophisticated design, inspired by the model of "ubiquitous computing" [7,16,19].

The article is organized as follows: Section 2 introduces the scope of preservation and Section 3 focuses on the problems associated with preservation. Section 4 describes the authors' proposed solution.

2 Preservation

Preservation is intended to grant unrestricted access to cultural materials, which must be made available "forever" – decades or centuries, or long enough to be concerned about the obsolescence of technology [10]. An official document issued by UNESCO [8] reported that in 2002 seventy to eighty per cent of documentary heritage in Eastern and Central Europe was estimated to be inaccessible or in urgent need of preservation. The most authoritative institutions in the field agree that at present the most reliable technology for long-term preservation is digital, as it allows easy copying without loss of information. As a drawback, specific dangers such as failure without any warning should be considered, as well as the necessity to re-think concepts such as authenticity, ownership and copyright of the documents.

Synthesizing tangible and intangible objects into digital preservation copies[1] causes the multiplicity of documents (multimedia) to be encoded as "unimedia" [15]. Despite the fact that digital technology is considered future proof, the exponential pace of technological evolution brings about a shift from the traditional focus on degradation of physical media to the awareness of the risks of obsolescence of the stored data.

Interaction introduces an additional element of complexity to the problem of the preservation of Interactive Multimedia Installations, already raised by some musical "open works" such as *Scambi* (1957) by Henry Pousser. A *systemic* approach to preservation could overcome the limits of the current approaches, which require that objects are (made) static for preservation. In this sense, an analogy can be made between interactive multimedia systems and *open systems*. According to [1], every living organism is essentially an open system that maintains itself in a continuous inflow and outflow (a building up and breaking down of components) so long as it is alive. The commonalities with interactive multimedia systems are remarkable.
A good model for preservation should base on time-dependent aspects of interactive systems, rather than distort the present ones to forcedly deal with it. Section 4 discusses a possible solution that considers these aspects.

Current trends of multimedia artistic works show an increasing attention for full-body interaction. According to the embodied approach to the study of music cognition [12], corporeal and nonverbal articulations may enable a paradigm shift

[1] In [11], a preservation copy (or archive copy) is defined as "the artifact designated to be stored and maintained as the preservation master". It is an organized data set that contains all the information carried by the original document, accompanied by the metadata and the documentation about the preservation process.

in the preservation of cultural heritage, in particular of interactive processes. The crucial idea is that body gestures may hold meaningful significations with respect to the subjective experience of involvement with music, i.e., that body movement may provide efficient musical descriptors different from the traditional text-based descriptors, which are effective for some features but totally fail to attain others.

A particular class of works that should be considered for preservation consists of the replications, the reinterpretations and the virtual models that resulted from important recovery actions, some of which were financed by the European Union, such as DREAM (Digital Re-working/re-appropriation of ElectroAcoustic Music, 2010-2012)[2] and VEP (Virtual Electronic Poem: VR-simulation of the Poème Électronique by Le Corbusier, E. Varèse and J. Xenakis (1958), 2002-2004)[3].

Finally, a sucessful model for preservation would enable the creation of a common European repository, that institutions (e.g., archives) and artists could populate with descriptions, data, pictures, videos and testimonies. The model would also result in a set of guidelines for a consistent organization of the data within the repository. Artists would be encouraged to produce a documentation about their new works along the lines of the framework: thus, the very important goal of actively involving the artists in the process of preservation would be achieved, and the long-term storage planning would be optimised.

3 Problems Related to Preservation

Some of the problems regarding the preservation of Interactive Multimedia Installations fall within the scope of established research fields (e.g., audio preservation), where standards and methodologies are available; some are addressed by novel research fields, where best practices are in the process of being defined. But there is also a wide area of intersection where different disciplines are called to integrate opposite (sometimes conflicting) approaches, in order to achieve satisfactory solutions.

Most of the disciplines that made a contribution to the table of music research during the twentieth century (e.g., psychology, sociology, acoustics, physiology, neurosciences, cognition sciences and computer science) describe music through a different viewpoint, and they are interested in different aspects (e.g., the propagation of pressure waves in space, the harmonic relations, the capacity to evoke emotions). No matter how good the individual descriptions are, none will attain a comprehensive picture, neither will disciplines that are just put next to each other without much interaction. It is the same for Interactive Multimedia Installations, where music is only one of the constitutive elements. This calls for an approach that goes beyond the single disciplines, becoming "transdisciplinary" [13] – making way for new professional figures, whose added value precisely resides in the ability of switching contexts.

[2] `http://dream.dei.unipd.it/`

[3] `http://www.edu.vrmmp.it/vep/`

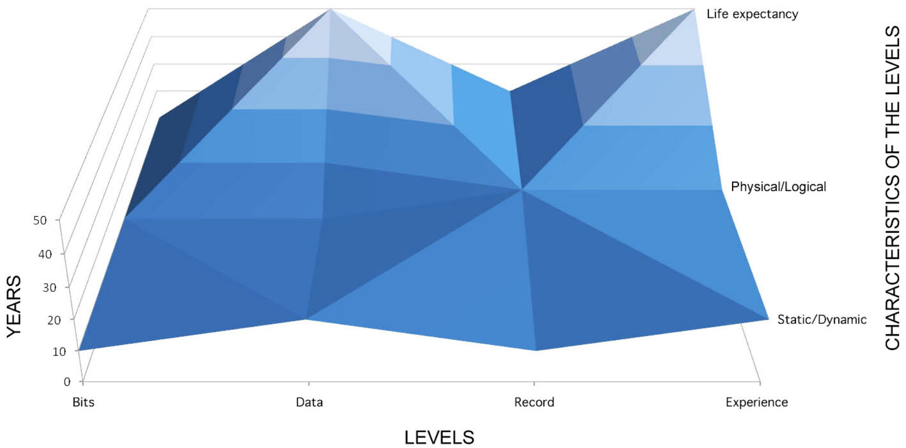


Fig. 1: Characteristics of the multilevel approach to preservation. Each level (bits, data, record, experience) can be static/dynamic, physical/logical, and has a limited life expectancy. Levels are depicted on the x-axis, properties on the y-axis, and values on the z-axis. The properties static/dynamic and physical/logical assume only two values or states: lower for static and physical, upper for dynamic and logical. Colors refer to the bins associated with the life expectancy of each level expressed in years.

Some of the main problems can be summarized as follows:

1. Complexity (meaningful distribution over multiple media);
2. Interaction (intrinsic and extrinsic);
3. Physical deterioration;
4. Obsolescence of:
   – Hardware;
   – Software environments;
   – File Formats;
   – Programming language;
5. Absence of score, or notation;

Current cataloguing standards provide that documents are classified by homogeneous typologies and, accordingly, that multimedia works are dismembered and their components grouped by typology. Interactive Multimedia Installations come as a *multidimensional* "assembly of artifacts" [2], i.e., they consist in the combination of several partial documents, mainly sonic/musical and visual documents representing intangible contents with a cultural and/or social signification. The documentary unity must be (temporarily) violated for cataloguing and subsequently restored to deliver the information as a whole. This approach leads to a variety of information systems using different formats for data storage [4], and the low or absent interoperability among repositories makes the reconstruction of the documentary unity a problematic or impossible task, thus wasting or betraying the ultimate meaning of the work. Defined by a high typological variety, multimedia are particularly threatened by casual dismembering – as any bundle of items whose informational potential resides in the relation of the parts.

A good model of Interactive Multimedia Installations intended for preservation should be able to support: (a) all approaches to preservation (i.e., future re-installation, historical/philological studies, musicological analysis, informed fruition, ...); and (b) all approaches to restoration (i.e., documental, aesthetical, sociological and reconstructive).

The definition of a conceptual model for the Interactive Multimedia Installations is a necessary step for any operative action.

4 Proposed Solution: A Multilevel Approach

One of the few works related to Interactive Multimedia Installations is the ontology approach used in [17] and [18] to describe them and their internal relations to support the preservation process. In [3], some of the authors proposed a functional categorization of documents as an extension of the CIDOC Conceptual Reference Model (CIDOC-CRM), an ISO standard for describing cultural heritage [5,6,9]. Starting from the assumption that the creative process is impossible to freeze, a possible solution may come from a combination of approaches, defined as distinct levels of preservation, not necessarily sequential, with different purposes and ways to be performed. Each level pursues different goals, although they might be overlapping contents. Two forms of preservation are considered: *static*, where records are created once and not altered, and textitdynamic, where records are changed and updated. Finally, levels may consist of a physical or logical content. Figure 1 shows each level and the associated properties.

Level 1. Preserve the Bits: each part of the original installation that can be directly preserved: static, physical, life expectancy 5-10 years.

All the data are kept in the original format (the problem of their interpretation is a matter aside), and the risk of introducing alterations must be avoided.

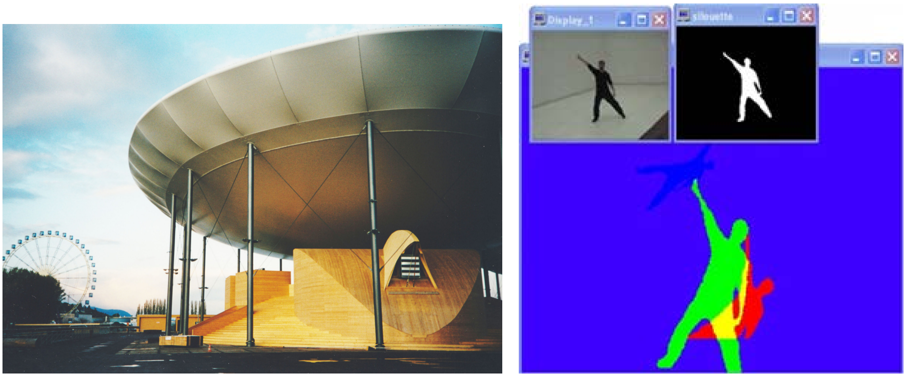
Level 2. Preserve the Data: technical notes, comments and useful information about the realization of the installation: dynamic, physical, life expectancy up to 30 years.

Includes a high level descriptions of algorithms and models.

Level 3. Preserve the Record: any element that was modified or updated in respect of the original installation: static, logical, life expectancy 10-20 years.
It includes reinterpretation of the patches and information about the context.

Level 4. Preserve the Experience: any document that bears witness to some aspect of the installation: dynamic, logical, life expectancy up to 30 years.
Includes hardware, software, interviews, audio/video recordings, usability tests of the original system, as well as information about people (composers, directors, performers, technicians) involved in the original performance and their roles.

It should be noted that some interactive sets provide that objects are used or consumed during interaction (food, perishable material, ...). In this case, one or more parts of the system may literally not exist after the process of interaction.



(a) Piazza Pinocchio (b) Casetta delle immagini

Fig. 2: Interactive Multimedia Installation *Piazza Pinocchio*, exhibited at the Expo 2002 in Neuchâtel, Switzerland, from May to October 2002. Left (a): rear view of the massive wooden structure that housed the installations inspired by the tale of children's novel Pinocchio. Right (b): one of the EyesWeb patches used during the exhibition, migrated from EyesWeb 2.4.1 to a new environment with EyesWeb XMI 5.1.0 on Windows XP.

4.1 Case Studies

The approach described is currently being applied to a selection of Interactive Multimedia Installations by Carlo De Pirro (1956-2008: composer and professor at the Conservatory of Music "Venezze" in Rovigo, Italy, from 1982 to 2008) at the Centro di Sonologia Computazionale (CSC) of the Department of Information Engineering, University of Padova, Italy. More detailed description of the case studies are reported in [3], in particular: 1) the multimedia installation *Piazza Pinocchio*, exhibited at the Expo 2002 in Neuchâtel, Switzerland, from May to October 2002; and 2) the *Carillon della Materia*, currently exhibited at the Parco Collodi in Pisa, Italy.

Piazza Pinocchio consisted in a closed environment dedicated to children, like a magic room, in which each gesture turned into sound, image, color (cross-modal interaction). The visitors got involved in a communication of expressive and emotional content in non-verbal interaction by multisensory interfaces within a shared and interactive mixed reality environment. The system focused on full-body movements as primary conveyors of expressive and emotional content. The audio/video processing was performed by the EyesWeb open platform[4].
The work was dismantled after exhibition and never reproduced due to its massive architectural structure. The original equipment and the software tools were documented (level 1). When the preservation process started, some audio files employed during the original performance were missing. Algorithms and models were described (level 2), and the original EyesWeb patches were migrated

[4] http://www.infomus.org/EywMain.html

to the EyesWeb XMI release and run on Vista OS (level 3). Interviews and photographic material are currently being collected and commented (level 4).

The *Carillon della Materia* is a wooden structure inspired by the tale of Pinocchio, where common tools of a carpenter's workshop turn into musical instruments, automatically controlled according to a musical score especially written by De Pirro. The wooden frame of the Carillon was damaged during the transfers to other exhibitions, and it was subsequently restored and reinforced (level 1). Interviews and photographic material were collected (level 4). Electronic controls were made on purpose and not maintained through the years, so today the Carillon is a silent piece of sculpture: the people with the knowledge about its original configuration are not available, and no video recordings were made to document the way the Carillon was supposed to move and sound in the author's intention. This example shows that the preservation of the physical components is nullified, if the knowledge to make a sense out of them is lost.

5 Conclusions

The main problems related to the preservation of Interactive Multimedia Installations were introduced. Effective methodologies for preservation are an urgent matter because the works' life expectancy is alarmingly short compared to other cultural materials. To date, acceptable methods to represent and preserve complex digital entities that contain combinations of text, data, images, audio, and video, and that require specific software applications, do not meet the requirements for an effective preservation of Interactive Multimedia Installations. Moreover, current cataloguing standards provide that documents are classified by homogeneous typologies and, consequently, that Interactive Multimedia Installations are dismembered for storage, which may result in the impossibility to reassemble the work as a whole unless protocols of interoperability among repositories are defined. The authors presented the core of a possible solution, consisting in a multilayered approach, able to support different goals for preservation (documenting, academic studies, . . .) and re-installation (new exhibitions, interpretations, tributes, . . .).

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Encoded Thoughts: Writing Code as an Art Practice

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Abstract. This paper is a reflexion on the role that code writing is presently assuming in the field of visual expression and art making. Drawing on methods of analysis already studied and applied to the processes of artistic expression using conventional means and techniques, this study crosses over to the new field of code art. The development of a visual discourse for self expression using traditional art methods is approached as a bridge for the understanding of the same process when code writing is the elected art practice. The observation and registration of the processes of aesthetic choices and decision making followed by the author during the development of a piece of code art, is taken as an example to clarify the visual concepts approached in this paper.

Keywords: visual expression, code art, aesthetics, programming, aesthetic discourse, art practice, code writing, interactive art.

"The act of observing is the only key that opens the door of the mysteries."
José Saramago (1922 – 2010)

1 Introduction

When I went to art school, back in the 70's, I was naïf enough to be expecting to be told what art is and how to make it. After a few months of learning and practicing, eventually I understood that things are not so simple. I would never get a set of rules, a recipe, which if followed carefully to the letter, would result in a so called "work of art".

Many years later, when I have got my first computer, I went straight to the pages of the manual dealing with points, lines and circles. Very soon I was producing computer generated animated pictures – out of a set of rules. Since the very beginning, these set of rules – my first pieces of computer code – were written as an art practice. Obviously, these pieces of code have nothing to do with the set of rules I was naively expecting from my art teachers. But my mind couldn't avoid the ironic connection.

At that time, I was fascinated with the way different visual artists come up with different aesthetic solutions for the same visual proposition. In a drawing class, for instance, even if everyone is using similar paper and charcoal pencils, and drawing the same subject, and even if we assume that all the student's work have the same

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aesthetic quality, the graphic solutions each one of them will come up with will be different. This observation led me to my interest on the way artists develop a personal language for visual expression, a language whose elements are constructed out of the tools, materials and techniques of their choice.

When I started my visual research with computers, this problem assumed a brand new and unexpected slope. Writing code is a totally different kind of art practice (or not?). No pencil, no paint, no brush, no paper, no canvas. Is it possible to develop a personal language with this technique?

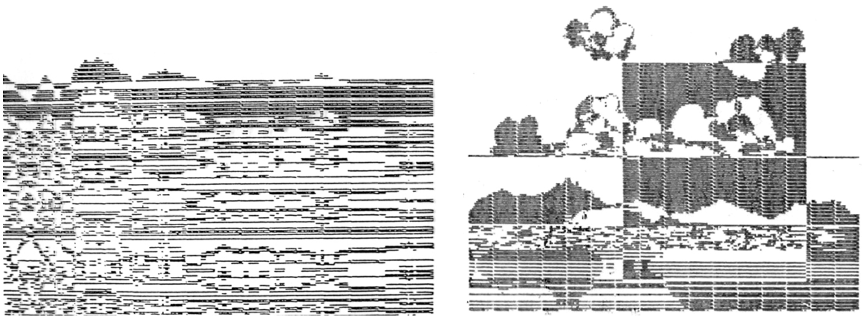

Fig. 1. Landscapes (printed frames from animations). ZX Spectrum 48K, 1985

My first computer, back in 1985, was a ZX Spectrum 48 K, and was programmed in BASIC. There was no other way of talking to this machine except through a programming language. All visual research I have followed with it and with the Apple II was, therefore, code based. I shared the fascination of these early computer days (and nights) with one of my colleagues at the art school where I was a teacher. Together we organized (arguably) the very first exhibition of computer generated art work in Portugal, in July 1985.

Looking at our computer animations running side by side at the exhibition room, I realized that, even if we were both using BASIC running on computers with very similar capabilities, our works would reflect our different personalities and our different aesthetic visions. We were producing work able to accurately, reflect the aesthetic messages of our personal visual projects. If we were using conventional media and conventional techniques, this would be seen as natural. But we were using a new medium that, at the time, would raise simultaneously, curiosity and distrust. Some people would consider the images and animations we were producing as interesting as an isolated experience, but hardly serious art work. Most people would simply reject it altogether, refusing to accept that visual expression could be achieved without a direct manual action from the artist. The concept of programming was, for them, a totally alien one. But I was clearly aware of the conceptual pathways, the creative steps, the aesthetic choices involved in the process of creating my code. Being a visual artist, and having worked with traditional media and techniques for a long time before using computers, I could recognize the patterns of thought, and the logics of the artistic process in course. It become of the biggest importance at that time, to make this process as clear for others as it was to me. A long time as passed since, and the circumstances are different now. Prejudice against computer generated images is over. But the problems raised by code writing as an art practice are still as relevant and interesting as before or maybe more. The visual practitioner has now a large spectrum of graphic software with user friendly interfaces to choose from. Programming has become an aesthetic choice, not a necessity.

Now that computers are a normal tool within the artistic process, and excellent software exists that successfully mimics traditional tools, art work that uses computers at any stage of its creation are finally making its way into art galleries and museums (and not only on specific events dedicated to computer generated art work) and finding acceptance, on the basis of its aesthetic quality and artistic relevance. Well established artists such as David Hockney are giving their blessings to graphic software, bringing down the last barriers. Computer generated pictures are not new anymore, and are not rejected – or accepted – simply because they are made with the help of a machine. They are becoming an art form as many others, subject to the same aesthetic standards. Many of these computer generated pictures are created with software that mimics, in very sophisticated ways, conventional painting, drawing and even sculpting techniques. The creative process involved in the development of these works is similar to the processes traditionally followed by artists to create their work, making it easier for people to identify with it, and therefore, to accept it.

But very good pprogramming languages are being developed by artists for artists, and many visual artists, including myself, are writing code as an option. The aesthetic potentialities of code writing for visual research are proving to be strong and sound. It is an art form as any other, but it poses its own problems and still raises some objections that I will now try to analyse.

2 Georg Nees and the Academics

In his contribution to Wolf Lieser's book *The World of Digital Art* [1], Frieder Nake refers an episode that helps to trace back some of the problems still posed by code writing as an art practice.

In February the 5th, 1965, in Stuttgart, an historical exhibition took place. Arguably for the first time, a series of computer generated pictures was shown to the public, and presented as "Computer Art". The author, Georg Nees (b. 1926), a mathematician, engineer and a philosopher, was working at the time at Siemens, in Erlangen, where a brand new automatic drawing machine had just arrived. Nees decided to play around with the machine. The result was a series of plotted drawings, generated through computer code. Following the publication of some of these drawings, Nees's work become known to the philosopher Max Bense (1910-90), who invited him to show his work at the Technische Hochschule where he, Bense, was a lecture at the time.

At the opening of the exhibition, Bense gave a speech based on a short text that become known as the Manifesto of Computer Art, "The projects of generative aesthetics"[2], followed by an explanation, by Nees, about the process involved in the creation of his pictures. Very few people were aware, at the time, of the existence of such machines as computers, let alone its use in a field as exclusive of human activity as art and creativity. At the end of Nees's explanation, one of the art students attending the event asked a question that can be considered the beginning of a long argument that lasts until today. The question was: 'Can you also teach your machine to draw with my characteristics?'

The implications of this question are very interesting. The student was concerned about the uniqueness of the characteristics of one's own art work, those characteristics that define the artist's own personal aesthetic vision. Original art work display these characteristics, which can exist at the level of the concept, the intention and the way they are conveyed, or can be dictated simply by the way the artist plays with his/her tools: the brush, the pencil, the actual fingers on clay. As an engineer, maybe not so familiar with the artistic process, Nees might have struggled with this question. Eventually, he gave a careful answer: "Yes, I can, if you can tell me what exactly your style is". According to Nake, "The artists suddenly had a premonition of threatening things to come." Ignorance generates fear, and the art students and artists from the Academy attending this meeting had no idea what a piece of code was, or how it was written and executed by the machine. They could only see an outrageous treat to their uniqueness as artists, and answered "The creative should always be superior to the computable" – implying, maybe, that it cannot be creative if it is computable?...

The meeting ended badly, with the academics leaving the room and slamming the door. Bense did his best to calm them down, calling after them "Gentlemen, we're talking about artificial art here!". But it was too late. Unwillingly, Bense and Nees gave rise to a misunderstanding that only history and the development of the technology was able to heal.

Because many of these early computer generated art works were made by engineers and computer scientists, they weren't always developed deliberately as aesthetic objects. Jasia Reichardt [3] refers this fact: 'Talking about his computer graphics, Nees insisted that they were not works of art but models for works of art. They belonged to the domain of aesthetics, but to a different category than that of art that requires a human imperative.' So, even Nees was convinced that, without some handmade human intervention the work wouldn't qualify as art. No wonder that academic artists, proud of their hand skills, couldn't accept as art a computer generated image.

Despite these painful beginnings, computer generated images eventually made their way into the world of art. Five exhibitions took place in the second half of 1968 that definitely spread the message. Cybernetic Serendipity was the first, and was held at the Institute of Contemporary Arts in London. This simple fact was a clear indication of some openness to these new experiments. As many others forms of artistic expression with painful beginnings, eventually the world accepted the inevitable: artists appropriate techniques and mediums created for completely different purposes and make them their own.

3 Conventional Art Practice

The process of developing a piece of art work seems to raise the curiosity of the viewer, like a mysterious, almost magic thing. And certainly, there have been knowledgeable people, mainly art critiques and art historians, studying the subject and writing extensively about it. In his book "Topics of our Time" [4], Gombrich dedicates a complete chapter to this subject: "Watching artists at work: Commitment and Improvisation in the History of Drawing". He starts by considering "intrepid" the artist who dares to set up his easel on a public place, allowing others to observe him while at work. I agree entirely.

I think Gombrich is conscious that the act of creating a visual work implies an intimate process of which only the artist is aware of - actually, of which sometimes not even the artist is aware of. A bit further on, Gombrich advises that, despite the title of the chapter, he will not be able to explain "(…) how Leonardo hesitated over the smile of the Mona Lisa or how Rembrandt struggled with the *Night Watch*.". In his own words, he has "to resign himself", considering that the intimacies of the creation process are out of his reach, even if sometimes, he is able "to infer from the evidence of sketches how the images we know emerged under the artist's hands."

Well, in my opinion, a visual artist is in a privileged position for the observation of this process. I actually think that the result of such observation can be an invaluable asset to all people concerned with this problem. An important part of my research consists on observing my own mind at work while developing a new piece of work. This is particularly relevant if the work is actually a piece of code. This observation and analysis can contribute to the understanding of how the artist's code can express his/her ideas, concepts and aesthetic intentions, in other words, how his/her visual language is developed.

There is no doubt that visual arts can be seen - and read - as a language. In her paper "How Does Art ´Speak´, and What Does it ´Say'? Conceptual Metaphor Theory as a Tool for Understanding the Artistic Process."[5], Karen Sullivan establishes a relationship between human speech/writing and the way communication is achieved through visual arts. Her work shows clearly that visual artists, consciously or not, consider their work as a language through which they communicate with an audience (viewer). Particularly relevant for this essay is Sullivan's observation that the ART IS CONVERSATION metaphor leads to the conclusion that art is a MONOLOGUE, unless there is an interaction of some sort with the audience/viewer (performance, interactive installations), in which case art becomes a DIALOGUE, an interaction between two speakers (in this case, the art work and the viewer). It implies also, a reaction and a response from each one of the speakers to the other, and this response implies some randomness, since it happens most of the time in unexpected ways.

Crossing over to the field of computer generated art work, and trying to shed some light on the way a visual language can be developed by writing code, I will now analyze some aspects of the development of my new piece of work, Encoded Thoughts (work in progress). Particular attention is given to the way the code is following and translating the most subjective aspects of the creative action.

4 Encoded Thoughts

4.1 Inspiration

For many years, I have been collecting photographs of the landscapes in Madeira Island, were I live. Most of these photographs are not intended as art works themselves, but simply as documents. I capture special moments of light and shadow, colors, textures, weather conditions. Many of these pictures become the basis and the inspiration for my visual research and art work. The intentional choice of specific pictures to achieve a certain purpose in the development of the art work is a fundamental aspect of my visual language. For this particular piece of work, I am playing with the colors, the luminosity, and the general feeling of the landscape, isolated from the landscape itself.

4.2 Concept

Encoded Thoughts was conceived as an interactive piece. For each image proposed to the viewer, there are infinite possible questions - and answers. To trigger as many answers as possible, interactivity was introduced. The randomness of the viewer's response to the visual questions posed by the selected picture, the dialogue established between the viewer and this image, is essential to trigger all the potential visual results. As all my other work, Encoded Thoughts was also conceived to be contemplative and generate feelings of peace and stillness of mind, like a meditation. This is also a "characteristic" of my work, another signature element of my visual language. In this piece, this is achieved by the choice of the proposed images: the code always generates soothing combinations of color and light – the color and light of the image itself.

To provide the means for interaction, an interface was designed. But, unlike paint boxes interfaces, this interface do not allow the viewer to create his/her own work. It was conceived to potentiate the randomness needed to fully unravel the potentialities of this piece. In other words, the viewer never becomes a "user". To achieve this, a strict control on the way the tools affect the proposed picture was imposed. I will now try to explain how this concept and ideas were translated by the code itself.

4.3 Code

Writing code as a visual researcher is not the same as writing code as an engineer. The ideas described above were all present in my mind at the time I started the piece, but there wasn't a programming strategy. The code would change and grow as a result of a complex and subjective process of aesthetic decision making during the creative process.

The (very basic) interface is self explanatory (see fig. 2). By clicking a button, the viewer can choose between 16 images (four at a time), carefully selected to fulfill the purposes described above. There are three tools, a square, a rectangle and a circle (I will come back to them in a minute), and a slider to control the size of the tool. The image of the viewer's choice presents itself as a canvas. With the mouse, the viewer picks up a tool and plays with the image, either by following a specific order or completely at random, and ends up with a totally new composition.

The first thing that becomes obvious is that there is no viewer's personal choice of colors. The colors are picked up by the code on the image itself, from the pixel under the position of the mouse, and displayed at the same position as a stroke from the tool, changing the image. Even when the image is already heavily transformed, the colors are picked up from the original picture. Like this, I ensure that the colors of the picture are the only ones used in the resultant composition, making this new image to be closely related to the original one.

```
int clx = mouseX; int cly = mouseY;
color c = photos[ctrl].get(clx,cly);
```

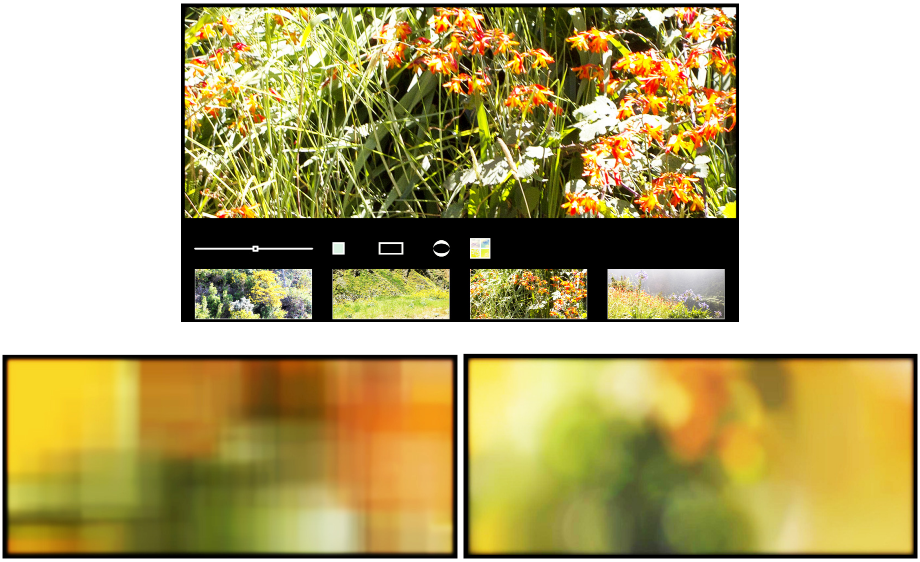

Fig. 2. Interface (above); Two possible results: square tool and blur (left), round tool and blur (right).

Now, what happens when we pick up and use, for instance, the square tool? In a first stage of the development of the code, the tool was producing solid squares of color. All the hues of the image were faithfully there, but the general feeling of the image (made of subtle combinations of hues and moods) would be lost. The code was changed to produce random transparency on each square. This would translate better the subtleties of the color combinations and the general mood of the image, creating interesting blends among the squares, and blending with the actual picture as well. But this wasn't yet entirely satisfactory. I played with the code as a painter plays with paint and brush, until reaching a visual solution, simple but effective: instead of perfect squares, the code produces rectangles with just a small difference between width and height. Randomness was introduced in the calculations, producing an infinite variety of sizes within a specific, close range (slValue is the value of the slider).

```
int rectw = int(random(slValue,slValue*2));
int recth = int(random(slValue,slValue*2));
```

The overlapping of the rectangles, tinted with colors from adjacent pixels, produced the desired soft, soothing effect. This effect can be emphasized at any time by blurring the image with the right button of the mouse.

The design of the other tools follows similar principles, but the rectangular tool fulfills another purpose. The width of the rectangles is always much larger than the height, creating a horizontal structure within the composition. This emphasizes the feeling of stillness and peace that I am trying to convey.

So, the viewer plays with the tools, until a new composition arises and nothing is left from the original image, except the colors, the light and the general mood. From each original image, an infinite number of new compositions can arise. The randomness introduced by the viewer's intervention is added to the randomness provided by the code itself. But the viewer's actions are, simultaneously, completely free and utterly conditioned: free to play with the tools at their will on the image of their choice, and conditioned by the limitations imposed by the code, in order to fulfill a specific purpose. As a result, each new composition arisen from the viewer's actions translates my personal aesthetic vision, but it is also a reflection of the viewer's aesthetic choices and creativity. It is a creative aesthetic symbiosis, intended to be spiritually rewarding for both, myself and the viewer enjoying my work.

5 Conclusions

In this paper, I have tried to demonstrate that code writing is a powerful and flexible tool for visual research and art making, as capable of expressing a personal aesthetic vision as paint and brush. Some answers to the questions posed by this approach to art making were attempted, but I am aware that I probably end up raising more questions than giving answers. But then, visual expression is a profoundly subjective matter, open to discussion, and constantly raising unanswered questions. So, I think it is most appropriate to finish my paper with another question, totally open to discussion: at the end of the day, what is the work of art, the code itself, or the images born from it? Well, another day, another paper…

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Aesthetics of ‘We’ Human-and-Technology

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Abstract. Technology presents that identity of we humans is performed by the collaborative action of the human and technology. The new identity provoked by technology can be called as ‘We’ human-and-technology. In the concept of ‘We’ human-and-technology, technology reconciles politics and the aesthetic. Technology based contemporary art articulates that politics and the aesthetic meet in creative tension between art and technology. Technology’s investigation of relation of politics and the aesthetic in contemporary art claims that art is politics. This claim comes from two ideas. First is the performative: the pairing of politics *and* the aesthetic is performed in collaborative action of ‘We’ human-and-technology. Second is the intervention: the contesting collaboration of politics *and* the aesthetic emancipates the sense, and reframes the distribution of the sensible. The way of technology posing the relation of politics *and* the aesthetic in contemporary art opens a new way of knowing linking art, technology and humanity: the understanding of ‘We’ human-and-technology in the collaborative action based interdependent perspective.

Keywords: ‘We’ human-and-technology, aesthetics, politics, collaborative action, the performative, sense.

1 We Are

Technology participates in the human condition. Like human-human communication, technology and humans act and react. In particular, computational technology is endowed with highly intelligent and perceptive qualities. It entirely differs from a simple machine manipulated by only human hands. A machine’s fundamental characteristic is the repetition of the same work. When a machine produces unexpected results from causes, we generally say that it is out of order. Meanwhile, computational technology such as Human-Computer Interaction/Interface (HCI), Artificial Intelligence (AI) and Artificial Life (AL) inversely finds new solutions as results unexpected by a programmer. When a computer outputs the optimization of problem through autonomous and emergent actions, we might say that it is creative.

Especially, a computer programmed by genetic/evolutionary algorithms has its own laws in that the system itself evolves. It can perform the autonomous and emergent action beyond human control. With the ability and autonomy and emergence, technology becomes a performer (a collaborator) collaborating with

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humans. It recalls that the relationship of human and technology is based on the reciprocal sharing of one purpose and process. Technology collaborating with humans presents that the identity of we humans is performed by collaborative action of human and technology. The new identity provoked by technology can be called as 'We' human-and-technology. It provides a new way of linking art, technology, and humanity in the collaborative action based interdependent perspective.

In *The Question Concerning Technology*, Martin Heidegger asserts that technology is not the technological [1]. It implies that technology is by no means the technological artifacts themselves. Instrumental understanding of technology conceals a free relationship of 'We' human-and-technology. Instrumentality misses the essence (*Wesen*) as the way in which 'We' human-and-technology pursue the collaboration. The collaborative relationship of 'We' human-and-technology invokes the Greek word *Techne* as a bringing-forth, a mode of *aletheuein*. It recovers that truth is *aletheia* for revealing (*das Entbergen*). The correctness of an idea is grounded in revealing. Technology is a mode of revealing the presence of truth. The revealing of technology connotes a change that is the negating of a former condition. It also promises an opening out from protective concealing.

From this ontological analysis, the concept of 'We' human-and-technology discerns two fundamental characteristics of revealing of modern technology. On the one side, the revealing that rules in modern technology is a challenge (*Herausfordern*), which puts to nature the unreasonable demand that it must supply energy that can be extracted and stored as such. The revealing that holds sway throughout modern technology does not unfold into a brining-forth in the sense of *poesis*. Rather it sets upon nature in the sense of exhausting it. On the other side, modern technology is evocatory. To challenge forth the energies of nature, the setting-in-order conceals a free relationship of nature, human, and technology. The key thing here is that the concealment reversely reveals the essence of technology. It reflects on the collaborative human condition; the history of 'We' human-and-technology. It finally triggers the question concerning the collaboration of 'We' human-and-technology: what is technology; what is the difference between human and non-human, animate and inanimate? The questioning rebuilds a way of knowing.

2 All Actors

Within the panoply of 'We' human-and-technology, technology reconciles between politics and the aesthetic. The relation of politics and the aesthetic has been asserted in a mutual degradation between two opposing points of view. First is a use of aesthetics in politics: how politics has turned to the aesthetic as either a support or an ideological antagonism. Second is a use of politics in aesthetics: how the aesthetic has social and political meaning. Technology undertakes a redefinition of the aesthetic that not only challenges the representational categories into which it has been placed but also redefines the aesthetic in terms of political existence. This challenge proposes a new definition agreeing with both politics *and* the aesthetic.

Technology's investigation of relation of politics *and* the aesthetic is amplified by contemporary art. One of significances of technology based contemporary art is that the collaborative action of 'We' human-and-technology becomes artwork itself. When artwork is constituted by collaborative action of 'We' human-and-technology, there is no distinction between actor and spectator, human and non-human, artist and audience.

Fig. 1. Jeehyun Oh, *GORI.Node Garden*, 2007, 'We' human-and-technology collaborative action Art, collection of the artist, photo: Jeehyun Oh

Fig. 2. Kohei Asano, *Garden*, 2009, 'We' human-and-technology collaborative action Art, collection of the artist, photo: Kohei Asano

There are two digital gardens. *GORI.Node Garden* (Fig.1) consists of artificial plants having three organs; stem and leaf are composed of long acrylic tube with a round magnetic disk, and the root is the control board. The plants grow through the collaborative action of human and computer. As the act of gardening, the human acts on the online chatting, and the computer reacts to the flow of data.[1] The liveness of

[1] *Gori Node Garden* consists of two parts; chat system running in the web server and controlling mechanics that make them connect. Each plant operates with a separate control board that has unique IP/MAC address and functions like a mini computer including CPU, small memory.

the garden depends only on the being together of human and computer, and they then become an equal gardener within the garden they have created.

The second, *Garden* (Fig.2) has more physical and bodily action. In the work, the human tosses scraps of paper lying on the floor into the air, and the computer calculates the quantity of action and projects some buds as a result. When the number of buds becomes over 200, flowers start blooming. These two gardens show that the collaborative action of 'We' human-and-technology has a structure of reciprocal conversation. As equal collaborators, human and technology communicate using actions, and there is nothing without the collaboration on the equality [2]. At this point, collaborative action of 'We' human-and-technology becomes actually an open work against the fixed meaning and authority.

The collaborative action of 'We' human-and-technology constitutes the new focus in technology's continuous interrogation of the ground that supports our understanding of the efficacy of the arts to change something in the world we live in. In the collaborative action, technology calls into question the recurrent production of spectators in the Western critical tradition and its contemporary mutations. The questioning dismantles the all too often characterization of the spectator: an obsession of passivity and ignorance in order to affirm that spectatorship is a capacity of all and anyone. It makes a new idea that undermines common premise of the spectator's idiocy. Knowledge most often regulates the agency of the spectator according to the hierarchical opposition of action and thought: spectator as passive and ignorant looker cannot 'act' because she/he does not 'know'. The modus operandi is footed on the hierarchy between 'active intelligence' and 'material passivity'.

Technology presents that it is high time to resituate spectatorship on different grounds. It declares that 'we are all actors.' The manifestation of 'We' actors is concerned with the political efficacy of actor and spectator. It affirms spectatorship as an action that intervenes to confirm or modify the consensual order. The reconceptualization of spectators galvanizes the 'actorship' of 'We' human-and-technology. It insists that spectators are active. As Jacques Rancière observes, the spectators see, feel, and understand something to the extent that they make their poems as the poet has done, as the actors, dancers, or performers have done [3]. The actorship performed by collaborative action of 'We' human-and-technology marks a new genealogy of equality. It seeks to directly produce social relations in order to erase the distance between the spectator and the real world, the distribution (confirmation) of capacities and incapacities between actors and spectators.

3 We Act Together

3.1 Art Is Politics

The parallelism of technology draws between actor and spectator. It designates that the point where politics *and* the aesthetic meet leads to creative tension between art, technology, and humanity. Instead of drawing a line intends to exclude, technology advocates inclusion, universality, and the plurality of modes of becoming. The question about the relation of politics *and* the aesthetic is then how technology could play a catalytic role for the reframing of knowledge. As a new negotiated point between politics *and* the aesthetic, technology reports on politics of art performed by collaborative action of ‘We’ human-and-technology. Politics of art provoked by technology can be defined as a third point where politics *and* the aesthetic collaborate with each other. It claims that ‘art is politics’. Although this remark distinguishes politics *and* aesthetics as belonging to different spheres, it speaks of a collaborative point through which art becomes known in terms of politics. This point provides a new way to avoid rehearing the knowledge that not only gives us politics *and* aesthetics but also give them to us within a way of thinking, or of representing idea. The question the point confronts is: how can politics *and* the aesthetic still be thought without recourse to the authenticity implied by any mode of representation? The way of technology posing this question becomes a new way of knowing. The questioning of technology is forms of intervention in specific contexts which becomes a way of knowing.

In this case, the relation of politics *and* the aesthetic is in the ‘doing’ related to technology as something that ‘does’ politics. The ‘doing’ related to the placing of ‘does’ is a curious act especially in a context that would avoid the representational knowledge in which the aesthetic was tied to the political. The regime of representation assumes that ‘to do’ is to represent. However, as a third point regarding politics *and* the aesthetic, politics of art performed by collaborative action of ‘We’ human-and-technology insists that ‘to do’ is to present: ‘to do’ is what happens in the regime of presentation. ‘To do’ occurs against the art as an imitation of the doing that characterizes politics. ‘To do’ denies that one of them (politics and the aesthetic) determines what is significant and what is not. ‘To do’ asks questions why must the relation of politics *and* aesthetics be placed within one of them? Why must it be quoted as politics *or* aesthetics when the articulation of its political *and* aesthetic significance is at stake? ‘To do’ is an agony disavowing the fundamental antagonism conditioning relation of politics *and* the aesthetic.

3.2 The Performative

With the performativity, the relation of politics *and* the aesthetic occurs. This occurrence between equal parts reconciles between politics *and* the aesthetic. On the one hand, it critiques the politicization of aesthetics: the historical and critical ease with which the aesthetic is confined to the ideological. On the other hand, it challenges the aestheticization of politics: an account of politics as a form of representation. In the collaborative action of ‘We’ human-and-technology, the pairing of politics *and* the aesthetic becomes the performative: the non-representational link between two systems of meaning and action. It attains position as a collaborative relation without characterizing it in either positive or negative terms. It pushes the realm of representational politics to a negative extreme. At the same time, it embraces the significance of its desired social critique and the politics that such a desire assumes. The relation of politics *and* the aesthetic therefore is in the double determination of commonality and exclusivity: it establishes at one and the same time something common that is both shared and exclusive parts. This double determination structures a network so that everything possessing visibility is assigned a part. The network recalls the 'actant-network' in Bruno Latour's insight to embrace both 'actors' (who act) and 'systems' (which behave) [4].

The third point where politics *and* the aesthetic meet is a contesting collaboration between actants (equal parts). Here, to become visible is that the relation takes place in equality: in order for mobilization to become visible, the relation must take place in equality. In short, the equality between actants in network is performative. The performativity is the beginning of the relation of politics *and* the aesthetic. The function of equality marks a collaboration that arises as soon as actants contest their invisibility by the performative. This contesting collaboration is the 'nature' (occasion) of politics *and* the aesthetic of 'We' human-and-technology. As a result, equality cannot be recognized as the object or issue of relation between politics *and* the aesthetic. Instead, it acts to 'give politics reality in the form of specific case [...] what makes an action political is not its object or the place where it is carried out, but solely its form, the form in which the confirmation of equality is inscribed in the setting up a dispute, of a community existing solely through being divided' [5]. The performativity of contesting collaboration between actants in network is a source for a new way of knowing provoked by technology.

3.3 The Sense

The third point where politics *and* the aesthetic meet recalls Friedrich Nietzsche's 'the will to power'. The definition of all beings depends on 'the will to power' which performs according to what happens. One can only get a sense of the being in what happens. What happens is what passes by us in the foreground and changes actions in the background. Within 'the game that the aeon plays with itself', the very moment of the sense is the unique existence of the being in time and space where it happens to be [6]. The sense of the uniqueness of human existence is troublesome because it is mediated by the technology. The sense as an autonomous and emergent experience is what happens: it is what it is rather than what it was or should be. The sense perception is what Rancière calls the distribution of the sensible in *The Aesthetic Dimension*. It is a certain modality, a form that is provided by sense [7]. It refers to Immanuel Kant's *Critique of Judgment* as making sense of a sense given; the faculty of sense as the capacity to both perceive a given and make sense of it [8]. The matter of sense perception (the distribution of the sensible) involves a mastery discourse that organizes and structures what can be apprehended by sense.

Aesthetics has always posed a problem with respect to determining its significance if not just its function, a problem recognized from the very beginning of political discourse in Plato's *Republic* and also in the history through which art is continually used as one form of representation or another [9]. The word aesthetic also bears the imprint of this problem. The aesthetic is the name that identifies the sense. At the same time, it is the category naming the form in which art appears. The third point where politics *and* the aesthetic meet clearly distinguishes itself from the representational mode that the aesthetic took on with the history of knowledge which is based on the instrumental rationality. It marks a recovery of the sensible.

The difference is that politics of art provoked by technology possesses a sensibility in the form of collaborative action of 'We' human-and-technology. It accounts politics on the distribution of the sensible: a mode of apprehension (visibility) of sensibility.

The pairing of politics *and* the aesthetic of 'We' human-and-technology insists on the emancipation as the means through which the sensible retains its proper significance. This significance appears as two things: the freeing from the regime of representation and the revealing of a mode of existence of sense experience. It constitutes the possibility of a category that is at once sensible but at the same time has no part within the distribution of meaning. The emancipation by politics *and* the aesthetic marks an intervention within the history of knowledge: the assignment to a certain form of sensible apprehension. It frees from an identification in which the sensible is subjugated to the idea (instrumental rationality) from a limited form within representation. The regime of representation is the regime of identification in which the sense is apprehended. The images involved in this regime have to be judged as a function of their intrinsic truth and their effects on the manner of being of individual and collective existence. The regime of representation is, therefore, ethical because its significance rests on an identification that presupposes the divine. In judgments about the image as a valid identification of a divinity, sense as an autonomous experience is understood as an instrument, a function of an imitation or representation.

As a third point provoked by technology, the pairing of politics *and* the aesthetic reconsiders the sensibility subjugated by rationality. It presents that the property of being the pairing of politics *and* the aesthetic is located in a 'specific sensorium'. It becomes free from the role that traditional representational idea has assigned to it. It becomes 'free appearance': emancipation from representation. The way of technology posing the relation of politics *and* the aesthetic forms the return to appearance. It consists in rendering the performative of politics *and* the aesthetic, in emancipating the sense that had only been perceived as an instrument to represent ideas, and in reframing the distribution of the sensible. This work creating contesting collaboration constitutes a new definition of the relation of politics *and* the aesthetic that has nothing to do with both the aestheticization of politics and politicization of aesthetics.

4 Coda

Technology explores a new definition of the relation of politics *and* the aesthetic in collaborative action of 'We' human-and-technology. It presents that the third point where politics *and* the aesthetic meet is in the creative tension between art, technology and humanity. Technology's investigation of the relation of politics *and* the aesthetic in contemporary art insists that art is politics. The claim consists of two characteristics. First is the performative of politics *and* the aesthetic. Second is the configuration of the sense and its distribution.

Within the panoply of 'We' human-and-technology, the subsequent insistence that art is politics is to produce a contesting collaboration between politics and the aesthetic. The third point where politics *and* the aesthetic meet rejects not only the separateness of aesthetics and politics. It also refuses the possibility of appropriation that art can be politicized: politics can be aestheticized. This way of technology posing contesting collaborations between two equal parts tells us that the relation between aesthetics *and* politics is, more precisely, the relation between the aesthetic of politics and the politics of the aesthetic, that is, the manner in which the third point where politics *and* the aesthetic meet configures the sense and its distribution.

In this sense, we might say that as a third point provoked by technology, the pairing of politics *and* the aesthetic of 'We' human-and-technology is an experience in itself. It needs affirmation that the sense is not a transitive (passive) exercise but an intransitive (active) one in which the possibility of future is always in play. To save the sense from subjugation of instrumental rationality is to present an experience in itself. It occurs against the long history of knowledge through which politics has turned to the aesthetic as either a support or an ideological antagonism, a history that has condemned the aesthetic to a representative role. When technology involves temporal configurations, the pairing of politics *and* the aesthetic happens at a double moment: the struggle of free appearance and the endless loss of self-evidence. The doubleness of double moment embodies the necessity of coincidence with politics *and* the aesthetic.

This double way of technology posing the third point of politics *and* the aesthetic cultivates the emancipated sense: that is, 'the seed of a new form of humanity, of a new form of individual and collective life' [10]. By alerting us to the implications of reducing the relation of politics *and* the aesthetic to the regime of representation, technology invites us to reflect on the condition for 'We' human-and-technology. Most importantly it opens a way for knowing linking art, technology and humanity. It takes care of ourselves in the new identity of 'We' human-and-technology.

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The Sense Making Process in *The Legible City*

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Abstract. Play has been intertwined with art for centuries although interactive arts seem to privilege this dimension in such ways that some artistic propositions became authentic open-ended games. This article explores the aesthetic experience with an interactive art installation called *The Legible City*. An empirical study was conducted using an Interpretative Phenomenological Analysis approach with the purpose to understand the influence of playfulness in the construction of meaning in *The Legible City*.

Keywords: Aesthetic Experience, Interactive Art, Free-play, Evaluation, IPA, The Legible City.

1 Introduction

Playfulness, fun and ludic experiences seem to have an increasing presence and importance in contemporary society. This doesn't mean that previous societies had no interest in such dimensions of private and social life, although a contemporary quest for fun and play seems to be increasingly perceived in human activities as art, design, architecture, advertising, engineering etc. As Mary Flanagan observes, with the emergence of organized sports, racetracks and the penny arcades during the industrial revolution, play became institutionalized [1]. Not only play became institutionalized but also touch, in a physical sense, became accepted and required in a society which was essentially *tactiloclasmic*[1] [2]. In the field of art, the emancipation of the spectator and the call for touch and physical participation which were premiered by artists as Marcel Duchamp, Naum Gabo or Man Ray were further explored in movements as Dadaism, Situationism and Fluxus. The proposals found in such movements were often events or performances, which relied on humor, variability, and playful and provocative instruction sets [1]. Interactive arts mediated by digital technologies are obviously rooted in these previous movements, which explored participation and bodily experience in group, human-to-human interaction or human to object/machine interaction.

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[1] Erkki Huhtamo explains that *tactiloclasms* are cases where physical touch isn't only absent but forbidden.

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2 Play and the Sense Making Process in Interactive Arts

The introduction of the computer in the field of arts allowed for new types of interaction between humans and objects, creating complex dialogues. Interactive arts' propositions have been exploring the engagement between spectator and artwork, developing experiences with very different and complex *interaction grammars*[2]. If the first interactive propositions at the beginning of the 20th century demanded simple actions to trigger some kinds of physical movements or structural changes, interactive artworks mediated by computers can be highly immersive, engaging the audience in complex sensorial play. The interactive artwork demands actions and as Jean-Louis Boissier observes, form emerges from a relationship established between participant and artwork [3].

The game of discovery of signs and symbols that characterizes the experience of traditional arts has then turned into a game of discovery that involves bodily performance. Despite their resemblance, games and open-ended interactive artworks present some significant structural differences. Despite the uncertain score and development, games are rule-oriented, towards competition and by specific goals. By contrast, the *free-play* observed in interactive art environments is free of clear goals and it is normally oriented by the pleasure of discovery and by the pleasure of the process itself. Such encounters privilege *funktionslust*[3] experiences not very different from what Roger Caillois names *paidia*[4]. There, participants are engaged in non-competitive, and non-linear performance, which have no fixed duration or path [7]. Play as a fun, free and voluntary activity standing outside of "ordinary" life [4] has been characterized as one of the most important dimensions of personal and social life, which is essential for our mental development, learning, creativity and development [1][6][4][8]. Although, despite of the relevance that play seems to have, interactive art has been criticized due to the climate of fun and the "lack of seriousness" observed in its playful propositions:

> "Does interactive work, enforced by the association with the computer game and because it requires some kind of rapport with audiences, fall into a trap and simply aid the cultural climate of fun, somehow automatically operating against seriousness?" [9]

Hans-Georg Gadamer observes regarding play in traditional arts that there is a "sacred seriousness" in every play, remembering that it's not just about divertissement [10]. We can easily come to very similar conclusions if we take into account the ludic and fun, nevertheless provocative dimension in the artistic propositions presented by Dadaists, Situationists and Fluxus artists [1].

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[2] Masaki Fujihata defines the grammar of interaction as the specific mode of interaction of an interactive artwork.

[3] Stephen Nachmanovitch describes the term *funktionslust* as the "pleasure of doing, of attaining an effect, as distinct as the pleasure of attaining the effect" [5].

[4] A source of play characterized by liberty, improvisation and spontaneity but also by an unstructured, almost anarchic movement, which is triggered by the pleasure to touch, taste and smell. Caillois uses as examples of such manifestations, a cat entangled with a ball of wool or the pleasure to endlessly cut paper with scissors or to make an assemblage collapse [6].

However one shouldn't immediately discard Cornwell's critics but rather try to understand their sense. Indeed not all the propositions in the field of interactive art mediated by computers afford a playful and fun behavior, although we frequently find playful experiences that engage the participant physically and emotionally but that seem to lack the provocative and activist side found in previous interactive propositions. Regarding our contemporary visual culture, Andrew Darley claims that technique and fascination by the mechanisms seem to have replaced the interest for meaning and the symbolic aspects of the image [11]. This attraction for image consumption and a very contemporary desire for interaction seem to have spread and infiltrated the field of arts and specially the field of interactive art. Then, very often such encounters seem to highlight the technical and material aspects of the piece instead of privileging a detached critical reflection. Notwithstanding the problem of such findings is not so much rooted in the playful dimensions that such works present but rather in the way they were conceived and designed.

In the book *Digital Art and Meaning*, Roberto Simanowski observes that in interactive art installations such as *Text Rain* by Camille Utterback, *Re:Positioning Fear* and *Body Movies* by Rafael Lozano Hemmer, the text and the symbolic elements are neglected because participants are often observed in self-absorbed and creative play [12]. The author upholds that rather than engaging participants in the reading and symbolic interpretation processes, these encounters afford an experience more rooted in sensorial and bodily discovery. He also acknowledges the impossibility to construct meaning according to the intentions of the authors unless the participant is able to grasp the linguistic and symbolic layer of the work [12].

When observing the videos of such installations one can notice how participants reappropriate the codes and the interaction grammar using them for their own ends and improvising in creative play. Indeed these images transpose the idea that participants are not able to make sense of the experience because they are seen improvising and giving new uses to the installation space, although maybe they were able to grasp the statement of the piece and then quickly moved on, in an attempt to discover other possibilities. Who can state the opposite just by watching videos and images and without even speak to the participants?

With the purpose to inspect how participants make sense of their experience with the interactive installation *The Legible City*, and to understand how *free-play* affects and influences the sense-making process we've conducted an empirical study. We have used a qualitative method involving interviews using an Interpretative Phenomenological Analysis approach to explore the felt and lived experience of participants

3 *The Legible City*: The Arcade Meets the Gallery

The end of the eighties was a very proliferous moment for creation in the field of digital and virtual art. The search for real-time, fluid and realistic images was part of the agenda of some multidisciplinary teams of artists, designers and engineers. By using HMD (Head Mounted Displays), CAVE[5] environments or cameras and sensors

[5] The CAVE (Cave Automatic Virtual Environment) is a cube, which is projected by video in all of the surfaces creating an interactive immersive environment.

that captured the movements of the participants, artists produced immersive and playful experiences, enveloping the participant's sensorial and intellectual faculties [13]. The quest for an interfaceless or "free of wires" experience seems to have oriented digital and new media artists since the early works developed by Myron Krueger during the seventies until our "Kinetic[6] days". *The Legible City* is inscribed in this search for immersive and ludic experience although it didn't seem to pursuit an interfaceless experience. One of the striking features of this installation is precisely the interface and the modality of interaction created by Jeffrey Shaw. When entering the dark space of the installation we find an ordinary bicycle with a small in-built monitor, standing in front of a big video projection where one can read 3D letters in pale colors. For a while we have the sensation of being inside an arcade room and we are automatically intrigued and attracted to explore the relationship between screen and bicycle. After seating on the bike we start to pedal and in a few moments we become completely absorbed by the sequences of letters parading on the screen. After a while, if the bike becomes transparent, our curiosity to find the "challenge" doesn't vanish and we pedal across the streets of Manhattan, Amsterdam or Karlsruhe trying to read the words and sentences composed by letters that replace the buildings in the streets. We ramble around, crashing against the letters in anarchic *free-play* mode, and search the limits of this almost infinite virtual space, we try to find a ghost that the little Pacman displayed in the bicycle's monitor could eventually eat but there's nothing in these empty cities apart from the memories of those streets inscribed in the form of text. According to Shaw, in the first version of The Legible City (Manhattan Version, 1989) one can follow eight different fictional storylines in the form of monologues by ex-Mayor Koch, Frank Lloyd Wright, Donald Trump, a tour guide, a confidence trickster, an ambassador and a taxi-driver [14]. In order to follow a specific story line, the participant should follow the letters with the same color. Lately Shaw upgraded the installation adding the map of Amsterdam (1990) and Karlsruhe (1991). In these maps the texts were taken from archives and are related to events, which took place in those streets [14].

As a piece that aims to tell stories to its participants, we were interested to know how do they make sense of such encounter. What stays from this experience in their minds? How do they experience it from a sensorial and intellectual perspective? And how do technical operationality and bodily activation influence the construction of meaning? Answering these questions involves the study of the participants' felt and lived experience during the aesthetic encounter. Rather than commenting and reflecting on the artistic qualities of the work, the study aims to understand how the sense making process occurs in an aesthetic paradigm, which depends on technical operationality.

4 Preparing the Study: Evaluation Methodology

The study of experience between human and computers has been extended beyond the domain of Interaction Design, Ergonomics, Informatics and Human Computer

[6] Kinetic is a motion sensor device used to play games with the Microsoft Xbox 360 console. It has been extensively used by artists and designers in the creation of interactive experiences, which demand bodily movements, gestures and other kind of complex inputs.

Interaction and for obvious reasons has entered the field of arts. The field of HCI has advanced an interesting variety of tools and methods to understand the different dimensions of experience: sensorial, communicative, intellectual, emotional etc.

Several methods have been already used and applied in the evaluation of interactive art experiences: direct observation [7] [15], interviews [7][15], shadowing [16] and video-cue recall[7] [15]. Such studies have brought interesting conclusions not only to the field of HCI, contributing with sensitizing-terms to describe experience and refining some of the methods, but also to the field of aesthetics, underlining above all the difficult task to understand and to make sense of someone making sense of a certain experience. Despite of their interest, very often the goal of evaluation studies have as goals the amplification of engagement [15] [16] and the improvement of technical details whereas the present study is mainly interested to understand how the participants of an interactive artwork makes sense of the semiotic elements, in this case, the sense making process of the text in an open-ended installation that clearly affords a playful behavior.

Regarding aesthetic experience as a sensitive activity that can be hardly moved to laboratory settings, we've conducted our study in natural conditions [17]. *The Legible City* was installed at CEAAC, an art gallery located in Strasbourg, France in the context of the exhibition *Digital Art Works: The Challenges of Conservation*. The study took place during three afternoons and 17 visitors contributed to it by giving semi-structured interviews.

Our sample is constituted by 17 participants with ages between 18 and 65 years old, presenting heterogeneous backgrounds and relationships with the art world. Our sample can be divided in two since 11 persons weren't aware of the study before experiencing the installation while the other 6 were informed.

Despite the quantity of information that we can obtain from observing the participant's interaction, we've decided to avoid observation in order to maintain the participant's experience as natural as possible. In this sense when participants were leaving the exhibition they were asked if they could contribute to our study by speaking about their experience of *The Legible City*. 6 persons were invited to visit the exhibition and to experience the installation so they could contribute to our study.

As we we'll see in the next section, the division in our sample shows that the persons who were aware of the study were more conscious and detached from the experience and as a consequence could describe it in a more detailed and organized way.

5 Interviews Using an IPA Approach

As mentioned above we haven't observed the interaction process between participants and artwork because in the first attempts we have noticed how perturbing a "foreigner" presence was while experiencing the installation. Some visitors were simply watching the installation space without trying the bicycle; others approached the observer to know how the installation worked then leaving without trying it. In some cases participants that tried were seen leaving the bicycle a few seconds after

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7 With a video-cue recall method each participant is confronted with a video of his own interaction with an apparatus and he's asked to describe what he was doing and thinking at a certain moment.

they started to pedal. Some signals of discomfort were noticed: looking at the sides and behind, towards the observer. These findings produced changes in our strategy and since we were mainly interested to understand if participants were able to construct meaning from the reading process we decided to skip the observations and concentrated the efforts in the individual interviews.

The study uses a qualitative approach, which has very common points with Interpretative Phenomenological Analysis (IPA). Such phenomenological approach is idiographic and aims to explore how a certain participant makes sense of a particular event and of his own personal and social world [18]. The sample size in IPA studies is normally small due to the high amount of information outcome [18].

According to Jonathan Smith the best way to collect information for IPA study is through semi-structured interviews [18]. Such interviews allow the researcher to engage in flexible dialogue with the participant. The initial questions should be as general as possible so the participant can freely speak about the subject, providing directions that the researcher was not thinking on. If the participant has difficulties to speak then the researcher should advance with more specific questions that he has previously prepared, using a *funneling*[8] technique [18]. Our interviews followed the model suggested by Smith and were recorded using a digital Dictaphone. The first questions are related to personal background: field of studies, professional activity, number of exhibitions visited in the last year and previous knowledge about the installation. After this introductory phase the participants were asked to describe their experience with *The Legible City*. The conversation evolved departing from some of the points focused by the participant and then, if the description was very short and if he/she had some difficulties, we followed specific questions regarding: the interaction sequence, the focus of the participant's attention before engaging in and during interaction, the first and second actions, the decision to stop, the approximated duration of the experience, the bodily sensations, the thoughts and memories evoked and the sense-making process of the text. These questions had no precise order although they were helpful to maintain and keep the conversation on-track. Aware of the impossibility to in depth, we'll discuss the main findings in the next section.

6 Data Analysis

In the first description of the experience, the majority of participants reported a sensation of amusement and pleasure whereas four of them reported a certain discomfort that was referred by them as a sensation of vertigo, a loose of balance when changing direction and in two cases a slight headache that prevented them to continue the ride. These kinds of symptoms have already been reported in several virtual reality experiences and in studies such as *Disney's Aladdin: First Steps Toward Storytelling in Virtual Reality* [19].

Some participants affirmed to be searching the goal of the "game" admitting that they felt somehow lost and confused: "the small Pac-man displayed in the small screen in the bike called my attention and I was checking if there was any phantoms

[8] This technique allows the interviewer to start with broad questions, allowing the respondents to give their own views, and then asking questions which are progressively more specific.

somewhere...or things to catch" (Participant A). Although most of the participants described an interaction that highly resembles the descriptions of *free- play* and *paidia:* "I was just hanging around with no purpose." (Participant B); "more than turning around I was amused while crossing the interior of the letters and while exploring the limits of the map." (P. C); "I verified the playability, how the system reacted to my movements, to the speed of pedaling. Then I started to pass the walls of the letters, I jumped into the water..." (P. A). One of the participants told us that he tried to concentrate on the lecture of the text for some time, following the streets and making an effort to keep on reading. Although after some time he was attracted by the small cavities formed by the intervals between the letters so he wandered around, breaking into the letters, searching in their back, in the small alleys and shortcutting the roads without a precise destination. A participant that had a longer experience said: "we don't think, we play"; "we relax while pedaling around"; "It's funny, and inventive, we don't care so much about the letters and words." Another participant observed that "the buildings become an abstraction and we don't pay attention to the text."

Most of the participants seemed to "test the interface" with the purpose to understand the functioning mode of the installation and after checking the different possibilities of interaction (grammar of interaction) and inspecting the limits of the map, they would leave the installation. Such findings are supported by the quantity of persons who were able to read and make sense of the text. 12 of the participants involved weren't able to remember any word even if the majority noticed that there were letters in the place of buildings. From the group of 5 persons that could remember at least one word, 3 of them knew about our study before experiencing the installation. Several participants reported concrete difficulties in reading the text: "the letters are too big…" (P. D); "the position of the text is weird" (P. E); "the different size of the letters and written in a foreigner language makes reading difficult" (P. F).

The thoughts and memories that were commonly triggered and reported are related to participants' past experiences with old video games and experiences lived by them in the real places represented by those maps. Not surprisingly, the reports which refer more clearly to the conceptual dimension and to a reflection about the meaning of the work come from the participants who are more connected to the art world (related activity and frequent visits to museums), although this is not a rule since some of these reports are more technical oriented. The comments and reflections that were more often reported are related to functional and technical aspects of the piece, supporting the claim of "testing the interface." Normally the participants who spent more time with the installation reported a reflection that goes beyond the technical and formal aspects and could also remember some words or even parts of sentences. Nevertheless none of the participants seemed to understand the code of color that connects the letters of the same sentence.

7 Discussion

This study shows that the textual layer of the experience provided by *The Legible City* is substantially neglected and ignored by participants in favor of free-play.

The continuous and absorbing flow afforded by this interactive experience seems to stimulate the ludic and playful dimension of the experience rather than stimulating the lecture of the text and a detached reflection about the relation between text and interaction mode. Thus, instead of a game of reading that demands concentration and a certain technical master of the apparatus, such "Flow-design" affords an unstructured, non-linear, non-competitive and without defined duration form of free-play that resembles *paidia*. These findings uphold the relevance of using evaluation methods in interactive art experiences and in particular the use of an IPA approach. Such methodology creates insight about the participant's felt and lived experience without interfering in the aesthetic encounter then, providing important informations that artists can use to adjust and enhance the objects they create. Finally, including a usability user-centered evaluation as a supporting tool for our IPA approach and a video-cue recall method could enhance our study and should be taken into account in further similar studies.

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Studying the Effect of Creative Joint Action on Musicians' Behavior

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Abstract. How does the individual behavior of a musician change in solo Vs. creative joint action? In this paper we consider music performance, an ideal ecological test bed to investigate non-verbal social behavior, to compare the expressive movement of violinists when playing solo or in a string quartet ensemble. In the presented study, by measuring its Sample Entropy, we observe that the movement of a musician's head in creative joint action is more regular with respect to the solo condition.

Keywords: music ensemble, entropy, expressive behavior, creative joint action.

1 Introduction

A very large proportion of behavioural change is induced by the social context (e.g., to perform joint action). People induce each other to move forward, or to step aside, or to retreat, by the movements they make, not on special occasions, but whenever they are doing things in the same space. That kind of influence is absolutely fundamental to human interaction and co-operation [1], but rigorous research on the topic is quite limited. Our aim in this paper is to identify a particular scenario that lends itself to rigorous research on this topic, and to introduce a hypothesis that we believe is potentially important for the area. Here and in what follows, we use 'behaviour' to exclude linguistic communication (as in the phrase 'do what I do, not what I say').

The ways in which behaviour can influence another person are very diverse, and one of the features of research on the topic is that it concentrates on some sub-areas, but leaves others relatively unstudied. Two questions tend to dominate research. One is what is being expressed, and the other is whether the message is true or misleading. That emphasis is a natural extension of research on linguistic communication, but it seems only partly appropriate when we consider how behaviour influences behaviour.

String quartets (SQs) offer a particularly promising context for investigating expressive and adaptive interactions [2,3]. Recent studies adopt music ensemble to study social interactions such as entrainment, dominance and leadership. The EU 7FP ICT-FET Project SIEMPRE (May 2010 - June 2013) has undertaken cross-disciplinary research to investigate novel paradigms and computational models of non-verbal creative group communication adopting music scenarios (www.siempre.infomus.org).

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Our approach consists in characterizing the behaviour regularity in Isolated Vs. Social context, that is, Solo Vs. Creative Joint Action performance. In the present study we focus on the distance of the musicians' head with respect to the ear of the SQ.

The ear refers to a subjective string quartet 'center', defined by the four musicians and located at nearly equal distance from each of them (see Figure 2). The ear is called such as it refers to a mental external listener that would gather the musical contributions of all the musicians. This center stands as a social reference for all musicians during the performance and helps them to coordinate and reach a coherence sound ensemble, aiming at transforming the SQ into a unique living organism. In this sense, the distance achieved from each musician's head towards the ear may reflect how each musician stands with respect to the group over the performance.

We aim at analyzing how the variation of the musician's head distance with respect to the ear is conditioned by the other musicians (e.g., effect of social context). In this context of human movement analysis, a particular measure of entropy called SampEn can be used as a method to distinguish between the two performance conditions (Solo Vs. Creative Joint Action performance) of a single musician.

2 Multimodal Measures

The problem addressed in this paper is inherently multimodal: differences between solo and ensemble condition may emerge from a number of different channels, including body movement, audio signal, physiological signals (e.g., respiration, heart rate, muscles tension).

A first, general question is: which are the measures explaining the Solo Vs. Creative Joint Action performance? For this reason, we need for a number of synchronized multimodal recordings. The Synchronized Data Acquisition module in Figure 1 is in charge to do this task, and presents some non-trivial technical difficulties: the different modalities correspond to input data channels characterized by different sampling rates, ranges, and sensor systems. The acquisition task is complex: we need to obtain fully synchronized multimodal data from a motion capture system, multichannel audio signals from all the instruments (using piezoelectric microphones on the violin body) and from environmental microphones, video signals from high-quality videocameras, and physiological signals.

The synchronized multimodal recordings of the musicians obtained for this experiment as well as the details of the SIEMPRE platform for multimodal recordings are made available to the research community from the EU ICT FET SIEMPRE web pages (www.siempre.infomus.org).

In this paper, we present the results obtained so far using only the analysis of the movement of the head of the musicians, leaving to further analysis the investigation on the other channels.

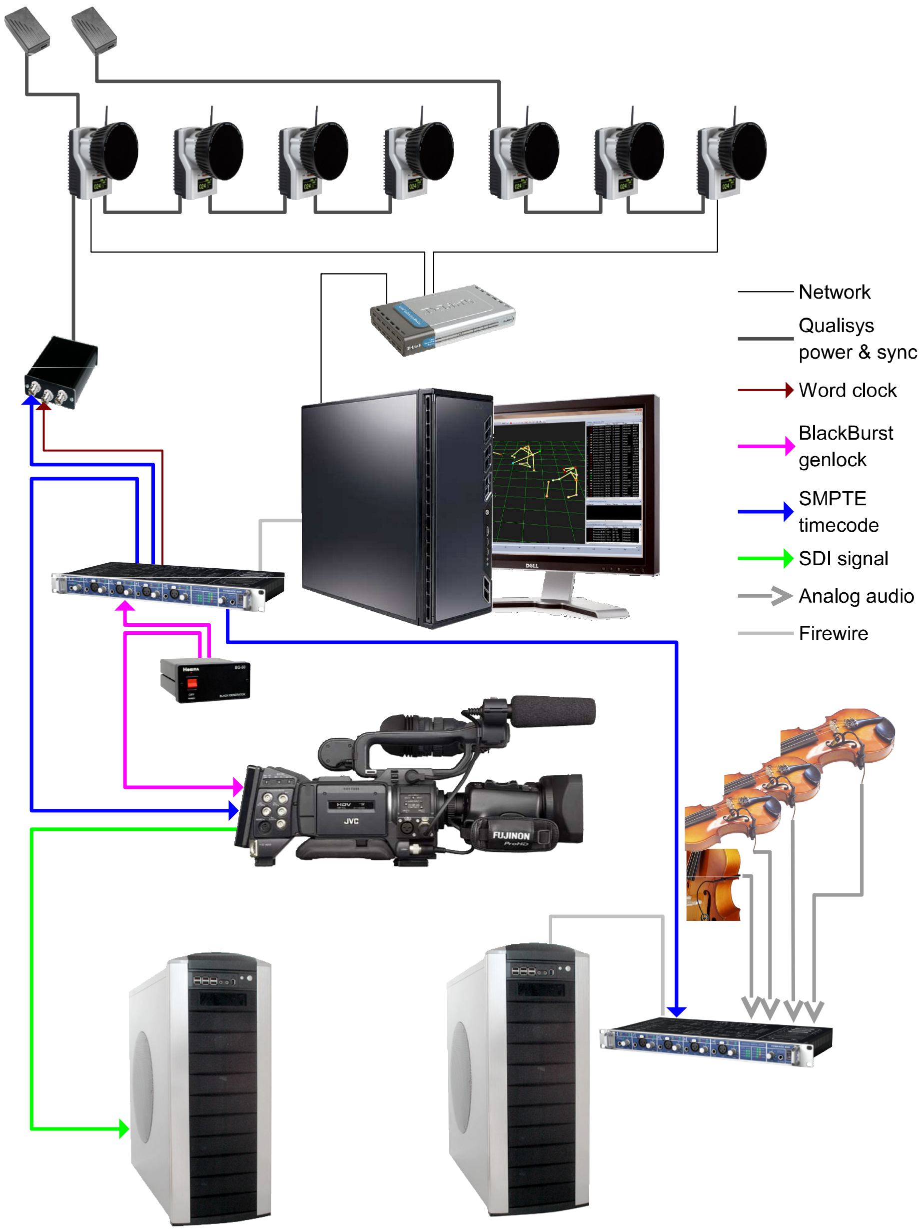

Fig. 1. The SIEMPRE software platform at the Casa Paganini – InfoMus research centre of University of Genoa for synchronized capture and recording of multimodal signals, based on our EyesWeb platform (www.eyesweb.org)

The overall scheme of the multimodal recordings platform is depicted in Figure 1.

Real-time applications have been developed in the EyesWeb XMI software platform [4], to synchronize and manage user-defined visualizations of the various channels (audio, video, motion capture, physiological data etc.).

The analysis presented in this paper concerns the time series data of the musicians' head distance to the ear of the SQ. Ongoing work in the SIEMPRE project considering the other multimodal channels are also in course. Head movement play a central role in the non-verbal communication in general [5] and in music in particular [6]. Head and upper body sway include movements, which are separate from technical or functional movements (instrumental gesture). In this sense, head movement and upper body sway are apt to express the phrasing and "breathing" of the music interpretation without being submitted to the constraints observed for other limbs such as the hands to produce the sound itself. They form shapes, embodied expressions of the models of the high-level musical structures the musician is interpreting. Head movements can also be explicit, to indicate specific moments during the performance requiring synchronized start, and may convey emotional states to facilitate interpersonal coping.

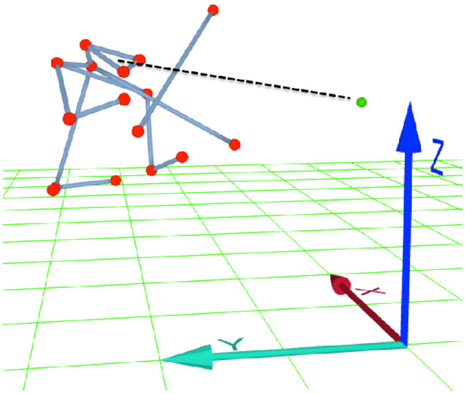

Fig. 2. Motion Capture (MoCap) data of the first violin, with particular detail of the musician's head center of gravity (COG) with respect to the *ear*, the subjective center of the string quartet (see the dashed line representing the distance between these two points)

3 Evaluation

We designed an experimental scenario to evaluate the proposed system. A multimodal setup has been created to record performances of the Quartetto di Cremona SQ. Analysis focused on the behavior of the first and second violin. Results are reported and show how musicians' head movement regularity characterizes the differences between playing solo Vs. playing in an ensemble.

The music piece performed by the SQ during the experiment was extracted from the Allegro of the String Quartet No 14 in D minor, known as Death and the Maiden, by F. Schubert. This piece is a staple of the quartet's repertoire and has been further divided into 5 musical segments. each characterized by a prevalence of a specific musical structure.

The SQ's first and second violinists were asked to play their part 6 times alone, and 5 times with the group. Five repetitions of the same 2 minutes length music segment without any break has been considered a tradeoff between the quality of the performance and the minimum amount of quantitative data necessary to ensure significant statistical analysis. Musicians were instructed to play at best, in a concert like situation. To disentangle possible effect of group performance on solo performance, first and second violinists had to perform 3 trials before and 3 trials after the group performance. The quality of each performance was assessed by musicians through post-performance ratings (e.g., level of satisfaction, expressivity, group cohesion). Extraneous factors such as personality and emotion that may contribute to one's sensitivity of being in a group were also assessed through a BFI questionnaire and through PANAS questionnaires submitted before and after each recording session [7,8].

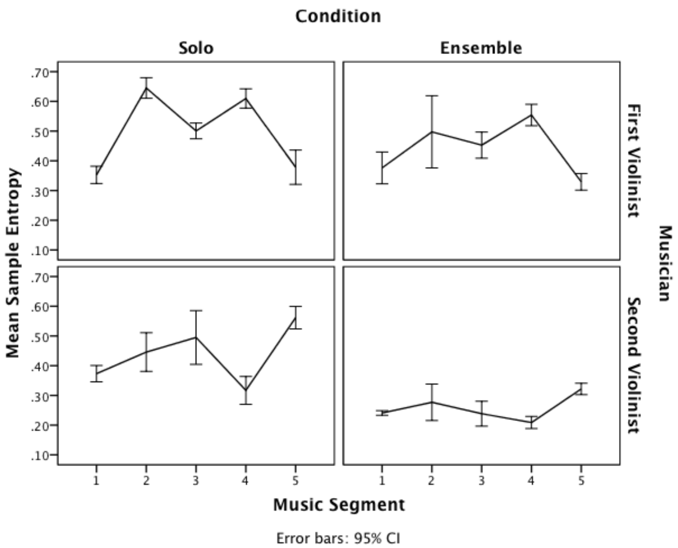

Fig. 3. Interaction plot of Condition, Musician and Music Segment on Sample Entropy

Empirical evidence, reported in Figure 3, shows that SampEn values of musician head distance with respect to the string quartet's ear can account for the difference between Solo Vs. Ensemble conditions. Playing with others decreases the entropy of human movement related to a point situated in space, which has a social value (the ear stands as common spatial landmark to facilitate joint action). It is thoroughly logical that someone who is part of a joint action tends to make her behavior more regular: it facilitates a global alignment of the ensemble. This result is independent from the musician and from the music segment. This result confirms recent findings by Vesper et al. 2011 [9]. The authors observed that participants, who were instructed to coordinate key presses in a two-choice reaction time task, decrease the variability of their actions in a joint context compared with the same task performed individually.

A hypothesis suggested by the authors is that reducing variability, hence increasing behavioural regularity, enables achieving better predictability.

Additional evaluation could be envisaged to assess explicitly how behaviour regularity facilitates temporal coordination in String Quartet. Recent work focusing on entrainment in small music ensemble (e.g., duet, quartet) use quantitative methods such as recurrence plot analysis to evaluate the degree of synchronization between musicians [10]. Correlation analyses between the synchronization indexes and entropy through SampEn could help in assessing whether such relationship between reducing variability and increasing coordination exists in the string quartet. Another question of interest is the following: even if the observed coordination between musicians is intentional, it is still not clear whether musicians rely on explicit knowledge of the relation between variability and coordination performance or whether they were using this strategic relation consciously. Actually, people may not plan to change their own behaviour in this specific way to enable their cofactor predicting better their upcoming actions.

4 Conclusion

The promising results obtained so far open perspectives for their consolidation and for further investigation. They also confirm the preliminary results obtained in [11], using different music fragments.

Future work includes the following: (i) to extend the analysis to other body parts (e.g., shoulders, trunk sway) and features (e.g., Motion Index); (ii) to verify is the same results are confirmed by other modalities: audio data, physiological data (EMG); (iii) to better understand the dependency between musicians' SampEn values (e.g., the more the Musician 1 decreases his entropy, the higher the entropy of the Musician 2 increases?); (iv) to compare with ratings of subjects observing the single musician (without knowing if he is playing alone or in ensemble; only video, or video plus audio).

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Towards Automated Analysis of Joint Music Performance in the Orchestra

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Abstract. Preliminary results from a study of expressivity and of non-verbal social signals in small groups of users are presented. Music is selected as experimental test-bed since it is a clear example of interactive and social activity, where affective non-verbal communication plays a fundamental role. In this experiment the orchestra is adopted as a social group characterized by a clear leader (the conductor) of two groups of musicians (the first and second violin sections). It is shown how a reduced set of simple movement features - heads movements - can be sufficient to explain the difference in the behavior of the first violin section between two performance conditions, characterized by different eye contact between the two violin sections and between the first section and the conductor.

Keywords: automated analysis of non-verbal behavior, expressive gesture analysis, computational models of joint music action.

1 Introduction

Music is a well-known example of interactive and social activity where affective non-verbal communication plays a fundamental role. Several works have already shown how a player can convey expressive intentions by his/her movements.

Among visual features, in this paper we focus on the so-called *ancillary* or *accompanist gestures* [7], i.e., movements of the body of a music player or of a music instrument, which are not directly related to the production of the sound (in contrast to *instrumental* or *effective gestures*, which are directly involved in sound production). For instance, the movements of the heads of string players during a performance are ancillary gestures, whereas the movements of their bows are (mainly) instrumental gestures. Instrumental gestures are obviously informative since, without them, musicians would not be able to express the different musical ideas they want to communicate. Ancillary gestures are informative, too, since often they allow one to recognize different expressive intentions, without looking at the instrumental gestures/listening to the performance.

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For instance, Davidson claimed that visual information alone is sufficient to discriminate among performances of the same piece of music played with different expressive intentions (inexpressive, normal and exaggerated) [3], and that the larger the amplitude of the movement, the deep the expressive intention [4]. This finding was also confirmed by other studies, e.g., Castellano et al. investigated the discriminatory power of several movement-related features for the case of a piano player [1], and Palmer et al. showed how the movement made by the *bell* of a clarinet is larger when the player performs more expressive interpretations of the same piece [5]. However, these works focus on a performance by one player only. More recent studies address non-verbal communication in larger musical ensembles such as a string quartet [6] and a section of an orchestra [2].

The present study is aimed at investigating how the behavior of a group of players spontaneously changes, concerning the head ancillary movement, when changing the way it can interact with the rest of the orchestra.

The paper is organized as follows. In Sections 2 and 3, the experimental methodology and data analysis are described, resp.. In Section 4, the obtained results are presented and discussed. Section 5 contains some conclusive remarks.

2 Experimental Methodology

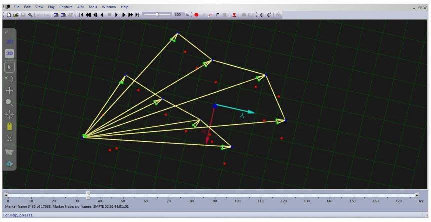
Two violin sections of an orchestra and two orchestra's professional conductors were involved in the study. Each section counted 4 players and was equipped with passive markers of the Qualisys motion capture system. More specifically, for each player one marker was placed on the head, two markers were placed above the eyes, and one on the nape (back of the neck). For the conductors, one marker was placed on the head. Additional markers were placed on the bows of the players and on the baton of the conductors. Two experimental conditions were tested, which only differ by the way a section (called from here on the *first section*) interact with the conductor and the other section (called from here on the *second section*). In one condition (condition A) the violinists from the first section - disposed in a single row - were able to see the conductor, but not the violinists from the second section. In the second condition (condition B) the violinists from the first section - still disposed in a single row - were able to see the second violin section, but not the conductor (since they were faced backwards with respect to him). Both conditions A and B were experimented with the two conductors. All the other variables (groups of violinists/piece) were the same for the two conditions[1] and each of them was repeated six times (three times with a conductor and three other times with another one). Figure 1 shows the two settings. Each recording consisted of about 1 minute of music excerpts from the Overture to the opera "Il signor Bruschino" by G. Rossini.

Concretely, the study focuses on measuring how much the movements of the heads of the musicians change when moving from condition A to condition B.

[1] Additional data were collected by varying the piece, but in this paper we present only the results obtained for a fixed piece.

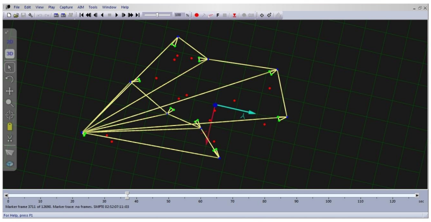
Likely, each musician has his/her individual behavior, but the hope behind the experiments (later confirmed by the results) is that a common pattern of behavior (different in each condition) can be extracted.

(a)



(b)

(c)



(d)

Fig. 1. Panels (a) and (c) show the players and the conductor when condition A and condition B are tested, resp.. Panels (b) and (d) show a snapshot of the head's markers positions of the players and the conductor when condition A and condition B are tested, resp.. Triangles correspond to positions and directions of heads. The red points are the unlabeled markers (mainly associated with the bows).

3 Data Analysis

Movement data were collected by using a Qualisys motion capture system equipped with 7 cameras, integrated with the EyesWeb XMI platform (see `www.eyesweb.org`) for obtaining synchronized multimodal data, including audio and physiological signals (not used in the work described in this paper). A reduced data set, made of 12 recordings, was extracted from the collected data, and movement features due to ancillary gestures were automatically computed.

The remaining of the data analysis has been performed in MATLAB 7.7 by computing the means and covariance matrices of the extracted features in order to find significant differences in such quantities between Conditions A and B.

Choice of the Features: the following features were computed in the data analysis. Their computation was made possible by the QTM representation of each marker, which provides its position in each frame.

1. For each musician i ($i = 1$: the conductor, $i = 2, \dots, 5$: the violinists in the first section, starting from the concertmaster, $i = 6, \dots, 9$: the violinists in the second section) and each frame j ($j = 1, \dots, N_{\text{frames}}$) of a same recording[2], we evaluated the current direction $\mathbf{d}_i^{(j)}$ in the horizontal plane of the head of the musician, then the corresponding sample mean direction $\bar{\mathbf{d}}_i$ with respect to all such frames. Each $\mathbf{d}_i^{(j)}$ is defined as the unit vector connecting the marker on the nape of the musician i to the point located in the middle of the line between the two other markers above his/her eyes, whereas $\bar{\mathbf{d}}_i$ is obtained by averaging each component of $\bar{\mathbf{d}}_i^{(j)}$ with respect to j and normalizing the obtained vector.
2. For each musician i and each frame j of a same recording, we evaluated the components $t_i^{(j)}$, $n_i^{(j)}$, and $z_i^{(j)}$ (parallel to $\bar{\mathbf{d}}_i$, orthogonal to $\bar{\mathbf{d}}_i$ in the horizontal plane, and orthogonal to the horizontal plane, resp.) of the position vector $\mathbf{p}_i^{(j)}$ of his/her head. Such a position vector is defined with respect to a fixed Cartesian coordinate system with the origin at the center of the stage (see Figures 1(b) and 1(d)).
3. For each frame, we have defined the vector $\mathbf{a}^{(j)} \in \mathbb{R}^{27}$ with components $t_1^{(j)}, n_1^{(j)}, z_1^{(j)}, t_2^{(j)}, n_2^{(j)}, z_2^{(j)} \dots, t_9^{(j)}, n_9^{(j)}, z_9^{(j)}$, then we have computed its sample mean $\bar{\mathbf{a}}$ with respect to the frames, and its sample covariance matrix

$$\texttt{sample cov}(\mathbf{a}) := \frac{1}{N_{\text{frames}} - 1} \sum_{j=1}^{N_{\text{frames}}} \left(\mathbf{a}^{(j)} - \bar{\mathbf{a}}\right) \left(\mathbf{a}^{(j)} - \bar{\mathbf{a}}\right)^T \in \mathbb{R}^{27 \times 27} .$$

   Here, $\mathbf{a}$ denotes the random variable and $\mathbf{a}^{(j)}$ its realization.
4. For each musician i and each frame j of the same recording, we computed the oriented angle $\theta_i^{(j)}$ between the two vectors $\mathbf{d}_i$ and $\mathbf{d}_i^{(j)}$. Then, we defined the vector $\mathbf{b}^{(j)} \in \mathbb{R}^9$ with components $\theta_1^{(j)}, \theta_2^{(j)}, \dots, \theta_9^{(j)}$ and we computed its sample mean $\bar{\mathbf{b}}$ with respect to the frames and its sample covariance matrix

$$\texttt{sample cov}(\mathbf{b}) := \frac{1}{N_{\text{frames}} - 1} \sum_{j=1}^{N_{\text{frames}}} \left(\mathbf{b}^{(j)} - \bar{\mathbf{b}}\right) \left(\mathbf{b}^{(j)} - \bar{\mathbf{b}}\right)^T \in \mathbb{R}^{9 \times 9} .$$

   Here, $\mathbf{b}$ denotes the random variable and $\mathbf{b}^{(j)}$ its realization.

Finally, for each of the two conditions, all the sample means and sample covariance matrices were averaged over the six repetitions of the same music piece (three for each conductor). Apart from $z_i^{(j)}$ and the related features, all the other features listed above can be extracted from the projections of the motion-capture data on the horizontal plane only. The reason for which in the definition of the directions of the heads we considered only such projections is that, for each musician, the two frontal markers were positioned much above his/her eyes,

[2] To simplify the notation, we do not use indices to distinguish among the three repetitions of the same experimental condition, between the two experimental conditions, and between the two conductors.

so the vertical components of the positions of such markers may be misleading in determining the direction of the head.

Before presenting the results, we describe some guidelines that were used in the data analysis.

- **Choice of the data:** we considered only the three markers associated with the heads of the musicians. Since all the features considered in the following have been calculated at a global scale (i.e., on the entire video, excluding only the frames preceding the performances and some noisy frames, e.g., frames with missing or unlabeled markers associated with the heads) the movement of the baton of the conductor was not taken into account.
- **Missing data:** in case of missing data (e.g., an unlabeled head marker or an undetected one), the corresponding frames were discarded and the features associated with such data were evaluated using only the remaining frames (thus reducing the value of N_{frames}). In particular, features defined as temporal means of certain measurements were computed by summing those measurements over all the available frames (with the exception of the ones containing missing data) and dividing by the number of such frames.
- **Segmentation of the video:** in order to reduce the noise in the data, the first frames in each video (the ones before the beginning of the music piece) were not been considered in the analysis. At least in principle, also the frames in which some musician is turning the page of his/her score should not be considered (or one should not take into account the movements of that musician in such frames only). However, due to the small number of such frames with respect to the total number of frames and the relatively slow movements involved in such "noisy" frames, we did not take into account this issue. So, we performed the analysis on the whole video (excluding only its beginning, which consists of several frames).

4 Results of the Analysis

In this section, we show the obtained average values of the features defined in Section 3 for the available recordings, resp. under condition A and under condition B. For simplicity of exposition, instead of considering all the elements of the vectors and matrices defined above, we vary the index i from 2 to 5 (i.e., we present only the values of the features associated with the violinists of the first section). For both conditions A and B, Table 1 and Table 2 show, resp., the average (with respect to six executions of the same piece) sample means of the components of the head positions of the violinists in the first section and the corresponding entries in the covariance matrix of the vector $\mathbf{a}$ of head positions. Similarly, for both conditions A and B, Table 3 and Table 4 show, resp., for the violinists in the first section, the average (with respect to six executions of the same piece) sample means of the oriented angles between the mean head directions and the current head directions and the corresponding entries in the covariance matrix of the vector $\mathbf{b}$ of oriented angles. Let us make

Table 1.

Avg. sample mean of the feature vector a (cm)												
	t_2	n_2	z_2	t_3	n_3	z_3	t_4	n_4	z_4	t_5	n_5	z_5
Condition A	198.6	8.8	114.6	76.1	70.9	125.0	-14.2	32.4	117.2	-82.6	-40.2	119.8
Condition B	-74.6	-159.3	113.6	-91.7	-55.2	123.3	12.6	-47.1	114.4	75.2	-38.4	117.5

Table 2.

Avg. sample covariance matrix of the feature vector a (cm^2)												
Condition A												
	t_2	n_2	z_2	t_3	n_3	z_3	t_4	n_4	z_4	t_5	n_5	z_5
t_2	5.1	2.9	0.5	-2.9	3.9	-0.2	4.2	-2.1	-0.6	4.1	-2.5	1.1
n_2	2.9	3.9	0.3	-2.0	5.7	-0.2	3.4	0.8	-0.4	2.6	-1.7	1.2
z_2	0.5	0.3	0.6	-0.8	-0.1	-0.0	0.7	-0.6	-0.1	1.7	-1.0	0.4
t_3	-2.9	-2.0	-0.8	9.7	-2.0	0.9	-2.9	1.5	-0.2	-3.7	3.2	-1.5
n_3	3.9	5.7	-0.1	-2.0	24.6	4.3	2.2	2.0	1.0	2.4	-7.3	3.1
z_3	-0.2	-0.2	-0.0	0.9	4.3	3.7	-0.2	-1.3	0.4	1.0	-6.0	1.9
t_4	4.2	3.4	0.7	-2.9	2.2	-0.2	14.3	-2.1	-0.9	4.7	-6.1	2.7
n_4	-2.1	0.8	-0.6	1.5	2.0	-1.3	-2.1	22.7	0.7	-3.9	6.5	-2.0
z_4	-0.6	-0.4	-0.1	-0.2	1.0	0.4	-0.9	0.7	0.8	0.1	-0.8	0.2
t_5	4.1	2.6	1.7	-3.7	2.4	1.0	4.7	-3.9	0.1	18.4	-14.1	5.1
n_5	-2.5	-1.7	-1.0	3.2	-7.3	-6.0	-6.1	6.5	-0.8	-14.1	40.0	-8.7
z_5	1.1	1.2	0.4	-1.5	3.1	1.9	2.7	-2.0	0.2	5.1	-8.7	3.9
Condition B												
	t_2	n_2	z_2	t_3	n_3	z_3	t_4	n_4	z_4	t_5	n_5	z_5
t_2	29.6	1.0	-3.60	0.5	-4.4	-0.6	5.8	9.8	-0.6	-0.8	4.4	-2.7
n_2	1.0	5.8	0.6	-0.8	1.4	0.8	-5.0	0.7	0.6	-1.7	1.6	1.2
z_2	-3.6	0.6	2.1	0.1	2.1	0.4	-3.1	-2.2	1.0	-2.3	-2.8	1.1
t_3	0.5	-0.8	0.1	4.5	1.6	-0.2	-3.1	2.1	1.0	-2.3	-2.1	0.1
n_3	-4.4	1.4	2.1	1.6	9.8	2.2	-7.3	0.3	0.7	-5.3	8.9	0.4
z_3	-0.6	0.8	0.4	-0.2	2.2	1.2	-0.8	0.3	0.2	-1.7	1.8	0.8
t_4	5.8	-5.0	-3.1	-3.1	-7.3	-0.8	36.0	-6.5	-3.7	10.7	-13.3	-1.7
n_4	9.8	0.7	-2.2	2.1	0.3	0.3	-6.5	14.2	-0.1	-2.3	10.5	-2.2
z_4	-0.6	0.6	1.0	1.0	0.7	0.2	-3.7	-0.1	1.9	-2.5	-3.8	2.0
t_5	-0.8	-1.7	-2.3	-2.3	-5.3	-1.7	10.7	-2.3	-2.5	35.3	-12.6	-3.2
n_5	4.4	1.6	-2.8	-2.1	8.9	1.8	-13.3	10.5	-3.8	-12.6	56.3	-6.2
z_5	-2.7	1.2	1.1	0.1	0.4	0.8	-1.7	-2.2	2.0	-3.2	-6.2	5.4

Table 3.

Avg. sample mean of the feature vector b (rad)				
	θ_2	θ_3	θ_4	θ_5
Condition A	0.0012	0.0013	0.0012	0.0007
Condition B	−0.0014	0.0048	0.0019	−0.0273

Table 4.

Avg. sample covariance matrix of the feature vector b (rad^2)				
Condition A				
	θ_2	θ_3	θ_4	θ_5
θ_2	0.0188	−0.0050	0.0103	0.0069
θ_3	−0.0050	0.0695	−0.0051	0.0338
θ_4	0.0103	−0.0051	0.0547	0.0143
θ_5	0.0069	0.0338	0.0143	0.0829
Condition B				
	θ_2	θ_3	θ_4	θ_5
θ_2	0.2156	0.0221	0.0103	−0.0402
θ_3	0.0221	0.1407	−0.0908	−0.0077
θ_4	0.0103	−0.0908	0.2547	0.0425
θ_5	−0.0402	−0.0077	0.0425	0.2680

some comments on the discriminatory power of the chosen features. Of course, as shown by Table 1, the average sample mean of the feature vector **a** for condition A is different from the one for condition B, but this depends only on the slightly different positions of the violinists in the two settings, and - above all - on the different sample mean directions of their heads in the two situations. Similarly, Table 3 basically confirms only that the four vectors $\bar{\mathbf{d}}_i$ $(i = 2, \ldots, 5)$ are the sample mean directions of the heads of the four violinists. It is more interesting to compare the average sample covariance matrices of the two feature vectors $\bar{\mathbf{a}}$ and $\bar{\mathbf{b}}$ for each of the conditions. In particular, inspection of the main diagonals of such matrices shows that the average - with respect to six executions of the same piece - trace of the matrix `sample cov`(**a**) (and its empirical standard deviation) is about 147.7 cm^2 (57.9 cm^2, resp.) for condition A and 202.1 cm^2 (99.6 cm^2, resp.) for condition B, whereas the average trace of the matrix `sample cov`(**b**) (and its empirical standard deviation) is about 0.2259 rad^2 (0.2191 rad^2, resp.) for condition A and 0.8790 rad^2 (0.3916 rad^2, resp.) for condition B, which is a more statistically significant difference. So, in a sense, larger deviations from the mean directions seem to be associated with condition B (in which the violinists of the first section are not able to see the conductor) with respect to condition A (in which they can see the conductor). This behavior in condition B may be motivated by the absence of a reference point (the conductor) to look at in such a situation. According to a further inspection of the available data - not shown here - this change in the relative size of the movements of the heads when passing from condition A to condition B seems not to depend on the conductor, although different absolute sizes of the movements of the heads of the musicians was observed for the two conductors.

5 Discussion

In this study we have considered all the features at a global scale (i.e., on the entire video). We plan to extend the analysis by computing features at a local scale, too. In this way we'll be able to take into account features such as the movement of the baton of the conductor, not examined in the present work. By concentrating on single musical phrases we'll have the possibility of addressing the issues related to turning pages (this can be done, e.g., by selecting musical phrases in which none of the musicians has to turn a page).

In particular, ongoing work focuses on automated analysis techniques based on temporal features, to measure synchronization and social roles within and between the two groups, and the influence of the conductor, with different conductors and different music performance conditions.

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Modeling Interaction in Rehearsals

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Abstract. In this article, we consider different ways of modeling interaction in the rehearsal of a music ensemble. As part of the study, three amateur musicians were to rehearse a jazz piece, and their progress was documented on video and in self-reports. The visible interaction between the musicians was then modeled in sequence diagrams using Unified Modeling Language (UML). The diagrams show a progress from verbal communication between the musicians towards more and more non-verbal interaction. In addition, we discuss the different ways a musician might form decisions in the performance (or in the case of a rehearsal, quasi-performance) when direct communication between the musicians becomes all but impossible.

Keywords: Music Informatics, Music Performance, Interaction, Logical Models, Game Theory, Decision Theory, UML.

1 Introduction

How do musicians coordinate their actions when playing together? The answer depends on to which extent the musicians can communicate in the situation. In a live performance, the musicians are usually not allowed to stop and discuss, whereas the rehearsal has a more free structure. On the other hand, the rehearsal may temporarily take on the character of a performance situation, e.g. if the musicians try to perform a piece from start to finish in order to rehearse for a concert. In this article we look at how a group of musicians rehearsing a specific piece of jazz music communicate and coordinate with respect to the problem of deciding who should take the next solo. Part of the communication and coordination process can be observed and subsequently described in *Unified Modeling Language* (UML) [1], whereas other aspects of the process are not observable, because they concern the musician's personal deliberations regarding how the others will act in the situation. For the latter aspects, we suggest different types of mechanisms that might take place, mechanisms that can be described in terms of models from epistemic logic, game theory and decision theory.

2 The Study Set-Up

Three amateur musicians rehearsed the piece "Caravan" by Duke Ellington, and their rehearsal process was captured on video. "Caravan" has a traditional jazz standard

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structure, in which a theme is alternated with solos performed by the individual musicians. As they had not rehearsed this music together before, the rehearsals were a natural way for them to gradually master the piece. Through the observations and annotated videos from the rehearsals, together with self-reports from the three musicians, the interaction of the musicians during the different rehearsals (including the verbal communication in between the actual playing) was detailed in UML models developed in collaboration with the students.

2.1 UML Models

UML is normally used in the field of object-oriented software engineering. The choice of UML for modeling the rehearsals was at the outset a convenience choice, as the three musicians, all of whom had a background in computer science, knew and were able to apply this modeling language to their interaction process. UML diagrams do, however, have the benefit of being easy and accessible graphic notations of systems that can be read by a wide audience. By applying this type of modeling to the system of a communication and coordination process between people, we not only get a powerful tool for analyzing an otherwise often oblique process such as a music rehearsal, but also a way of making the resulting models accessible to a large audience within the field of computer music modeling. Many types of UML diagrams exist. In the case of interacting musicians, *Use Cases* model the dependencies between the musicians and their goals. *Use Cases* can be further developed to *State Machine Diagrams* and *Class Diagrams*, if the goal is observation and modeling studies, however, the *Sequence Diagram* is of particular interest. In the *Sequence Diagram*, the vertical lines correspond to each agent – in this case each musician – and the arrows correspond to the messages between the musicians.

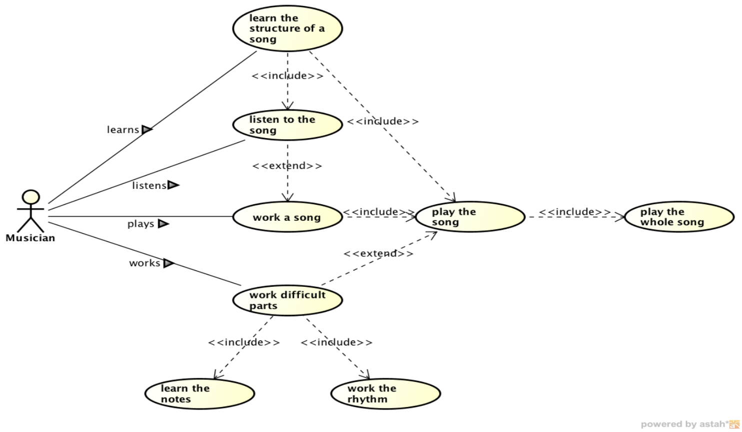

Fig. 1. Use *Case* of musician learning to play music

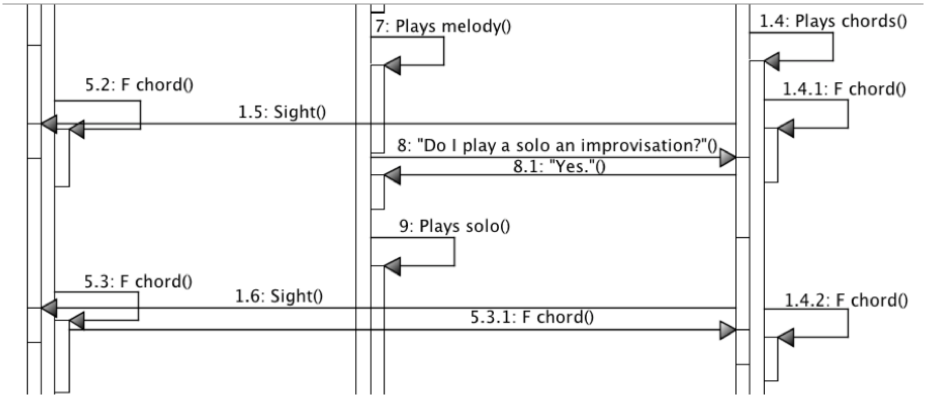

Fig. 2. Sequence *Diagram* of musicians in a rehearsal (detail). Verbal communication at point 8.

In Fig.1 an example of a Use Case is shown, in which the musician rehearses a piece of music alone, and in Fig.2 a detail of a Sequence Diagram is shown in which the amateur musicians rehearse a jazz tune. The three amateur musicians were a bass player (leftmost agent in the UML diagrams), a keyboard player (middle agent in the UML diagrams) and guitar player (rightmost agent in the UML diagrams), respectively. We will return to these diagrams below.

2.2 Philosophical Models for Coordination Processes

In his PhD dissertation [2], Søren R. Frimodt-Møller has discussed how performing musicians form decisions not only as a result of their individual intentions for the performance, but also as a result of their assumptions regarding the intentions of the other performers, and of how they conceive of the rules of the performance context (either rules inherent in the specific piece, rules pertaining to the genre, or rules relative to the specific ensemble that have been established while preparing for the performance). Sections 3.2-3.4 of this paper reflect the considerations of possible modeling schemes for these types of interaction situations.

3 Different Starting Points for Reaching Agreement in the Coordination Process

How do the three amateur musicians reach an agreement regarding who should take the next solo in the jazz piece they are rehearsing? Intuitively, there are different starting points for reaching such an agreement:

1. The structure of the jazz piece itself and the musicians' knowledge of it
2. Communication between the musicians
3. The individual musician's expectations for the actions of the other musicians
4. The musician's alertness with respect to seeking a compromise between his own intentions for the performance and those of the other musicians

Regarding (4), this presupposes that the musician does indeed have intentions for what he wants to achieve in the specific performance. In some senses, musicians act in a manner similar to the belief-desire-intention paradigm of Bratman [3], in which beliefs and desires combine to form intentions. Of course, individual decisions, and the planning steps that precede these, are usually not externalized to a level where they can be observed. Only the individual musician is able to know the exact nature of his own belief-desire-intention process. Musicians may, however, obtain knowledge about belief-desire-intention processes of other musicians via information gathered in the interaction process, i.e. by observing the other players. Let us first begin by considering how the other starting points with respect to reaching agreement in the coordination process come into play.

3.1 Communication between the Musicians

During the rehearsal, three different modes of communication may occur: *verbal*, i.e. when the musicians talk to each other; *non-verbal,* e.g. when the musicians nod, smile etc. at each other, and *musical*: Often, musicians are so skilled that they only communicate with each other via subtle signals in the music itself, such as stressing a particular note, playing something slightly louder or changing the character of a particular phrase. In order for non-verbal and musical communication to take place in an ensemble, the musicians must feel themselves linked to each other as a united group. Several unpublished observational studies have been carried out at Aalborg University Esbjerg, both with professional and amateur musicians, in order to describe the interaction between musicians. These observations have suggested that the smaller a group is, the stronger the link between its parts will - and must - be, and the more accurate the musicians will be. Another important conclusion that has been drawn from these initial observations is that at the level of professional performance, a performance of music based on notation (scores, parts etc.) contains very little visible communication. Therefore, subsequent observations have focused on either improvised music, e.g. in collaboration with guitarist Fredrik Søgaard during his improvisation classes at the conservatory in Esbjerg, or on the rehearsals of amateur musicians, such as the ones discussed in this article. It is also important to note, however, that the jazz piece being rehearsed by the amateur musicians in this study has a fairly closed structure compared to other jazz pieces that afford longer and more free improvisations (performances based on such pieces are the subject of the semiotics-influenced models of jazz performance developed by, among others, Peter Reinholdsson [4] and Ole Kühl [5]). The constraints on the amateur performers provided by the jazz piece itself are thus somewhere in between the classical composition-based performance and the fully improvised performance.

In the sequence diagrams (figures 2-4), the communication process in the ensemble trying to reach a decision as to who will play next solo in the piece “Caravan” by Duke Ellington can be observed.

In the first rehearsals, the communication mode was verbal, as can be seen in Fig. 2. In the beginning, the musicians often stop and discuss something before continuing. The second mode of communication being developed was gestural, e.g. via a hand gesture, as illustrated in Fig. 3, or by looking at the person you believe should play the solo (Fig. 4).

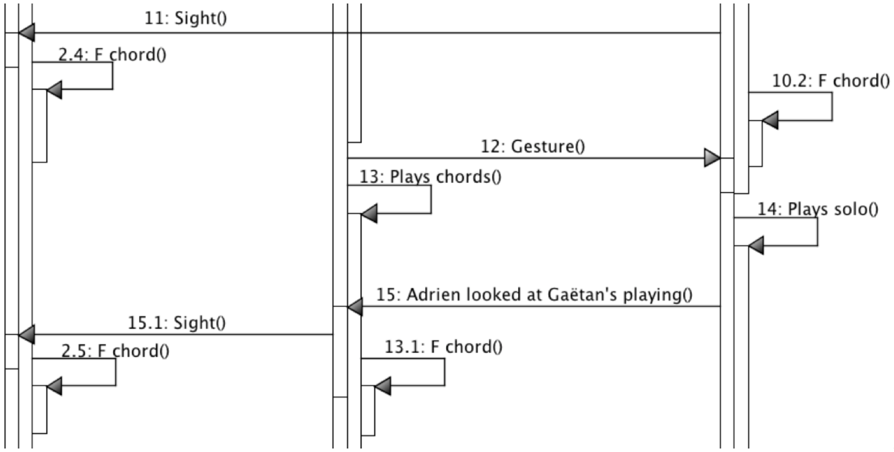

Fig. 3. Sequence *Diagram* of the three musicians rehearsing (detail). Gesture at point 12.

Finally, as the musicians gradually agreed on the structure of the music and got to know it enough, communication was gradually replaced by a mutual awareness of this structure. The awareness of structure (e.g. with respect to taking turns) reduces communication between musicians and allows them to focus more on their individual voices and the interplay between them in the music.

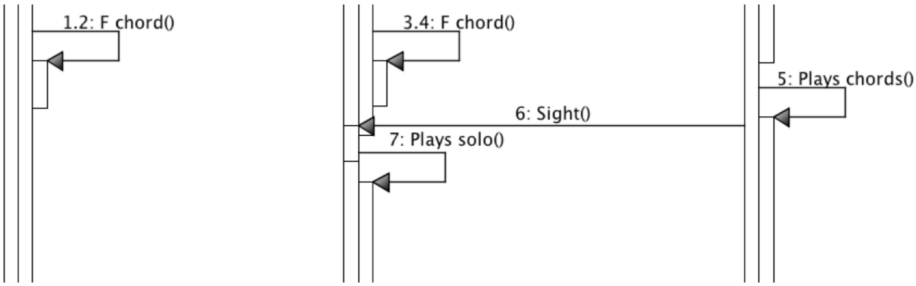

Fig. 4. Sequence *Diagram* of musicians in a rehearsal (detail). Guitarist looks at keyboard player at point 6.

3.2 Awareness of and Agreement on the Structure of a Piece

First of all, one could argue that the structure of the piece itself suggests a certain order of solos, or maybe the piece combined with the genre within which it occurs allows the skilled musician to deduce which order of instruments would be more natural. In any case, the better prior agreement on the structure of the piece, the better the musicians should be at coordinating. In the rehearsals that are the object of study here, the musicians gradually learn the structure of the piece together and gradually agree on a structure for the performance.

Once the musicians in e.g. the three person jazz ensemble discussed above - have reached a mutual awareness of the structure of the piece, this mutual awareness helps them solve certain synchronization problems, because they can often assume that the general structure of the piece is *common knowledge* in the group. Common knowledge of some fact *p* in a group of people *G* involves not only that everyone in *G* knows that *p*, but also that everyone in *G* (potentially) knows that everyone in *G* knows that *p*, that everyone in *G* knows that everyone in *G* (potentially) knows that everyone in *G* knows that *p* and so on ad infinitum. Common knowledge as described by e.g. Fagin et al ([6], p.9) is typically approximated following a situation where *p* is a public announcement to *G*. In the music ensemble, a type of information that might attain the status of common knowledge is agreements that are verbalized (and thus made 'public') during the rehearsals. Should the musicians suddenly not be synchronized in accordance with their initial plan for the performance, the musicians will by default try to follow the general strategies they consider to be common knowledge in the ensemble, based on how they remember the rehearsals. Using classical epistemic logic as a modeling tool, it can be shown that if common knowledge in *G* of *p*, notated $C_G p$, has not been established before the performance, $C_G p$ is actually unattainable during a performance due to the unreliable nature of non-verbal communication and symbolic communication through the music itself. Even so, the heuristic of simply doing what you think everyone has agreed on is, however, likely to improve coordination, because it is likely that others will also reason according to this heuristic by default. (For a detailed, formalized explanation of the mechanisms of common knowledge in the music ensemble, see [2], 181-196.)

3.3 Expectations for the Actions of Other Musicians

What would happen, if the musicians were not able to communicate, could not count on messages to be delivered in a sufficiently reliable fashion, and had not established a prior agreement on the structure of the piece they were playing? As hinted at above, the interaction between musicians playing together is not only dependent on verbal and non-verbal signaling between musicians, but also on the 'signs' communicated via the music performed by the individual musicians. Interpreting such musical signs is not a trivial matter in situations where the musicians cannot communicate directly. Here, the decision-making process for an individual musician depends partially on her own personal intentions for the performance, and partially on her expectations for how the other musicians are going to conceive of the situation at hand.

Suppose that the initial verbal communication of the rehearsal was not an option, e.g. if the three musicians sat down at a public jam session and were to perform together without having rehearsed the relevant piece in advance. In this case, a musician's predictions of how likely each of the other players is to take the next solo would be affected by how he considers it possible that they categorize the different possible orders of taking turns to play solo. (The case in which two musicians agree to take on the same solo spot as a duet – rather than a 'duel' – is one we do not consider in this paper. Whether duets are allowed is, however, dependent on the tradition in which the performance occurs). For instance, it might be that a musician thinks that one of the other players will monopolize the task as soloist, insisting on playing solo at each possible slot in the piece, but it might also be that he considers it likely that everyone will want the three musicians to take turns to play solo, and that the solos should occur in a very common order, e.g. guitar first, keyboard second and bass third. Each musician may consider these possibilities to varying degrees, but what really matters is how likely they think it is that each of the other musicians interprets the structure of taking turns in a specific way. In short, the choices of the musicians depend on their expectations for each other. These expectations may of course be influenced by prior rehearsals in other contexts, i.e. if the musicians in fact know each other in advance. This role of expectations echo the branch of game theory developed by Bacharach et al [7] called *variable frame theory*. In this field of theory, coordination games (e.g. where two people who are not allowed to communicate will get the highest pay off when simultaneously choosing the same object out of a selection of possible objects) are described as a reasoning process where one considers how the opponent 'frames' or, in other words, categorizes the different options at hand, and how this 'framing' makes her consider particular choices more 'salient' than others. The better the participating players know each other in advance, the more accurate their expectations for each other's choices will be. This seems to be paralleled by the fact that musicians often are more comfortable playing with musicians whom they already know well. (For a detailed discussion of the applicability of variable frame theory to the analysis of the musician's reasoning process, see [2], 202-208.)

3.4 Seeking a Compromise between Intentions

As has been mentioned above, intentions play an important role in a musician's decision-making process.

Olivier Roy [8] has discussed - with regard to decisions in general - the role a person's intentions play in the formation of plans. Transferred to the domain of music performance, the general idea is that in a given situation, the musician can choose to follow a strategy in line with a strategy profile (a combination of strategies, one for each musician in the ensemble) chosen from a limited set of possible strategy profiles. The musician chooses a strategy profile that has one or more possible outcomes that she intends to achieve. If the musician has reason to believe that the other musicians are not following the same strategy profile, she will have to search for a new profile that is in accordance with what she considers to be the possible intentions of the other musicians, but *ceteris paribus* still in accordance with her own intentions. What the formal model based on these ideas (see [2], 209-225 for a detailed account of this model) shows is that if we disregard the possibility of unintended actions, the musicians should gradually better their chances of coordination with each new step of searching for a new profile (as they will be able to rule out certain strategy profiles at each step). Returning to the example of the jazz ensemble, if a musician has an intention to play solo in the next slot, he might in some cases simply try to go for playing the solo, once he approaches the solo spot. In the meantime, he may, however, suddenly realize that someone else has the same intention, e.g. because the other player makes preparatory gestures for commencing a solo, or if - in the worst case - they start a solo at the same time (the worst case, given that we are not considering the possibility of duets, as mentioned earlier). In this case, the musician needs to find a new global strategy to play his part in, namely one that will make sense of the other player's behavior, e.g. a strategy profile where the first musician does not play solo in the initially intended spot, but waits until the next one. In general, the role of intentions is, however, more apparent in situations where there is more than one way in which a musician's initial intention can be realized, e.g. if the musician has an intention to incorporate a particular type of phrase *at some point* in the performance.

4 Conclusions and Further Perspectives

The UML models of the three rehearsing jazz musicians showed the gradual emergence of different modes of communication: First verbal communication was used; later, when the musicians got to know the piece better, gestures (hand and eye) were used; and eventually, the decision regarding who should play the next solo was made according to the musicians' awareness of the musical structure. When musicians cannot communicate directly, e.g. at certain times in the actual performance, they also rely on their expectations for how the other musicians conceive of the situation, a decision process that may be clarified by the use the modeling schemes discussed in section 3.2-3.4. These modeling schemes especially highlight the importance of remaining sensitive to the actions of the other players. In short, this research project provides a set of descriptive tools to capture some of the intuitive insights regarding interaction that performers already possess, and may be a step towards a comprehensive understanding of performance interaction in general.

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The Choreographer in Action: Hints for Augmented Choreography

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Abstract. Choreographers may exploit digital technologies to create augmented choreographies where the behavior of dancers determines the behavior of projections, lighting and other scenographic effects. This paper presents the preliminary results of ethnographic studies about how choreographers work from an interaction design perspective. Finally the paper describes the first elements of a choreographers-oriented design process for an Augmented Choreography.

Keywords: augmented choreography, interactive performance, interaction design, ethnography.

1 Introduction

Choreography is the art of designing sequences of movement performed by several dancers [7], where movements are composed by shapes and structures [11]. With *Augmented Choreography* we mean a Choreography whose shapes and structures are realized by the interaction between dancers and digital technologies, where what comes on stage is created and controlled by the choreographer. He/She designs the resultant interaction between performers, audience and the artistic intent. Currently choreographers aiming to realize augmented choreographies are constrained by several factors, coming from the current technology-driven mainstream approach. In a previous study we presented our software architectural approach, and some development experimentations [5], for an *end-user* software framework where choreographers can define augmented choreography via user friendly languages hiding technological details (Fig.°1). Furthermore, in collaboration with some Italian choreographers, we have investigated digital transcription techniques and existing notation systems for choreographies, paving the way towards a definition of the main features of a language for Augmented Choreography [3].

Developing new user friendly tools for choreographers is not possible without a deeply understanding of what choreographers do when they create their new ballets. Therefore, almost one year ago, we have began a study of choreographers in action. At this scope we observed some choreographers during their work sessions with

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dancers. The artistic partners involved in these studies are Matteo Levaggi, a resident choreographer at "Il Balletto Teatro di Torino" (we could observe him while he was working both with his own company of six professional dancers and with the students of dance at "M.A.S Milano[1]") and Roberto Altamura from "Milano City Ballet". In this paper we present the first outcomes of our study, with the aim to raise a discussion that will help us to deepen our understanding of the choreographic practice. The paper is organized as follows: firstly we present some related works while in section 3 we briefly outline our approach and how we developed our studies up to now. Afterwards in section 4 it is described what we have seen in the choreographer's work when interacting, both, with (his) professional dancers and with dance students. Later on we recall some first hints clarifying what we have understood about dance, choreography and the interaction between choreographer and dancers, from the viewpoint of Augmented Choreography. In section 5 we conclude the paper with a set of sensitizing terms from the real practice to act as guidelines and to direct focus of the design process.

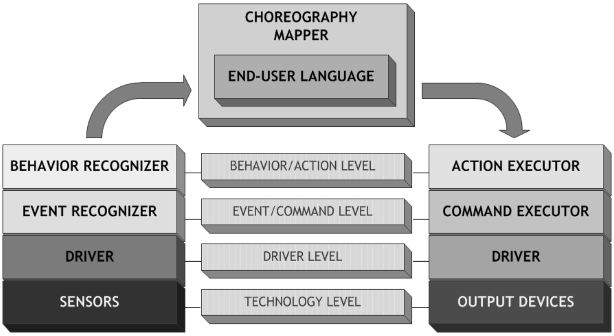

Fig. 1. End-user augmented choreography framework

2 Related Work

In the innovation history there are many cases of collaboration between artists and technologists. Especially in recent years we have seen enthrall performances as expression of how technology can well communicate with dance. Revealing examples are the show "Glow", an illuminating choreographic essay by the choreographer Gideon Obarzanek and software creator Frieder Weiss [17], defined by the creators a "living painting". Using the latest interactive video technologies a digital landscape is generated in real time in response to the dancer's movement, creating a beautiful evolving creature. Another example is "Apparition" by Klaus Obermaier and Ars Electronica Future Laboratory that takes interactive performance to another level through the creation of a unique stage work integrating live performance, sound, projection and an interactive system comprising real-time image generation and

[1] M.A.S. is for "Musica, Arte e Spettacolo" a prestigious dance school in Milan.

computer vision [15]. Moreover some studies aimed to demonstrate the importance of the staging public performances to involve emerging technology, although it can be a time consuming and expensive process [4]. We can see how several emblazoned actors of both technological and artistic landscapes had started significant collaborations. On the arts side, famous examples are Ars Electronica [14], the International Symposium of Electronic Arts [20] and institutions such as the ZKM (Germany) [24], the ICA (UK) [19], Banff (Canada) [16] and many others. On the technology side, there are research laboratories such as the MIT Media Lab [21], the Open Ended Group [22], the Xerox PARC's RED group [23] and the European projects such as eRENA and eSCAPE under the i^3 initiative [18].

3 About Our Observational Approach

Several studies demonstrate how to implement a standard ethnomethodologically informed approach to ethnography. It consists in the observation of the naturally occurring embodied action and interaction of the participants as they interact with an open-ended work [12]. This method represent one of the first way of developing an understanding of how user "go about" producing information of relevance [9]. It is nevertheless true that we have not found experiences in literature of social methods in studying the choreographers artistic creation process.

Our study of choreographers can be considered, in general terms, an application of ethnographic methods. Martyn Hammersely illustrates the main elements of "what ethnography is", identifying the following features [2]:

- a strong emphasis on exploring the nature of particular social phenomena, rather than setting out to test hypotheses about them;
- a tendency to work primarily with "unstructured" data that have not been coded at the point of data collection in terms of a closed set of analytic categories;
- investigation of a small number of cases, perhaps just one, in detail;
- analysis of data that involves explicit interpretation of the meanings and functions of human actions, the product of which mainly takes the form of verbal descriptions and explanations, with qualifications and statistical analysis playing a subordinate role at most.

Ethnography is also defined as product and process of research [1]: the product is an ethnography – a written manuscript of one's observations of the culture under study. The process involves prolonged observation of a group (choreographer and dancers in our case). We underline also that we have used the special form of ethnography, sometimes called 'quick and dirty ethnography' [10], developed in the Computer Supported Collaborative Work (CSCW) community for its application within system design projects [13], where observations are generally short and, by necessity, incomplete and the elicited knowledge is almost immediately restituted to the observed practitioners to raise discussion and open them to innovative viewpoints.

In our studies on Choreographer's practice we made use of three particular techniques:

- *Participant observation*. We have been immersed in the daily lives and routines of choreographers and dancers (Fig.°2);
- *Interviews*. Ethnographers also learn about a culture or group by speaking with informants or members of the culture or group. In our case the choreographers are being the object of the interview. The interviews we conducted are both informal and semi-structured;
- *Collection of artifacts and texts.* Ethnographers may also learn about a group or culture by collecting and studying artifacts (e.g. written protocols, charts, flowsheets, educational handouts) and material used by members of the group in their daily lives. In a preliminary study we have analyzed more than twenty manuals of dance notation systems and five ICT-based tools used to describe dances and ballets [8].

Fig. 2. Example of participants observation during a dance lesson in "La Lavanderia a Vapore", Tourin, with the choreographer Matteo Levaggi

4 The Choreographer

The choreographer is the creator of dance performances, i.e. he is the designer of their choreography. According to the literature we have read on the subject, all choreographers we have meet agree that a choreography is the synthesis of a large variety of visual, musical, cultural stimuli: in order to transform them into an original, meaningful, moving choreography, the choreographer needs to combine culture, skill and experience. A new choreography emerges around a theme, that can be a music piece, but also a painting, a literary text, a philosophical question, or, even, an image, a thing, a body, or a combination of any of them. Around this creative kernel, the choreographer engages himself in a very peculiar design performance. It is a design performance, because, as any design [6], it brings forth as a new dance performance. In order to do it, the choreographer creates his/her design object, collecting, creating, transforming and connecting a large variety of things, movements, inscriptions, etc. It is a peculiar design performance, because, some of the people collaborating with the choreographer – i.e. the dancers are the most important things constituting the object of design and play, as well, a fundamental role in the thing that is the outcome of the choreography: the dance performance. Therefore while typical designers, as architects, work with drawings, 3d-models, materials, choreographers interact with dancers defining positions, individual and collective movements, associating them to music, and situating them on stage, so that dancers embody the thing they are designing: the dance performance.

4.1 The Creation Process

At this stage it should be clear that to be a good choreographer requires great technical skills and a great professional experience as well as a deep knowledge of the history of dance, creativity and imagination. The choreographer is always distilling in any movement he designs a large amount of ideas, suggestions, emotions and he is always facing the problem that the movements he creates will make visible the richness of their inspiration and their true multidimensional sense, only if and when the dancers are able to perform those movements embodying their full richness.

Inspiration is a short flash that the choreographer develops with his/her experience and artistic sensibility. For example, Roberto Altamura (Milano City Ballet[2]) to create a new choreography draws inspiration from whatever comes to his mind, or simply listening to a particular music. He works on the fragments he has in mind with the help of his collaborators to transform them in the first elements of the choreography. Working with dancers, inspires him with new parts, aspects, qualities of the dance performance he is creating. This is later developed and passed to the dancers in a dialogue which, if successful, converges into a fully defined choreography that the dancers transform into a completely defined dance performance.

We could observe and analyze this second phase or dimension. We were lucky enough to have the possibility to observe Matteo Levaggi working both with the professional dancers of his company and with the dance students at MAS. In the next sub-sections, at the beginning we will recall what we have seen in the two cases and then we will elaborate the similarities and differences.

4.2 From Ideas to Movements

Of course the work of a choreographer with dance students is quite different from how he behaves with the expert dancers of his company. Indeed on the one side, the choreographer shows a movement to the students and interacts, even physically, with them in order to let them do the movement as it should be done. The problem of the expressivity of their performance is left to a second phase, when the movement is understood and correctly performed. Therefore observing the choreographer, while working with his students, has been quite instructive. Indeed we could understand the essence of dance as movements of bodies in tension. The choreographer indicates and/or shows a movement to them, and they repeat it, until they are able to perform it

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[2] The school directed by the choreographer Roberto Altamura.

in the sense of moving their body as requested. Often this trials are made without music, without taking into account any time or rhythm constraint, so that they can concentrate on the steps to do.

When students are able to repeat the movement, the choreographer corrects them in order to obtain that any part of their body (arms, legs, trunk, neck, head, …) is in tension during the movement, according to his design. Again, students repeat steps and movements and the choreographer and the dance teacher correct them so that movements become dance. It is an ongoing challenge to a deeper and fuller tension of their body, in some case, as if they should overcome the laws of physics and the limits of their body.

The next phase is learning to behave on stage as a group. When several students try to synchronize their movements again we have different moments: at first, their focus is on becoming able to keep their mutual positions while moving in accordance with the indications; only when this is achieved, dance students try to perform that movement according to the music, and the choreography takes form. While performing as a team, students use their body of memory and try to make their steps more accurate. During this exercise, the interaction between the choreographer and the students looks like more intense than what happens between him and the dancers of his company: the attention moves to its sense towards the quality of the performance: the choreographer begins to use the adjectives qualifying steps and movements and tries to transform students in dancers: technical problems are dissolved and expression becomes the issue.

Indeed with dancers of his company the choreographer goes almost immediately to the expression he wants to get, assuming that they can execute any movement correctly (there are exceptions to this as a difficult or new movement even if generally the problem is not doing a movement correctly, but doing it with right expressivity). In this case the interaction takes the form of a collaboration where dancers contribute to the choreography itself shaping the performance with their sensibility and skills (it is frequent that some choreographies, or parts of a choreography, are designed for a specific dancers so that his capabilities are valued in the dance performance up to mark it). The choreographer rather than giving technical indications, explains how a movement should be done and the sense that it has within the choreography. Dancers are not passive executors but they interpret the indications of the choreographer, who may ask them to move in a more or less ‘coloured’ way (i.e. emphasizing at different grades the amplitude of their movements), or in a more or less ‘danced’ way (i.e. in a more or less strict conjunction with the music and its rhythm) or to reflect the heaviness (when the full orchestra is playing) or lightness (when an instrument plays a *solo*).

4.3 Terms and Expressions

The first goal of this study is the distinction between the concepts of “augmentation” and “decoration” of the technology used to dance. Often the technologists offer to artists special effects and animations that constraints movements of the dancers in order to better emphasize the graphical effects. In this sense technology is just another decorative performance’s element, as lights, costumes and set design. In this sense, movements are medium and not the object of the choreography. On the other side there is the idea that technology and computer graphics are part of the body of the dancers. In fact the choreographers use the bodies like expression instruments, and often they are unsatisfied about the limits of the human physiology. Examples of these limits are:

- Sex;
- Mass and Gravity;
- Length and flexibility of the limbs.

To better clear these hurdles, the choreographer uses particular terms and metaphors that represent an important elements of the relationship between choreographer and dancers. We have selected these expressions given in Table 1.

Table 1. Terms and expressions used by the choreographer to describes movements

Expression	Sense	Sentence
Boost	Could be referred directed to a point in the space or at a limb.	*"Boosted by this leg"*
Wave	Movements without rigidness	*"Like a calm wave"*
Color	Relationship between movements and music	*"Music colors the arms"*
To Fill/To Empty	Heaviness of the body	*"Fill the body!"*
Smooth	Particular kind of boost	*"The body boost smooth ahead."*
Darkness	It denotes movements with a lack of self-confidence	*"..like big steps in the darkness!"*
Danced (more/less)	Emphasis in a dance's step	*"Follow the hands with a more danced manner"*

5 Conclusions and Ongoing Work

In this paper we have recalled some important aspects of the choreographer design process. We think that this work will allow us to approach at Augmented Choreography project not only from the technical point of view. The next step will be experimenting what we have discovered in this study to realize a public stage performance in collaboration with the choreographer Matteo Levaggi where an Augmented Choreography will be performed. This will be a good chance both to test our results and to survey new elements of the choreographer design process.

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Social Exploration of 1D Games

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Abstract. In this paper the apparently meaningless concept of a 1 dimensional computer game is explored, via netnography. A small number of games was designed and implemented, in close contact with online communities of players and developers, providing evidence that 1 dimension is enough to produce interesting gameplay, to allow for level design and even to leave room for artistic considerations on 1D rendering. General techniques to re-design classic 2D games into 1D are also emerging from this exploration.

Keywords: game design, netnography, new genres, HCI.

1 Introduction

Computer games have been classified in many ways [11], however, most of the games can be divide in 3 dimensional (or 3D) and 2D games. But what about 1D? The inspiration to explore the domain of 1D games came from browsing among several on-line communities, whose members were engaged in a conversation about the topic. Therefore, it was decided to conduct our investigation through the method of netnography, which is a form of ethnography applied to online communities ([1], [2]), and combine it with user centered design (UCD) [10]. Our initial survey suggests that a few 1D games already exist, but most of them were created to prove that 1D games are meaningless or ludicrous. For instance, the author of Tetris 1D[1] seems to make fun of the fact that in 1D no 2D rotations are possible, leaving no room for the typical gameplay of the classic 2D Tetris. Similarly Wolfenstein 1D [2] is not a proper game, but mostly a tribute to Wolfenstein 3D (developed by id Software and published by Apogee Software in 1992). 1D games are somehow recognizable among game designers and developers, but negatively characterized as something to avoid or to laugh about: we propose to consider 1D games a *non-genre*.

[1] `http://www.kongregate.com/games/zigah111/tetris-1d-2-0`
[2] `http://wonder-tonic.com/wolf1d/`

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In order to explore the 1D games design space, we re-designed famous 2D games so that they could still be playable and recognizably related to the original games, even with only a single (vertical or horizontal) line of pixels as visualization. We call this re-design process *flattening*. Keeping a game recognizable after flattening it, requires finding out what is the *spirit* or *identity* of that game, in relation to how the players feel, think and interact with the game itself. Our exploration is therefore centered on the players' perception of games, and on the artistic expressivity that 1D games might offer, as a medium for game design.

In the rest of the paper we present our netnographic investigation in the 1D non-genre and the games we designed and implemented (section 2); then (section 3) we analyze online forum discussions, and finally (section 4) we discuss what this exploration of 1D games achieved as well as future work.

2 Exploration of the 1D Non-genre

According to [1] netnography requires four essential steps, which can be reconducted to common ethnographic practice: 1. cultural entrée, 2. gathering and analyzing data, 3. ensuring trustworthy interpretation, 4. conducting ethical research. The first step requires identifying particular online forums, based upon the product or service to investigate, and the "specific research questions". Moreover, in order to gain rich data, the communities of interest should have a high rate of posting, with detailed and descriptive messages (as in [1]). Our study instead started from few negative online comments about the very idea of 1D games; afterwards, we decided to conduct our investigation following other communities (6 in all, including Facebook). Application of netnography is supposed to require a long time commitment ([1], [2]), and at this time our study is being running for five months, starting from May 2012, then in July we designed and implemented circa 15 prototypes of 1D games, of which 6 are currently playable. The games were shared on Facebook during iterative development, as typical in UCD [10], and later on 2 online communities of game developers ([7] and [8]).

With the games available online and publicized on 3 communities, a systematic netnographic analysis was undertaken, the second step in the methodology. The conversation exchanges from the Internet are kept and annotated, with respect to the meaning conveyed among the community members (as suggested in [1]). Regarding achieving trustworthy interpretations (step 3), netnography is based upon textual discourse, which may represent a "controlled self-image" of the community members, so that it may be difficult to reason upon their motives. However, this is a risk also in ethnography (see [1]), which focuses on studying the behavior expressed by a group of people and not on analyzing the individuals expressing it. Moreover, to provide a solid ground to netnographic data, [1] and [2] suggest combining the method with others, such as *in person* interviews. In the present study, netnography is combined with UCD. Moreover, we approached data collection with a "purposive sampling of material" (as stated in [9]), an approach to netnography used in marketing research, according to which noteworthy messages and conversation are selected and interpreted "in terms of a particular sample" (from [9]), hence it is not necessary that the sample is representative of other populations. Our focus was on people, who are interested in games and in exploring their essence, in terms of visualization and experience. Analysis of row data was based on grounded theory, as suggested by [2], so that we went through the conversations, copied on a separate file and coded them. The aim of this analysis was to identifying emerging themes and possible design inspirations, in relation to how people perceive 1D games. Recurring and interesting utterances were transcribed on post-its, which were pasted on large sheets of papers, so to represent emergent themes into tangible and visual clusters, as it is common practice in design research [10]. Since the conversations we analyzed were concise and straight to the point, and we did not know exactly what to expect, this method revealed to be effective and well suited for the study.

Finally, inadequately reporting messages and utterances from conversations in online communities, might result in psychological arm to community members (as explained in [1]), therefore, a researcher is supposed to act correctly with respect to privacy, confidentiality, and informed consent. It is recommended that researchers reveal their identities and purposes, to the members of the communities they follow, and that they are careful when reporting literal quotes, which online represent the individual identity of the members. Taking these recommendations into account, the communities that were followed through participant observations, were informed of this study and affiliation of the researchers. Moreover, in respect of the members' privacy, literal quotes from individual members will not be reported, both in the case of the communities we joined as well as the ones we only observed. Data are only reported in relation to the emerging themes we identified from the observed conversations and used for the design of our games.

2.1 Our 1D Games

The games were created following a user-centered iterative development approach, in line with agile development. The main goal was to transpose famous 2D games in 1D, possibly in multiple ways, and keep in contact with players, to validate the design as quickly as possible (with new versions created in few hours). All the games are written in Javascript, they all use HTML5 canvas for graphics, and the code is willingly simple and portable, so that the games can run on most browsers and on most Wi-Fi enabled mobile devices. Dropbox was used to distribute our 1D games[3].

The classic and popular games we decided to *flatten* were: Tetris[4], pinball-style games, Bloxorz[5], Sokoban[6] and Rogue[7]. For each of these games we designed different flattenings, i.e. different 1D games have been derived from the same classic 2D game, and for each 1D game prototype many version have been developed, usually between 3 and 5.

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[3] All our games are available at `https://dl.dropbox.com/u/1518199/1D%20games/index.html`

[4] `http://www.tetris.com/`

[5] `http://www.bloxorzgame.com/`

[6] `http://www.sokoban.jp/`

[7] `http://www.gamasutra.com/view/feature/4013/the_history_of_rogue_have__you_.php`

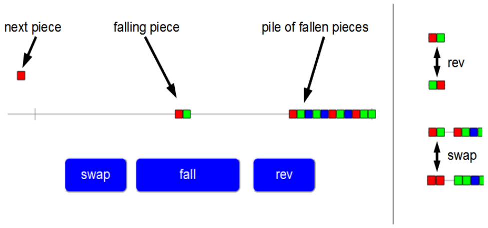

Fig. 1. 1Dminos, our transposition of tetris onto 1D. As in the classic tetris, a piece is falling (from left to right) and will join the pile of fallen pieces. The game also shows the next piece that will fall, to help the player better plan a strategy.

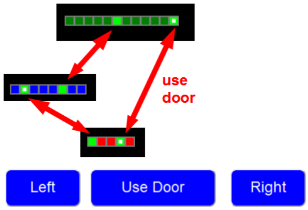

Fig. 3. Rogue1D is the flattening of the classic Rogue. The user interface allows to move left and right, and to go through a door. These 1D doors are like portals, connecting different linear rooms, and allowing for exploration of a graph-like 1D maze.

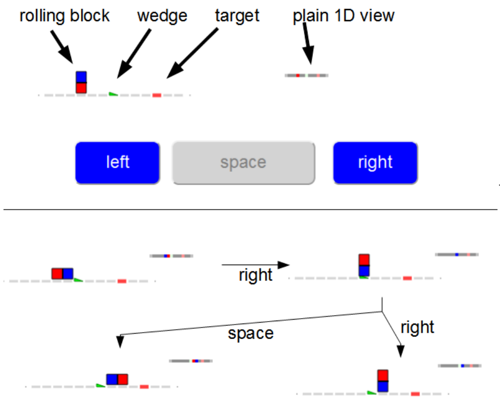

Fig. 2. Blox1D. The top part of the figure shows the game as it appears to the player, with 3 buttons and both an artistic and a plain 1D views. The bottom part of the figure instead shows some steps of the possible interactions between player and this game.

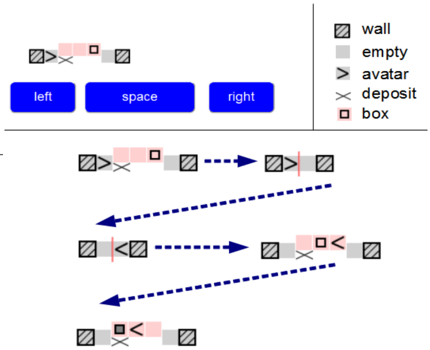

Fig. 4. Soko1D, a 1D version of Sokoban. The lower half of the figure shows the player solving a level, by way of folding and unfolding a section of the level.

Fig. 1 shows the game 1Dminos, one of our 1D remakes of Tetris. To decide how to reduce Tetris pieces and operations from 2D to 1D, we followed a structuralist approach [3]. First we considered all Tetris pieces and the actions available to the user: horizontal translation, and clockwise and counter-clockwise 90 degrees rotation. According to our analysis, key factors are: shape (distribution of squares in 2D to form connected figures), horizontal and vertical position, and orientation of shapes.

The goal of a game can then be expressed in relation to pieces and operations, the artificial conflict and the rules [11]: in Tetris, connecting shapes in particular ways, a kind of *fitting*. Rotation and horizontal translation affect shapes, since their fitting might change. The player has to find strategies to control the one falling shape with respect to the shapes that already fell. This structuralist analysis helps when defining a flattening of Tetris. We proceeded considering: how shapes would be in 1D, and which operations can be defined that "remind of" the 2D translation and 2D rotation. We decided to flatten shapes into color patterns: a 1D shape is simply a sequence of a few colored squares. As operations we chose **reverse** and **swapping** of the right-most square of the falling piece and the top square on the top of the pile (see Fig. 1). Now we can rephrase Tetris main goal in 1D, as fitting of colored sequences. Fig. 1 also shows the user interface of the 1Dminos game: composed of 3 large buttons, it is usable both on a computer and on mobile devices.

The same structural analysis that was conducted in the case of Tetris, was applied also to other famous games, such as Pinball, Space Invaders, Bloxorz, Rogue and Sokoban. The 1D Pinball and 1D Space invaders were just considered to expand the range of games that could be flattened, and their design is still very incomplete. Bloxorz is about *rolling* a three-dimensional block on a 2D surface, until it falls down a square hole. The block measures 1 by 1 by 2 units, and the player can roll it in 2 different directions (vertical and horizontal, with respect to the floor). Flattening this game, which is 2.5 D was challenging, and we concentrated on the asymmetry that the 3D block induces with respect to the 2D floor. The resulting design (after a few partial prototypes) is visible in Fig. 2. Given the *artistic* visualization that we implemented for blox1D, the game might look more 2D than 1D, therefore we added a *plain 1D* view to show that blox1D is still perfectly playable with a strictly mono-dimensional visualization.

Rogue1D is an attempt at flattening a 2D adventure game. The original game Rogue, is a classic that started a genre, and its gameplay has to do with exploration of a 2D maze composed of rooms and corridors, populated with monsters and filled with items. The main challenge in flattening this kind of games is in rendering the idea of free exploration, but with only 1 dimension. Few prototypes were designed and implemented; the latest is the one shown in Fig. 3. In 1D the maze is replaced by linear rooms (i.e. corridors) connected by portal-like doors. A door is a bi-directional gate that connects a tile in one room with a tile in another room, so the entire maze is just a graph. The player can see only the current 1D room: we have sliced a 2D maze, and present a single horizontal slice at any given time, therefore time acts as second dimension during the exploration of the maze (a general technique inspired by the discussion about 2, 3 and 4 dimensions in [4]).

Finally, Sokoban is a classic *transport puzzle* from the 1980s. The player has to push boxes around in a warehouse, trying to get them to storage locations. Boxes cannot be pulled, and are blocked by walls and other boxes, hence the complexity of the game.

Flattening Sokoban proved more complex than with the other games: it required almost 1 week and produced many very different prototypes. The final one, called soko1D, is depicted in Fig. 4. The inspiration for the flattening came from trains and the way railroad switches work, by enabling or excluding entire sections of tracks. In Soko1D (as shown in the lower part of Fig. 4) the level is linear, and can contain boxes, deposits and walls. The level itself is composed of sections, some of which can be folded, i.e. excluded; boxes contained within a folded section still exist, but are inaccessible as long as the section stays folded. Fig. 4 (lower half) shows how the player can fold, move around the section containing a box and a deposit, then unfold and push the box left-to-right, eventually winning. The latest soko1D prototype has 9 levels of increasing complexity, an indication in our opinion that level design can actually be meaningful within the 1D genre.

3 Themes in Players' Feedback

Initial analysis of online conversations about the dimensionality of existing games (like Super Mario Bros [3] or 1D Tetris) suggested 4 main themes: non-genre, essence of what is a 1D game, experience, design. The same 4 themes also emerged later in analyzing the feedback we received for our 1D games.

The first theme emerged from comments about the impossibility of having 1D games; and inspired us to take up the challenge and explore the 1D non-genre. These comments are of three kinds: direct critics of the concept of 1D games, ironic celebrations of a 1D game and its author, or positive comments about an engaging 1D game. This last kind of comments express surprise: a person would initially state that 1D games are nonsensical, then change opinion, after playing a particular game.

Regarding the second theme, essence of 1D game, two main subthemes emerged, called: geometry and view. Geometry comments claim that 1D games should respect the basic geometrical principle that a 1D space has only one axis (vertical or horizontal). Hence, the games should all be represented on one line of pixels. Other comments reflect a different understanding of 1D games, related to the visualization and movement of the character. According to this interpretation, even Super Mario Bros can be arguably seen as 1D, as the character moves mainly in one direction. Moreover, some individuals claimed that a 1D game could be the 1D view of a 2D world, some comments mentioned as an example the book Flatland [5]. The game Z-rox[8] seem to match this definition of 1D, as it visualizes a bi-dimensional shape (a character in this game) crossing a line, and the player has to guess which character it was, just by observing its 1D projection. Other comments focus on usability, and maintain that a designer can take the freedom to scale a line of pixels to a line of colored squares.

Finally, few comments fall in between the geometry and view themes, so that a game can be acknowledged as 1D, and yet its visualization considered as 2D. In the design of our games we adopted the view theme, which emphasizes gameplay and user experience (defined as the main goal of game design also in [12]).

Two main sub-themes emerged regarding the theme of experience: appreciation and critics, reflecting positive and negative judgments. Positive comments overlap with the non-genre theme, as they express players' surprise in finding an engaging 1D

[8] Freely available at: `http://www.kongregate.com/games/EvilDog/z-rox`

game, often praising the authors for being a creative, original thinker. In some cases, the authors of such comments said that they have thought or tried, to design a 1D game before[9], showing that 1D games can also be engaging from a developer's perspective. However, negative comments claimed that 1D games are “not so fun” or that the game play is “vague”. Hence, a sub-theme related to understanding seemed to emerge, in which 1D games are said to be confusing or difficult, so that it takes a while before a player can enjoy them. The same comments appeared also in a positive light, as some individuals enjoyed these challenges, as part of the gameplay.

Finally some individuals provided interesting design suggestions, such as adding tutorials or menus to clarify the goal of a 1D game and how to play. In one case it was suggested to add a button that allows players to re-start from the level where they were playing, and not from beginning. Given the small size of these games, it was suggested that they could be interesting apps for mobile devices, such as smart phones and Nintendo DS. Some of these comments even suggested specific 1D games as a possible source of inspiration, such as: line[10] and gauge[11] for iPhone. The authors of the game line explored the possibility of a one-dimensional shooter game; they developed their game as a collection of mini-games, with minimalistic graphics and gray colors. The forum comments that followed the post about line were generally positive. Gauge is a commercial game for iPhone, where the player taps on a single button (i.e. the entire screen) to control a size-changing horizontal gauge; the closer the gauge gets to the edge of the screen, the more points the player gets, but if the gauge exceeds the screen the player loses. While this game is clearly of the 1D kind, nothing about one dimensional gameplay is explicitly written in its description, strengthening our concept that 1D is a non-genre.

4 Reflections and Conclusion

After creating few 1D games and reflecting on online feedback, we can formulate a more precise and inclusive definition of this non-genre. A 1D game is:

a game that can be rendered and played, at least in principle, with a single line of pixels, either vertical or horizontal

From a visualization point of view, this definition allows for quite sophisticated renderings, provided it is always possible (at least in principle) to simplify the graphics into a single line of (colored) pixels without affecting playability.

In our games we use 3 kinds of 1D visualizations: black and white pixels, colored pixels (or squares, as in 1Dminos Fig. 1), and *artistic rendering* (e.g. in soko1D, Fig. 4). So far we have flattened 2D adventure and 2D puzzle games; a reusable technique that emerged involves slicing of a 2D space in horizontal strips, with a single strip perceived while playing. Both Rogue1D and Soko1D follow this approach, while the *folding feature* of Soko1D show that 1D games can stretch towards 1.5D.

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[9] Similar comments were posted also for our games.
[10] `http://forums.tigsource.com/index.php?topic=17734.0`
[11] `http://www.148apps.com/reviews/gauge-review/`

Another reusable technique is to perform a structural analysis before designing the flattening of a 2D game. The results of the analysis suggest, but do not dictate, what the flattening should focus on, still leaving plenty of artistic freedom to the 1D game designer.

In conclusion we believe that 1D games possess a minimalistic quality that can be useful when reflecting on game identity, and we would like to use participatory design to gain more insights on whether 1D games could become a viable tool when teaching game design and game programming. For instance 1D games could be used in conjunction with paper Turing Machines [6].

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