AR'istophanes: Mixed Reality Live Stage Entertainment with Spectator Interaction

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Abstract. Mixed Reality and Augmented Reality for live stage productions have been used ever more frequently by artists over the past few years. AR'istophanes is an experimental stage production aimed at bringing the new technical possibilities of Mixed and Augmented Reality to the stages of this world. This document describes the first phase of pre-production from 2011 to 2012 and demonstrates the possibilities of integrating motion capturing and 3D animation. This also includes the use of Smartphone Apps and real-time rendering. Audience interaction is a key focus in this production – which means technical approaches are demonstrated and opinions were collected from potential viewers.

Keywords: Mixed Reality, Augmented Reality, Interaction, Theatre, Live Entertainment, Optical See-Through Glasses.

1 Introduction

Nowadays, technology offers quite a number of options for exploring live performance activities. Theatre, in particular, offers new ways of performing with different approaches. Interaction between a real person and a virtual one can lead into 3D environments and deliver to spectators new experiences of content creation. Stage designers extend their traditional props to interactive ones or combine them into Mixed Reality environments. Traditional audiences often have to learn how to participate in these new scenarios and sometimes need special hardware to consume the Mixed Reality scenarios. Augmented Reality, in combination with Smartphones and high-end computer hardware, is already quite a powerful tool for supporting new Mixed Reality approaches with very detailed real-time character animation and interaction. Over the past few years many stage companies and tech-driven researchers have developed new theatre experiences often known as "Digital Theatre".

Based on their own research the authors propose a unique method of performance and stage setup:

R. Shumaker (Ed.): VAMR/HCII 2013, Part II, LNCS 8022, pp. 390–399, 2013.

AR'istophanes [1] is a Mixed Reality play which was developed in 2011 by Thiemo Kastel. The story is based on the Aristophanes play Eirene – The Peace. Preproduction of the 3D content like virtual characters with motion capture and lip-sync animations and the overall control of different Smartphone and computer Apps were developed and largely all produced with a group of students in July 2011 and July 2012.

The stage itself is subdivided into several layers, where the play happens. Unlike classical theatre productions AR'istophanes offers more than one space where the play can be acted out. Beside the main stage with a holographic projection of the virtual characters, the play is also performed on the spectator's optical see-through glasses [2]. AR'istophanes enables spectators to interact live and in real-time with the director of the play. This includes the use of so-called personal optical see-through glasses in conjunction with Smartphones.

What is real or virtual depends on the director's genius during the live performance. The director's creativity is directly linked via a network to the actor's wearable information system. This information system is the same as the spectator's. Based on the spectators' live feedback via Smartphone the director can decide during the play whether a virtual or real character should enter the next scene. This leads to a direct involvement of the spectators and from day to day each performance of the play becomes an independent and exclusive piece of entertainment. The metadata of each play can then be recorded and made available on the Facebook social media platform for other theatre directors. Via touchscreen devices spectators would be able to share screenshots and comments with their smart community on Facebook. The smart community could also include contacts to the actors, director and production crew of the play enabling the audience to gain deeper insights into their artistic work.

Augmented Reality requires a trigger to play on Smartphone-stored content or loaded content from the Internet. Typical triggers for Smartphones are camera or position i.e. GPS-based. This overall spectator experience is only possible in a smart theatre environment (Smart Venue) with Future Media Internet products and services.

2 Digital Theatre Productions

2.1 Live Entertainment Productions with Spectator Interaction

Active audience involvement in stage productions can create exciting experiences. The actors or director do not know in advance how the audience will react when their collaboration is requested. In his book Digital Performance Steve Dixon formulates four types of interactive art and performance [3]. These are:

Navigation, Participation, Conversation and Collaboration

In our view, the opportunities of participation and collaboration are particularly interesting when Smartphones are used for this at live productions due to the possibilities they provide for interacting at "Smart Venues".

2.2 Augmented Reality Used at Theatre Productions

Even if the general public is still fairly unfamiliar with Mixed Reality productions, quite a few projects have already taken place aimed at connecting the audience and the performance thereby taking it to a new level.

One of the first theatre productions that used AR was *Everyman: The Ultimate Commodity* [4]. The production was performed in Singapore (2006) and Toronto. Daniel Jernigan's theatre group referred to the first definitions of AR by Ronald Azuma and G. Bishop when developing this performance. As they themselves state, this is the first time the option of moving AR markers and holding the actors in a station position is used. Typical black/white tracking markers were held in front of the actors' faces and these were then filmed live. A computer generated the AR by giving the actors different faces. The result was then projected onto a screen. The audience then saw the projection and in front of it other actors acting alongside the projected ones. The artists' summary of these attempts is formulated in relatively neutral terms:

"In the final analysis, however, we believe that our project serves as a reasonable example of how any attempt to integrate technology into theatre can be a double-edged sword, as technology can simultaneously be both supportive of – and disruptive to – the themes and aesthetics of a particular production."

3 Eirene – The Peace by Aristophanes

Created in 421 BC the comedy *Eirene* (The Peace) was staged by the poet Aristophanes at the great Dionysia of that year. It depicts the problems caused by the turmoil of the Athenian-Spartan War, in particular those affecting hard-hit farmers who take a delegation to the Olympians and successfully deliver the goddess Eirene from exile. The fairly simple plot based on the daily news of the war is enlivened by a wealth of fantastic and unreal events and contains detailed parodist allusions to Euripides' *Bellerophon* [5].

Aristophanes was born in Athens around 445 BC. At that time Athens was the capital of Attica and the largest city in Greece next to Sparta. At Aristophanes' birth a period of peace and prosperity prevailed in Athens under Pericles (peace with the Spartans and also with the Persians already in 449 BC) which was to end with the 20-year Peloponnesian War (431BC-404 BC) [6]. Aristophanes' idea of the world was shaped more conservatively and his political and philosophical inclinations (preference for aristocracy and older philosophy over democracy and the Sophists) are always present in his plays causing him to clash with prominent contemporaries (Euripides, Socrates and others).

4 Stage Setup for AR'istophanes

Since time immemorial mankind has always tried to elude its own perception – from cave paintings to 3D cinema man always been fascinated by the power of the image. In a period where technology offers numerous possibilities we decided to take a step

forward and propose something that will change our perception of reality, offering an experience that many will want to repeat.

The stage will need equipment that can deliver with quality a believable illusion, good enough to deceive the eye of an ordinary citizen. In order to provide a complete and convincing illusion we must be sure to use state-of-the-art technologies in video-projection and holograms for Mixed Reality experiences. The idea is to use a layer for a virtual character. The technology for projecting holograms created by Musion seems to fit our needs [7].

Musion has a hardware setup called "Musion Eyeliner" that features a high-quality projector, placed on the ceiling of the structure pointing down, projecting to a mirror that will reflect the image to a 6 by 4m (standard), very thin and almost invisible foil. The foil is rotated 45-degrees relative to the ground. If the projection sent the image directly to the foil spectators would see some of the projector light reflected at them and this would spoil the illusion. With 45-degree angle the light sent by the projector is not reflected back to the audience, creating a more realistic hologram. The design is briefly explained in Figure 1:

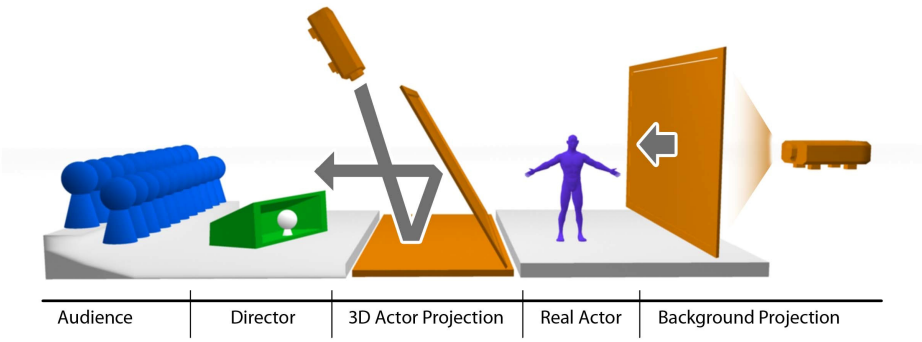

Fig. 1. Side perspective of the Stage Setup for AR'istophanes

In order to establish a connection between all participants, all computers for the projections and Smartphones/tablets must be on the same network (Fig. 2).

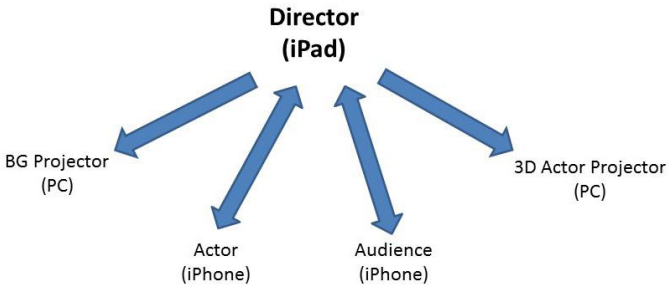

Fig. 2. Data schematic – one-way arrows represent only output from the director and two-way arrows represent input/output from the director

5 3D Content Creation for AR'istophanes

5.1 Low-Cost Motion Capturing

> *"Motion capture is the process of recording a live motion event and translating it into usable mathematical terms by tracking a number of key points in space over time and combining them to obtain a single three-dimensional representation of the performance. In brief, it is the technology that enables the process of translating a live performance into a digital performance."* (Menache 2000, p.1) [8]

Motion capture is a process which allows us to record actions quickly and to import the information in 3D software to animate the characters. Thanks to motion capture it is possible to animate characters in a really realistic way, also with complicated actions. It is indeed hard to achieve these kinds of realistic movements using key frames or other animation techniques. The problem of motion capture has been that it was only affordable for large companies or big-budget film productions. Fortunately, Microsoft's Kinect Xbox reached the market in 2010 [9]. Initially thought of as a way to revolutionise video games, this hardware became a target for programmers who adapted it to all kinds of other uses. The Kinect is used in games for detecting the player's movements and controlling virtual characters. In the same way, it is possible to use this depth information to capture the motion of an actor and use it to animate a 3D character. For this purpose, the right software is required. For the AR'istophanes project we chose to use ipiSoft software. ipiSoft is a piece of software that can record a video using the ipiRecorder and record the depth information of a person in a room. It can then transfer this information in ipiStudio to a track and save the information in the format needed for the rest of the animation [10]. Figure 3 shows the setup of this capturing system.

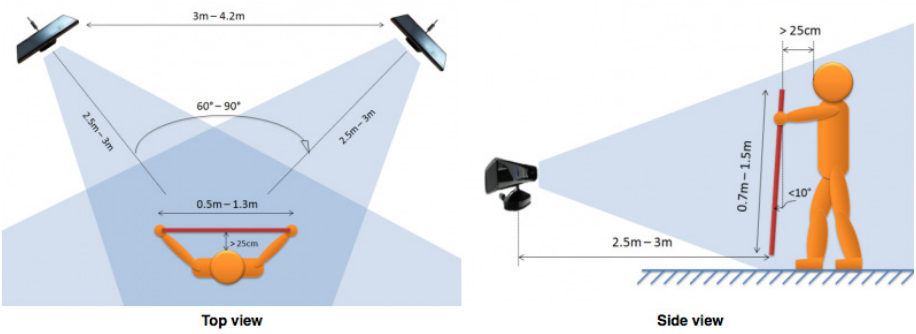

Fig. 3. Positioning for calibration of the Kinect for a good depth-capture

5.2 Character Design for Real-Time Rendering

Unity3D

Unity is a high-performance rendering engine permitting the development of computer games and interactive 3D graphics applications. The development environment

runs in Microsoft Windows and Mac OSX. Potential target platforms here, alongside PCs, are also game consoles, mobile devices and web browsers. For AR'istophanes the only platforms used are iOS, Android and Microsoft Windows.

Generate 3D Objects for Unity
3D objects for Unity can be generated with any 3D software. As an export format .FBX is mainly used. When generating 3D objects for Unity3D the following aspects need to be taken into account:

(a) Optimised Mesh Division

The extent to which you allocate divisions to the 3D objects in the modelling phase is crucial here. For instance, too many polygons on a 3D object will unnecessarily compromise the performance of a PC or other medium (mobile device). Figure 4 depicts two fairly complex 3D objects.

The house on the left contains 1523 polygons. Its optimised version on the right has three times fewer polygons. For a game engine like Unity3D a 3D object with an optimised number of polygons is best suited as fluid representations are also possible even on lower-performing end devices.

(b) Real Size of the 3D Object

It is very practical to model 3D objects in real scale. This means you can keep real proportions and avoid additional adaptive scaling of the objects in Unity (Fig. 5).

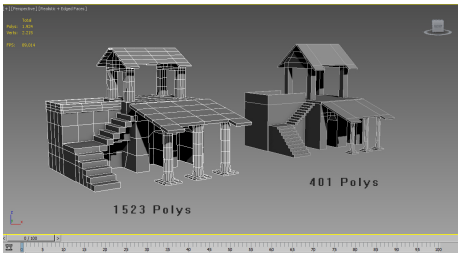

Fig. 4. Optimization of the Number of Polygons

Fig. 5. Correct Proportions when Modelling

Animated 3D Objects in Unity

In Unity it is possible to move objects via pre-defined paths, scripts or physical paths. Character animation can be realised using a skeleton system. Using a skeleton, individual character body parts are animated. Head animation is usually generated separately. One face animation technique is morph animation. Character animations are prepared within and imported from external programs like 3DS Max.

Creation of 3D Heads using Facial Studio
Facial Studio (Microsoft Windows Edition) is a software program used to create 3D heads easily and simply. More than 500 parameters are available here for the generation and deformation of a head. You can import your own photo in two shots (front and side) and create a head with an automatic texture using control points (Fig. 8).

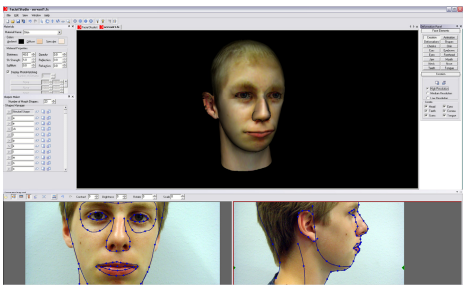

Fig. 6. Facial Studio (Windows Edition)

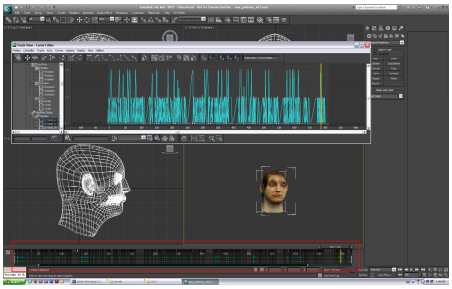

Fig. 7. Key Frames after Lip-Synching

By adapting these control points to a photo you automatically create a 3D geometry with the image texture of imported photos. When the head is finished you can create different facial expressions individually and save them as morph targets. These different facial expressions can then be animated using an external 3D program. You can import a 3D head like this as an .FBX file – for instance in Autodesk 3D Studio Max.

Voice-O-Matic for Lipsynching
The imported head has different facial expressions as morph targets and also those that correspond to speech phonemes. Using this information and the Voice-O-Matic plug-in (3D Studio Max Edition) it is possible to achieve quick and automatic lip-synching with a language for any desired audio file. In a few seconds key frames are created on a timeline. The individual key frames can then also be manipulated and optimised manually in an animation editor. Voice-O-Matic saves a great deal of time on lip-synching (Fig. 9).

Exporting 3D Characters for Unity
Once lip-synching is completed you link a 3D head to an animated body. For Unity it is vital a 3D character does not have unnecessary divisions in the mesh as this can very much compromise the performance of a computer. To import a 3D character in Unity3D one other factor needs to be taken into consideration: the 3D head is purely a morph animation.

6 Mixed Reality Development

6.1 Augmented Reality for Spectators

“Augmented Reality (AR) technology for digital composition of animation with real scenes is to bring a new digital entertainment experience to the viewers. Augmented Reality is a form of human-machine interaction. The key feature of the Augmented Reality technology is to present auxiliary information in the field of view for an individual automatically without human intervention. The effect is similar to composing computer-animated images with real scenes.”[11]

This reference describes accurately the intention we have planned for the audience: Interaction between the audience and the play, the feeling they are actively participating in the play. For this purpose optical see-thorough AR Glasses were chosen. Unfortunately, these glasses are state-of-the art technology and not yet in circulation. For this reason, we have only performed preparatory work and will do the tests as soon the glasses arrive.

6.2 Augmented Reality for Actors

In AR'istophanes actors are to be equipped with the same technical system as the audience. This allows very fluid interaction as some information can be represented quickly via the glasses – for instance using simple symbols.

7 Spectators Interaction with the Director and Actors

7.1 Interaction Control System

The interaction will be an ever present element with every participant, whether on stage or in the audience. The director is the only agent interacting directly with each individual as all other individuals only interact with each other indirectly. This is how it works:

The director can ascribe different behaviours to the virtual actor: acting for the story, as an idle listener to the real actor or one waiting for the results of the audience survey. This kind of improvisation of a character from the virtual world can make people relate to the character, since it behaves in a human manner; reacting to events instead of having scripted behaviour.

Actors will also use Augmented Reality glasses to obtain information about the play, to know what happens next or any kind of information the director might find relevant to share; for example, survey results, an upcoming event or a change in mood or attitude of the character being played. The spectators will be able to answer queries sent by the director. These queries can be about small things – details like the colour of a character's clothing, or more important things like changing the course of the plot. The director can work with the information provided by the audience and can decide what is best for the play to keep it interesting.

More interesting details can be added to the play's environment. Let us suppose the intrigue in the play becomes denser. Here the director can add dynamic environment effects like rain, snow, de-saturate colours or dim the lights to create a more fitting environment. This is particularly interesting as it gives different directors to opportunity to test their creative abilities, delivering to the audience and actors an "ever new" and dynamic experience. This system is being developed in Unity 3D, a game creation platform that can deliver the adequate mechanisms for the realisation of all those features listed so far. All participants must have installed the AR'istophanes App on their Smartphone (in the case of spectators and actors) or a tablet in the case of the director.

7.2 Spectator Experience

Thanks to Augmented Reality the audience is no longer passive. Spectators take part in the story directly. The Augmented Reality glasses allow spectators to control the show. At any time they can ask for more information about the play (this information will be chosen by the director before) giving them a better understanding of the show. If the director so wishes spectators can have a direct influence on the story. In this way it would be possible for spectators to choose between different story endings. There is still one question that remains unanswered: Is the audience interested in performances of this kind? A show like this brings to the audience an interactive dimension like never before. But will people be keen to take part in the show, or is this a change they are not willing to take on board?

The next chapter will present the results of a survey carried out from November 2012 to February 2013 to discover what people expect from this kind of show and how much involvement they are prepared to provide.

7.3 Results of the Survey

The first thing to note here is that this kind of performance is aimed more at a younger audience. Indeed, the younger generation are accustomed to using Smartphones for every possible reason which makes it easier for them to imagine a play where they would be involved directly with their Smartphones. Accordingly, it is harder to appeal to older audiences with Augmented Reality theatre because they would first need a "course" to learn how to use the application. However, with the help of assistants this audience group could also participate in an interactive performance.

As mentioned earlier in the paper, this kind of performance is still relatively unfamiliar to the general public and only 37% have already experienced a theatrical production with audience interaction. 72% would not wish to use the opportunity of interaction at an interactive theatre production.

Concerning the use of optical see-through Augmented Reality glasses, 68% are willing to use them directly, 26% want to give it a try first and only 5% do not want to use them at all. The audience is relatively positive about this AR experience. However, some are still not sure whether wearing AR glasses might be bothersome as these glasses are still not yet available on the market.

Most respondents (60%) agree to paying more because of the advanced technology a show of this kind would offer. However, most of them (51%) are not willing to pay more than Euro 2 extra for this technology. 40% of the audience are still not prepared to pay more than a normal ticket despite the added technology. Regarding the application, 78% of respondents are ready to download the free App to use on their cell phone. The remainder of audience expect organisers to provide Smartphones at the entrance for people to use. On a positive note for this kind of performance, 69% of people already own a Smartphone and 20% who currently do not have one wish to own one in the near future. By February 2013 34 people from 7 countries had taken part in the public survey. 88% of those polled were aged 16 to 35.

8 Further Work

As we approach our project's final goals, we continue to test all parameters and attempt to overcome any obstacles we might encounter. Sometimes is not possible to incorporate all features designed for a project, but creativity enables us to navigate problems and sometimes develop new ideas and methods for improving our product. The next step in our work will be to test stress Unity with more demanding tasks. We will gauge its ability to handle long morph animations so as to avoid the need to split sequences of animations from the same character. Improving the quality of the 3D meshes and textures is also something we aim to improve without compromising global performance of the game engine. Due to the rapid technological development of mobile end devices and real-time rendering software the quality of the 3D character is sure to improve and will take up a large proportion of our work. We are confident that optical see-through Augmented Reality glasses with reasonable display sizes will be available at consumer prices. There is certainly still a great deal of work to be done before a real production is ready to be presented on the stages of this world.

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