Recreating Daily life in Pompeii

Nadia Magnenat-Thalmann and George Papagiannakis

MIRALab. University of Geneva. Switzerland

Resume

We propose an integrated Mixed Reality methodology for recreating ancient daily life that features realistic simulations of animated virtual human actors (clothes, body, skin, face) who augment real environments and re-enact staged storytelling dramas. We aim to go further from traditional concepts of static cultural artifacts or rigid geometrical and 2D textual augmentations and allow for 3D, interactive, augmented historical character-based event representations in a mobile and wearable setup. This is the main contribution of the described work as well as the proposed extensions to AR Enabling technologies: a VR/AR character simulation kernel framework with real-time, clothed virtual humans that are dynamically superimposed on live camera input, animated and acting based on a predefined, historically correct scenario. We demonstrate such a real-time case study on the actual site of ancient Pompeii.

Keywords: *ARTIFICIAL, AUGMENTED, AND VIRTUAL REALITIES, ANIMATION, THREE-DIMENSIONAL GRAPHICS AND REALISM, VISUALIZATION TECHNIQUES AND METHODOLOGIES.*

1. Introduction

Mixed Realities [Milgram et al] and their concept of cyber-real space interplay invoke such interactive digital narratives that promote new patterns of understanding. However, the "narrative" part, which refers to a set of events happening during a certain period of time and providing aesthetic, dramaturgical and emotional elements, objects and attitudes [Tamura et al] is still an early topic of research. Mixing such aesthetic ambiences with virtual character augmentations [Papagiannakis et al] 0and adding dramatic tension has developed very recently these narrative patterns into an exciting new edutainment medium [Tamura et al]. Since recently, AR Systems had various difficulties to manage such a time-travel in a fully interactive manner, due to hardware & software complexities in AR 'Enabling Technologies [Azuma et al]. Generally the setup of such systems was only operational in specific places (indoors-outdoors) or with specific objects which were used for training purposes rendering them not easily applicable in different sites. Furthermore, almost none of these systems feature full real-time virtual human simulation. With our approach, based on an efficient real-time tracking system, which require only a small pre-recorded sequence as a database, we can setup the AR experience with animated virtual humans anywhere. With the interplay of a modern real-time framework for integrated interactive virtual character simulation, we can enhance the experience with full virtual character simulations. Even if the environmental conditions are drastically altered, thus causing problems for the real-time camera tracker, we can re-train the camera tracker to allow it to continue its operation [Papagiannakis et al].

The proposed set of algorithms and methodologies aim to extend the "AR Enabling Technologies" in order to further support real-time, mobile, dramaturgical and behavioured Mixed Reality simulations, as opposed to static annotations or rigid geometrical objects. Fig. 1 depicts fully simulated virtual humans (skin, clothes, face, body) augmenting a cultural heritage site.

This paper is organized as following: in Section 2 the related previous work in the area of MR simulations is presented. Section 3 describes the main architecture, whereas Section 4 the complete methodology for modeling, animation and simulation of virtual actors. Section 5 presents the results on the site of ancient Pompeii and Section 6 our conclusions.

Fig. 1. Example of mixed reality animated characters acting a storytelling drama on the site of ancient Pompeii (view from the mobile AR-life system i-glasses)

2. Previous Work

On AR integrated platforms, a number of projects are currently exploring a variety of applications in different domains such as cultural heritage [Stricker et al], training and maintenance [Wohlgemuth et al] and games [Thomas et al]. Special focus has recently been applied to system design and architecture in order to provide the various AR enabling technologies a framework for proper collaboration and interplay. Azuma 0 describes an extensive bibliography on current state-of-the-art AR systems & frameworks. However, few of these systems take the modern approach that a realistic mixed reality application, rich in AR virtual character experiences, should be based on a complete VR Framework (featuring game-engine like components) with the addition of the "AR enabling Technologies" like a) Real-time Camera Tracking b) AR Displays and interfaces c) Registration and Calibration. Virtual characters were also used in the MR-Project 0 where a complete VR/AR framework for Mixed Reality applications had been created. Apart from the custom tracking/rendering modules a specialized video and see-through HMD has been devised. However, none of the aforementioned AR systems can achieve to date, realistic, complete virtual human simulation in AR featuring skeletal animation, skin deformation, facial-speech and clothes simulation. For realizing the dynamic notions of character based Augmented Heritage, the above features are a prerequisite.

A complete STAR report on recent AR frameworks as well as applications on Cultural Heritage is presented in [Papagiannakis et al 2008].

3. AR System Framework for virtual human simulation

Our AR-Life system is based on the VHD++ [Ponder et al], component-based framework engine developed by VRLAB-EPFL and MIRALab-UNIGE which allows quick prototyping of VR-AR applications featuring integrated real-time virtual character simulation technologies, depicted in. The key innovation is focused in the area of component-based framework that allows the plug-and-play of different heterogeneous human simulation technologies such as: Real-time character rendering in AR (supporting real-virtual occlusions), real-time camera tracking, facial simulation and speech, body animation with skinning, 3D sound, cloth simulation and behavioral scripting of actions.

The integrated to the AR framework tracking component is based on a two-stage approach. Firstly the system uses a recorded sequence of the operating environment in order to train the recognition module. The recognition module contains a database with invariant feature descriptors for the entire scene. The runtime module then recognizes features in scenes by comparing them to entries in its scene database. By combining many of these recognized features it calculates the location of the camera and thus the user position and orientation in the operating environment. The main design principle was to maximize the flexibility while keeping excellent real-time performance. The different components may be grouped into the two following main categories:

- System kernel components responsible for the interactive real-time simulation initialization and execution.
- Interaction components driving external VR devices and providing various GUIs allowing for interactive scenario authoring, triggering and control.

Finally the content to be created and used by the system was specified, which may be classified into the two following main categories: a) Static and b) Dynamic content building blocks such as models of the 3D scenes, virtual humans, objects, animations, behaviors, speech, sounds, python scripts, etc.

4. Real-time Virtual Human Simulation

The addition of historically consistent virtual humans into virtual cultural heritage reconstructions allows a better understanding of the use of the architectural structures present on the site, and permits the creation of more realistic simulations of such ancient spaces with the inclusion of specific ambiences, atmospheres or dramatic elements. Hence, in order to both enhance our simulations with the inclusion of such dimensions, and to allow for a better understanding of the social functions inherently pertaining to the virtually restituted structures, the choice to stage a daily life scenario to be performed at the augmented Termopolium building in Pompeii, has been made. After having gathered all the Cultural and historical information and sources, the preparation of the 3D virtual humans has been carried out according to the specific restrictions inherent to the real time simulation. The following section gives an overview of the different phases that were necessary to complete the modeling and animation of virtual human models that have been implemented into our virtual and augmented reality case study.

In order to succeed a scientifically valid virtual restitution of a given heritage site, one of the most critical aspects of the preliminary data collection phase is the gathering of pertinent and reliable historical sources both concerning the studied edifices and the social aspects structuring the daily life of the people that used to live at such times. Since in archeology related virtual reconstruction projects the amount of available architectural data is often limited, due to the fact that parts of the concerned structures are often now missing, it is therefore necessary to proceed to the formulation of restitution hypothesis in order to constitute a complete restitution of the structural and visual qualities of the sites targeted by the 3D visualization attempts. Consequently, a close collaboration with external advisors providing pertinent expertise, combined with the use of modern 3D visualization tools and technologies as a mean to test, study and validate specific structural hypothesis, is an essential requirement to achieve a coherent representation of the simulated sites. In this section we will briefly introduce some historical data concerning the two sites constituting our case studies and we will present the different sources that were employed as a base for the realization of our VR and AR real time simulations.

Historical and archeological sources

To achieve a convincing virtual representation, one of the most critical aspects of the preliminary data collection phase is the gathering of pertinent and reliable historical sources concerning the social aspects structuring the daily life of the people that used to live at such times. Such elements may range from the identification of specific codified social conducts, rules, or particular dress codes, such as the ones that could be related to their clothing or hairstyling culture and practices (samples shown in Fig. 2), to the creation of virtual models and animated scenarios that correctly represent the daily habits that were typical of the studied site at a given historical period. Hence, a highly interdisciplinary approach has been deployed in order to gather all the significant data required to fully cover the extent of the information necessary to succeed a historically coherent 3D restitution of the virtually inhabited heritage sites targeted by our case studies.

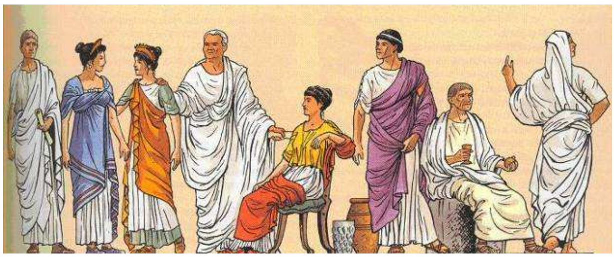

Fig. 2 Roman outfits and hairstyles of the 2nd century

Modelling the virtual humans

In order to create the animated virtual humans, the definition of the 3D meshes and the design of the skin surfaces of their body models have been conducted employing automatic generation methods, using real world measurement data, coupled with manual editing and refining. The main approach that was implemented in our case studies utilizes an in-house system based on examples [Seo et al]. The benefits of such method are threefold: first, the resolutions of the generated models are adapted for real time animation purposes; second, different bodies can be generated easily and rapidly modifying the base parameters of the template models (basic setup presented in Figure 8); third, since the implemented system uses real world data as reference by conforming a template model onto a scanned model, the generated meshes visually provide realistic results. The main assumption underlying such methodology is that any body geometry can be either obtained or approximated by deforming a template model. In order to succeed the necessary fitting process, a number of existing methods, could be used effectively. However, the basic idea that has been adopted in the present case is based on a feature based approach, as presented in [Seo et al], where a set of pre-selected landmarks and feature points is used to measure the fitting accuracy and guide the automatic conformation.

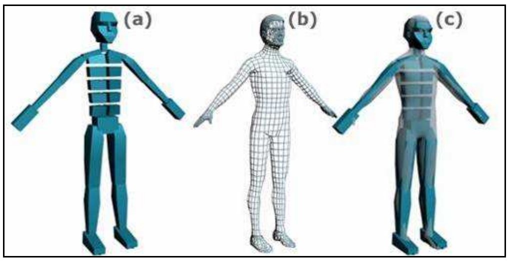

Fig. 3 Skeleton hierarchy (a), template model (b), skinning setup (c).

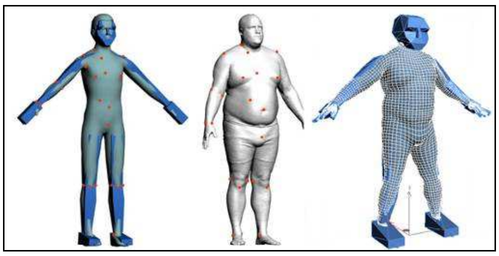

Fig. 4 Skeleton fitting and fine skin refinement

Creation of the 3D garments

To re-create the visual appearance exhibited by ancient clothes, source data such as frescos, mosaics and statues, coupled with written descriptions and complementary historical information concerning the garments, fabrics, colors and accessories has been used as a base to dress the virtual humans (Fig. 5). The virtual garment assembly is executed using an in-house platform that employs general mechanical and collision detection schemes to allow the rapid 3D virtual prototyping of multiple interacting garments [Volino et al].

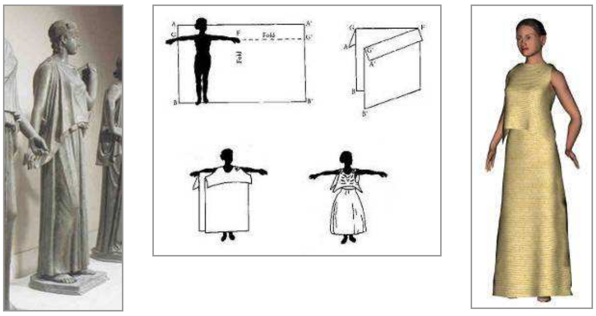

Fig. 5 Virtual Garment based on real ancient dress

Animating the virtual characters

To create the animation files to be applied to the virtual humans, a VICON Optical Motion Capture system based on markers [Egges et al] has been used (Fig. 6). As previously introduced, in order to assist such process, several video references where employed as support for the motion capturing sessions: idigitally recorded video sequences featuring real actors playing the scenarios to be virtually reproduced have been prepared with the assistance of the historical advisors.

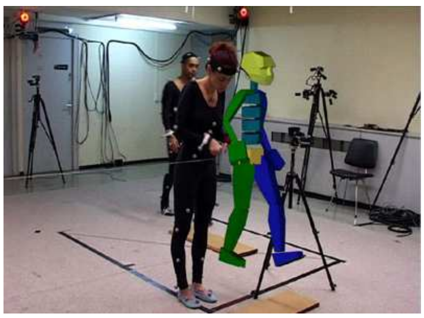

Fig. 6 Optical motion capturing session

After the completion of a post-processing phase, the captured movements that correspond to the various parts of the scenarios to be reenacted have been converted to separate keyframed animations ready to be applied to our H-Anim skeleton hierarchy compliant virtual characters (Fig. 7). Since the final animation resulting from the application of motion captured data generally exhibits a realistic motion behavior but a limited flexibility, in our case studies the different recorded tracks have been connected to each other to produce complex smooth sequences featuring no interruption during their execution. To this end, a specialized blending engine that can blend several different types of motions, including real-time idle motions and key-frame animations [Egges et al], has been implemented as a service into our in-house VR-AR framework [Ponder et al] to control both face and body animation. Consequently, for each virtual human loaded into a given scene, an XML file containing the description of all the actions and animation files that need to be available for playback during the real time simulation, and including the specific configuration of the parameters that drive the blending engine, has been prepared.

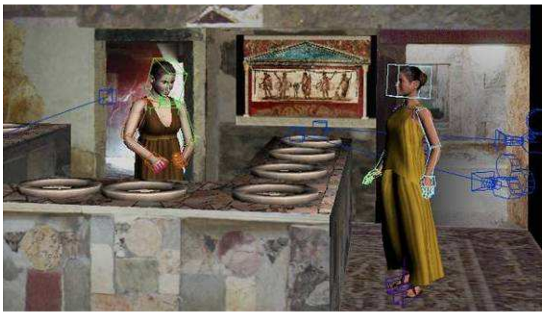

Fig. 7 Motion captured data loaded on top of a Virtual Human 3D model.

Thus, an Animation Property that contains a blending schedule allowing the definition of some specific options, such as whether or not facial and/or body animation should be played or if the translation/orientation of the virtual character should be considered as defined on the global or local coordinate system, has been defined for each 3D virtual human participating in the real time simulation. Finally, the implemented service also includes an integrated player that plays and blends in real time the scheduled animations in a separate thread for all the humans in the scene during the 3D simulation.

5. Results

With the help of the Superintendence of Pompeii [Pompeii], who provided us with all necessary archaeological and historical information, we have selected the 'thermopolium' (tavern) of Vetutius Placidus and we contacted our experiments there. The results are depicted in the following Fig. 8, Fig. 9, Fig. 10 and where the technologies employed for simulating and authoring our virtual humans where already described in [Papagiannakis et al].

Fig. 8. The Real Pompeian 'thermopolium' that was augmented with virtual animated virtual characters. In this figure the scene is set-up for camera tracking preprocessing; consequently the laptop is put in the backpack for the run phase.

Fig. 9. The Mobile AR-Life simulator system(top left). The previously shown laptop is inserted in the backpack for the run phase. The IEEE1394 camera is attached on the i-glasses(top right) and a wireless trackball allows for interaction with the MR application(bottom left). The custom splitter cable(bottom left) allows for the i-glasses light lithium rechargeable battery to power both the HMD and the firewire camera (since in laptops the firewire port does not provide power). Thus true mobility is achieved surpassing existing car battery custom made heavier solutions [5]. More visitors have tried and tested on the site the AR-Life system (bottom right).

Fig. 10 Real-time virtual Pompeian characters in the real site of the Pompeiian thermopolium. Note the use of geometry 'occluders' that allow part of the real scene to occlude part of the virtual human

6. Conclusions

Nowadays, when laymen visit some cultural heritage site, generally, they cannot fully grasp the ancient vibrant life that used to be integrated in the present ancient ruins. This is particularly true with ruins such as the ancient city of Pompeii, where we would like to observe and understand the behaviors and social patterns of living people from ancient Roman times, superimposed in the natural environment of the city. With the extensions to "AR Enabling techonogies" and algorithms that we propose for camera tracking, virtual human simulation and AR illumination model, coupled under a complete real-time framework for character simulation, we aim provide new dramaturgical notions for Mixed Reality. Such notions could extend further research in MR and develop it as an exciting edutainment medium.

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