REAL-TIME RECREATED CEREMONIES IN VR RESTITUTED CULTURAL HERITAGE SITES

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ABSTRACT:

This paper presents the case study of a real-time interactive digital narrative and real-time visualisation of the Namaz Pray of a simulated Ottoman Imam in the 16th century virtually restored mosque of Cucuk Hagia Sophia (previous St. Sergius and Bacchus church) as well as in the Hagia Sophia mosque (previous cathedral of Hagia Sophia), in Istanbul, Turkey. Inspired by a hermeneutical approach, this case study illustrates that the abandonment of traditional concepts of static cultural artefacts with interactive, augmented historical character-based narrative representations, can propel virtual reconstructions of cultural heritage sites to an exciting new edutainment medium. Furthermore, as the cultural tradition is conceived as a reservoir of living forces that can be experienced only if it is freed from the petrifaction exerted during the centuries, a reconstruction and real-time immersive visualisation is presented that captures such 'living forces' by simulating these edifices both as churches (original form) and as mosques, fully respecting the archaeological, historical and architectural premises. Instrumental to that approach is the rapid real-time immersive 3D application prototyping, that it is feasible only due to the adoption a component-based real-time framework for VR character simulation.

1. INTRODUCTION

1.1 Character-based virtual cultural heritage

Virtual Reality and its concept of cyber-real space invoke such interactive digital narratives that promote new patterns of understanding. The word "narrative" refers to a set of events happening during a certain period of time and providing aesthetic, dramaturgical and emotional elements, objects and attitudes [Nandi et al]. Mixing such aesthetic ambiences with virtual augmentations and adding dramatic tension, can develop these narrative patterns into an exciting new edutainment medium. The *abandonment of traditional concepts of static cultural artefacts with interactive, augmented historical character-based event representation* is an important component of this redefinition. For digital narratives realized with Virtual Reality, the conditioned notion of artefact gives away to a far more liberated notion; as suspended in virtual reality space, the visitor leaves the prison of petrified cultural heritage and emerges in a contextualized world of informative intangible sensation. In such a world, "the dream of perfect FORMS becomes the dream of information" [Coyne]. Such a transition is attempted with the real-time ceremonial visualisation in two world acclaimed cultural heritage sites, such as the S.S. Sergius & Bacchus and the Hagia Sophia edifices. In the following sections the Cultural Heritage Hermeneutical motivation is presented following by the previous related work in the virtual heritage field. The real-time character simulation section presents the virtual character simulation technologies, the architectural evolution of the edifices and the real-time VR architecture framework need. Finally, the immersive real-time VR application is described followed by the concluding remarks.

1.2 Virtual cultural heritage hermeneutics

What consequences flow from the premises at the level of such 'Intangible cultural heritage' such as a Namaz Pray of an Ottoman Imam? Hermeneutics teaches us that all meaning is context-dependent and therefore unstable. The resulting conception of culture is thus poetic and creative rather than ethical or epistemological. Thus, such Heideggerian [Heideger] notions invite us to transform and to appropriate creatively the contents of cultural traditions towards a conception of culture as a realm of unstable and indeterminate possibilities waiting for further exploration and new interpretative horizons. *We may actually say that cultural ideal consists basically in an endless process of active and creative interpretations of past productions*. The cultural tradition is conceived as a reservoir of living forces that can be experienced only if we free them from the petrifaction exerted during the centuries. Such living forces are the characters of ancient ceremonies, the associated time-context and specific function of an edifice etc.

Such 'interactive contextualized narratives' and 'hermeneutic experiences' are in fact stirring the fleeting notion of history and time-travel, based on the new emerging cultural fabric of the 21st century. That results in intriguing possibilities for new digital narratives that will pervade the information age raising new issues on cultural heritage representation, space, time, interpretation, interaction, identity and the real.

1.3 Previous Work

The most related character-based VR and virtual cultural heritage applications are summarised in the previous work of Papagiannakis et al as well as Foni et al. The historical and non-real time design & 3D modelling methodologies for both

the current case study edifices and virtual humans are fully covered by Foni et. al.

This paper solely focuses on the real-time immersive visualisation and interactive narratives of the recreated ceremony with real-time virtual characters. Especially as none of the cultural heritage applications covered in Foni et al, is focusing on the ceremonial character-based restitution or provides immersive VR real-time visualisation (3D stereo viewing). The present case study illustrates the adoption in virtual heritage of not only architectural visualisation but also high quality virtual character recreation with face, body, cloth, speech simulation. Furthermore, the Cathedral of Hagia Sophia, one of the largest and most significant cathedrals in the world, has never been fully virtually restored and visualised in real-time before. Ponder et al describes the main architecture, requirements, specification and uses of the VHD++ real-time framework. Finally Ulicny et al presents another application of the same VHD++ framework for virtual heritage dedicated to crowd simulation and rule-based scenarios.

2. REAL-TIME CHARACTER SIMULATION

2.1 Virtual Namaz pray

The detailed scenario of the Morning Namaz Pray during the 16th century restored Hagia Sophia and S. Sergius and Bacchus edifices, was prepared by the [YTU] historians, architects and scientific personnel. Following that was the motion capture process, defined by [Molet et al] utilising the VICON optical motion capture system and a real person re-enacting the Namaz pray thus being recorded digitally. After the needed post-processing the individual movements that correspond to the various parts of the pray are available as separate keyframe animations, ready to be applied to the H-Anim created virtual characters. After the YTU and DTU (Denmark Technical University) teams provided the simulated echoic 3D sound speeches that correspond to the verses of the pray, it was possible to have a database of matched speeches and body animations. Thus the 2 essential parts of the Namaz pray ceremony, were then ready to be applied to the virtual Imam and other characters.

2.2 Virtual Characters

After the modelling of the H-Anim virtual characters (as described in Foni et al) the face processing starts according to the processes and tools described in Kshirsagar et al so that the virtual characters are ready for facial animation and speech simulation. Next step in the pre-processing stage is when the virtual body and clothes are being prepared for animation and deformation, according to the skinning process described in Cordier et.al. Finally the fully body-cloth-face-speech enabled virtual character is exported in the H-Anim format. The following figure illustrates some resulted virtual characters.

Figure 1 Character source images (left) vs. 3D modelled characters (right)

2.3 Evolution of the edifice throughout time

Due to the hermeneutic need to revive the time-dependent context of the restored edifices, the need has arisen for restitution as churches originally and later as been transformed to mosques. However, the Byzantine restitution of the edifices proved of high risk as not sufficient architectural-historical-archaeological data were at hand. Thus it was commonly agreed after discussions with the CAHRISMA project cultural partners, that the Byzantine interior restitution will depict only architectural modifications without image-fresco restorations which were unobtainable in most cases. Thus the simulations resulted as depicted in the Results section.

2.4 Rapid application prototyping using a real-time framework for VAR character simulation

In order to proceed with the rapid development of such demanding high performance interactive immersive VR application, featuring advanced virtual human simulation technologies we adopted the VHD++ real-time framework as described by Ponder et al. (illustrated in the following figure)

Figure 2 Concept of a generic VHD++ runtime engine with components (plug-ins)

VHD++ addresses the most common problems related to the development, extension and integration of heterogeneous simulation technologies under a single system roof while combines both framework (complexity curbing) and component (complexity hiding) based software engineering methodologies. As a result a large scale architecture and code reuse is being achieved which radically increases development efficiency and robustness of the final VR and virtual character application. Figure 2 illustrates a graphical overview of the VHD++ framework. Without the adoption of such a framework it would have been extremely time consuming and technically not guaranteed that we would result in such a VR application featuring all these real-time heterogeneous technologies supported by the necessary processing tools: a) immersive 3D real-time graphics, b) immersive 3D sound, c) VR interaction, d) virtual human animation with skinning, e) real-time cloth simulation, f) facial animation, emotion and speech.

3. RESULTS

The following figures illustrate the results of the adoption of the VHD++ framework for the rapid creation of the immersive VR application prototype. A Christie Mirage 1000 wall projector was used to provide both active and passive stereo projection, as VHD++ supports sequential stereo rendering (viewed with either shutter or polarised glasses). Thus the immersive aspect of the VR simulation was ensured. The final VR application was executed in a PC system, rendering real-time environments ranging from 60k to 400k polygons, 10k-polygons humans with deformable skins, while running on a Win 2000, 2GB RAM, Pentium 1.5GHz, with NVIDIA Quadro 4 980XGL graphics card, yielding 25fps performance.
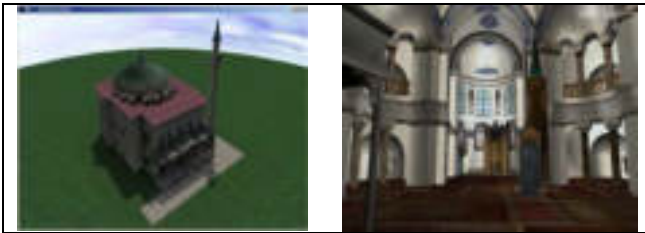

Figure 3 S.Sergius & Bacchus Ottoman Mosque

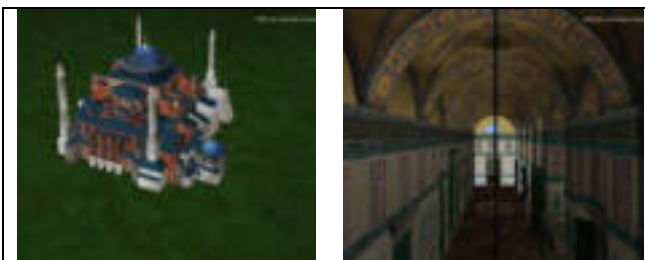**Figure 4 S.Sergius & Bacchus Byzantine Church**

Figure 5 Hagia Sophia Ottoman Mosque

Figure 6 Hagia Sophia Byzantine Church

Figure 7 S.Sergius & Bacchus Mosque with real-time virtual Imam in recreated Namaz Pray

Figure 8 S.Sergius & Bacchus Mosque with a group of virtual characters

4. CONCLUSIONS

We are living in a world in which the arts, sciences and technology are becoming inextricably integrated strands in a new emerging cultural fabric [Coyne]. Our knowledge of ourselves expands with the advent of new technologies that provide new tools for both communication and expression as well as a social context for daily experiences. Culture is in its broader sense a 'product' of our everyday life and experiences [Salzburg Research]. The actual records of culture are constituted from performances to artefacts that have been created in a persistent manner but inevitable decay. That is depicted in the notion of cultural heritage where it consists of what is called "Tangible Heritage" such as buildings, artefacts and media as well as the "Intangible Heritage" containing art expressions (music, dance, literature etc.), languages, folklore etc. Michael Chrichton in his novel Timeline [Chrichton] gives an example of a social context of the future where time travel to the past can be a unique mean of actually feeling experiences characterised by both pathos[1] and ethos[2], integral connotations of the term cultural heritage.

Virtual restitution of highly complex heritage sites requires accurate choices for each phase of the modelling, texturing or lighting processes and special attention must be used when the

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[1] **Pathos**: 1. that quality in speech, writing, music, or artistic representation (or in events, circumstances, persons, etc.), which excites a feeling of pity or sadness… 2. In reference to art, esp. ancient Greek art: The quality of the transient or emotional, as opposed to the permanent or ideal. Source: Oxford English Dictionary

[2] **Ethos**: 1. the characteristic spirit, prevalent tone of sentiment, of a people or community; the 'genius' of an institution or system. 2. In reference to ancient æsthetic criticism and rhetoric. Aristotle's statement that Polygnotus excelled all other painters in the representation of 'ethos' app. meant simply that his pictures expressed 'character'; but as Aristotle elsewhere says that this painter portrayed men as nobler than they really are, some modern writers have taken ethos to mean 'ideal excellence.'… Source: Oxford English Dictionary

models have to be prepared for real-time platforms. Furthermore precise and reliable source data is critical for a scientifically correct and accurate restitution. Interpretative and comparative issues are also necessary when the restitution is targeting lost architectural elements of the heritage site.

The present paper is a continuation and real-time finalisation of the work that we started as described in Foni et al. Thus hereby we conclude the steps of the real-time virtual realistic inhabited restitution of S. Sergius & Bacchus and Hagia Sophia in Istanbul, both as Byzantine cathedrals and Islamic mosques. The common problems, pitfalls from the modelling and pre-processing stages (Foni et al) and real-time solutions and specific choices are analyzed and explained in order to establish a complete real-time methodology of bringing large, complex and endangered edifices to life and simulating historical characters as well as their architectural evolution. It has to be noted, that Hagia Sophia was proved to be a very challenging edifice to reconstruct, due to its immense complexity, size and detail. Of course complex edifices of that scale are never fully and finally reconstructed due to their immense detail (e.g. lamps etc.) and with the current efforts we tried to encapsulate as much as possible in the given project time.

Finally the use of new immersive VR technologies, in conjunction and with the essential support of traditional sources and materials, has been presented here in order to describe a complete methodology for the restoration and renovation process of ancient monuments.

Hence with the utilization of the mentioned methodology for the situations where architectural restoration and protection are not available, virtual restoration and conservation is exhibited. Such virtual heritage simulations are a fundamental aspect for the full understanding of the historical and social development of vast communities and form a 'virtual material witness' of the process of civilization.

5. REFERENCES

Chrichton, M., Timeline, Alfred A. Knoph, New York, 1999.

Coyne, R., Technoromanticism, digital narrative, holism and the romance of the real, The MIT Press, Cambridge, Mass. 1999, pp. viii)

Foni, A., Papagiannakis, G., Magnenat-Thalmann, N., "Virtual Hagia Sophia: Restitution, Visualization and Virtual Life Simulation", UNESCO World Heritage Congress, October 2002

Heidegger, M., Sein und Zeit, Max Niemeyer Verlag, Tübingen, 1993, p. 38 (translated according to the English translation of J. Macquarrie and E. Robinson; Blackwell, 1962).

Kshirsagar, S., Garchery, S., Magnenat-Thalmann, N., Feature Point Based Mesh deformation Applied to MPEG-4 Facial Animation, Proceedings Deform'2000; Geneva, Switzerland, Nov. 29-20, Workshop on Virtual Humans by IFIP Working Group 5.10 (Computer Graphics and Virtual Worlds) published by Kluwer Academic Publishers, pp 23-34., November, 2000
Cordier, F., Magnenat-Thalmann N., Real-time Animation of Dressed Virtual Humans, Eurographics Conference Proceedings, Blackwell Publishers, July, 2002

Molet, T., Boulic, R., Thalmann, D., A Real-Time Anatomical Converter for Human Motion Capture, 7th EUROGRAPHICS Int. Workshop on Computer Animation and Simulation'96, Poitier, France, G. Hegron and R. Boulic eds., ISBN 3-211-828-850, Springer-Verlag Wien, pp 79-94., 1996

Nandi A., Marichal X., Transfiction, proceedings of Virtual Reality International Conference, Laval May 2000.

Papagiannakis, G., L'Hoste, G., Foni, A., Magnenat-Thalmann, N., "Real-Time Photo Realistic Simulation of Complex Heritage Edifices ", Proceedings of VSMM2001 (Virtual Systems and Multimedia), San Francisco - USA, October 2001

Ponder, M., Papagiannakis, G., Molet, T., Magnenat Thalmann, N., Thalmann, D., VHD++ Development Framework: Towards Extendible, Component Based VR/AR Simulation Engine Featuring Advanced Virtual Character Technologies, IEEE Computer Society Press, Proceedings of Computer Graphics International (CGI), 2003 (to appear)

Salzburg Research Forschungsgesellschaft m.b.H, Technological Landscapes for Tomorrow's Cultural Economy (DIGICULT):Definitions-trends-hypotheses, http://www.salzburgresearch.at, working paper presented on 04/04/2001

Ulicny, B., Thalmann, D., Crowd simulation for virtual heritage, Proc. First International Workshop on 3D Virtual Heritage, Geneva, pp.28-32, 2002.

YTU Project team, CAHRISMA, Project No:ICA3-CT-1999-00007, Internal Project Consortium document: Detailed scenarion on Namaz Pray, Yildiz Technical University, February 2003.

6. ACKNOWLEDGEMENTS

7. APPENDIX

The Following Figures illustrate further examples of the Hagia Sophia fully real-time VR reconstructed edifice (as a 16th century mosque), which constitutes the only known, published effort of this kind and scale, for the selected cultural heritage site (added in 1996 in the annual list of endangered monuments by the World Monuments Watch).