MAP-i PhD proposal 2010-2011

Real-time Auralisation and audio-visual Synchronisation for Virtual Reality applications

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Research context

The importance of Virtual Reality (VR) has grown rapidly in recent years, with an ever-increasing range of applications in the most diverse areas. Most of the effort in the design and development of VR systems has been directed at providing visual immersion. The development of increasingly convincing models demands that other senses also be considered, especially hearing – we are still very much in the 'silent era' of VR.

This proposal stems from a line of research initiated four years ago in IEETA which aims precisely at integrating visual and aural immersion in Virtual and Augmented Reality environments. Systems based on VR glasses (figure 1), orientation sensors (figure 2), accelerometers and headphones have been used. One of the most important outcomes so far has been the auralisation software package developed in the MSc project 'Virtual Hall' [1], which allows the generation of 3D spatial sound taking into account the position of the virtual sound source, the acoustic characteristics of the virtual room and the listener's head orientation, tracked in real time.

Figura 1 - HMD i-glasses *SVGA Pro*

Figura 2 - Sensor de orientação *Intertrax*

To further explore this line of research, a collaboration link has been established with UM. Their Visualisation and Perception Lab (LVP) is equipped with one of the most sophisticated CAVE[1]-like systems in the country, featuring a 2.2m x 9.6m continuous projection screen formed by 3 flexible configuration panels (0, 90 or 135º) and three DLP (*Digital Light Processing*) projectors. It will be possible to walk in the virtual environment, with the help of a *treadmill* that can be synchronised with the visual scene. The system is also equipped with user *tracking* devices using inertial and optical (infra-red) technologies.

The LVP VR system has been used chiefly in Psychophysics research work and is now being equipped to include the audio component. In the experiments on human motion perception currently underway, using avatars, it is crucial to ensure not only accurate spatialisation of the auditory stimuli (so that they seem to originate from the intended point) but also synchronisation with the virtual visual stimuli (e. g. avatar steps). Appropriate instrumentation is being installed to control this synchronisation. The aim is to avoid audio and video chain intrinsic latencies (and their possible variability) affecting it and so jeopardising the experimental results.

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[1] *CAVE Automatic Virtual Environment*

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This Aveiro-Minho collaboration has just received a significant boost with the approval by FCT of the joint project '*AcousticAVE - Auralisation Models and Applications in Virtual Reality Environments*' (PTDC/EEA-ELC/112137/2009, with 106223€ funding). The University of York (*AudioLab* – http://www.elec.york.ac.uk/research/audio.html) is also involved in this project, due to start in May 2011.

Objectives

The following list summarises some of the main objectives:

- In-depth, systematic review of the 'state-of-the-art' regarding VR environments integrating audio (aural immersion).

- Detailed study of the audio-video synchronisation issue, in order to work out (through computation and/or experimental measurement) the latencies of the audio and video chains and their variability in different platforms (particularly those used in IEETA and LVP) under different conditions. It is particularly important to investigate the impact of processing user-tracking data in real time.

- Compared study, particularly under the audio-video synchronisation perspective, of the 3D audio reproduction alternatives, namely:
    - *Binaural* – based on HRTF processing and earphones.
    - Through *soundfield synthesis* – based on a loudspeaker array.

- Development of a complete auralisation package, based as much as possible on the 2006/07 and 2007/08 project 'Virtual Hall' [1]. Among others, the following evolutions are envisaged:
    - Integration of efficient artificial reverberation algorithms;
    - GPU parallelisation of the (geometric) acoustic model of the virtual room;
    - Porting to the LVP CAVE-like platform.

- Validation of the developed auralisation system through tests, both objective (performance in terms of latencies and their variability; synchronisation between the audio and video VR scenes) and subjective (usability).

- Demonstration of practical applicability through selected case-studies, preferably involving:
    - Research on human motion perception (Psychophysics).
    - Heritage interpretation and promotion (virtual tours to monuments and/or protected sites [2]).

References

[1] Casaleiro R., Seco R., Campos G., Dias P, Sousa Santos B. (2007) 'Sala de Espectáculos Virtual: Articulação em Tempo Real dos Ambientes Visual e Acústico' (*Actas do 15º **Encontro Português de Computação Gráfica***, Porto Salvo, Outubro 15-17, pp. 51-57).

[2] Dias, P., Campos, G., Casaleiro, R., Seco, R., Santos, V., Santos, B. S. (2008) '3D Reconstruction and Auralization of the "Painted Dolmen" of Antelas'. *Proceedings of the Electronic Imaging 2008 Conference (**EI'2008**), SPIE Vol. 6805, 6805OY, Three-Dimensional Image Capture and Applications 2008,* San Jose, California, USA, January 28-29.