

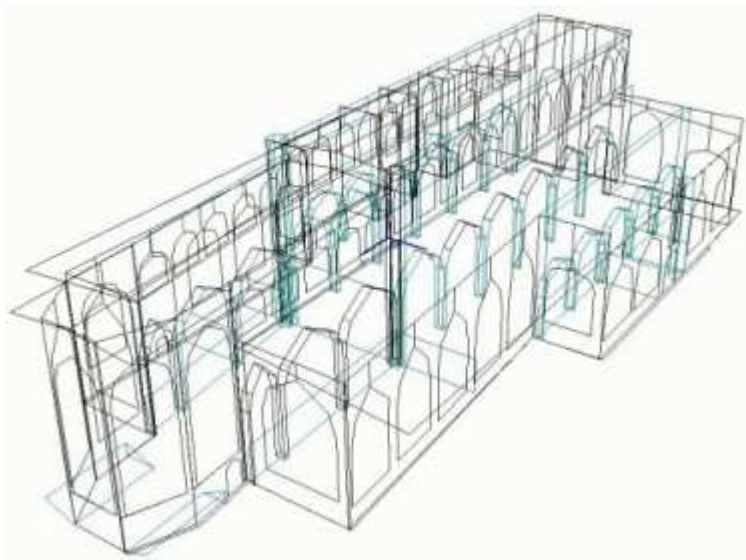
Virtual Audio and Past Environments

Audio and Acoustics in Heritage Applications

Monday 17th March, National Centre for Early Music, York

Final Report

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Introduction:

This report is a summary of the workshop event held on Monday 17th March at the National Centre for Early Music, York, focusing on audio and acoustics in past environments and heritage applications. An audience of 40 delegates listened to and discussed a wide variety of presentations given by 11 invited speakers already working in this area. These speakers were from diverse backgrounds across the spectrum of arts, humanities, science and engineering research, with specific areas including musicology, archaeology, architecture, acoustics, audio engineering, speech and singing. Industry input was directed by one of our speakers from Sony Computer Entertainment Europe and wider European interests in this area were represented by our international guest speaker from the University of Aveiro, Portugal. The audience for the event also reflected the diverse multi-disciplinary programme for the day, and included representatives from English Heritage, AHRC as well as many interested students working in the area. The main programme of presentations was followed in the evening by a 'Sound Tour' around a number of heritage sites in York where a wide-ranging programme of contemporary and traditional audio/musical works had been curated specially for this event.

This event was inspired by Dr Murphy's attendance at the AHRC ICT Methods Network seminar on Theoretical Approaches to Virtual Representations of Past Environments in February 2007. There was much interesting and relevant work presented here on the role of virtual reality, graphics and interactive environments in historical and archaeological research. Audio however was very under-represented although generated significant interest at the time. As a result and with encouragement from colleagues at the Methods Network, plans for the virtual audio and past environments event were developed.

Acknowledgements:

This event has been supported by the AHRC ICT Methods Network, EPSRC, and the EPSRC funded Spatial Audio Creative Engineering Network (SpACE-Net). We also thank the National Centre for Early Music, Ebor Singers, and Sightsonic – York's annual international festival of digital arts, for their additional support.

Background:

Virtual interactive environments, especially in online gaming and similar applications, are now a highly popular sector in the entertainment industry, offering high quality graphical rendering of virtual worlds, user interaction and immersion. Such graphical virtualization techniques have for some time been used in the fields of archaeology, history, and heritage as a means to better understand, interact and experience past environments. However the aspects of sound design and audio processing that work alongside these applications and development platforms are usually perfunctory at best and make little use of recent related creative and technological developments. Most people would also agree that good and considered use of high quality sound design can work with the imagination to evoke powerful images or memories, or provide important auditory cues to the nature of events in the virtual environment, either in support of or parallel to the visual stimulus. As a particular example, such techniques have long been used in film sound design and are now accepted as commonplace.

Additionally, architectural acoustic modelling and measurement techniques have more recently moved from purely lab-based research and analysis to include real-time walk through virtual environments - as used, for instance in building design work - and the study of heritage sites. Of particular note in the latter case is the European CAHRISMA project (Conservation of the Acoustical Heritage by the Revival and Identification of the Sinan's Mosques Acoustics – now finished). The main goal of this project was to introduce and develop the concept of "Hybrid Architectural Heritage" covering acoustic as well as more accepted visual features.

The aim of this workshop was therefore to explore multi-disciplinary approaches to audio, acoustics, and sound design, and identify how techniques and current research are being (or might be) applied to heritage and related applications. The original intention was for the workshop to

focus specifically on virtual acoustic environments, both techniques and applications. However it was clear from early on in our planning that there were other music/audio/acoustics researchers working in the wider context of heritage and past environments that were keen to contribute and hence the original scope was expanded to provide a wider forum for learning and discussion.

Overview of themes and research areas:

1. Virtual Acoustics and acoustic modelling:

This first session, lasting for the whole morning, concerned the development, use and application of acoustic modelling techniques in a variety of heritage applications. This research is related to what is known as 'Auralization', which is formally defined as, "the rendering audible, by physical or mathematical modelling, the sound field of a source in a space, in such a way as to simulate the binaural listening experience at a given position in the modelled space"¹. Auralization can therefore be considered as making the listener perceive a sound event within a sound environment as realistically as possible (compare with the term 'visualization' from which it is originally derived).

Dr Gui Campos (University of Aveiro, Portugal) presented "Acoustic Modelling and 3D Virtual Reconstruction of a Neolithic site", discussing different mathematical modelling strategies that could be used to auralize a particular environment and why Neolithic chambered tombs were appropriate for further study. His argument was focused on two specific reasons: (i) the construction and small volumes of these sites made them excellent test cases for new acoustic modelling methods that otherwise demonstrate prohibitively long rendering times when applied to large spaces; (ii) in Portugal, many of these sites are off limits to the general public or are unknown about, hence there is a very clear need to develop new means of education, promotion and interaction with these important sites.

Charlotte Downing, Peter Rutherford (presenting) and Robin Wilson (School of the Built Environment, University of Nottingham) developed these ideas further in their paper, "Virtual acoustic reconstruction and the role of auditory and visual cues for enabling musical performance". In particular they stressed the role of content design for such acoustic models and auralization applications – what sound sources should be heard in these virtual spaces and why? The results of a study relating to musical performance in virtual spaces were summarised, highlighting the importance of multi-modal perception and the use of visual cues with auditory stimulus.

Professor Jian Kang presented "Virtual audio in heritage performance spaces" on behalf of himself and **Dr. Kalliopi Chourmouziadou (School of Architecture, University of Sheffield)**. This paper explored the acoustics of Greek/Roman and Chinese theatres with a focus on some of the special features of these outdoor performance spaces, including diffraction/diffusion effects from seating areas, and the importance of the stage area in terms of what the audience will hear. The results demonstrated an interesting development in the acoustics of these spaces alongside the construction trends evidenced over the history of their use. Professor Kang also highlighted the importance of acoustics, construction and the performance tradition of the spaces involved, citing a recent redevelopment of a Chinese theatre designed by western architects/acousticians as an example of perhaps what should not be done.

Dr Damian Murphy (AudioLab, University of York) closed this session with his work, "Archaeological acoustic space measurement for convolution reverberation and auralization applications". This summarised recent acoustic measurement and rendering techniques in the context of a survey of historical sites (including one Neolithic passage tomb). Although the main focus of this work was in the creative use of the obtained results, Dr Murphy was also interested in how the large data-sets gathered might be used to reveal information as to how a space was constructed, designed or used, and a number of examples were presented. He also discussed the importance and implications of gathering and working with such a large data-set. One of the

¹ M. Kleiner, B.-I. Dalenbäck, and P. Svensson, "Auralization - An Overview", *J. Audio Eng. Soc.*, 41(11), Nov. 1993, pp.861-875.

creative outcomes from this work that makes use of the auralization of acoustic measurements gathered from York Minster was also later presented as part of the Sound Tour.

There was plenty of opportunity over lunch for networking and a virtual presentation was played on behalf of **David Knight and Gianna Giannakopoulou (University of Southampton)** who were not able to attend at the last minute, entitled, "Opening the ears and eyes of Archaeology".

2. Performance and Acoustic Space:

The discussion of performance in virtual acoustics continued in the first afternoon session. **Jude Brereton (presenting) and David Howard (AudioLab, University of York)**, presented, "The voice, singing and performance in acoustic space", and showed results that examined specific features of the singing voice in a performance space and an anechoic (no acoustic) environment, demonstrating that a singer must work "harder" in an environment that gives no acoustic feedback. The importance of such effects and related cross-modal perception when performing in a more traditional "heritage space" as might be employed when developing virtual acoustic applications was highlighted, linking nicely with Peter Rutherford's morning presentation.

Dr Anthony Masinton (Department of Archaeology, University of York), returned to the theme of acoustic modelling, but from a very different perspective in, "The acoustics of past spaces: Understanding sound in ecclesiastic heritage". The question being considered in this work is, "How much was the development of church space affected by acoustic considerations, and what was the affect of architectural development on the experience of Mass?" The author admits that this is a challenging question to address demanding that not only must the acoustic properties of the ecclesiastic space as it currently exists be measured and understood, but also that the acoustics of the space throughout its past history should also be known. This understanding must also be set within the context of the historical soundscape specific to that space in the past as well. A case study at the parish church of St Patrick, Patrington, East Yorkshire, was presented and a multi-disciplinary approach has been taken to understanding the role of acoustics in the development of the space between the end of the thirteenth century and the beginning of the fifteenth. Dr Masinton concluded that the development of the building is driven by acoustic considerations as much as visual or structural needs and that an acoustic architectural history of the church develops a richer understanding of sound in ecclesiastic heritage.

3. Audio tools and development environments:

The second afternoon session moves away from the specifics of working with virtual acoustic spaces onto tools and techniques that might be employed for attempting this type of work. **Dr Michael Kelly (Sony Computer Entertainment Europe)** presented "Building interactive audio environments using game audio tools". This was an industry perspective presentation for a general audience designed to give an insight into audio for games to those less familiar with the field. An overview of the game audio process was covered, together with the unprecedented levels of technology, performance and software tools now available for developing interactive 3D virtual environments with high quality graphics *and* audio. The aim was to demonstrate how some of these ideas might be applied in other specific contexts more familiar to the individual audience members. For instance Dr Masinton who presented in the last session has already been exploring how his modelling work might transfer to a game development platform to help future-proof the data set being worked with and allow interactive elements to be introduced.

Dr Jez Wells (AudioLab, University of York) continued this session with the presentation, "Audio heritage - tools and techniques for the renovation of historically significant recordings". This was the first of our more general presentations on the role of audio in heritage. The argument here is that just as musical works offer an insight into the cultural, intellectual and aesthetic worldview of their composers, their capture and existence as audio recordings offers a similar insight into the worldview of their performers. Many recordings of historical significance are captured and stored using equipment and materials that are primitive by modern standards leading to signal degradations that can obscure the performances they convey and the audio heritage they represent. Techniques for renovation of these works are explored, in the context of one particular

case study, that of Michael Howard conducting the Renaissance Singers and the choir of Ely Cathedral, being an important example of the British post-war early music movement.

4. Sound and Music in Heritage Applications:

The final session of the day continued with the presentation of more general work in this area. **Elizabeth Blake and Dr Ian Cross (Department of Archaeology/Centre for Music and Science, University of Cambridge)** co-presented, "Sound and music in prehistoric context", stating that archaeological contexts and artefacts pose specific and unique problems for understanding musical sound that cannot always be considered or measured using contemporary western methods or philosophies. The importance of a multi-disciplinary approach was again stressed as was the characterisation of the broad acoustical environment applicable to the time. An example of such an approach was presented, investigating the use of Upper Palaeolithic flint 'tools' for sound production, which included some actual examples and demonstrations.

Dr Kenneth McAlpine (Computing & Creative Technologies, University of Abertay, Dundee) then presented his paper, "Sampling the past: how technology can open access to musical instrument collections". This work explored the case for delivering cultural access to historic musical instruments in playable condition that are otherwise too old, fragile, or unstable, or that require frequent and costly maintenance, using digital technology. The use of technology to deliver virtual alternatives was discussed with the additional benefits this brings, for instance in terms of tuning stability, over the primary desire to facilitate better access and interaction for the general public. This work was discussed in the context of a specific case study involving the creation of a fully-playable digital model of a Kirkman harpsichord from 1776, now part of a collection held at Hospitalfield House in Arbroath.

The final session of the day was presented by **Professor Mark Edmonds (Department of Archaeology, University of York)**, entitled, "First light: An archaeology of Jodrell Bank". This is an on ongoing project at the radio telescope at Jodrell Bank, Cheshire, and has taken a number of forms, designed to explore the changing significance of the monument over time, from the immediate post-war period to the present day. The presentation particularly focused on the particular problems and potentials associated with creating an archaeology of a place whose history and significance is bound up with sound.

5. Evening Session: Sound Tour

One of the most novel aspects of this workshop was the sound tour, curated by the organizers to highlight the use of sound and music in a number of heritage sites around the City of York. Many people had mentioned when registering how much they were looking forward to this aspect of the day, and about 20 delegates returned to the National Centre for Early Music at 7pm for the first stop on the tour.

The first piece was **Croisda Liom A Cadal** from Dusk Songs, composed by Kerry Andrew and performed by the Ebor Singers. The piece makes use of spatial location and perception as the choir move around and through the audience. The National Centre is a highly specified and acoustically treated performance venue for all forms of music despite being situated in a renovated church more traditionally used for ecclesiastical music performance, providing an interesting and 'acoustically optimal' setting for the work.

From here we moved to 14th Century Bedern Hall to hear the contemporary sound/light installation **A Sense of Place [Revisited III] by Damian Murphy, Mark Hildred and John Oxley**. This work explores aspects of the history of York through the use of sound and narrative and the link between key sites within the City – one of which being the area of Bedern itself. The composition and subsequent presentation uses a virtual acoustic recreation of York Minster through which all the sounds of the piece are heard.

The third stop on the tour was at Number 3 Blake Street, dating from the 16th Century, where Angie Atmadjaja presented **States of Being .1**, the first of two sound paintings and a site dependent

audio installation. This work is inspired by Bridget Riley's work and explores minimal sound, audio perception and sound movement in a series of quiet, minimal audio pieces.

The fourth stop was the Quire in York Minster for the service of **Compline**. In the course of the service the Ebor Singers sang an introit at the crossing of the Minster - *Amicus Meus - Victoria*, an anthem in the Quire - *O vos omnes - Victoria*, and a second anthem at the end of the service in the Lady Chapel *Trahe me post te - Guerrero*, exploring the spatial properties of this magnificent acoustic environment as the crossing and Lady Chapel are exterior to and at different locations from the Quire itself.

Finally, in the Chapter House of the Minster the Ebor Singers again performed **Croisda Liom A Cadal** – but this time in the acoustic environment for which it was actually composed, providing an interesting contrast to the “ideal” performance venue it was performed in at the start of the tour.

The sound tour was cited by at least one of our delegates as, “evening performances that were both stimulating and as diverse in nature as one could imagine”.

Summary and Conclusions

Informal feedback for the day has been highly positive, and certainly from an organisational point of view we are very pleased with the event as a whole. We had thought that we would be ‘speaking to ourselves’ on the day – that is, attendees would be formed mainly from our invited speakers, being audio researchers who have an interest in applying their work in this novel area. However, we far exceeded the numbers of delegates that we expected (we were expecting 20 people). As is clearly evident in the overview given above, the input to the day both in terms of presentations and attendance was far more diverse and multi-disciplinary as a result. The implication therefore being an event with a remit that was much broader in scope and also richer in depth and content. Some common themes have emerged from the day and these include:

- Audio has a significant role to play in many aspects of understanding and interacting with past environments from the most ancient (Upper Palaeolithic flint 'tools') to the most modern (Jodrell Bank).
- Audio processing software and hardware options can now deliver interactive auditory environments of previously unprecedented levels of quality and immersion.
- There are still issues in terms of the use of acoustic modelling techniques – what are the most appropriate or valid algorithms and what can we learn from the results that are presented?
- With even the best models in place, consideration must be made in terms of the performance, presentation and context of audio material placed within the virtual environment.
- Multi-model perception is key for effective interaction and immersion.
- Successful work in this area demands a multi-disciplinary approach that moves beyond individual programmes or discipline specific areas of research.

Additionally from this workshop it is clear that there is a significant interest in this area amongst researchers in the UK, and the heritage of the UK itself provides an ideal basis for moving this work forward. We hope that this event will help to foster a community that will be able to move to meet the demands of audio focused heritage research. This event has also become very timely given that on the 5th March 2008, the EPSRC/AHRC Science and Heritage Programme have announced a future call for networks and clusters to be finalised and announced later in 2008. I now believe that our growing community will be encouraged and ready to address this call when finally announced such that we can provide a stronger platform for this work both in the UK and internationally. Finally, a permanent record of this event, including delegates, programme, and abstracts will be maintained at the following website:

http://www-users.york.ac.uk/~dtm3/acoustics_heritage.html

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dtm; jb, March 2008.