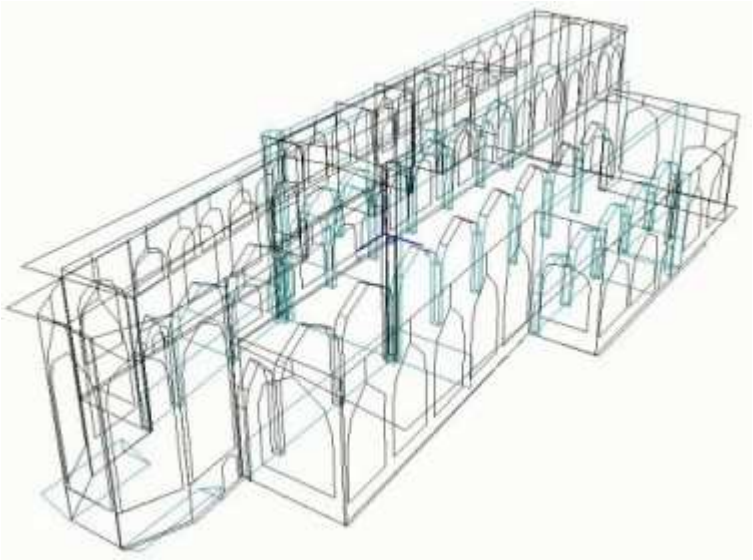
Virtual Audio and Past Environments

Audio and Acoustics in Heritage Applications

Monday 17th March
National Centre for Early Music
York



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Welcome

With support from the AHRC Methods Network and SpACE-Net:

Virtual Audio and Past Environments: Audio and Acoustics in Heritage Applications

National Centre for Early Music
http://www.ncem.co.uk/

Monday 17th March 2008

Virtual interactive environments, especially in online gaming and similar applications, are now a highly popular sector in the entertainment industry, and offer high quality graphical rendering of virtual worlds and user interaction and immersion. Such graphical virtualization techniques have long been used in the fields of archaeology, history, and heritage as a means to better understand, interact and experience past environments. However despite significant advances in desktop computer processing and associated graphics rendering, sound design and audio processing techniques are usually perfunctory at best in such applications and make little use of recent similar creative and technological developments in the field of acoustics and audio processing. 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, by Arup Acoustics in their 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.

This workshop aims to explore multi-disciplinary approaches to audio, acoustics, and sound design, and how techniques and current research might be applied to heritage and related applications. The day will consist of a series of presentations and discussion, leading to a unique evening programme of artistic events at a number of sites across York City Centre.

Schedule

10 am **Arrival and Coffee/Tea**

Virtual Acoustics and acoustic modelling:

10.15 am **Dr Gui Campos.**
University of Aveiro, Portugal:
Acoustic Modelling and 3D Virtual Reconstruction of a Neolithic site.

10.45 am **Charlotte Downing, Peter Rutherford and Robin Wilson.**
School of the Built Environment, University of Nottingham:
Virtual acoustic reconstruction and the role of auditory and visual cues for enabling musical performance.

11.15 am **Coffee**

11.30 am **Professor Jian Kang and Dr. Kalliopi Chourmouziadou.**
School of Architecture, University of Sheffield:
Virtual audio in heritage performance spaces.

12.00 noon **Dr Damian Murphy.**
AudioLab, University of York:
Archaeological acoustic space measurement for convolution reverberation and auralization applications.

12.30 pm **Lunch**

Powerpoint presentation showing:
David J Knight and Gianna Giannakopoulou.
University of Southampton
Opening the ears and eyes of Archaeology

Performance and Acoustic Space:

1.15 pm **Jude Brereton and David Howard.**
AudioLab, University of York:
The voice, singing and performance in acoustic space.

1.45 pm **Dr Anthony Masinton.**
Department of Archaeology, University of York:
The acoustics of past spaces: Understanding sound in ecclesiastic heritage.

Audio tools and development environments:

2.15 pm **Dr Michael Kelly.**
Sony Computer Entertainment Europe:
Building interactive audio environments using game audio tools.

2.45 pm **Dr Jez Wells.**
AudioLab, University of York:

Audio heritage - Tools and techniques for the renovation of historically significant recordings.

3.15 pm **Coffee/Tea:**

Sound and Music in Heritage Applications:

3.30 pm **Elizabeth Blake and Dr Ian Cross.**
Department of Archaeology/Centre for Music and Science, University of Cambridge:
Sound and music in prehistoric context

4.00 pm **Dr Kenneth McAlpine.**
Computing & Creative Technologies, University of Abertay, Dundee.
Sampling the past: how technology can open access to musical instrument collections.

4.30 pm **Professor Mark Edmonds.**
Department of Archaeology, University of York:
First light: An archaeology of Jodrell Bank

5.00 pm **End**

To Hotels, restaurants, the pub etc.

7.00pm SOUND TOUR – see separate info sheet

Reconvene at the National Centre for Early Music

Abstracts

Acoustic Modelling and 3D Virtual Reconstruction of a Neolithic site.

Paulo Dias, Guilherme Campos, Vítor Santos, Ricardo Casaleiro, Ricardo Seco, Beatriz S. Santos

University of Aveiro, Portugal

The importance of Virtual Reality (VR) systems has grown rapidly in recent years, with an ever-increasing range of applications in the most diverse areas. The conservation and promotion of archaeological heritage may greatly benefit from their use.

VR research has tended to focus mainly on vision, the predominant sense in human perception. However, the creation of increasingly convincing VR models demands that other senses, especially hearing, also be considered. Our research is directed precisely at combining visual and acoustic immersion: making the user see and hear as if she was really there. This requires not only recording the visual and acoustic properties of the real-world environment and integrating them into the 3D virtual model but also tracking user movements and updating the audiovisual scene accordingly in real-time.

The Painted Dolmen (Anta Pintada) of Antelas, in Oliveira de Frades, listed as Portuguese national monument, was deemed an excellent case-study for this work. Among the numerous Neolithic sites of the Vouga basin, this passage grave stands out for the unique paintings found in its interior. Extremely fragile (a considerable part was irremediably lost through exposure to light in early archaeological campaigns), they require strict conservation measures, including restricted visitor access.

The problem of reconciling heritage conservation with the need to provide public access is by no means exclusive of this site. In some cases, such as Lascaux (France) and Newgrange (Ireland), site replicas were built. The development of VR models may provide an alternative solution. The heritage conservation authorities responsible for the Anta Pintada are keen on this idea, which may also offer advantages in terms of promotion (especially through the Internet) and museological presentation of the site.

Additional motivation for studying the Anta Pintada and including the audio dimension in its virtual reconstruction came from the growing interest in Acoustic Archaeology. Intriguing acoustic properties have been found in many ancient man-made structures; there is a suggestion that those properties might have been deliberately engineered. The suggestion is particularly strong for Neolithic passage-graves such as this one.

The geometry of the chamber was recorded in situ using a 3D laser scanner. A number of scans were taken at different positions to minimise occlusions. Reconstruction software was developed to combine them into a complete 3D visual model. The final result was an iso-surface approximating the interior shape of the chamber. Each polygon of this surface was assigned the acoustic absorption coefficient of the corresponding boundary material. The 3D audiovisual model was then developed for a VR environment comprising head-mounted display (HMD) I-glasses SVGAPro, an orientation sensor (tracker) InterTrax 2 with three degrees of freedom and stereo headphones.

The auralisation software is based on the image-source method. This is a first approach, since geometric models have well-known limitations in rooms with irregular surfaces. The immediate advantage lies in their inherent computational efficiency, which allows real-time operation. The program computes the early reflections forming the initial part of the chamber's impulse response (IR), which carry the most significant cues for source localisation. These reflections are processed through Head Related Transfer Functions (HRTF) updated in real-time according to the orientation of the user's head, so that sound

waves appear to come from the correct location in space, in agreement with the visual scene. The reverberation tail of the IR is generated by an algorithm designed to match the reverberation time of the chamber, calculated from the actual acoustic absorption coefficients of its surfaces. The sound output to the headphones is obtained by convolving the IR with anechoic recordings of the virtual audio source.

Acknowledgements
The authors express their gratitude to the City Council of Oliveira de Frades, for granting them access to the Anta Pintada, and paricularly Filipe Soares (City Council / Municipal Museum) for his kind collaboration.

Virtual acoustic reconstruction and the role of auditory and visual cues for enabling musical performance.

Charlotte Downing, Peter Rutherford and Robin Wilson.

School of the Built Environment, University of Nottingham:

Cultural heritage represents an area of intense pubic interest and supports a major industry that services both national and international tourism. While much of this activity centres on national monuments that may be experienced in something approximating their original state, many visitor attractions are sites upon which the ruins of buildings stand. Material is often produced to help the visitor appreciate what once occurred on the site and performances such as re-enactments are often staged to add gravitas to the information that is being presented. Televised archaeological digs targeted at the armchair tourist possibly represent the most accessible cameo of this work, illustrating evidence collection, analysis, visual reconstruction of place and re-enactment of activity. It is a condensed reflection of the activities that take place within the heritage sector to both understand and convey place.

Taking what might be considered an overcritical view of traditional heritage activities it is possible to say that they rely heavily on visual media to communicate with the viewer. In many cases this reflects issues of practicality and cost. The use of recorded content replayed on hand held media players brings in a level of interactivity to the visitor's experience and has the power to deliver aural as well as visual content. Once in electronic format, this information stream finds a natural home on the web, often allowing virtual visitors to navigate and experience 3d reconstructions of the original.

In stark contrast to the amount of effort that is put into reconstructing the way places used to look, very little has been done to explore they way they used to sound. Archive material exists that captures relatively recent performance within architecturally significant spaces. At best these are appreciated for the performances themselves rather than for the acoustic of the space within which they occur. Research that has taken place in parallel with the development of virtual visual space seeking to artificially recreate the acoustic environment has yielded computational tools that have the capability to generate convincing reconstructions of how space shapes sound. These pave the way to bring virtual space to life - populating virtual space and permitting it to be heard as well as seen.

This presentation questions the process for producing the aural content of acoustically reconstructed space and in so doing identifies a broad, challenging and truly multidisciplinary research problem. The traditional approach of using anechoically pre-

recorded stock or bespoke material as the input for the auralization process overlooks a key interaction that should be accounted for if the results are to have integrity. The space in which performance occurs may be thought of as an additional member of the cast. It is one with which performers either knowingly or unwittingly interact both aurally and visually, as they seek to give of their best. Attempts to produce aural content matching the efforts behind attaining a visually authentic representation of space should account for these often subtle, but highly important effects.

The role these cross-modal perceptual interactions play when trying to successfully facilitate authentic performances has been explored in a brief investigation that looked at the influence of both vision and audition on soloist woodwind musician's perceptions of their performance within both a simulated and real recital hall. Anechoic to full real-time auralized conditions, with and without visual representations of the space under test were used to find the condition that most suitably represents performance within a real performance environment. We ask a fundamental question: can musicians have a similar performance experience in a simulated recital hall environment as in a real recital hall? The answer has a major bearing on recreating authentic performance for acoustic heritage studies. We conclude by discussing some of the practicalities associated with both the production and relay of acoustic heritage content.

Virtual audio in heritage performance spaces

Professor Jian Kang and Dr. Kalliopi Chourmouziadou.

School of Architecture, University of Sheffield

The acoustics in heritage performance spaces, including Greek/Roman and Chinese theatres, have attracted much attention recently, especially because many of them are still in use today. Since many of such heritage performance spaces have been destroyed or partly damaged, it would be of importance to recreate their sound environment. However, there are many special features in these outdoor performance spaces, including the diffraction/diffusion from the seating areas, and the absorption of various materials. In this research, acoustic simulation methods for such spaces have been systematically explored. Consequently, the importance of various architectural elements, such as stages, has been examined. Finally, some typical virtual audios have been produced.

Archaeological acoustic space measurement for convolution reverberation and auralization applications.

Dr Damian Murphy

AudioLab, University of York

Developments in measuring the acoustic characteristics of concert halls and opera houses are leading to standardized methods of impulse response capture for a wide variety of auralization applications. This work reviews results from a recent UK survey of non-traditional performance venues focused in the field of acoustic archaeology. Sites are selected and analyzed based on features of interest in terms of their acoustic properties. As well as providing some insight as to the characteristics and construction of these spaces, the resulting database of measurements has a primary use in convolution based reverberation and auralization. Applications of this work are also presented. Computer based acoustic modelling techniques have been used to reconstruct the sound of Old

Coventry Cathedral, based on available architectural data. A recent sound installation - A Sense of Place - based on one of the selected sites is also presented and discussed and demonstrates that good and considered use of 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.

The voice, singing and performance in acoustic space
Jude Brereton and David Howard

AudioLab, University of York:

The acoustics of the performance space is one of the most important factors in singing performance. However, the effect of the acoustic environment on the singing voice has not yet been systematically investigated. A professional singer, asked to perform in a variety of venues, has to constantly adapt many aspects of their performance such as tempo, vibrato, dynamics, and articulation of the text, as well as aspects of voice production over which the singer may have less direct control, such as vocal fold function and the resulting spectral balance of the sound.

This presentation describes a recent investigation of performance, voice source and spectral characteristics of the singing voice in two very different acoustic environments: the Chapter House of York Minster, and an acoustically treated hemi-anechoic chamber at the University of York. Recordings of speech, vocal tasks and a prepared piece were made in the two acoustic environments by two experienced singers, one female, one male. The output waveform from an electrolaryngograph was also recorded to enable analysis of larynx closed quotient and fundamental frequency.

Analysis of the recorded data indicates that the singers produced greater voice amplitude level but used less efficient vocal fold function in the anechoic environment. This is reflected in the singers' own reports that singing in the anechoic environment was "harder work" and resulted in difficulty maintaining good intonation and a pleasing voice quality especially in the higher and lower extremes of the voice range.

The acoustics of past spaces: Understanding sound in ecclesiastic heritage
Dr Anthony Masinton

Department of Archaeology, University of York

While it is well known that the development of ecclesiastic music of the medieval and early modern periods was influenced by the acoustic properties of contemporary ecclesiastic spaces, those properties are rarely taken into consideration when the architectural development of medieval church space is studied. However, the primary event which medieval church buildings were meant to house - the celebration of Mass - was chiefly an audial experience. Alterations to the spatial arrangement and architecture of medieval churches also altered the acoustic properties of these spaces and therefore the primary sensory experience of the form of worship for which such spaces were designed. How much, then, was the development of church space affected by acoustic considerations, and what was the affect of architectural development on the experience of Mass?

These questions are challenging. They require that not only the acoustic properties of specific ecclesiastic space as they exist at present be measured and understood, but that the acoustics of that space as it existed throughout its past history also be known. This understanding must be set within the context of the historical soundscape specific to that space in the past as well.

At the parish church of St Patrick, Patrington, East Yorkshire, a broadly interdisciplinary 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. This approach has drawn on a number of resources from archaeology, liturgical history, linguistics, performance, computer-based modelling and theology. New recordings of elements of the late medieval Mass specific to the diocese of York have been created and auralised within a virtual model of the church as it existed at specific stages in its medieval past. These have been used in conjunction with the archaeological and documentary history of the building to provide an insight into how alterations to the church fabric and furniture at various stages affected the audial experience of the space in specific ways which gave prominence to different groups within the parish community. The development of the building is driven by acoustic considerations as much as visual or structural needs. The result is an acoustic architectural history of the church and a richer understanding of sound in ecclesiastic heritage.

Building interactive audio environments using game audio tools.
Dr Michael Kelly.

Sony Computer Entertainment Europe:

Modern games consoles provide complicated mixing systems with advanced signal processing effects and access to gigabytes of audio data on game discs. Despite recent leaps in technology, evolution of sound design techniques and massive growth in the size of the games industry, little is generally known about the game audio process outside of the games industry. This talk presents an overview of game-audio and discusses how it can be used within non-game applications.

Since the first games written in the early 1970's, it is clear that things have changed. In modern games, soundtracks must provide the same fidelity offered by a movie but still remain non-repetitive over many hours of gameplay. In fact, the expectation of the consumer has now surpassed that for films; a game must convincingly respond to the unpredictable actions of the player whilst offering the same level of immersion. However, despite technological advances, many of the same design challenges still exist. Interactive media requires that the same processes used to create linear soundtracks must be applied in real-time, at lower cost to the consumer and in a single box alongside the other hardware used by the game. It remains necessary to convey the interactive, and often three-dimensional, audio environment in which the player is situated in a way that remains convincing to the user whilst they explore that environment. Even so, is it possible, necessary, or even appropriate to simulate the properties of a natural physical environment?

Game audio professionals have found many ways to approach these questions and address these challenges. There is now a wide variety of expertise and a large number of specialist roles in the area of interactive audio. Whereas once the entire soundtrack of a

game was the responsibility of a single programmer with other demands on their time, current high-budget titles now employ the skills of large teams of programmers, sound designers and musicians. These teams make use of customised and advanced technology and tools to aid them in their tasks.

This talk outlines the methods and the workflow which contributes towards a current game title. It highlights the technology and tools used to create in-game audio by demonstrating software which is in-use within published games. The talk also shows how the experience and technology from the game-audio industry can be applied to other fields by demonstrating non-game applications which employ game design methodologies. The talk concludes by examining the changing nature of games, the relevance of standardisation in game-audio and the growing reuse of game audio technology outside of game applications.

The session is aimed at a general audience. Whilst providing an introductory-level outline of relevant audio technology, it also aims to give a valuable insight into audio for games to those less familiar with this field. The audience should take away a clear idea of the game audio process and, where relevant, see how some of these ideas may be applied within their own work.

Audio heritage - Tools and techniques for the renovation of historically significant recordings.

Dr Jez Wells

AudioLab, University of York:

As the birth of historically informed performance practice recedes ever further into the past so it acquires a historical significance of its own. Just as musical works offer us an insight into the cultural, intellectual and aesthetic worldview of their composers, their capture as audio recordings offers a similar insight into the worldview of their performers. Many recordings which have historical significance were captured and stored using equipment and materials that were primitive by modern standards leading to signal degradations and corruptions that obscure, to a lesser or greater extent, the performances they convey and the audio heritage they represent.

This presentation will look at techniques for the renovation of such recordings. It will consider how the existing signal, knowledge of the space in which it was recorded and, potentially, knowledge of other similar performances can help in the process of piecing together a depiction of *the* performance in *that* space at *that* time.

As an example a recent project to ‘renovate’ recordings made fifty years ago, right at the birth of stereo consumer media, by Michael Howard conducting the Renaissance Singers and the choir of Ely Cathedral, will be presented. Howard pioneered the use of male sopranos in the performance of Palestrina and was the architect of the renowned ‘Ely sound’. These recordings are an important example of the British post-war early music movement The process, from locating master tapes and securing reproduction rights through removing noise from some parts of the recording (as well as adding noise to others) to re-reverberation, will be described. Possibilities for the future of restoration/renovation of audio recordings will also be presented.

Sound and music in prehistoric context

Elizabeth Blake and Dr Ian Cross.

Dept. of Archaeology/Centre for Music and Science, University of Cambridge

Archaeological contexts and artefacts pose specific and perhaps unique problems for understanding musical sound. When we seek to apply current techniques to characterise the acoustical properties of archaeologically significant spaces, we are likely to be employing measurements that have been shaped by contemporary western perspectives on what is, or is not, considered acoustically aesthetic or functional. While the application of these techniques may be informative, their results require to be evaluated in the context of an understanding of the broader acoustical environment that is likely to have shaped the auditory perceptions of humans in the archaeological area and epoch under investigation, as well as an understanding of the factors that may shape the uses of sound in non-western contexts. A similar problem is encountered in the assessment of archaeological artefacts for their sonic or musical potential. Some artefacts can be identified as unambiguously sonic or musical on the basis of structural homology with contemporary or historic musical instruments or sound-producing tools familiar within western culture. However, artefacts lacking such evident homologies run the risk of being misidentified unless a principled understanding of the potential of their physical properties to produce sound is applied in their analysis, or if analogies with objects used to produce musical sound in non-western societies can be recognized.

These considerations suggest that exploration of sound in archaeological contexts requires a multi-disciplinary approach, with contributions from architectural and environmental acousticians, physicists, ethnomusicologists and archaeologists. Characterisation of the broad acoustical environment applicable to the time is necessary, using both 'concert hall' metrics as well as environmental measures such as LAEQ, and the identification of acoustical features that deviate markedly from 'acoustical background' is crucial. For example, it can be postulated that the open environments likely to have been exploited by early human hunter-gatherers in Palaeolithic Europe will have afforded a limited number of contexts yielding psychoacoustically significant levels of indirect sound; contexts in which indirect sound was highlighted, such as the interiors of cave spaces, may have been sharply differentiated from the everyday sonic world in the experience of early Europeans. Inferences about prospective archaic uses of such sonically unusual environments can be made on the basis of their characterisation in terms of reverberation time, EDT, C50 etc., but must also take into account the effects of phenomena that would be regarded as undesirable in contemporary acoustical contexts, such as the locations and dynamics of echoes and sharply-tuned resonances, as well as features such as flutter echoes.

Similarly, classification of objects as sound-producing or musical requires formation of well-founded hypotheses concerning the function and scope of such activities in the archaeological culture in question, as well as the experimental exploration of the potential of that culture's artefacts to be used in such activities. As an example of such an approach, we shall briefly present here results of a recent project investigating the putative use of Upper Palaeolithic flint 'tools' for sound production. The results of this project might offer scope for extension by means of sound virtualisation, in terms of considering how uses of such 'sound tools' may have exploited acoustical singularities of sites.

Sampling the past: how technology can open access to musical instrument collections.

Dr Kenneth McAlpine.

Computing & Creative Technologies, University of Abertay, Dundee.

This paper aims to explore through practical application the case for delivering cultural access to fragile or historic musical instruments using digital technology. At present, there are a number of historical musical instruments in playable condition. However, due to their age and fragility, most are neither robust nor stable, and require costly and frequent maintenance. We explore how modern music technology can be used to capture the acoustic qualities of such instruments in the digital domain, and provide a fully-playable virtual alternative that plays and responds to player input as does the original. In so doing, the digitised instrument then provides the general public access to antique musical instruments in a very direct, yet sympathetic manner.

The process of digitisation also brings significant advantages over the original acoustic instrument. For example, the tuning of the digital instrument can be controlled precisely, and additional tuning mechanisms and temperaments can be applied instantaneously, without having manually to retune the instrument.

In this paper we detail by means of a case study this philosophical approach to heritage preservation, illustrating the discussion with sound examples and photographs. We outline some possible uses of such technology and conclude by showing the digital instrument in a performance context.

First light: An archaeology of Jodrell Bank

Professor Mark Edmonds.

Department of Archaeology, University of York:

This paper draws on ongoing work at the radio telescope at Jodrell Bank, Cheshire. This work has taken a number of forms, and is designed to explore the changing significance of the monument over time, from the immediate post-war period to the present day. Here, an emphasis is placed on the particular problems and potentials associated with creating an archaeology of a place whose history and significance is bound up with sound.

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