

# Virtual and Augmented Acoustic Auralization

## ARUP Acoustics Scotland/DDS SoundLab, Glasgow

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### Report on the third I-Hear-Too workshop, Wednesday 25th November, 2009

#### Introduction

Arup's Seb Jouan welcomed the workshop participants from academia, heritage, acoustic industries, and artistic practice to the third workshop in the ihear2 programme. This workshop's venue was chosen in order to showcase the new premises of Arup Acoustics, Scotland; Seb Jouan, as Arup Associate, explained the promising new venture he leads called "iXDdesigns" (Interactive Cross-Disciplinary Designs) which will be officially opened in December 2009. Throughout the day, individualized tours for workshop participants were conducted by Seb and his team.

#### iXDLab Tour and Presentation of Heritage Applications

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At the end of this report you can find the overview of Arup DDS Sound Lab collaboration, explaining the design of the iXDLab, describing Ambisonic Recording and Playback, Auralisation, Multisource Auralisation, Sonic Art, Historical Reconstitution and City Modelling, and 3D Walkthrough.

#### 1) Sound in Heritage workshop

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The Research Question here was to find solutions to the problem that "sound is often the poor relation of visual stimuli" in heritage presentation and interpretation. What has been learnt by members of the ihear2 network? A realization that there is a huge variety of research in progress, but that the heritage sector does not often use sound in a way that is well thought out. Yet sound is a very quick and rapid way of conveying information about sense of space and place. Discussion about the relationship between the 'audio' and the 'tour'; it is usually all about the tour and not about the audio! Even the expensive PDA used at Charles Darwin's Down House was not risk-taking in its sound delivery. Suggestions were made for experimentation, and for improving the nation's audio tours, but this needs a test case with both outdoor and indoor situations. This perhaps also requires a new type of headphone that do not cut out social relationships, especially as heritage visitors often visit as a group, and particularly as a family. Augmented audio? One ear? Both ears with transparent headset also pulling in ambient sounds? York Minster's 'ihear2 Live' was a novel experience because it allowed the building to be the headphones: how could this be delivered with new technology? The most important issue for audio tours is the content, and interactivity can mean that audio becomes more than simply an audio guidebook. It could be a 'wow!'-factor, engaging with the past, providing a multiplicity of stories and layering of sounds offered at heritage sites, which creates an overall improved level of story-telling beyond a single narrative and provides a 'point:counterpoint' effect. Audio could offer a new experience of how people relate to the space and to one another, and the technology can be a vehicle that offers different ways of looking, hearing, and discovering. Stonehenge is the possible testbed for developing such means of interaction and creating effective engagement through the use of audio, but there are time pressures to develop and deliver new interpretation audio for 2012 with Stonehenge's refit and reopening.

## 2) Artistic Interventions workshop

The Research Question here focused on the relationship between the artist and the heritage institution. Sound can really stretch and challenge an audience to new explorations with heritage. Artists are often parachuted in for a particular commission to fit an event, and there needs to be more long-term engagement. Because of the intensity of the engagement that artists have with a space, their output is the creation of art works rather than aspects of heritage interpretation; this relationship therefore needs further clarification with heritage sites. A new way forward was suggested for artists to engage not just with the venue but with the historians, art historians, and archaeologists who have studied the space, and this would produce multi-faceted and durable work at heritage sites. There remains a problem of categorization: is this sound art or is it a concert, and how do you explain that sound can offer another layer of exploration and engagement with a heritage site? We need to develop research that examines the impact on audiences of contemporary art interventions in heritage spaces. Further, how can we use technology so that installations become more durable so that they leave a trace, so that the sound exploration can become part of the heritage presentation, rather than a one-off event? Participants discussed the need for further experimentation with technology: again, the use of ipods and mp3 players, exploring both sound and visuals. Parabolic speakers are able to give sound experiences to a group. Binaural audio was also discussed, but there is a problem because the sound is delivered as if it is inside your head, and it therefore works better when integrated with visuals. A way forward is to create new spaces: sound installation galleries at heritage sites, e.g. La Monte Young's Loft Installations. Such dedicated spaces would allow for technological experimentation but also longevity which allows audiences to explore heritage sites via sound presentations. Lastly, the discussion explored the present problems of the ephemerality of sound installations in heritage spaces and the need to document and curate artistic interventions. Partnership could develop with British Library Sound Archive on this issue, particularly with their Drama and Literature Curator. There is a need to allow for multiple voices, representing responses to the installation, rather than a single objective document, when curating artistic interventions at heritage sites. As such, there is a need when archiving the ihear2 event to include recordings, photos, reports, and audience research. ihear2, as practice-based research, must be archived and written up as research, and the best method would be by archiving ihear2 and submitting to 'ScreenWork' a peer-reviewed DVD publication with explanatory texts ('ScreenWork' is an edited peer-reviewed publication of Screen Media Practice Research). In addition to archiving and writing up the practice-based research from the Minster event, ihear2 needs to develop an outdoor location to take the process forward and design a format for artistic intervention archiving at heritage sites. This will develop processes for sustainable artistic practice in the sector.

## 3) Auralization in Heritage workshop

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The Research Question here is concerned with how audiences interact with sites, and also how one incorporates the frontier technological work of partners like Arup with heritage practice who can offer new means of delivery. In this area, ambisonics are perhaps too subtle for heritage experience. Discussion about the relationship between sound and visuals, and 'multi-sensory' was considered the best way forward with a focus on how to work and engage with 3D sound. Might an example be Stonehenge, where one can offer configurations of soundscapes that no longer exist and reconstruct the historic experience for the visitor? Is reconstruction as interpretation appropriate? Yes, if the sound delivery is a method of explaining the competing theories and understandings of Stonehenge's build and purposes. Recognize the tension between design and heritage sector in use of recreation, and make this into the discovery element for the audience. The Arup Auralization demonstrations illustrate the value of learning to listen and process the detail of auralization. An outdoor experience

could be developed where visitor can experience the space by moving their head, and moving their person through the space, giving a dynamic aspect to the experience. Dynamic aspect is the key here: providing a physical interaction with the space rather than thumb-controlled interaction but this cannot merely be auralization because it needs to be married with visualization. How do we deliver this experience to the visitor? A discussion of interactive auralization, CATT walk, and the potential defects suggested 2D is more natural and effective than 3D examples. Adding footsteps to a soundscape can make it immersive and evocative. The purpose is to change the visitor through their interaction and experience of the site. As in session one, discussion centred on the importance of layered interpretation and offering story-telling to the visitor, and the ability to navigate pathways exploring competing evidence and interpretations.

#### **4) Feedback workshop to discuss 'What Next?'**

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ihear2 group focused on how to develop practice-based research. A project with Arup could experiment with sound delivery to heritage sites in outdoor and indoor environments. A heritage site that has both would be good, such as Bolsover Castle. One project could focus on an enhanced sound and visual experimentation married together, such as a VR headset with the visitor in an immersive sensory device; another could allow for group and social engagement, through experimentation with transparent headsets which are a lighter touch for delivery, providing a microphone outside the headphones that channels the outside and ambient sound in to the headset. This research project should allow for experimentation with the portable gear that visitors show up with, such as mp3 players and mobiles. For proof of concept, there is a need for a site where experimentation can happen. Develop relationship with English Heritage to discuss potential for Stonehenge, and/or Bolsover Castle. IPUP suggests starting with audio guide and adding layers of content and interactivity, and evaluating with audience research throughout the project. York Minster is another potential partner. Discussion also focused on our partners at British Library, and the potential to offer a sound engagement in the Reading Room as a place and space where acoustic work could be done to develop artistic practice. ihear2 needs to think about easy delivery for practitioners at heritage sites, so tailoring the technology to the things that visitors already own would offer great value to the sector. Creative reinterpretation is the key, as well as the delivery to the AV equipment that people already own. Consider approaching HLF for a 50K to pilot at a site.

## **Introduction to IXDLab and iXDdesigns**

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The recent 'ihear2' discussions in Glasgow included an introduction to iXDdesigns and a tour of the iXDLab with a presentation of the technologies available and their possible applications in Heritage representation.

### **Arup and DDS collaboration**

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iXDdesigns (Interactive Cross-Disciplinary Designs) is a collaboration between Arup and the Glasgow School of Art's Digital Design Studio (DDS). The collaboration combines Arup's expertise in virtual acoustics and auralisation techniques based on the Arup SoundLab and DDS expertise in computer modelling and visualization.

## The iXDLab

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The iXDLab is purpose-built, audio-visual research lab based in the Hub building in Glasgow's media quarter at Pacific Quay. The iXDLab has been specifically designed to provide complete acoustic isolation from the outside world and to provide an optimal environment in which to explore surround sound and virtual acoustic technologies. A sphere of 12 loudspeakers with a subwoofer (called an ambisonic array) is set up within the space to render a three dimensional soundfield. The lab also houses a stereoscopic projector and screen, which makes the iXDLab the only Arup SoundLab to allow 3D visualisation and animation. The iXDLab provides an excellent space in which to perform research into multi-sensory immersive technology.

### Ambisonic recording and playback

One of the main strengths of iXDdesigns is the ability to capture and playback three dimensional soundfields. This is made possible through the use of a technology known as Ambisonics. Ambisonics is a comprehensive approach to the capture, storage and playback of three dimensional directional sound. Developed in the 1970s by Michael Gerzon, this technique allows the possibility of recording a 3D surround soundfield and reproducing it over a number of different speaker set-ups including traditional stereo and 5.1 systems.

The recording is made possible through the use of an ambisonic or Soundfield microphone which uses multiple microphone capsules to record the sound occurring in 3 dimensions with the addition of an overall pressure channel. A complete 3D soundfield can be stored on 4 channels of audio which are then fed into a decoder which calculates how to reconstruct the soundfield over any specified speaker configuration.

The presentation showed some recordings including that of a motorbike rushing down a country path, and some young children playing in a playground in France. In particular a recording was presented of a famous 'Soundmark' in Edinburgh known as the 'One o' Clock Cannon'. This final recording was of particular interest to the group as the archiving and study of soundscapes and soundmarks is fast becoming a necessary area of study to provide a more immersive presentation of heritage sites. This raised some interesting discussions and ideas about projects which might use ambisonics as a way of recording and preserving these soundmarks for future generations.

### Auralisation

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The presentation then moved on to showcase another key technique used in the iXDLab, Auralisation. Before discussing its operation some key acoustic concepts were introduced.

Every room has an individual acoustic signature known as its Impulse response. The impulse response can be described as the room's reaction to a loud and short percussive sound like a gun shot or hand clap. This measurement describes a lot of very useful information about the space including the reflection sequence and reverberation time.

A three dimensional impulse response can be recorded using a soundfield microphone or calculated using acoustic modelling software. The process of auralisation utilises a mathematical technique allowing the impulse response to be applied to an anechoic sound (an acoustically 'dead' i.e. no reflections). This has the effect of making the recorded sound appear as if it was played within this space with all the 3 dimensional information being preserved and rendered using an ambisonic playback system.

The process of auralisation has a number of extremely useful applications. From a technical point of view it can be used to demonstrate the effect of using certain acoustic interventions in building projects. The really exciting use of this technology appears when it is used creatively. For instance it allows musicians or composers to hear what their pieces may sound like in any performance space under any number of circumstances.

An interesting discussion took place within the group after listening to an orchestra play in two of the most famous concert halls in the world, the Musikvereinsaal in Vienna and Concertgebouw in Amsterdam. It was revealed later that the orchestra had never actually played in these spaces and the presentation was in fact a very convincing computer simulation.

By auralising a space we are in fact preserving a part of it. If the building is destroyed, the impulse response can be used to recreate the effect of the acoustics on any sound. A number of projects are already underway to archive impulse responses of famous concert halls but this could easily be extended to heritage sites.

## Multisource auralisation

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A demonstration of the state-of-the-art techniques in auralisation were also presented. Traditionally, auralisation is usually achieved by using an impulse response from a single point on stage. This technique is valid for single sound sources but suffers when an entire orchestra is auralised from this single point. By using recordings obtained from the Helsinki University of Technology and by auralising from multiple locations where the instruments are likely to be positioned, a great improvement can be heard in the overall realism of the orchestral auralisation. Each instrument sounds more distinct and closer to how it sounds in a real environment.

These recordings have raised a number of interesting questions about approaches to auralisation which will serve the basis of future research projects. These may influence the process in which sounds for use in heritage sites are captured and to what level of detail they need to be reproduced in order to provide a convincing illusion.

## Sonic Art

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The presentation then moved on to describe in more detail the creative use of this technology with an auralisation of a piece by Bill Fontana which was performed in the Tate Modern Art Gallery in London. This piece used sensors attached to the Millennium Bridge, to capture vibrations occurring as a result of wind rushing past the cables or people walking across the bridge itself. These signals were auralised using a computer model of the Turbine hall allowing different scenarios to be explored by the composer. An interesting aspect of this is the Turbine Hall's characteristic 'hum' which is caused by a nearby generator. It was decided to also recreate this within the auralisation. The interaction between this 100Hz hum and the frequency content of the vibrations on the bridge inspired the name of the piece 'Harmonic Bridge' This piece was later installed in the Turbine Hall.

This provoked some very interesting discussions about retaining the Turbine hall Hum as it is due to be removed as part of renovations but is felt to be part of the space's character. The scope of this discussion expanded onto other situations in which soundmarks and soundscapes could be recorded and archived for future use and analysis.

## Historical reconstitution and city modelling

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A project which the DDS is currently involved in is the reconstitution of sites of special historical interest. This work is being commissioned by Historic Scotland. By using a laser scanning technique and applying photo-realistic textures to the data, an extremely convincing model of Stirling Castle has been constructed. This model can then be animated as required and thus explored and interacted with. These models are compatible with current acoustic modelling software allowing a multi-sensory reconstruction of the building to be stored.

The DDS have recently undertaken a project to use this scanning technique to build a cityscape model of Glasgow. This project involved firstly, the use of LIDAR scanning from an aircraft to obtain a basic scale model of Glasgow. The next phase involved scanning individual buildings and applying photorealistic textures. As with Stirling Castle, these models are compatible with Acoustic modelling software, which allows the exciting possibility of presenting and archiving a realistic and explorable city environment.

## 3D Walkthrough

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The presentation ended with an interactive demonstration of these technologies working together. By using the auralisation techniques described previously, a large number of impulse responses have been calculated inside a model of a concert hall. A computer program then allows you to move between these responses by interpolating between them, the position of the listener is controlled by a games controller. The positional information is then sent to a graphics engine allowing the visual scene to be rendered in 3D and the graphics appropriately rendered. A number of different virtual musicians were rendered allowing the user to experience different types of music and explore the differences in sound at any point inside the concert hall. It was even possible to move onto the stage and experience what the music would sound like for the musicians.

The walkthrough provides a great demonstration of the available technology and raises many questions about where and how it can be applied. With the addition of the game controller, a new level of interactivity is achieved which serves to enhance the users engagement with the space. An interesting prospect would be to create a similar presentation of a heritage space allowing the user to explore it as opposed to the experience being largely passive.