INVOLVING THE PUBLIC IN NOISE SURVEYS VIA MOBILE TECHNOLOGY

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1 INTRODUCTION TO THE PROJECT

The IMPRINtS project (Internet and Mobile technologies for a Public Role In Noise Surveying) aims to enable and encourage public participation in a large-scale environmental noise survey. The primary objective of this work is to raise public awareness of the science of environmental noise and the impact of soundscapes on the quality of life. The term soundscapes describes differing acoustic environments, which each of us is subjected to throughout our lives[1]. It is suggested that these soundscapes play an important part in our lives; making us feel comfortable, productive, happy or uneasy and distracted[2]. Soundscapes also provide the contextual references that contribute to our feelings of belonging and place. The soundscapes we inhabit can be perceived as a welcome hustle and bustle or as a noise nuisance. Creating the most appropriate soundscape is a challenge for the planning, development and construction of spaces and impacts on how we, as individuals, choose to spend each day. The increased engagement of the public in themes that the project aims to foster, will act as a driver for better urban planning, construction and development.

Advances in mobile computing offer the opportunity to allow many people to participate in sound surveys. Recent developments in mobile technology will be utilised, including: mobile phones, PDAs, mobile/PC connectivity and distributed application technologies from the project website. The combined use of these technologies will contribute to the project in two respects: 1) It enables environmental noise data from a large participant base to be automatically collated and analysed at the main web server. 2) It enables participants to include subjective responses to the soundscapes they inhabit, providing a more nuanced understanding of the context and reasons for human responses to environmental sounds. The potential to gather vast amounts of data from a huge number of participants should provide new insights into how sounds vary spatially and peoples' relationships to their acoustic environments. The data gathered, combined with the inferences made, can be used to better inform strategies for environmental noise abatement and the enhancement of public spaces through increased soundscape consideration. However, there are a number of technological challenges to be overcome, not least the issue of calibration.

2 BACKGROUND

2.1 The Current Ambient Noise Methodology

The current heightened interest in ambient noise is reflected by Defra's *Neighbour Noise Strategy and Ambient Noise Strategy*[3], supplemented by national noise mapping schemes such as *'The UK National Noise Incidence Study (NIS) 2000/2001'*[4] and the implementation of the Sound Immission Contour Mapping (SICM) system for Greater London.

> *"… the development of the [Ambient Noise] strategy is, therefore, very much a data and information gathering exercise. To move towards further action for noise control we must gather: - information on the ambient noise climate in the country. In simple terms, the number of people affected by different levels of noise, the source of that noise (road, rail,*

> *airports and industry) and the location of the people affected. This will be undertaken by producing noise maps of the main sources of noise - a major new exercise for which we have put aside £13m"*[3]

The typical method of noise data retrieval is based on spot measurements performed by consultants with the use of specialist equipment, the process of which is inevitably limited by scope, scale and expense. The resultant noise maps are therefore built loosely from predictions based on measurements at static positions, usually close to identified noise sources, from which some basic idea of a persons expected noise exposure levels can be predicted by considering a persons movement patterns. These predictions can also be used to determine a pattern for the number of people exposed to unacceptable noise levels by comparisons to the World Health Organisation guidelines. These typical noise data retrieval methods cannot satisfactorily determine the levels of noise people are exposed to in their daily lives without the measurement equipment following the individual.

The regulation of noise at work in the UK has been in existence for a number of decades. Increasing evidence suggests a greater risk is posed by hearing loss induced by leisure noise exposure. Research carried out by the Royal National Institute for Deaf People (RNID), involved measuring the noise levels on the dance floors of nightclubs throughout the UK. This work discovered that the lowest reading was 89.8 dB and the highest at 110.2 dB, louder than a pneumatic drill. By introducing the technology developed in this project to members of the public, it would be possible for these individuals to monitor their own levels of noise exposure, empowering people to take control of their auditory health.

2.2 Benefits of Public Participation

The huge potential for public participation in noise surveying using mobile and internet technologies has yet to be utilised. Similar experiments in large-scale public-resource computing have already taken place in other fields, notably astronomy where the SETI project (Search for Extraterrestrial Intelligence) increased public awareness of their work and goals through members of the public providing background computing resources to process the projects vast data sets[5]. Today, a vast majority of the public carry mobile phones which contain microphones and comparatively sophisticated digital signal processing technology. The processing power these devices posses enables them to be used as audio recorders as well as digital signal processing tools. Recent advances in mobile technology and functionality mean that we are at a point where members of the public are able to record and document the soundscapes they are experiencing. The amount and type of data this technique can gather, using the traditional methodologies of noise surveying are unheard of. Data on the preferences and opinions of individual members of the public can be used to make inferences on the subjective effects of acoustic environments, linking these individual responses to objective acoustic data to eventually ascertain the perceived "Quality" of the soundscape.

The outcomes will address the role that sound plays in the design process and appreciation of public spaces. With strong guidelines in place to determine what is acceptable and unacceptable in terms of aesthetics, the sound environment is lacking in these considerations and not as widely incorporated into urban planning and assessment. A possible reason for this is the ease at which the visual environment can be captured, designed and replicated compared to the difficulty of achieving this process in the acoustic environment. By empowering the public with the means to control what is being monitored, and allowing the individual to record specific impressions of this data, a more representative and complete analysis of the acoustic environment can be achieved.

3 PROJECT METHODOLOGY

3.1 Technical Aspects

There are three principle stages in the acquisition and analysis of the data gathered by the project.

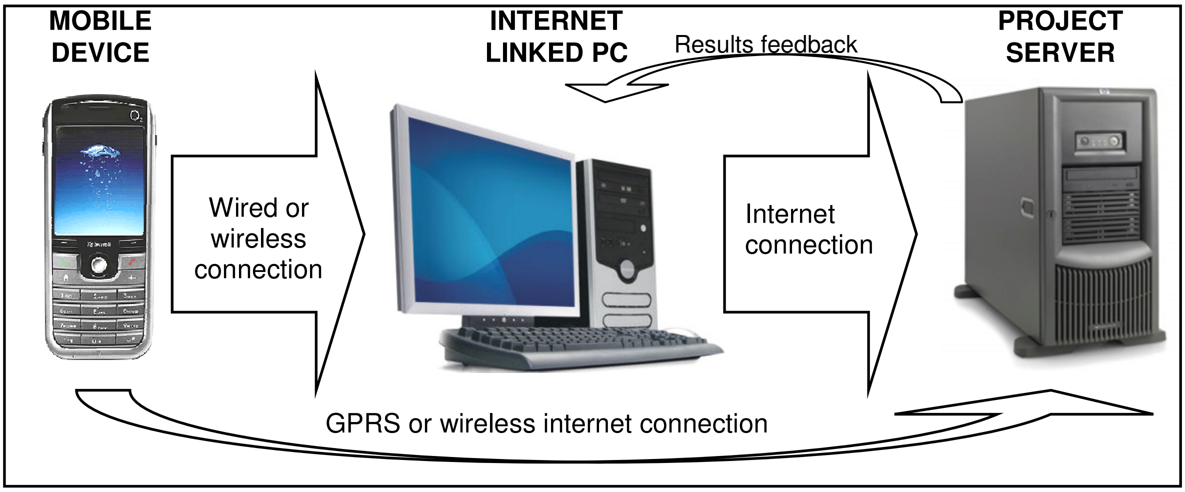

Figure 1 - Three main stages in data capture, collation and analysis

With the widespread adoption of broadband internet, wireless network technology, managed application development and XML web services[6]; the retrieval, collation and analysis of objective and subjective soundscape data from numerous locations is possible using popular consumer hardware.

The first stage involves a small Java application downloaded to the participant's mobile phone from the project website or installed onto the mobile via a home computer after downloading it from the site. The software exploits the audio capture functionality of the mobile phones through the Java JSR135 (Multi Media API)[7]. This API[*] allows the capture of high bandwidth audio through the device's microphone. The participant will be encouraged to capture short recordings of soundscapes they regularly encounter in their daily lives. They will then be presented with the results of some simple signal analysis performed by the software on that particular captured short soundscape. This serves to inform the participant on elements of the temporal, spectral and level characteristics of the soundscape and to enhance their understanding of the acoustic properties of the sounds that surround them. It also allows some of the computational load of the signal analysis to be performed by the participant's mobile phone, taking the load off the project servers when the data is retrieved. The form this data is presented must be readily interpretable by members of the public. Sample data can then be communicated to the project's central server, either directly from the handset using the mobile network with GPRS[†] packets or via an inbuilt wireless internet connection on more modern handsets.

In order to ensure the reliability of the captured audio data and reduce systematic error, a process of calibration must be devised that participants of the project can carry out. Calibration serves two purposes: the first being the actual acoustic calibration of the mobile device which is crucial to the usability of the audio analysis data and secondly to highlight the importance of calibration to the participant. For this process to be truly rewarding/appealing to the user, a fun and interactive method will need to be devised. To ensure participants follow best practice procedures when taking measurements, detailed instructions will be provided both online and on the handset at the time the

[*] Application Programming Interface
[†] General Packet Radio Service

measurement is taken. Alongside this objective acoustic data, the participants will be prompted to enter a range of subjective responses to the soundscapes they have captured. These responses will be in the form of free textual input into the device using the handset's keypad and more closed responses using differential grid techniques and quantitive methods. With the recent addition of GPS receivers and triangulation routines in the most recent mobile handset's and PDAs, accurate location data can be sent along with the other data providing spatial and temporal information with respect to noise and soundscape distribution.

It is likely that the majority of participants will transmit the data back to the project server via their internet linked home computer via USB cable, Bluetooth or infra-red wireless connections. The benefits of this method will be the addition of downloadable multimedia software which will streamline this process for the participant as well as providing a range of further interactive multimedia activities to engage and educate participants. These will include educational applications involving the user's participation in the analysis of the captured soundscapes incorporating different forms of visualisation of the audio data and fun activities for them to engage in, such as audio warping and manipulation. Utilising the expanded processing power of the PC-based client applications will provide the means to perform further and more advanced signal processing on the audio data as well as the responses provided by the participants.

Through the use of XML web services, a standard and secure means of automating the transferral of data between all technologies will be established. The server application can thus automatically collate, analyse and present data received from any of the enabled technologies (mobile, PC, PDA etc) providing visual feedback to the participants on their contribution to the project.

3.2 Schools Pilot Study

A pilot study involving 300 Key Stage 4 students will be undertaken before the national survey has begun to enhance the public engagement benefits of the project and to develop optimum sampling methodologies. This will involve 10 collaborating schools in Manchester, where two hour interactive lessons will be carried out in each. These lessons will be designed to promote interest in the fields of Environmental Science and Acoustics through the practical use of the project's mobile and computing technology alongside acoustic measurement equipment. The objectives of these lessons are suited to the KS4 science programme of study as they supplement the majority of the knowledge, skills and understanding sections of "How Science Works".

> *"… in order to understand how science works, learners need skills such as practical collection of data, working safely, presenting scientific information; they need to understand the power of science to explain phenomena, the way understanding of science changes over time and the applications of contemporary scientific developments"*[8]

The calibration techniques, mobile client applications and web-based resources will be prototyped to asses the significance of both systematic and stochastic errors, as well as ensuring that optimum techniques are utilised. This stage will be critical to the success of the national survey which will be shaped around the findings and decisions made in the pilot study.

Preliminary studies will compare results with more traditional methods of noise surveying. The public method of noise surveying will naturally generate a higher percentage of erroneous data, but the advantages of being able to sample a larger number of environments and gain a better understanding of public perception, will hopefully outweigh many of the disadvantages.

Similar projects using mobile devices in a learning strategy have proved successful in integrating mobile technology into the classroom[9].

> **Learning Lab: Inclusive Education using Mobile Devices**[10]
> Pupils used mobile phones with cameras for problem solving outside. They used

GPS to map their route to school and then enhanced their maps with pictures and captions associated with their movements and lives.
Equipment used: Mobile phones, cameras and GPS devices
Age: 13-15
Learning Lab team (CKS), Bangalore and New Delhi, INDIA 2004

A New Sense of Place[11]
Investigating how wireless technology can influence children's perception of virtual and real spaces and help them to re-engage with their own environment.
Equipment: PDAs, GPS, HP research ideas
Age: 9-10
Mobile Bristol, UK

Advanced Physics Using Handhelds[12]
The handhelds were used to help understand scientific concepts such as gradients of electronic fields as well as general data recording. The results of the group with handhelds were compared with those without.
Equipment: 16-18 Palm handhelds, PalmPix cameras, portable keyboard.
Age: 16-18
Palm Education Pioneers (PEP), University School of Nashville, Tennessee, USA

The current project amalgamates the technologies used in previous projects[10-12] to deliver a mobile ICT based learning tool, accessible to a wide range of learners due to its use of popular consumer hardware.

3.3 National Survey

Participants will register on a database and mailing list and be invited to download the client applications that will need to be executed on mobile and desktop computing devices. Instructions will be provided for the setup, calibration and operation of each element of the applications. The applications will be designed to be simple to use and self-explanatory to cater for a wider range of users with varying levels of computing proficiency. Participation will be as large and widespread as achievable, promoting heightened awareness of environmental noise issues and reducing stochastic errors as well as increasing the scope of potential inferences that can be made.

The initial target for participants is 3000, although the server will have the potential to cater for a much larger number. Funds are available for promotion of the project including advertising , flyers and travel costs to science fairs and similar promotional outlets. National events related to the project, such as Noise Action Day could be utilised to publicise and promote the enlisting of participants as well as gaining the attention of journalists, companies, communities and organisations that have an interest in related fields.

Throughout the duration of the project, participants will have access to a well publicised multimedia web site detailing issues related to Environmental Science, Acoustics and the KS4 resources. This site will also provide research findings of the project and allow participants to identify their contribution to the work being done, thus personalising the experience.

3.4 Project Evaluation

Different forms of evaluation will be performed to assess the effectiveness of the project. The public engagement will be evaluated using questionnaires sent out to all participants after the national survey period. This will provide feedback on how effective the project was in its public engagement aims, including how individuals have benefited from their involvement.

The project website will facilitate a message board and a mailing list which will keep participants up-to-date on the projects progress and promotes further engagement and discussion both locally and nationally.

The school pilot studies will incorporate student assessment to evaluate the extent to which the students have engaged with the study. Follow-up work will be set that will assess the students understanding of the theory and related aspects of the project.

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