Industrial Soundscapes

Exploring audio augmented reality through mobile applications

Fredrik Johansson
Slöjdgatan 4
903 25 Umeå
fredrik@signar.se
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Abstract
The aim of this paper is to shed some light on the concepts of creating digital soundscapes and audio augmented reality. Research in this particular field is mainly carried out within the ubiquitous computing community. Even though the technology for a small scaled approach of this concept is already at hand, it will take some time to make technology for it as ubiquitous as researchers want it to be.

Keywords
Soundscape, audio augmented reality, noise pollution, context awareness

1. Introduction

The hypothesis of this paper is that mobile technology is available that could enable "soundscapes" that would support industrial work, even within extremely noisy environments.

The introduction of this paper is intended to give the reader a brief introduction to soundscape research, its terminology and to the conflicts between digital soundscapes and sounds from the context.

To support the hypothesis stated above this paper will introduce current technology that can create soundscapes and audio augmented reality.

The main idea of augmenting a persons or community's soundscape is to enhance the existing soundscape with informative sounds based on information that is digitally stored, derived from the context or sound from the users' interaction with objects and people.

One of the main benefits of the enhanced soundscape concept is the wide range of environments it could be used in. Wheater it be everyday life, at work or wherever people will gain from accessing information through sounds.

Defining Soundscape

The term soundscape originates from the early 1970s and the work of R. Murray Schafer and his colleagues at the Simon Fraser University in Canada [8].
The definition of the word soundscape is "an environment of sound" with emphasis on the way it is perceived and understood by its community and the individuals present.

The use of the term soundscape in this article will refer to an artificially enhanced sound based environment. Four different classes of sounds emerged from the studies of Schafer. These classes were:

- Keynotes
- Signals
- Soundmarks
- Sound romances

A keynote sound is the tonal centre of a soundscape. For example the keynote of an ocean town would be the sound of the sea. The hum of the computer hard drive is the keynote for many of our work environments. An infrequent and also alarming informational sound is classified as a signal. A police siren or email alerts are typical examples. A soundmark is the acoustic equivalent of a land mark. It sonically distinguishes and identifies a particular location. Finally, sound romances are those sounds that inspire a feeling of for instance nostalgia or remembrance. The different classes of sound described above are important to remember when creating artificial soundscapes. The user shouldn't for instance be presented with a soundmark that differs from the actual location of the user.

Dangers of Noise vs. Silence

When considering noise in a work area from the perspective of the workers habituating it you might ask what this is doing to the workers and their ability to perform their tasks. Roland Rylander [3] who is a researcher in the field of environmental health says that a common reaction of noise is a feeling of disturbance of ongoing activities such as work tasks. This feeling is usually referred to as "annoyance". A long-term exposure of noise can however lead to more serious effects such as strong feelings of exhaustion and defeat.

When heavy noise frequently occurs in our surrounding the human instinct is to stop the noise, or at least stop the noise from reaching our hearing sense. When the later method is used, whether it is by holding your hands over your ears or by using headphones designed to block external sound, all sound disappears, even sound that we need to maintain social and contextual awareness.

Research has shown [3] that staying for a long period of time in an environment where sounds are completely absent causes a feeling of isolation and insecurity. Man requires a background of sounds for normal functioning and also for satisfaction.

2. Industrial Soundscapes

When referring to real industrial soundscapes noise is one of the first thoughts that come to mind. With audio augmentation this environment polluted with noise can be changed into an efficient environment where users can get relevant information clear and be able to customize the sound experience to fit their needs and optimizing their contextual awareness through extensive information about a particular location that only exist in the audio augmented reality.

Sound beyond feedback

Sound is a popular media to distribute feedback or other information to support interaction with a system. For instance most people have experienced the sound of failure when

something goes wrong with a computer program or the positive feedback sound when a computer installation has been completed successfully. These sounds can be called non-speech sounds and deliver a meaning that is easily interpreted by user because of the use of sounds that are connected with real world events such as whistles, horn or a cheering crowd.

Even though none-speech audio [2] is a common factor when it comes to supporting interface design in many different areas of implementation, it is almost always used as a secondary medium that supports or contributes to the primary interaction system. With audio augmented soundscapes the digital sounds have to go beyond feedback.

The best and most obvious approach for enhancing soundscapes is in theory to augment the external world rather than replacing it [7]. When doing this, advantages of computation can be made without conflicting with social concerns. Unfortunately, when it comes to extremely noisy environments all external information has to be interpreted by the system. With this fact stated the focus must be on how to create a soundscape that supports all interaction by the user and don't limit the users' contextual and social awareness.

Contextual Awareness

In order to address this problem correctly one must answer the question why the contextual and social awareness would change when the external sound information is transformed into digital sounds. Of course this depends on the method used when transforming the information and how the information is presented to the user. The fact is that the problem with an entirely virtual sound based interaction system is the difficulty of finding sound representation of tasks, events and information that make sense and are understandable to the user. Even though the user of the system still has their visual input, it is hard to map this input without the soundmarks of the real soundscape. With this stated it is clear that the application will have to transform the real soundscape without losing its main characteristics, such as the origin of the sound. Another question is how the system will present sounds that do not originate from the external soundscape, like digitally stored information.

Soundscape Technology

When considering the audio enhancement of an industrial, noisy soundscape there are a number of different approaches or concepts to choose from. This paper will focus solely on mobile technology, but when describing it, other approaches will also be mentioned. This is due to the fact that in order to make the mobile soundscape system work in the long run, context based applications must be constructed to help the mobile devices reduce the amount of energy and computing power that the application requires.

Co-worker Communication

One of the main aspects to consider when working with noisy environments is of course the noise, but also the systems ability to extract and present valuable and vital information originated from the context.

The first problem, namely the problem with noise can be bridged by equipping each worker with a set of noise-cancelling headphones. This solution only solves one part of the problem, and it also creates a problem. The user now lacks the social and awareness.

This problem and the problem with extracting valuable and vital information are far more difficult to find an optimal solution to. To do this the system have to analyse sounds created in the context and distinguish which sound is important to the user, what type of category the sound would fit in, if an artificial sound should be sent to the user, or if information could be added by altering the signal of importance. The list of possible scenarios is vast. To address the problem of letting important contextual information through to a user wearing noise cancelling headphones. The "Headphones with a sense" [6] system can be altered to fit the needs. This system detects people in the surrounding using IR. When a person approaches, the noise-cancelling function is turned off so that verbal communication is possible. The system does however not work well in very noisy environment. Instead of turning off the noise-cancelling function an additional communication channel between the two users can be established through Bluetooth or IR. When the communication is established a sound can notify the user that a co-worker is within talking vicinity. The use of Bluetooth in this scenario is to create a sphere of communication so that more than two co-workers can join a conversation. The use of IR can force sounds through Kansei interaction [10] which is used when a worker wants to hear sounds from far vicinity.
The Kansei interaction is based on unconscious human behaviour such as putting your hand behind your ears while trying to hear something carefully. The technology uses IR to sense the distance from the workers hands to the headphone. The location, object or co-worker is selected by facing the specified entity.

Devices and Connectivity
To use the "Headphones with a sense" and the enhancement technology described above each worker has to wear noise-cancelling headphones with mounted Bluetooth sensors, IR transceivers and microphones that are physically connected to a mobile device running protocols and supporting the system with battery. The device itself will be connected to the worksite wireless network through 802.11.

Location and Events
With each industrial worksite the use of sound will differ because of the workers different needs to retrieve contextual information through sound. When looking at the research performed by Alexanderson et al [2] the workers mainly used sound to:

- Identify things and places
- Notification about status of surrounding artefacts
- Maintain social awareness

These are all important aspects to consider when creating a soundscape for a specific industrial worksite.

To help the user with identification of location through sound, each specific location on a worksite can be given a specific soundmark that tells the user what the current context is.
The most important thing to consider is that sounds played for the user should map seamlessly with the real world and the users' visual input. If this mapping isn't established the user will lose a great deal of contextual awareness. The soundmarks should preferably be created so that a familiar worker directly feels that it makes sense and relate it to the real context. To make this system more comprehensible sounds from each particular location can

be recorded and stored in a database. When the user enters the specified area the device retrieves the stored sound and plays it.

Customized sounds
When creating the soundscape all static sounds of the workplace should be recorded. If the system knows every sound that can occur, it can choose to ignore static background noise and listen after specific event. If such an event takes place the system can sense it and play the appropriate signal corresponding to the event or a recorded version of the event. It is this part that the user should be able to customize. Let's say that there is a new worker on the site and he has never been there before. He would certainly gain from the ability to choose whether the information should be by recorded keynotes, soundmarks and signals from the real context or by selected sounds that he understands and feel comfortable with.

Hazard tagging
Another concept of soundscape augmentation is the "Hazard tagging" that is an idea originating from the project "A New Sense of Place" [9]. It refers to a digitally stored object with information such as speech or informative sound about a specific place specified by coordinates or IR-tags. The information is stored in a central database and can be accessed through IR or Bluetooth vicinity. This concept can be widely used in the industrial soundscape to create extensive information about a specific location.

If something goes wrong or if new information is discovered by a specific worker, he should be able to set a "Hazard tag" such as an alarm signal or a specific repair signal to a specific object or location. This would be done by some kind of interaction with the handheld device.

3. Discussion
After studying articles and papers written by researchers all over the world, it's clear that this kind of technology is on the rise, the ability to customize how you want the world to be interpreted, without noise.

With this information at hand it stands clear that each area where the virtual soundscape is to be implemented in has to be thoroughly inspected and each eventuality of event considered. The system works well in a closed environment where static sounds like engines or other kind of machines is known to the system. The goal of this system is to enhance relevant information and not to exclude the user from gaining valuable information from the environment.

4. References

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