Sensory Threads: Perceiving the Imperceptible

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Abstract. We perceive just a tiny proportion of the phenomena that surround us everyday. Sensory Threads is a technologically mediated collective sensing expedition which allows people to explore imperceptible phenomena in the world around them. We present a description of the technical system and reflect on our design decisions. Key questions we are concerned with centre around how to represent imperceptible phenomena in real time both inside a building, and outside, and how to engender a sense of collective engagement. We also consider the value created through the multi-disciplinary work involved in constructing such an experience.

Keywords. Sensing, Collective, Interaction, Expedition, Tangible, Wireless, Soundscape, Mobile, Resonance.

1. Introduction

As we move through the world in which we live we are surrounded by a myriad of imperceptible phenomena such as high and low frequency sound and non-visible light. The Sensory Threads project considers our bodies to be a vital part of this environment. Using environmental and body sensing technologies Sensory Threads allows us to explore the imperceptible, and immerse ourselves in the complex patterns and rhythms that occur in world around us.

Sensory Threads comprises two elements: firstly a group expedition through a city in which participants are augmented with wearable technology and real-time audio feedback which creates a communally engaging experience of imperceptible phenomena; Secondly, a gallery based installation which allows for the replay of sensory experiences using a combination of tactile feedback, visuals and audio. In this paper we first describe the design of the group expedition and key design challenges. We then describe the gallery based interaction with real and recorded sensory data, and finally reflect on the design process involved in the project as a whole.

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2. Expedition

In the expedition, groups of four people are sent on an hour long mission to explore the imperceptible city using a set of wearable sensing devices. In contrast to other technologically mediated urban experiences such as pervasive games (e.g. Uncle Roy All Around You [1]) and urban sensing experiences such as Snout [2], Sensory Threads focuses on the collective experience of a group of explorers experiencing the city in real time. There is no end ‘goal’ such as finding a certain location, and the motivation is less about raising awareness of environmental issues, and more on creating a novel and engaging collective experience. Indeed, Sensory Threads is a development of the Snout project and seeks to explore the collective aspects of exploration and perception.

In the expedition, each person wears a device which records data from one type of sensor (heart rate, light, sound, spatial density). Each person’s individual sensor stream is sent to a ‘heart’ computer carried by one of the explorers. The four sensor streams are then used as input to an interactive soundscape which is produced by the heart computer. Participants listen to the soundcape using wireless headphones as they move around the city. The heart computer also records the location of the explorers using GPS which allows the system to track of where the explorers have been. Each sensor influences a different aspect of the generated soundscape. As discussed later in this paper, this creates a complex group dynamic, where participants engage with their own actions in the space as well as the communal sensing experience.

3. The Sensors

In this section we describe the technical configuration of the sensors carried by each of the explorers which are mounted on specially made costumes (see Figure 1). Figure 1a illustrates one of the hats worn by explorers which includes a sensor in the top, and technology in the bag. Figure 1b illustrates sensors which are attached to an explorer’s body, and connected to technology in the shoulder bag. Each bag contains a version of the Snout Sensing Platform [2], a specially designed Linux based hardware sensing platform for participatory sensing illustrated in Figure 2. In the rest of this section we explain how the different pieces of technology interact

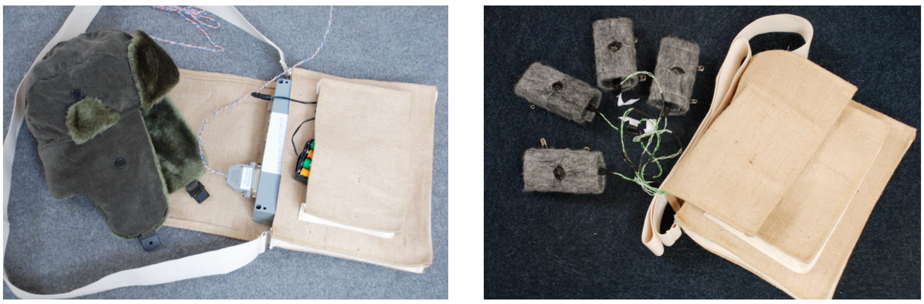

Figure 1a. Sensory Threads hat and bag, **1b**. Sensors and bag

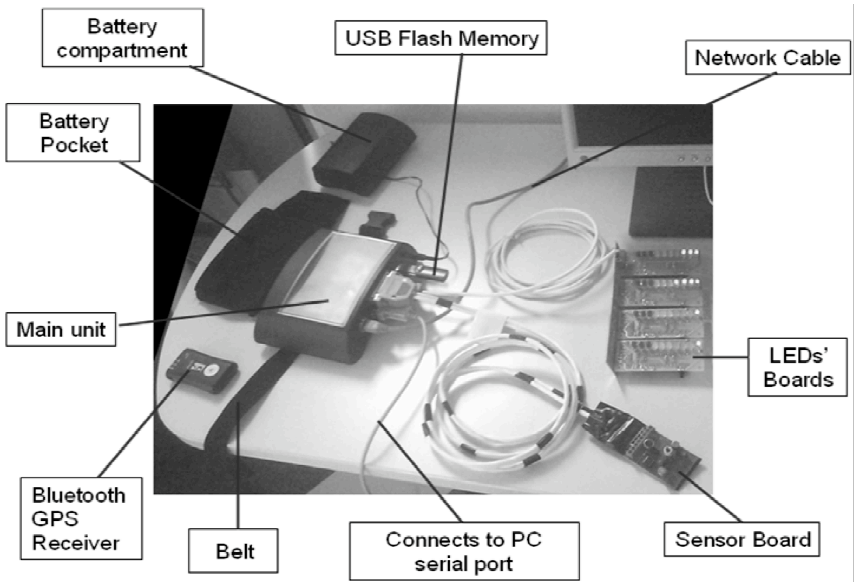

Figure 2. Snout sensing platform.

In the expedition, one explorer is designated the heart, and wears a heart rate monitoring strap as well as carrying the 'heart' computer - a small netbook style laptop in a their shoulder bag. The heartbeat of a person is intimately linked to their speed of movement, and the terrain in which they are moving, so creates an interesting bridge between the body and the environment in which it is located.

The heart computer records the sensor data from each participant, and creates the soundscape which is relayed to the explorers via wireless headphones. This creates a feedback loop whereby explorers are able to move around and hear how their actions change the soundscape. The heart computer also records the position of the group of explorers using a GPS device which it wirelessly transmits in real time with the sensor data to a server for use in the installation experience discussed later.

One of the other explorers has a noise meter on their hat (figure 1a). This detects ambient noise levels around the explorer. This is affected by many things, such as crowds, traffic, or the conversation the other explorers.

The third explorer has a light meter mounted on their hat (figure 1a) which detects levels of light falling upon the costume. This is affected by people passing by, changes in the weather, by being covered by one of the explorers, overhanging buildings and shadows, and also by changes in posture of the explorer, which may alter the shadowing of the sun or other light sources.

Finally, the fourth explorer attaches four ultrasound rangefinders to the front, left, right and back of their clothes (figure 1b). These detect the distance of the closest object in each direction. This allows detection of how cramped a space the person is exploring, or can provide a rough estimate of the density of a crowd surrounding them. It is also interesting in that it gives a very directional signal, which can differentiate between situations such as being in a narrow empty corridor (left and right sensors give close readings), and walking amongst a group of people in single file (front and back sensors give close readings).

4. Soundscape

People taking part in the Sensory Threads expedition hear an evolving, interactive soundscape which aims to create a collective experience in which participants perceive the imperceptible around them and the others in their group. The soundscape is generated in realtime using SuperCollider [3], an audio synthesis system running on the low power heart netbook.

Designing a collectively engaging soundscape involves the careful balancing of intuitiveness, responsiveness, attractiveness, and stimulation. In the rest of this section we first outline, and then discuss in more detail, a number of design 'tensions' which arose as we attempted to design a soundscape through which participants could perceive the imperceptible as an individual and a group:

Sense of identity versus collective integration. In a collectively engaging experience it is important to be able to appreciate how your actions relate to the imperceptible phenomena, and contribute to the collectively emerging shared soundscape.

Sonification versus aesthetic appeal. Conventional data sonification (see [4] for a discussion) focuses on making clear audio representations of data and typically pays little attention to the aesthetic quality of the sounds produced, whereas interactive sound art focuses on the aesthetic, typically at the expense of the representational power of audio. We strove to design and aesthetically pleasing audio representation of the data.

Recognizability versus listener fatigue. In longitudinal audio experiences there is a tension between creating sounds which participants can easily recognise and yet do not become irritating or ignored over the period of the experience. Moreover, participants' movements changes to the data readings, yet, as the readings are of imperceptible phenomena, it may be difficult for participants to grasp the connection between their actions and the phenomena that is represented.

Addressing these tensions has involved a number of research and design challenges in iteratively creating an interactive soundscape driven by four real-time wearable environmental sensor data streams as outlined below.

First, the sense of identity and collective integration is facilitated by using not just different sounds for each data stream, but also different modulations of the sounds. We used mappings of sensor data to: pitch, pulse, filter, and density of sound. These were selected and carefully refined through the iterative process to create a soundscape in which different sensor data sounds complemented each other, yet gave participants a sense of their own sensors' contribution. This sense of identity in the collective experience contributes to the emergence of mutual engagement [5] between the participants as they explore the imperceptible.

A key issue arose in the development of the soundscapes with respect to sense of identity: the impact of sensor responsiveness. For participants to gain a sense of identity with their sensor in the collective soundscape, they need to be able to appreciate how physical changes they make affect the sensor. Therefore, sensors are required whose readings may change rapidly, and the environment needs to contain sufficient potential for sensor reading change for the participants to appreciate the effect of their actions. For example, benzine sensors are probably not suitable for the collective audio environment as there may be few sources of benzine in the environment, and changes in sensor readings will be quite small. On the other hand, ultraviolet light sensors in an urban night time environment may be more appropriate as they will respond rapidly to changes in lighting e.g. streetlights, internal lighting, vehicle lighting.

Second, we paid particular attention to the overall aesthetic of the piece whilst ensuring that each data stream was directly mapped to a sound (as discussed in the first point). The overall aesthetic is ambient electronica with sounds spread across the audio spectrum to create a balanced soundscape. We worked hard to move away from jarring sounds (e.g. noise generators/ sine waves) to create a softer, less confrontational soundscape. A further consideration with selection of sounds was the mapping from sensor type to sound. For instance, it would be tempting to map a noise sensor to the volume of static noise in the soundscape, but whilst this is a literal mapping, it may be confusing as the louder the environment becomes, the louder the static noise in the soundscape would be. Instead, we argue for selecting sounds and modulations that somehow capture the essence of the phenomena being sensed. For instance, we may map sonar readings (proximal density) to intensity of a sound to create a sense of audio claustrophobia when the participants are in a densely populated area. In this way we heighten the perception of the participant by augmenting their usual senses with our audio representations of imperceptible phenomena.

Thirdly, we expect participants may be involved with the soundcape for up to one hour and so introduced some temporal development into the audio to reduce listener fatigue and boredom. In particular, we introduced a generative element to the pitch of one of the sounds. This particular sound is a medium to high pitch tone whose onset is controlled by the value of the data it represents - the higher the data reading, the faster the tone is triggered. Over time a motif is generatively evolved to replace the single tone whilst the onset of the motif is still triggered by the data. In this way we have two dimensions of representation in one sound stream: a primary representation of the sensory data (onset), and a secondary representation of the time elapsed since the experience started (increasingly complex musical motif). There are clearly issues here with selecting appropriate primary and secondary representations which we will investigate further.

Finally, as discussed in the next section, the soundscape will also be used as part of the playback of recorded sensory expeditions through auditory and tactile representations of the recorded imperceptible phenomena. This raises issues of how the piece should develop, or not, over time (our third design tension) when people playback and navigate through the experience. For example, if people navigate directly to the end of the expedition, it is not clear whether the sounds heard should be the sounds heard by the participants at the original time of the expedition, or whether the secondary representations should be relative to the time spent in playback mode. In effect, we are asking whether the sensory augmentation is always live (and so relative to the participant), or whether in playback the augmentation attempts to recreate the recorded experience. This is currently an open issue that we are investigating through our ongoing studies.

5. Playback Interface

The second part of Sensory Threads is the gallery located experience interface referred to as the *Rumbler*. This has two purposes: firstly, to relay *live* expedition experiences occurring outdoors into a gallery; and secondly, to provide a *playback* interface for journeying through time and space to explore the multi-dimensional reservoir of sensory data recorded by previous expeditions. The design uses a combination of sound, visuals and touch to create a multi-sensory representation of explorers' imperceptible experiences.

The core of the physical installation is the Rumbler - a large box made from a tea crate (3 feet tall). This box has a video screen on the top, which shows a map (illustrated in figure 3a), displaying the position currently being explored. Figure 3b illustrates the internal construction of the playback device which is encased in a tea crate during use. The box also contains a large subwoofer speaker. This is used to create very low frequency sounds which make the box resonate to create a nuanced set of vibrations when the box is touched. In this way we transform imperceptible phenomena into vibrations that are sensed by the ears (sound), and also by the body (through the resonating tea chest).This large shaking and booming box also acts to attract people's attention to the installation. Four smaller resonators are also part of the installation. These are made from hacked and repurposed computer game control pads with variable rumble support. Each of these mini-resonators represents one sensor's readings through vibration providing a physical connection to the imperceptible experiences of one explorer. Finally, a set of speakers in the exhibition space provide an audio play-back of the soundscape itself.

Figure 3a. Map display.

3b. Internals of the Rumbler.

In live mode, the box is non-interactive; the displayed map moves to the position of the latest sensor readings (which are displayed as dots on the map), the large and small resonators can be felt to respond to the sensor readings, and the soundscape can be heard as the explorers hear it.

In playback mode, the box itself becomes an interaction device. Tilting the box causes the map to move in the direction of the tilting. This allows for the exploration of new paths through the previously recorded sensor readings. The large box means that multiple people can tilt it at once engendering a new form of collective exploration of the imperceptible. Moreover, in order to feel the individual sensor experiences from the miniature resonators, two or more people must collaborate, with one tilting the large resonator whilst the other feels the mini-resonator. This is designed to encourage groups of multiple people to explore the sensor data together, in a manner analogous to the outdoor explorers.

6. Summary

Sensory Threads makes the imperceptible perceptible and creates a collective sensing experience for groups of participants. Through our design process a highly inter-disciplinary team from several university departments worked in tandem with an external arts organization - Proboscis. Members of Proboscis were the primary drivers of the conceptual side of the project and also created the physical designs of the costumes and interfaces. This interaction generated large amounts of intellectual and social capital which we will disseminate and develop through exhibitions and public expeditions. Our further work will explore our understanding and evaluation of these new forms of technologically mediated social expeditions with a view to enticing alternate views on the world beyond our perception.

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