Ground Me! An Interactive Sound Art Installation

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ABSTRACT
This paper describes the design, implementation and outcome of *Ground Me!*, an interactive sound installation set up in the Sonic Lab of the Sonic Arts Research Centre. The site-specific interactive installation consists of multiple copper poles hanging from the Sonic Lab's ceiling panels, which trigger samples of electricity sounds when grounded through the visitor's' body to the space's metallic floor.

Keywords
Interactive sound installation, body impedance, skin conductivity, site-specific sound installation, human network, Sonic Lab, Arduino.

1. INTRODUCTION
Ground Me! is an interactive sound installation that was held in the Sonic Lab of the Sonic Arts Research Centre (SARC) at Queen's University Belfast on May 19, 2008. The installation addressed three main topics of interest of the author: site-specific art installations, skin conductivity and body impedance for interaction, and visitors' behavior with electricity and human contact.

Figure 1. Ground Me! at the Sonic Lab

1.1 Site-Specific Interactive Installations
Site-specific installations are meant to exist in a particular location, where the interaction is with a specific building, landscape or architecture. What makes site-specific installations particularly interesting is the ability of the artist to exploit the characteristics and uniqueness of a specific place. This sometimes involves the transformation of a space, or giving it a different and creative use than the one it was built or meant for. Adding interaction to a site-specific installation provides a whole new layer of possibilities that can explore the space with the aid of other disciplines, such as science or technology.

1.2 Working with the Sonic Lab
The Sonic Laboratory is a unique multi-functional concert hall / research laboratory in Belfast[1], Northern Ireland. This site was selected for an interactive sound installation due to its technical versatility and sonic spacialization. One of the key elements of the Sonic Lab is that as the audience enters the lab at ground floor level, they walk out onto an acoustically transparent modular grid floor, suspended 4m above the structural floor of the lab located at lower ground floor level, as can be seen in Figure 2.

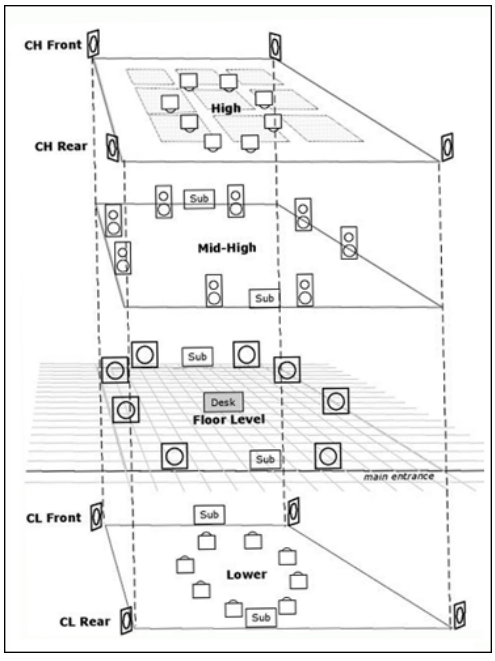

Figure 2. Diagram of SARC's Sonic Laboratory

Besides the features described above, the Sonic Lab has another unique characteristic that had not been exploited for artistic purposes; the grid floor is made of a metallic material which is

[1] http://www.sarc.qub.ac.uk/main.php?page=building&bID=1 [accessed 01 February, 2010]

conductive and connected to the ground of the venue's electrical circuit. This makes the Sonic Lab an exceptional location for connecting circuits that can literally ground to the floor.

1.3 Body Impedance and Skin Conductivity

The human body conducts electricity; an attribute that has been exploited for quite some time to create electronic systems that react and respond to the human body when connected to a circuit [1]. Perhaps the most popular example within the NIME community is *The CrackleBox,* created in 1975 by Michael Waisvisz'. This "portable self-powered alternative 'keyboard' analog audio synthesizer with inbuilt loudspeaker" [2] has 6 conductive terminals that are used to generate sounds depending on the different connections and body impedance of the performer. One of the most interesting aspects of the *CrackleBox* is that two or more performers can use it at the same time by touching their hands or other body parts.

The amount of current that flows when a person is connected to a voltage source will depend on the applied voltage and the person's body impedance. This varies between each human being, and depends on the surface of contact, the person's body fat, the pressure applied in the contact area and moisture (body sweat) [3]. Nevertheless, values for human body impedance are normally in the order of 10's of KΩ to several MΩ.

1.4 Social Behavior

Any international visitor coming to the UK will shortly learn social etiquettes inherent to the local customs. An interesting one, at least for Latin cultures, is regarding physical contact. This, as explained to the outsider, should be kept to a minimum and "is considered taboo" [4] (page 63).

Therefore, the third aim of *Ground Me!* is to create an interactive installation where people would be required to hold hands with other visitors, creating different human circuits that would generate sounds according to these connections. The idea behind this concept is to create a minor feeling of unease and nervousness that would intensify the reaction to the sounds triggered by the connections.

Figure 3. Copper pole used in the installation

2. IMPLEMENTATION

In order to use the Sonic Lab's grid floor as ground of an electrical circuit, the visitors should have access to a positive end of the circuit, to which they can connect and close the circuit by touching ground. Hanging 16 copper poles from the ceiling panels, which people could touch, was the chosen solution for this. An example of a cooper pole used in the installations is shown in Figure 3.

As an aesthetic and metaphoric enhancement, 4 chairs were hanged from the ceiling. Two of which were connected to the electrical ground to allow visitors not only to connect to the floor, but also to these chairs to trigger sounds (see Figure 1).

2.1 Hardware, Firmware and Software

The Arduino open-source electronics prototyping platform[2] was used to interface the sensors with the computer used for sound generation. To avoid any risk of electrical shock, all the electronic system should run off batteries, assuring that there is no physical connection between the body and the mains power. For this reason, the communication between the Arduino and the computer was done using Bluetooth technology, but it could have also been accomplished by a wired connection with optical isolation.

For each pole, a simple voltage divider circuit, shown in Figure 4, was implemented to read the voltage variations at the person's level into the Arduino analog inputs. As explained in section 1.3, the value captured by the micro-controller will depend on the physical properties of the visitor and the quality of the connection to the pole and ground (surface of contact), hence the value read by the analog input will be a continuous variable voltage.

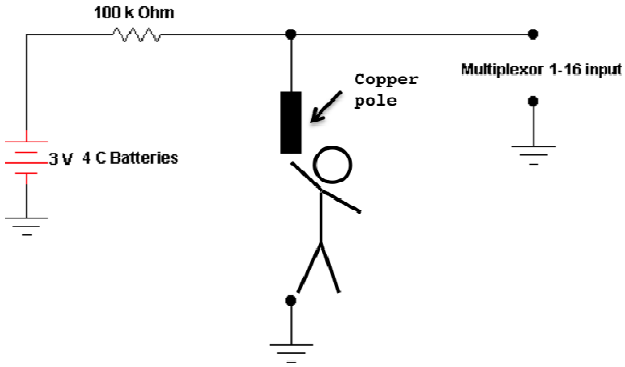

Figure 4. Electrical circuit used to measure people's impedance

In order to expand the 6 analog inputs of the BT Arduino, two 74HC4051 multiplexors were used to obtain 16 analog inputs. This was achieved by writing a specific firmware that would sample the 16 inputs at 100Hz and send them through the serial port to the computer running Max/MSP[3] software for sound generation. For this installation, the sound generation was done using a Digidesign DIGI002[4] audio interface, to obtain 8 independent audio outputs.

2.2 Hacking into the Sonic Lab's System

The Sonic Lab allows great versatility to make connections to different male and female XLR terminals positioned in several locations inside the lab. All these terminals are copied in the main patch panel situated in a neighboring corridor. This was the place selected to install the electronics and computer, as shown in Figure 5.

[2] www.arduino.cc [accessed 01 February, 2010]

[3] www.cycling74.com [accessed 01 February, 2010]

[4] www.digidesign.com [accessed 01 February, 2010]

Due to the significant size of cables and distances involved in the installation, microphone cables were used to hang and at the same time connect to the copper poles via crocodile cables.

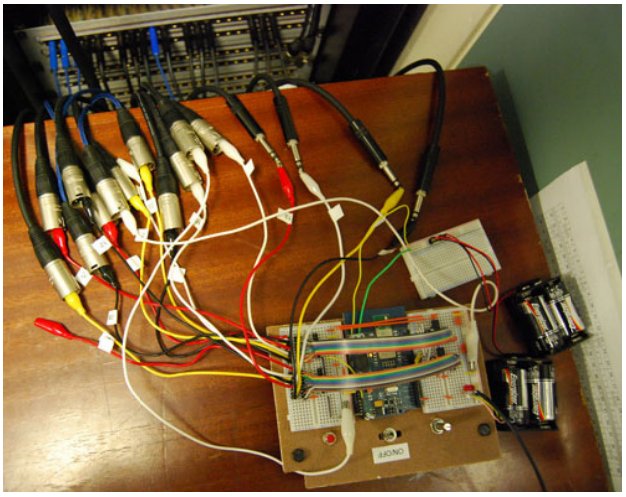

Figure 5. Arduino connections to the Sonic Lab's patch panel

Figure 6 shows a diagram of the whole system, with both the sensor and audio signal flow.

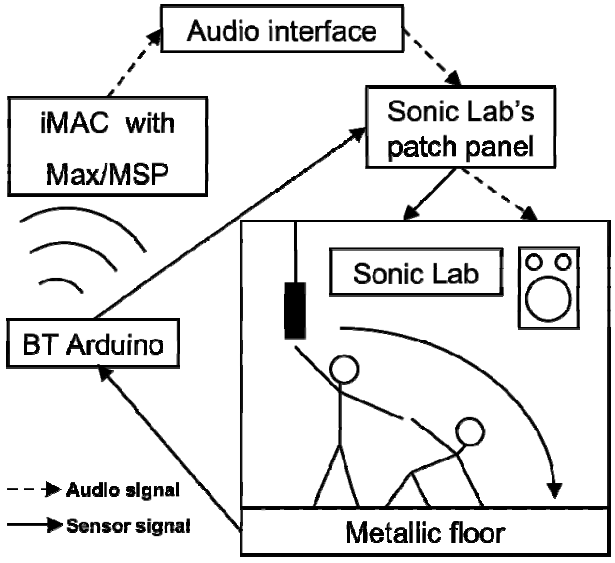

Figure 6. Signal flow diagram for Ground Me!

2.3 Sound Design

In order to enhance the concept of using the human body as part of an electrical circuit, several samples of recorded electricity sounds, such as electrical shocks, sparks and voltage zaps were selected and edited. These were triggered when the visitors grounded any of the copper poles, having a different sample for each pole. When a person grounded a particular pole, the sound level of the sample loop would increase proportionally to the conductance of the human connection. In other words, a better conductivity gave a louder electricity sound.

The audio loops generated by Max/MSP were connected to different outputs of the soundcard, which were connected to the main mixer in the Sonic Lab. This allowed 8 different layers of sounds, which were diffused into 8 groups of speakers of the multichannel space.

Even though the initial option was to have the Sonic Lab in silence if no pole was triggered, during the installation process, it was noticed that the Arduino analog inputs presented a small fluctuation in their voltage reading (0-20mV), which was different for each input. This could be due to the presence of induced noise in the circuit, or to small variations in the ground level. Nonetheless, when connected to the sample loops, the apparent random variations created a remarkable ambient sound in the Sonic Lab, creating an always changing layer of electrical sounds. This was utilized as a default or stand-by environment for the installation.

It is noteworthy to mention that in order to create proper interaction causality (i.e, a clear sonic reaction to touching the pole), it was important to have a significant level difference between the triggered sound and the ambient level when a pole was grounded.

3. OUTCOME

3.1 Interaction

Without giving any instructions other than what the title suggests, visitors found their way to play with the sound installation. Intuition moved them to take each other's hand in order to make the ground connection. After a few minutes, they started to experiment different ways of interaction in various and creative behaviors.

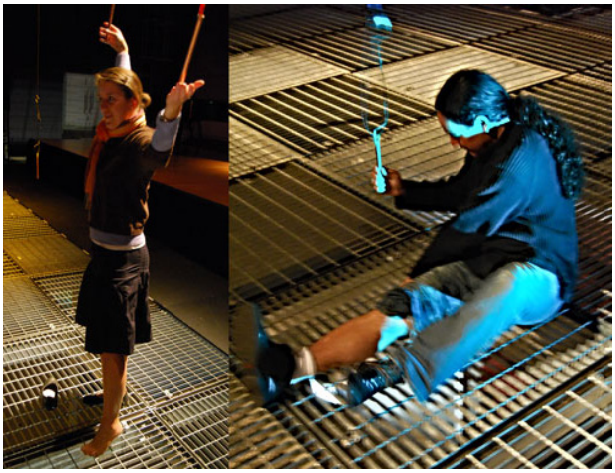

Figure 7. Visitors making ground connection with barefoot (left) and calf (right)

Some poles were intentionally placed at a height that would require two or more people to hold hands or touch each other in order to ground the circuit. However, a number of visitors discovered that taking their shoes off would also allow them to reach ground (see Figure 7 (left)). Others experimented making connections with different parts of their body, as can be seen in Figure 7 (right), where a person is connecting to ground using his calf. People also tried different interconnections of the poles, trying serial and parallel connections, or connecting various poles to a single intersection (see Figure 8).

A very interesting outcome, was a spontaneous music jam session that began when several visitors where at the installation at the same time.

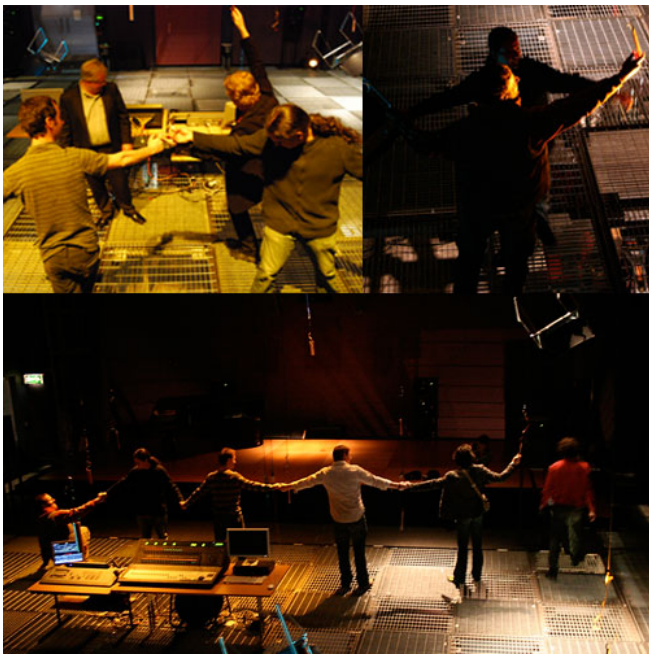

Figure 8. Multiple connection configurations

3.2 Feedback

After experiencing the installation in the Sonic Lab, the visitors were asked to leave a comment about *Ground Me!*. Among the multiple comments, which were all positive, the words 'playful' and 'fun' were recurrent.

Several people asked if the sounds were actually the sound of electricity flowing through their bodies, which indicates that the sound design created the effect of having an electrostatic discharge in the audience. Moreover, a number of visitors claimed that they felt the electric shock when they first grounded a pole. This was only a psychosomatic effect, since the current flow was too small to be perceived. It could be related to the effect that Michel Chion defines as *synchresis*, which is a neologism that merges the words synchronism and synthesis. *Synchresis* is defined as the spontaneous psycho-physiological reflex of the human nervous system to perceive as one a same phenomenon that manifests visually and sonically at the same time [5].

4. CONCLUSIONS AND FUTURE WORK

Visitors had an excellent response to the installation, playing with different configurations for extended periods of time, and giving both positive and valuable feedback.

One of the most important enhancements that could be made to *Ground Me!,* is to make a better use of the variety of interconnections possible between people and ground. Even though the conductance to audio level correlation proved to create a proper causality effect, this was not enough when people experimented with different configurations (see Figure 8). In other words, there was only a slight difference in the sound generated when two or five people were connected in serial, for example. The system had a better response when people played with the amount of contact surface at either ends of the connection. There are two solutions that could improve this issue. First, a different proportionality relationship could be used to map conductance to sound level (e.g. exponential). Second, the system could change or modify other properties of the sound being played when the conductance crosses a certain threshold. This would involve making a series of measurements regarding networks of body impedances in different configurations and body conditions to calibrate the system.

Ground Me! showed an interesting potential for group performances, where each pole could be mapped to different musical sounds and used for group interpretations. This suggests the use of the system for a choreographed interactive performance.

Finally, and a on a technical level, the use of a wired opto-isolated communication between the micro-controller and computer is suggested to avoid any disruptions caused by Bluetooth instability.

5. DOCUMENTATION

The installation was documented and all audiovisual material is available online at the Music Sensors and Emotion website[5].

6. ACKNOLEWDEMENTS

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7. REFERENCES

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