

ELEVATOR PITCH

Final project report for Interactive Sonic Arts

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This report covers the design process and iterations of my final project for interactive sonic arts "elevator pitch".

2 From instrument to installation

1 Inspiration

In 1964 Pask proposed a cybernetic theater. He envisioned a performance where performers and audience are entangled through feedback loops. According to Pickering, introducing connected systems to performances creates its own dynamics - a performative level of 'doing rather than knowing.' [3]

It is my general goal to provide such an environment with my interactive sonic installation.

One piece that I took inspiration from is not explicitly part of the realm of sonic arts. In 2013, art studio Random International exhibited its installation Rain Room at New York's MoMa. ¹ Showers are installed on the ceiling of this room and connected to 3D cameras that can measure the exact position of a person on the floor. A microcomputer ensures that it is constantly raining except directly over the visitor.

As a computer scientist this deeply resonates with my idea of how to design a computer's role in the life of people. Computers should react to a person's presence with adjusting the environment, it is not the person that needs to get active. Interaction between both parties is hidden and only observable by its consequences. The user should feel a natural enhancement of their own action instead of a separate action by the computer. This is the level of cohesion that I would like to achieve in later implementations.

If you ask me about my personal motivation for this project, for me this is a chance to explore sonic feedback design. I hope to take clues from this experiment for my future journey in the context of HCI.

During an elevator ride people tend to distribute themselves according to the relationship they have with each other. This kind of behaviour is not exclusive to elevators but happens in any public space where multiple people come together. But especially in elevators the personal space defined by those relationships often gets violated in an elevator. [1] This tense environment can be turned into sound: So my initial idea was to transform the elevator into a multi-user instrument. Such an instrument can be defined by user-number, user-role flexibility and Interdependencies. [2]

The elevator is played by a flexible number of people, depending on its transportation limit. Although it is interesting in particular if there is a meaningful mapping for only one person. Each visitor has the same role in playing the instrument by a many-to-one-mapping. This is because a sensor measures the location of each passenger. I expect a lot of interdependencies happening between the passengers, since to not violate the personal space people try to balance the available space. For example we can observe that if only one person enters an elevator, everyone else is moving a bit too. My first approach was a many-to-one-mapping should respond to this as follows: The location of passengers is turned into a complete graph with weighted distances as an internal representation. The algorithm then computes a metric of how evenly spaced the vertices are in the graph. The metric is then used to distort the harmonics of a looping music track that is played in the elevator.

¹ [Smithsonian Magazine, Rain Room](#)

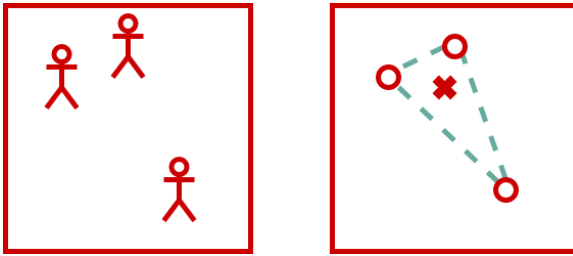


Figure 1: Left: visitors on the square field, Right: translated points and centroid of the convex polygon

There is no specific distinction between audience and performers in my project. Each person entering the installation, a square field, becomes a 'passenger'. There is no knowledge required and besides a warning for video-recording the installation itself does not aim to raise any expectations. I want the passengers to be able to hear the tension that comes with violation of personal space and I expect a resulting interdependency between players and their music from that too. At this point I realized that the primary feature of my work is not the transformation of actions to sound, but how the system itself responds to the behaviour of the passengers and the social context in which this behaviour is embedded. This means I'm not trying to design an instrument but an installation. I'll therefore have to treat it differently in my analysis. This does not mean that the concept introduced by [2] are useless for the design of the installation but that I have to further extend my considerations with schemes meant for installations.

Digital instruments feature a mapping from a physical gesture to a sound. An action is transformed in multiple transformation layers to a sonic feedback. It is important to note, that the instrumentalist will have a certain intention connected to their gestures. In an interactive sonic installation the visitor can't be treated as an instrumentalist, because there is no prevailing intention involved. This is why Schacher favors for an ecological view instead of the classic action - perception loop. [4]

3 Space, Context and Users

The ecological view adds non-technical dimensions that are related the socio-cultural context

and the perceptual and cognitive aspects to the analysis of the existing action - perception loop. [4] The socio-cultural context of Elevator Pitch is derived from it's setting. My installation is designed for intermediate rooms like hallways, elevators and floors which do primarily exist to create a pathway between two places that people want to go to. Of course, there are also vast differences between those places. In a hallway everyone decides on their own speed. In contrast to an elevator where multiple people get cramped into a tiny space for a fixed period of time. The time can be different between the people depending on the selected destination but there are clear procedures and signals that formalise the ride. In contrast to the floor the elevator is already a very controlled environment.

Even though the elevator features very interesting conditions for social behaviour and was the initial motivation for this installation it also comes with impracticalities. An elevator is a small space that requires good image detection to separate the individuals but also comes with security and operational regulations that make it hard to install a camera and sound system. Because I aim for the social context of a 'between space' where people are just passing by on their way to very different destinations I can also settle for a hallway as an alternative. In this regard it should be similar to the elevator, but with the option to easily install a camera and play audio. It also changes the presence of personal space. Because of the openness personal space does not get violated easily instead personal space becomes more of a choice revealing which people choose to be close to each other.

4 Final Technical Setup

For the course Interactive Sonic Arts I created a version of Elevator Pitch designed for an open atrium in one of our buildings. One camera is observing a square field on the floor. I used my android smartphone with the "DroidCam" application as a video camera. It was installed on a microphone stand on the second level of the atrium facing down on the floor of the first level. The smartphone application makes the videostream accessible on the network where it gets picked up by my laptop on the first level. There the locations of the visitors are translated to coordinates

respective to the upper left corner of the observed area by making use of the OpenCV library. A python script computes three measures that are explained in detail below and send them to a pure data sketch via network sockets that uses the measures for sound transformations. The sound output of pure data is then played by an attached speaker.

5 Gesture Space

The atrium is an interesting setting and different to a hallway in some ways. The space is traversable from three different directions creating nine different enter-exit combinations for an individual. Attached to the route is also the mode of traversal: Individuals can go straight from site to site as well as wandering through the space on an inefficient route. The speed at which the space is traversed may vary as well. One side is obstructed by a water fall that is currently out of service. The obstructed site also features benches where people sit down from time to time. We can already derive two different types of behaviour from this that are dominant in the setting: Resting and Traversing. For individuals, these two possibilities of using the space, the different combinations for traversing the space and the mode of traversal form the native gesture space of my sonic installation. When multiple people use the space the gesture space expands to the social interactions between the people in the space eg. approaching each other, forming a group or distancing to each other.

6 Interaction Literacy

Schacher outlines that there is a need for inherent richness of the mapping in interactive sonic installations. This is because we can't rely on the visitors intention to "play" the installation like an instrumentalist and invest in a high learning curve. [4] The interaction itself must be interesting enough on it's own to convince the visitor to further explore the installation. Therefore a good design should not only take the gesture space into account but also the intentionality of the gesture, the visitor attitude and behaviour patterns.

Interaction literacy means to make design choices that improve the learning process. Those can include the immediateness, adaptability of

the system and the adaptation of the visitor. [4] In my installation there are three dominant transformations: Energy transformation, distribution transformation and spatial transformation. All transformations provide immediate feedback for certain types of interactions in the space which gives those actions a certain "directedness" through the sonic feedback loop. It also adapts to social behaviour between multiple visitors. In contrast to the energy and spatial transformation the distribution transformation also features a sonic aspect that might lead the visitor to adapt to a task that they perceive as being part of the interaction proposed by the installation. I'll further explain the different transformation type and how they connect with interaction literacy in detail below.

6.1 Energy transformation

The energy transformation provides completely different sonic responses to resting and traversing.

The energy transformation is defined by the change of the joint centroid. To calculate the joint centroid each visitor's position is conceived as a vertex of a two-dimensional convex shape. For n points in $P = \{x_1, x_2, \dots, x_n \in \mathbb{R}^2\}$ we can calculate the centroid of the polygon:

$$c = \frac{x_1 + x_2 + \dots + x_n}{n}$$

The centroid is recorded every 200ms. The distance between the centroid and the last recorded centroid defines the energy level. The energy level is then applied to a bandpass filter in combination with a white noise generator where it increases or decreases the bandpass defining frequency. I already used this filter in the third assignment for interactive sonic arts that focused on noise. In result a low energy level which means a slow change of the centroid will result in a low pitched wind sound. A high energy level which means a fast change of the centroid will result in a high pitched wind sound. This is a natural mapping in terms of human perception since the energy of physical movement is mapped to the sound of moving air. Those fluctuations that characterise a sound are even referred to as motion when it comes to defining a sonic object. [5] To include the psychological aspect of how the sound

is perceived is also part of the ecological view on a sonic installation.

It is also important to note, that the individual loses freedom of control in gradients when others join in the space. In this case the centroid is dependent on the movement of multiple visitors. If the visitors coordinate their behaviour, which can be understood as a social gesture, the system responds again with the before learned sonic transformation. But this is a special case. This feature might be best explorable when only two visitors are in the field but after this number visitors most likely will have lost their control over the energy transformation. At this stage the two other transformation will be more prominent and provide feedback to the social interaction happening in the space.

6.2 Distribution transformation

To take into account how the visitors are distributed in the space I introduce another measure: The minimal distance deviation d is computed by making use of the minimal distance from one visitor to all the other visitors. Each visitor may have a different minimal distance. The difference between the shortest and longest minimal distance among the visitors directly influences the minimal distance deviation.

$$d = 1 - \frac{\min \bigcup_{i,j \in [1,n]} (\|x_i x_j\| | i \neq j)}{\max \bigcup_{i,j \in [1,n]} (\|x_i x_j\| | i \neq j)}$$

One mathematical quality of the deviation is that it is only equal to zero if and only if the polygon formed by the visitors is regular or in other words the polygon approaches a circle with increasing number of visitors. For more unbalanced distances the deviation approaches one. In the case of only two visitors the deviation is always equal to one and will have no effect.

The deviation is mapped to a wah-wah effect that is added to a low-frequency sine wave which sounds similar to the sound you hear next to power lines with high voltage. As mentioned before I want the visitors to be able to feel the tension that is created through their space inbetween. I thought that such a tone that is connected to electric voltage would be a fitting mapping choice. Balanced distribution map to no wah-wah in the sound output where as unbalanced distributions will have a wah-wah effect. This adds an additional perceivable quality that is only present if

more than two visitors are in the square field. This aims to reward curiosity and invite the visitors to further explore the installation. It also requires a form of coordination between multiple people since some aspects of the mapping are not controllable on an individual level. It also implies a task for the visitors. The wah-wah effect is supposed to play with the impression of purity and unpurity. I expect the visitors to desire the pure transformation of the sound which would map to a balanced distribution. I chose this transformation because in my understanding this is a metaphor for social equality. If everyone distance themselves equally they hide the relationships that were revealed by them before through the space they had inbetween. I'm not trying to argue here that relationships are a bad thing, but we do have to release them from time to time to make space for the possibilities of bonding with strangers. If people that were strangers before choose to cooperate with each other to interact with the installation this also results in them getting aware of each other.

I will continue on this hypothesis and if it reveals to be true in the observations section.

6.3 Spatial transformation

The spatial transformation influences the loudness of the sound that is also effected by the wah-wah effect through the distribution transformation. Both transformations only apply if more than three people are in the space.

To evaluate the loudness every position of a visitor is treated as a corner of a polygon. The corners are linked in such a way that no edge of the polygon crosses another edge. The resulting area of the polygon is then equal to the convex hull of all position vectors of the visitors. The area is then mapped to the loudness on a logarithmic scale.

7 Public Presentations

I planned three public presentations. Two already held at York University in the beginning of December. The first one during the final presentation of the interactive sonic arts course and another one during the Digital Media winter exhibition.

After I return to Germany, I also want to present this piece during the winter work show

in February at my German home university, Bauhaus-Universität Weimar, in cooperation with our department for human computer interaction. I hope to also make use of their expertise to evaluate my experimental installation from a different perspective.

8 Observations

After observing the installation on four different occasions, two test-runs and two presentations, I can conclude that the transformations do succeed in sparking curiosity and invite to explore the installation. In contrast to that I also observed how people didn't seem to realize that they were influencing the sound when traversing the space or resting on a bench in the space. This had multiple reasons. Some obvious ones: People were wearing headphones and not able to hear the sound. Or they were too busy to pay attention. This is a natural characteristic of a room that exists to be traversed and a behaviour I already expected. When it comes to my opinion it's not crucial that just some do experience the artwork because they have the time to pay attention. At least as long as these few people do exist. I also asked some individuals right after traversing the space. Sometimes the area was just too crowded that people were still hearing sound but did not thought they would be the one influencing it.

One person even circumvented the detection system by moving trash bins into the view of the camera. Therefore the person did decrease the need to coordinate with other people for exploring the installation. You could say the person hacked my system. However, this person and multiple others finally collaborated. For specific goals, like increasing the sine tone without sacrificing purity, all individuals need to move in a coordinated way which is not possible with a trash bin.

9 Future Work

I have to admit that in crowded situations the current set of transformations do not reveal the action-sound feedback loop. A possible solution to that could be to evaluate the energy level on

an individual level maybe even with multiple wind instances and multiple speakers that provide spatial audio. On the other hand it's important to not sacrifice how social behaviour is mapped in the installation when doing that.

I think it is also worth to improve the tracking with classification powered by machine learning. It would be interesting to design the system in a way that it also classifies the modes of

In cooperation with our department of HCI I could think of designing a small study to evaluate the effectiveness of different sonic feedbacks bases on the different qualities of a sonic object outlined by Schaeffer. [5]

10 Documentation

Additional documentation is provided within the connected folder. The documentation includes the source code, pictures and videos.

References

- [1] Douglas R. Buchanan, Morton Goldman, and Ralph Juhnke. "Eye Contact, Sex, and the Violation of Personal Space". In: *The Journal of Social Psychology* 103.1 (1977), pp. 19–25. DOI: [10.1080/00224545.1977.9713291](https://doi.org/10.1080/00224545.1977.9713291). eprint: <https://doi.org/10.1080/00224545.1977.9713291>. URL: <https://doi.org/10.1080/00224545.1977.9713291>.
- [2] Sergi Jordà. "Multi-user Instruments: Models, Examples and Promises". In: Jan. 2005, pp. 23–26.
- [3] Andrew Pickering. "Ontological Theatre Gordon Pask, Cybernetics, and the Arts". In: *Cybernetics & Human Knowing* 14 (Jan. 2007), pp. 43–57.
- [4] Jan C. Schacher. "Action and Perception in Interactive Sound Installations: An Ecological Approach". In: *NIME*. 2009.
- [5] Doug Van Nort. "Instrumental Listening: sonic gesture as design principle". In: *Organised Sound* 14.2 (2009), pp. 177187. DOI: [10.1017/S1355771809000284](https://doi.org/10.1017/S1355771809000284).