Title: A framework for creating interactive sound installations

Theme: Interactive sound systems

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Abstract:

This paper presents a framework designed to help artists create interactive sound installations by focusing on wireless communication and modularity. The system integrates microcontrollers, PureData for audio, Touch Designer for visuals, and OSC for communication. Initially aimed at creating a kit for display window installations, the project evolved to provide a broader framework for sound artists.

The development included analyzing existing art installations, detailing hardware/software components like ESP32 microcontrollers and ESP-NOW for inter-board communication, and creating three use cases ("Spaceship," "Ballin'," and "What's In the Box") to demonstrate functionality. Artists evaluated two use cases through interviews.

Key evaluation findings highlighted themes of creative, playful exploration; some confusion about the framework's precise capabilities and a desire for more control; its social interaction potential; its flexibility beyond sound installations; and overall creative inspiration. Stress tests indicated an average latency of 44ms and satisfactory range.

The paper concludes that the framework successfully enables the creation of interactive sound installations and meets requirements. However, it currently suits technically proficient artists or those with technical collaborators. Future improvements could involve more sensor options, reduced latency, a GUI, and detailed documentation.

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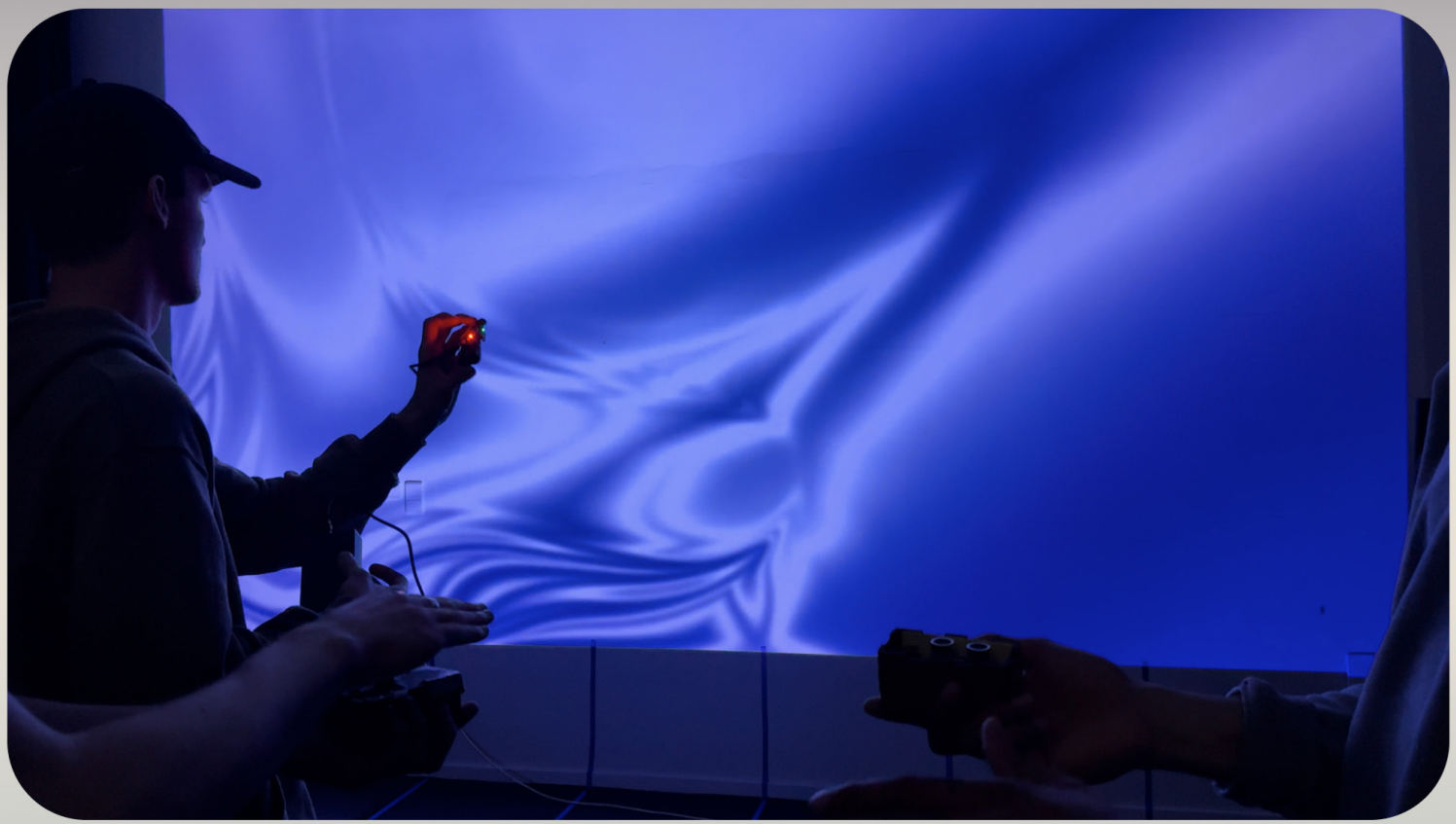
MEDIALOGY 4TH SEMESTER GROUP 3

IPASIF

A FRAMEWORK FOR CREATING INTERACTIVE PERFORMANCE AND SOUND INSTALLATIONS



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Contents

1 Introduction

Interactive sound installations offer unique opportunities to blend technology, art, and audience participation. Over time, sound installations have evolved to better utilize modern technology, which is the focus of this paper. Going forward, the paper will describe the creative and technical process of creating a framework that houses the ability to incorporate and capitalize on modern technology by putting the artist at the center of that process. It will be targeted towards artists and is designed to streamline their process by expanding on their creative freedom. The core functionalities of the framework include wireless communication and a modular approach, allowing for scalability and flexibility. The framework is comprised of four essential components: microcontrollers responsible for transmitting and receiving sensor data, PureData for audio synthesis and playback, TouchDesigner for visual representation, and the communication protocol OSC.

This paper will analyze the subject of art installations, provide an in-depth analysis of the current state of the art, and document the development and implementation of the hardware and software elements in the framework.

Furthermore, the paper will provide an overview of three example use cases, two of which have been evaluated by artists along with the framework itself through interviews. Lastly, through traditional coding, emerging themes from the interviews will be explored and along with the project as a whole, evaluated and discussed.

All the code from the project can be found on the github: `https://github.com/fnorre23/Framework-for-sound-installations.git`

2 Initial problem statement

How can we make a kit for interactive sound installations for display windows (with complementary visuals)?

3 Analysis

The following analysis seeks to find common, novel, and interesting aspects of interactive sound installations in order to individualize their parts and make them interchangeable. This allows for an approach, centered around each component and their connections, creating interactive sound installations for sound artists, bridging the gap between technical and musical ability.

Analyzing peer-reviewed articles, books, and state-of-the-art projects, the analysis will start by looking into what an art installation is, what constitutes interactive sound installations, and how it can be categorized using a comprehensive framework. Furthermore, the analysis will go into how sound is synthesized and processed, as well as the relationship between auditory and visual elements. Lastly, the interactions and system design within the state-of-the-art projects will be analyzed using the framework.

3.1 Art installations

The term 'Art installation' loosely refers to the creation of art that the viewer can physically enter [1]. It can be temporary or permanent, predominantly found in exhibition spaces such as museums and galleries [2][1]. The term became prominent in the late 1960s [3], which in turn makes it a relatively new art form. As the art form has evolved, the term has now expanded to describe any arrangement of objects in any given space [1]. It is also important to note that technology has greatly influenced the artistic practices and abilities [4].

Art installations are distinguished from other typical media as they involve the viewer as a literal presence within the art space. In its essence, it is designed to transform a space, exterior or interior, that can take into account the entire sensory experience of the viewer [2].

3.2 Interactive sound installation

Art installations are a broad concept that encompasses many sensory experiences, one such experience is the interactive sound art installation, which is the focus of this project. An interactive sound art installation is often also a musical interface, as it typically allows the audience to trigger and alter the parameters of the generated sound [5]. However, audience interaction is not required to classify it as a sound installation, as sometimes the manipulation of sound parameters is carried out by external sources, such as the wind and temperature outside, data from statistics, or electronic components. [5].

3.2.1 Framework for describing sound installations

With such varying ideas and broad definitions of interactive sound installations, it can be difficult to differentiate and categorize them. Fraisse et al. [5] have developed a framework to describe and categorize sound installations within a taxonomy, consisting of three perspectives: artistic intention, system design, and interaction. Each perspective has further defined themes to categorize the taxa, and within these themes, the taxa are defined. Based on the data set used when Fraisse et al. developed this framework, each sound installation is placed in all relevant taxa. It should be noted that, for this framework, Fraisse et. al. set their definition of interactive sound installation as interactive environments in which sound is one of the main mediums of expression or communication.

Artistic intention describes the artist's intention with their work and the contextual aspects and considerations taken before designing. **Interaction** describes who and how many interactors the installation allows and, more importantly, the type of interaction between the audience and the installation. Lastly, the **system design** describes the practical aspects of the installation

and the equipment used.

This project will focus on the interaction and system design perspectives of interactive sound installations, as artistic intention is for the artist to incorporate.

The following tables describe the respective themes within each perspective from the taxonomy developed by Fraisse et. al. [5] :

Interaction	**Description**
Inter-actor	The number of people involved simultaneously in the musical interaction.
Interaction type	It refers to the specific nature of the relation between the inter-actor and the installation.
Feedback type	It refers to the output modalities, also called feedback modalities.
Input and output	It refers to the number of input and output modalities available to the user or visitor (two actual themes).
Musical control	It refers to the level of control available to the user.

Table 1: Interaction themes

System design	**Description**
Spatialization	It refers to the number of sound sources used, their spatial disposition, and their diffusion and control parameters that are used to create a spatialized musical experience for visitors.
Sound generation	It concerns the nature of the installation's sound-emitting device(s).
Type of input device	It describes the kind of device(s) that provides to the installation the data and control signals that are processed as part of the interaction. This theme reflects the technical details extracted from the documentation. As such, some taxa consist of types of sensors, while others correspond to devices containing multiple sensors.

Table 2: System design themes

This framework provides a lens through which we can categorize and describe interactive sound installations, which will prove helpful in the state-of-the-art analysis (see section 3.7).

3.3 Sonic interaction design

When exploring interactive sound installation, it is relevant to look into the intersection between sound design, and interaction. Sonic Interaction Design (SID) describes the process of designing interactive art and music, which directly correlates to the creation of sound installations. Applying its key principles can aid in the design of both the installation and auditory experience. SID is a method of influencing the way a product is perceived by the target audience. Sound can be

shaped and used to influence emotions and convey information and meaning in interactions[6] [7] .

The theoretical foundations of SID couple human auditory perception, cognition, and emotion, where the main principle is a close connection between the audible experience and action in interactive feedback loops. When users manipulate an interface and it produces sound in response, the sound will in turn influence the user's next action [8]. A given system has the potential to let users explore complex patterns in the sound and discover how their actions can manipulate and influence the system.[9].

SID is achieved by high-quality sound with human-centered design to enable immediate and continuous feedback loops. Intelligent mapping strategies can ensure that the user's actions translate into sound in a meaningful way, instead of just feeling like random noise; it might be sound that can grab attention, convey information, and/or evoke emotions.

3.4 Sound synthesis

As the project has a heavy focus on sound, an exploration of sound and sound synthesis could benefit its development. The synthesis of sound deals with the digital domain of sound. The way sound is understood can generally be split into three different domains. Real-world sound, analog signals, and digital signals. This paper will mostly concentrate on analog and digital signals and their processing.

Real-world sound is the way humans perceive sound. It is the physical phenomenon of sound waves being created by air particles being pushed by objects impacting or vibrating, creating a variation in the air pressure [10].

When a sound is recorded to a vinyl LP or DAW (Digital Audio Workstation), a way is needed to convert or represent and store the variation in the air pressure. Microphones are used to measure variation in air pressure and convert it to an electrical signal. Conversely, loudspeakers convert the electrical signal into variations in air pressure. [10].

In digital sound synthesis, analog signals are converted to a digital representation of the analog signal with bits, meaning that each measurement (bit) or sample is either 1 or 0. In practice, this means a bit depth of 16-bit is

$$2^{16} = 65536 \tag{1}$$

A sample can therefore have 65536 possible values with a bit depth of 16 bits. The speed at which samples are recorded over time in seconds is called the sample rate. A common sample rate is 44.1 KHz (Kilo-Hertz) which is CD quality. This means, recording at a sample rate of 44.1 KHz, 44100 samples are taken per second [10].

The way digital sound is created and represented allows for modulations and calculations to modify the signal in ways that would not be possible with analog or real-world sound, thus introducing digital sound synthesis.

Sound synthesis allows for the modeling of "artificial" sounds. These sounds can mimic familiar sounds or dream up completely new sonic experiences. But common for all, or at least most synthesizers, is that they are fundamentally built with oscillators. These oscillators can produce different types of waveforms, such as sine, square, or triangle waves, and even waveforms more complex than that. While many forms of synthesis exist, this section will focus on four types: Subtractive, Wavetable, Granular, and FM.

Types of Sound Synthesis	Description
Subtractive	Subtractive synthesis deals with removing frequencies by filtering to model the sound to one's liking. Filters are often offered as low-pass (cuts off high frequencies) or high-pass (cuts off low frequencies). These filters are applied to the oscillator(s), influencing both the frequency and amplitude of the signal [11].
Wavetable	Wavetable synthesis operates by using waveforms that go beyond the common waves found in other types of synthesis. These waves can take on any shape imaginable. This is done by storing a snippet of a wave and sampling it. This could be done by recording another sound and using a snippet of its waveform to provide the oscillator with a wave [11].
Granular	Similar to wavetable, granular synthesis uses sampling to create new sounds. Where granular synthesis differs is in what it samples. With granular synthesis, a snippet of the recording (and not just its waveform) is the basis for the output. These short samples, called grains, are played repeatedly to the point where the sample is no longer recognizable, thereby becoming a completely new sound [11].
FM	Frequency Modulation synthesis is "a periodic variation in the frequency of one signal produced by another signal." [11] In its simplest form, an FM synthesizer is made up of a modulator (signal affecting) and a carrier (signal being affected). The modulator's frequency will add higher frequency partials to the carrier and create complex patterns [11].

Table 3: Types of sound synthesis

3.4.1 Audio Processes

To control the sound, additional components come together and form a synthesizer. As in subtractive synthesis, filters can still be utilized to model the sound, whether that be a wavetable or FM synthesizer. Other than filters, this next section will cover envelopes and LFOs.

3.4.1.1 Envelopes

An envelope consists of four parameters: attack, decay, sustain, and release. When triggered, the parameters will affect the amplitude of the oscillator over time. Only when the envelope is triggered will the signal become audible.

Once triggered (e.g. a key press):

- **Attack**: will decide the time it will take the signal to reach the desired amplitude from zero
- **Decay**: comes after the attack and controls the time it takes to decrease the amplitude, after the attack, to the next parameter, sustain.
- **Sustain**: then sustains the amplitude at a certain value until the key is no longer held.

- **Release**: will then decide how long it will take for the amplitude to decrease until it reaches zero again.

Envelopes are not only limited to controlling amplitude but can also control filters, effects, or single parameters [12].

3.4.1.2 Filters

Where envelopes in some sense sculpt the amplitude, a filter sculpts the frequencies of the oscillator. If you take a low-pass filter, it will allow the passing of low frequencies and exclude everything outside the bounds of the filter. The transition of the filter concerns itself with the slope of a filter. A filter's cutoff point does not mean that nothing beyond that point is audible, and depending on the value, dB represents the transition more or less of the remaining frequencies will be heard. Most common filters reduce the amplitude of these remaining frequencies by 12 or 24 dB per octave [12]. Lastly, the resonance control controls how much of the signal is sent back into the filter, emphasizing the frequencies at the cutoff point. Increasing the resonance will affect the transition period as well.

3.4.1.3 Low-Frequency Oscillators

There are no real distinctions in how low-frequency oscillators (LFOs) and common oscillators operate. They both produce waves but have different use cases. LFOs run at lower frequencies, a standard from 1-20 Hz (although they do not have to) and are often used to modulate parameters within a synthesizer. The parameter affected will rise and fall in sync with the wave of the LFO, e.g., the cutoff parameter of a low-pass filter affords the sound a sense of movement [12].

3.5 Audio-visual elements

Interactive sound installation, often times deals with multiple types of feedback, and at times a visual representation of the sound is incorporated. There is no definite way to visually represent sound. In its fundamental theoretical form, sound is represented as waveforms or spectrograms [13]. Going beyond the scientific graphical representation, the research paper [14] establishes the point that *"There are only subjective, more or less metaphorical representations, in heterogeneous sound or musical context."* This presents an opportunity where creating visualizations for musical compositions in sound installations is not bound by any objective direction but can be any artistic expression that the artist wants to convey.

3.5.1 Audio-visual relationship

Having an audio-visual relationship can be determined as having work that is audio-visually composed. Where the auditory and visual elements have been combined [15, p10] .

A novel term that correlates to the aspect of the research of the project, proposed by Balandino Di Donato, Christopher Dewey and Tychonas Michailidis in their article [16], is called Human Sound Interaction (HSI). It is the idea of taking some of the major relevant principles of Sonic Interaction Design and investigating the human factors within the context.

The article refers to another research study [17] on how music invites certain gestural affordances to mimic the timbral and dynamic qualities of the sound that is played. Although inconsistencies were present in the results, most of the participants generally gesturally mimicked the sound heard. This made Belandino Di Donato and co. derive the concept of affordance of musical sound. Affordances are an established concept within interaction design. It is a configuration of properties of a given physical object that provides a direct link between perception and action, usually nurtured with an interactive medium. Affordance of musical sound or in musical interfaces, the sound is one of these physical properties [18].

3.6 Hardware & software resources

3.6.1 Sensors

When working with interactive installations, inputs are how we communicate with the system. In an audio-visual installation, sensors can be part of that input by recording and converting physical values such as movement, light, sound, touch, etc. to binary data. The data is then used to control different parameters in the installation. As Jacob Freden[19] writes, *"sensors are the interface devices between various physical values and the electronic circuits that "understand" only the language of moving electrical charges."* The list of possible sensors to use is very long and diverse in the data it sends and receives. The data received will need to be evaluated and mapped to a function in a visual or audio installation.

3.6.2 Pure Data

Pure data is an open source visual programming language for multimedia [20]. It is widely used in audio signal processing to program different sounds and create instruments and plugins. It can take in sensor data and change the sound parameters in order to interact with the audio part of the installation. Making it useful in an interactive audiovisual art installation.

3.6.3 Touch Designer

To represent audio visually, Touch Designer [21] provides tools to customize visual output. It is a visual programming environment made for multimedia applications. It is designed to be flexible in the sense that it can take any data as input, or provide output to any digital need. This flexibility makes it suitable for visual audio representations, as it can receive the digitized audio signal, where a reactive system can be built around it.

3.6.4 Embedded microcontrollers

When building physical prototypes, the output from the sensors and buttons is often received and interpreted by embedded microcontrollers or a microcontroller unit (MCU). An embedded microcontroller is a compact circuit designed to perform a single operation in a system. In other words, they are small computers designed to handle single or multiple smaller operations in a larger system.

There exist different controllers made primarily for different purposes. Some of the most common boards that could prove useful in this project are:

1. Teensy [22] - simple and powerful MCU
2. ESP32 [23] - Features Wi-fi and Bluetooth chip
3. Bela [24] - MCU made specifically for sensors and audio

3.6.5 UDP and OSC

UDP is short for User Datagram Protocol and is useful for sending data across a network [25]. This comes with a risk of packet loss as UDP does not create a "handshake" with a receiving program as with TCP (Transmission Control Protocol). This reduces latency, which, in the use case of this project, is preferable, as the system needs to be and feel responsive. This means that all data sent is not guaranteed to be delivered.

OSC is a communication protocol between hardware and applications originally created as a more flexible and low-latency alternative to the MIDI protocol. Originally, OSC was meant for music production, but has been adopted in other fields such as visuals and 3D engines. Compared to MIDI, OSC has a higher resolution as the control parameters are not limited to a number between 0 and 127. [26]

3.7 SOTA

The following section will examine existing interactive sound installations to gather inspiration. The installations will be explained, and then further analyzed through the framework by Fraisse [5], to gain a deeper understanding of the interactions present and their system design. (For further details on the framework, see section 3.2)

3.7.1 Knotted Gate Presence Weave by MSHR

In 2017, the Museum of Arts and Design [27] curated an exhibition consisting of three floors of interactive, multi-sensory experiences, with a focus on "*sound as a material, activating its potential to shape space and environment, while drawing out the ability of the auditory to provide a fresh perspective on how surroundings, and the body, are perceived and engaged,*" as described by head curator Shannon R. Stratton [28].

One installation in this exhibition is the 'Knotted Gate Presence Weave' by MSHR, which is "*a cybernetic musical composition that uses circuitry, visitor presence and sculptural arrangement as its score.*" [29]. The installation is "*a series of archways functioning as metaphorical 'gates' in reference to a logic gate - an elementary building block of a digital circuit that regulates the flow of electricity through an input of binary values.*"[28].

Figure 1: Knotted Gate Presence Weave

Inter-actor	Interaction type	Feedback type	Input DoF	Output DoF	Musical Control
Few	User's motion	Auditory/Visual	1	2	Process

Table 4: Interaction analysis of Knotted Gate Presence Weave

The interaction of the installation is simple, as it only has 1 input degree of freedom, which is the user walking through the gates. The installation involves the user, and their impact can be heard and seen, but allows for interaction without much thought or control. It demonstrates how the interaction does not need to be complex to provide the user with an engaging experience.

Spatialization				Sound generation	Input device
Directivity	Diff. orientation	Num. sources	Control	Unknown	Unknown
Non-directive	Unknown	Multiple	Unknown		

Table 5: System design analysis of Knotted Gate Presence Weave

The system design is unknown and has not been described in detail. Therefore, a proper analysis of the installation's setup is not possible.

3.7.2 Cave of Sounds

Cave of Sounds is a 2012 project by a group from the Music Hackspace [30] in collaboration with Tim Murray-Browne [30], intending to create new instruments. The result was 8 bespoke and unique instruments, designed to be played with no prior musical knowledge, all able to be played together. They were set up in a circle facing inward, attempting to create the feeling of excitement, the same way they imagine prehistoric musical rituals around a fire must have.

Looking at the setup (see figure 2), it can be seen that from each instrument, a beam of lights leads towards a central octagonal structure, where all the lights converge at the center. The musical playing slightly affects this light, but does not seem central to the installation's design. The direction of everything is, however, as it aims to encourage the visitors to look up and connect with the other people playing.

Figure 2: Cave of Sounds Installation

Inter-actor	Interaction type	Feedback type	Input DoF	Output DoF	Musical Control
Few	User's motion	Auditory/Visual	8	9	Process

Table 6: Interaction analysis of Cave of Sounds

Spatialization				Sound generation	Input device
Directivity	Diff. orientation	Num. sources	Control	Unknown	Unknown
Directional	Unknown	Multiple	Unknown		

Table 7: System design analysis of Cave of Sounds

3.7.3 AlloBrain

AlloBrain is an interactive installation developed by the AlloSphere Research group at the University of California, Santa Barbara. [31] The system takes in neural input and, in real time, interprets it to generate sound and visuals, in a large-scale immersive environment in which people are placed. The system takes in brainwave activity using EEG headsets and translates that into both auditory and visual output. This creates a closed feedback loop where the user's internal cognitive state influences the environment, which can then affect the user's state. [32]

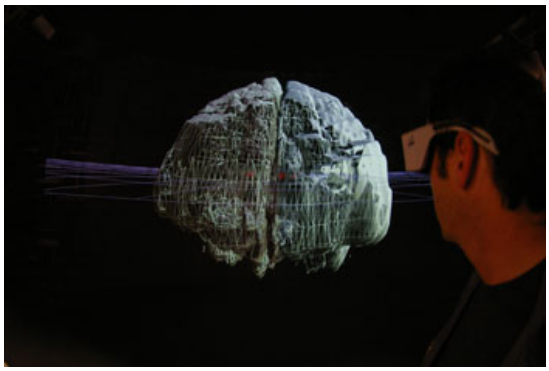


Figure 3: Allobrain

Unlike previously stated interactive systems, the allobrain does not use tactile or motion-based interactive systems, which are commonly used. [32]

Looking at the interaction structure (see table 8), AlloBrain does not use physical interaction but enables a high degree of real-time musical and visual modulation through neuro feedback.

Inter-actor	Interaction type	Feedback type	Input DoF	Output DoF	Musical Control
One	Brain activity	Auditory/Visual	1	22	Process

Table 8: Interaction analysis of Allobrain

Spatialization				Sound generation	Input device
Directivity	Diff. orientation	Num. sources	Control	Speakers	EEG
Non-directive	Dynamic	Multiple	Automated Spatialization		

Table 9: System design analysis of Allobrain

3.7.4 DAVE + GABE interactive installation studio

DAVE + GABE is a studio that focuses on the relationship between light, music, and interactions. They have a large catalog of projects relevant to this study, yet their project "ARC" is especially interesting given the type of interaction it is focused on.

ARC consists of 5 different instruments on a table in a room surrounded by a ring of 20 speakers. The 5 unique and tactile instruments focus on the concept of a collaboration between artist and audience. The audience can influence the music, where sounds either slowly rotate around the room or rapidly bounce back and forth, enabled by the ring of speakers (See figure 4)[33] [34].

Figure 4: "ARC" by DAVE + GABE

Inter-actor	Interaction type	Feedback type	Input DoF	Output DoF	Musical Control
Few	Embodied	Auditory/Visual	5	20	Process

Table 10: Interaction analysis of ARC by DAVE + GABE

Spatialization				Sound generation	Input device
Directivity	Diff. orientation	Num. sources	Control	Speakers	Custom instruments
Directional	Same point	Multiple	Automated		

Table 11: System design analysis of ARC by DAVE + GABE

3.7.5 Urban Musical Game

The Urban Musical Game [35] was a project developed by IRCAM, the design agency NoDesign, and the Phonotonic association in collaboration with composer Andrea Cera. It revolves around the idea of extending musical playing techniques to common objects, in this case, embedding the musical interaction in a sports ball, and creating a few games revolving around a sports ball and its movement. It was first presented at the Futur En Seine in 2011 in Paris, where more than 500 users participated.

Figure 5: Urban Musical Game

It supports complex movements that can be mapped as pleased, leading to a plethora of opportunities. Movements included roll, shake, dance, throw and hit, and more. They developed 4 games, such as *The Band*, which focuses on collective music creation, involving 3 sports balls, mapped to different instruments, allowing for playing as a band. Or the game *TheBomb*, developed for children, where a ball is passed around until it sonically "explodes", removing that player from the game. The ball can be spun to cool down the "bomb".

The ball uses internal measurement units (IMU), which are composed of a 3D accelerometer and a 3-axis gyroscope. The data is then sent wirelessly between the emitter and the receptors, and then sent to a central computer using an ethernet network and OSC. The data is then analyzed and processed through Max/MSP.

This project shows the strengths and flexibility of wireless communication, allowing for more complex interactions between the installation's participants and the interface provided. It promotes the idea of high-level musical interaction through playing techniques, allowing translation of any type of performance to a musical one.

Inter-actor	Interaction type	Feedback type	Input DoF	Output DoF	Musical Control
Few	Embodied	Auditory/Visual	7	1	Process

Table 12: Interaction analysis of Urban Musical Game

Spatialization				Sound generation	Input device
Directivity	Diff. orientation	Num. sources	Control	Speakers	Sports ball
Directional	Unknown	Unknown	Channel-based		

Table 13: System design analysis of Urban Musical Game

3.7.6 The Bluetooth Radio Ball Interface (BRBI)

The Bluetooth Radio Ball Interface (BRBI, pronounced "Barbie") by Woon Seung Yeo is a wireless interface for motion tracking and sonification [36]. It is a Wireless Accelerometer/Tilt Controller (version 2) by Sparkfun Electronics, embedded into a palm-sized foam ball, meant to be moved about, either precisely, or general gestures, such as spinning or throwing.

To measure the movement data of the ball, Yeo uses a Wireless Accelerometer/Tilt Controller (Version 2) from Sparkfun Electronics, which contains an MMA7260Q, a 3-axis, low-g accelerometer. The device communicates via Bluetooth to a Mac computer, then reformats the data through WiTilt (W2O) to OSC. The W2O software was developed by Yeo, specifically for this project. W2O software also provides some configuration options, such as calibration, setting active channels, sensor range, etc. The OSC-formatted data is then up to the user to handle from there. An example is given of how Max/MSP can receive the data, from which the user can incorporate it into their musical software endeavors.

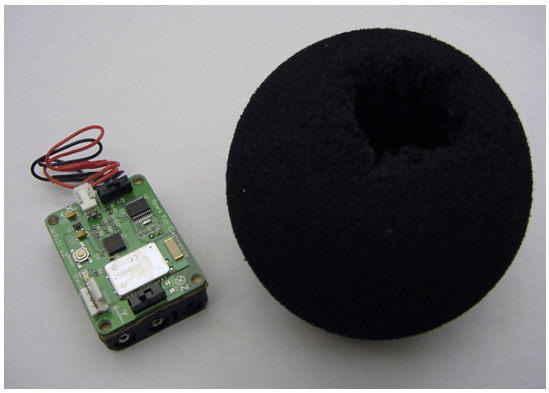


Figure 6: BRBI

The project displays the strengths of wireless communication and proposes a novel interface

for musical performance and sonification. It provides vast flexibility, as there exists a ton of OSC-compatible applications.

However, the system does come with some limitations. The W2O software for converting and communicating the ball's motions via OSC is Mac-exclusive as it is written in Xcode, limiting an entire group of potential users based on their computer's operating system. The implementation and usage of gestures are mentioned, but not documented, making it difficult for potential users to use such aspects for their own projects.

Inter-actor	Interaction type	Feedback type	Input DoF	Output DoF	Musical Control
Few	Embodied	Auditory	Multiple	1	Timbre

Table 14: Interaction analysis of BRBI

Spatialization				Sound generation	Input device
Directivity	Diff. orientation	Num. sources	Control	Unknown	Sports ball
Unknown	Unknown	Unknown	Unknown		

Table 15: System design analysis of BRBI

3.7.7 Other work

The state of the art in interactive sound installations is plentiful, and it would not be feasible to cover it all in this analysis. The previously covered installations are just some of the many inspiring installations that influence this project.

Some other influences, which we were not able to cover fully within this analysis, include:

- Ryoji Ikeda, a visual and sound artist, focused on creating patterns and sounds for performances and installations from a variety of data; using Pure Data, MAX MSP, and custom software [37].
- Zimoun, an artist, composer, and musician, creates minimal installations using mechanical components to sculpt sound, transforming spaces into sound objects. Often, these consist of DC motors by themselves or attached to an object, which range from cardboard boxes to wooden structures and ceramic plates [38].
- Playdodo's Music Playing Wall is an interactive sound installation that works as a musical interface using touch sensors, conductive ink, and projection mapping.
  [39]
- Nina Waisman is a former dancer turned installation artist. Nina Waisman works primarily with how movement and sensation play a role in forming thought [40]. Her interactive sound installations, such as Space Shifter 2.0, explore the intersection between human movement, sensory perception, and cultural context. Space Shifter 2.0 features twelve sensory cables suspended against a wall. Visitors can then move their bodies between these cables to play sounds[41].
- Forest of Resonating Lamps is an installation, focused on '*the beauty of continuity*' [42]. It involves seemingly randomly placed lamps, with light that changes based on a person's presence. The lamps also emit sound when they light up. The trajectory of the lamps that light up is mathematically determined and also intersects with other people's light trajectories [42].
- The music ball project is a project with a goal of creating novel instruments/controllers. Multiple types of interactions and sensors were tested and used for creating different mu-

sical balls. This includes sensor-based music balls, electroacoustic music balls and even balls for children and ADHD diagnosed individuals [43].
- Balance ball interface is project that introduced a novel musical interface. Using a balancing ball the project proposed the usability of expressing larger human performances, like rolling, lifting, gliding and diving. The interface allowed for multiple configurations of parameters velocity, tempo and note; enabling these various interactions [44].

3.8 Collaboration

This project was done in collaboration with two artists, Lars Greve and Tina Tarpgaard.

Lars Greve is a Danish musician and sound artist. He has an Advanced Postgraduate Diploma in Music from Rhythmic Music Conservatory[45] and is the founder and artistic director of 'Resonerende Rum', which is an institute for sharing and creating contemporary musical projects with the aim of strengthening culture and community[46].

Tina Tarpgaard is a Danish dancer and performance artist. She is the founder of Recoil Performance Group, which creates choreography and cross-aesthetic performances[46]. Currently, she is the artistic director of the Sydhavn Theater. A theater founded in 2014, that has since gone beyond the walls of their studio and now creates various artistic innovations, embracing the diversity and culture of their neighborhood and urban spaces[47].

Throughout the project, these collaborators were consulted to iteratively give feedback on what had been created, as well as come up with ideas of their own, and how they might see this framework used in their respective work, and more importantly, what aspects they do not find useful.

3.9 FPS

Through analyzing and exploring technology, the state of the art, and with inspiration from collaborator meetings, the scope of the project broadened, to provide a framework for artists to create interactive sound installations. Ultimately, the final problem states:

Can we create a framework for sound artists to create and perform sound installations?

4 List of Requirements

The list of requirements were developed based on the analysis, and inspired by data found in the framework developed be Fraisse et. al.

Functional

- Must use a minimum of 3 different sensor inputs
- Must have sound as the primary output
- Must include visual elements that reflect the sound
- Must have at least one interactive element per sensor
- Sensor inputs must be used to manipulate the sound

Non-Functional

- Must use *PureData* to synthesize sound
- Must use *Open Sound Control* for communication
- Must use *Touch Designer* for visual representation

5 Design & Implementation

5.1 Framework

The design of the framework focuses on an artists ability to create interactive sound installation art. With a focus on modularity, the framework will cater an environment that will simplify various processes, thereby speeding up the production time and freeing time for more creativity.

The framework is built around the wireless connectivity of the OSC protocol (see section 3.6.5). By having Pure Data as the main terminal, it is possible to send live or sampled audio through OSC into Pure Data which can then be modulated or modified to whatever extent the user finds relevant. Furthermore, any data from other components within the framework, such as Sensor data, Touch designer, Python etc. can also be sent to Pure Data, giving possibilities for a multitude of sound interactions. The framework can also send audio from Pure Data or sensor/python data directly into Touch Designer for creating audio or sensor reactive visuals.

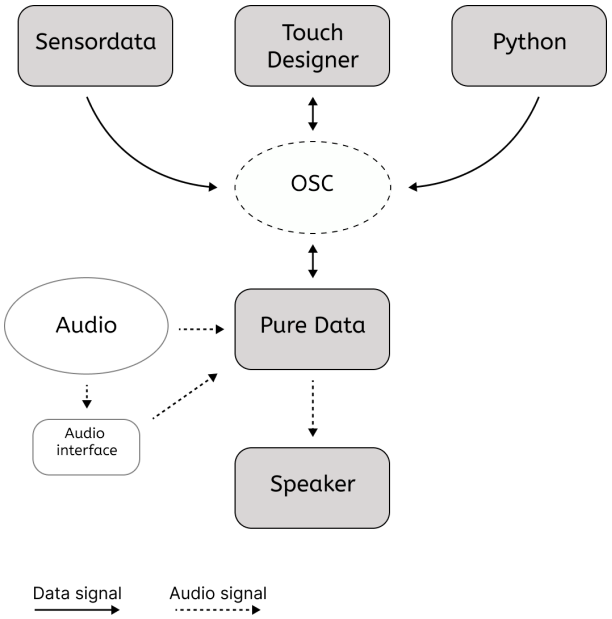


Figure 7: Framework Diagram

5.1.1 Microcontrollers

The microcontrollers mainly used are the StampS3 ESP32 modules [48], and other ESP32 variants, because of the wireless connectivity the ESP32 offers. It has both Wi-Fi hosting and client capabilities that, along with the small form factor of the StampS3, makes them suitable for a wide range of applications.

The overall setup of the microcontrollers consists of a single controller acting as a hotspot (host board), that the rest connect to (client boards). Each client board is responsible for reading data, and sending that data to the hosting board. The computer that is to receive and utilize the sensor data will also connect to the hosting board, and receive the data through OSC.

5.1.1.1 Reading sensor data

Each client board is responsible for reading, preferably, a single sensor and sending its values. It is however possible to read multiple sensors from a single board, whether it is different or same types, the programming just gets more intricate.

Each client board has to be specifically programmed depending on the type of sensor. Therefore as the framework is adapted to a specific case, the boards too need to be programmed for its

needs. For communication, each client board sends a struct containing an integer with the ID of the board, and the values of the sensors, whatever value type they may be. The host board can then identify where it is receiving data from, based on the ID integer provided, and place the rest of the data in the correct size struct. For example, a client board reading joystick values will send two floats for the X and Y axis, and a bool for the button. As the host board receives this data, it will know the size of the data, based on the joystick clients ID integer. This way, the values will not get placed into the wrong size struct, resulting in incorrect data upon receiving.

The code below is the struct being sent from an arbitrary client board, in this specific case a distance sensor:

```
datatypedef struct struct_message
{
    int id;
    float distance;
} struct_message;
```

The following code, on the receiving end, is then responsible for checking the received ID, and copying the data into the correct size struct based on the ID, and lastly calling a method for sending the values to pure data, which will be explained further in a later section.

```
if(receivedID == 2 && len == sizeof(distancestruct))
{
    Serial.println("Received ID: 2");
    memcpy(&distanceData, incomingData, sizeof(distancestruct));

    SendToPD(distanceData.distance, "/distance", OUT_PORT_DIST);
}
```

5.1.1.2 Utilizing the ESP-NOW and OSC Library

To communicate between the microcontroller client and host boards, a wireless communication protocol called ESP-NOW, developed by Espressif specifically for ESP32, is used ([49]). ESP-NOW is a quick, low-latency, and low-power solution to communicate between multiple ESP32 microcontrollers. It can be used in various ways to either send from multiple senders to one host (as is done in this project) or from one sender to multiple receivers. The connection is made by having both boards set to Wi-Fi station mode and the sending board connecting to the receiving board by its MAC address, which is set up in code. This way, no other initialization is required, and the connection is instant when the boards are turned on. This makes it suitable for this framework as it provides an instant and easy way to reconnect a sensor if, for example, a battery dies or a wire gets pulled out. [50]

The following code is the sender wi-fi initialization process in the Setup method. It sets the board in wi-fi station mode and then tries to connect to the host board wi-fi, then initializes ESP-now.

```
// Connect to the ESPnow network
WiFi.mode(WIFI_STA);
WiFi.begin("ESP32now")

// Init ESP-NOW
if (esp_now_init() != ESP_OK)
{
    Serial.println("Error initializing ESP-NOW");
    return;
}
```

After starting wi-fi and initializing ESP-now it needs to define a peer to send data to (the host board). The following code is responsible for calling a callback function (**OnDataSent**) which

is used to check if a message has been sent and delivered. It also searches for the MAC address (**broadcastAddress**) of the receiver and sets it as the peer device. It is important to note that the MAC address needs to be known in order for ESPNOW to work. Therefore prior to running this code, the MAC address of the host board needs to be identified.

```
esp_now_register_send_cb(OnDataSent);
memcpy(peerInfo.peer_addr, broadcastAddress, 6);
peerInfo.channel = 0;
peerInfo.encrypt = false;

if (esp_now_add_peer(&peerInfo) != ESP_OK)
{
    Serial.println("Failed to add peer");
    return;
}
```

On the receiving side, the code to initialize Wi-Fi and ESP-Now is largely the same, but where the board is set to both Wi-Fi Station and Access Point mode at the same time. Station mode is what is used by ESPNOW to connect boards automatically. Access Point mode makes the ESP32 act as a hotspot available to all devices. Both modes are enabled since the sensor data is sent over ESPNOW between the boards. This data then has to be sent further via OSC messages over the Wi-Fi to a computer running Pd and TouchDesigner, hence the need for the hotspot.

When the data is received on the ESP32 host board, we utilize the OSC communication protocol to repack the data into a structure that is supported by OSC, then send the data to the receiving computer through the hotspot via UDP. We use different ports for each different sensor giving us the ability to add more sensors and still keep a relative simple data management overview. Figure 8 shows a simple graphical overview of the connectivity between the ESP's.

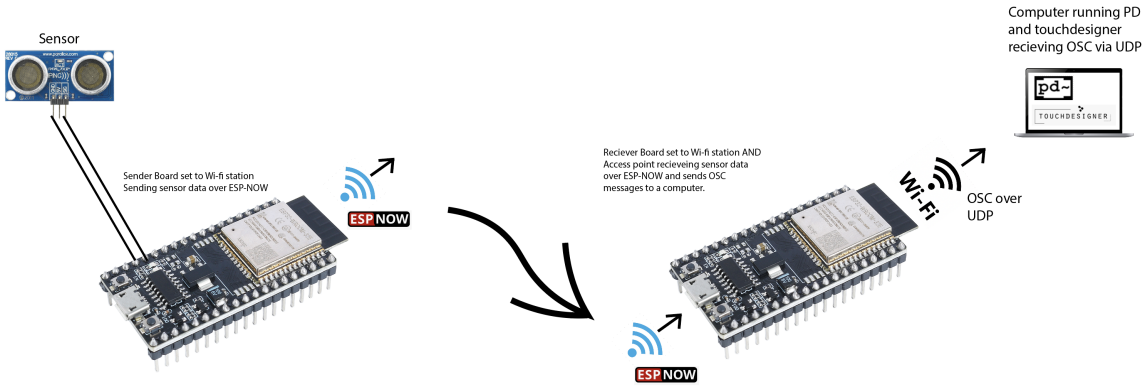


Figure 8: ESP32 send/receive system

The following code is the UDP setup part of code where the target IP address is defined together with which port is handling which sensor.

```
// UDP settings - This is for sending OSC messages
// Define UDP object for OSC
WiFiUDP pdudp;
// Destination IP for sending OSC
IPAddress IPOut(192, 168, 4, 2);

```

```

// Each sensor sending on a different port
#define OUT_PORT_JOY 3001
#define OUT_PORT_DIST 3002
#define OUT_PORT_SLID 3003
```

Below is the method handling OSC messages and sending them to the computer. We have multiple method overloads depending on which sensor the data comes from because the structure varies from sensor to sensor.

```
// For sending ONE float or value
void SendToPD(float message, char* name, int port)
    {
    Serial.print("Sending␣OSC:␣");
    Serial.println(message);
    OSCMessage msg(name);
    msg.add(message);
    pdudp.beginPacket(IPOut, port);
    msg.send(pdudp);
    int success = pdudp.endPacket();
    msg.empty();
    //Serial.println(success ? "OSC Sent!" : "OSC Failed!");
    }
```

5.1.2 Touch Designer

Touch Designer was used for the visual production to demonstrate a fraction of what is possible to create using data from either live sound or sensor inputs. The selection of this program, was both the engines capabilities in real time rendering, and that it has extensive OSC integration. It offers a modular way of creating patches, while keeping it flexible and capable of creating visually engaging visuals.[51]

The first example use case illustrates how Touch Designer can be an effective tool within this framework, as it offers users the flexibility to create complex, real-time interactive experiences, that interact seamlessly with sensor and/or sound data.

Example projects: - Short interactive spaceship/sun (see section 5.4.1)

- Blob tracking for video file input Blob tracking can be used to isolate subjects, in videos or pictures . If you have a dancer ex. performing something, you can extract the outline of the performer using blob tracking. Then apply different kinds of effects to this outline, can give you a system that reacts to the dancers movement. This specific project takes in a video file, and through various image processing techniques, isolates the subject. [52]

Touch Designer is a useful tool if you want to have real time visual creations. The versatility and modular approach makes it perfect for the diversity of art installations. The possibility to easily integrate it to receive data, from sources like sensors or tools like Mediapipe for Python, gives the tool more flexibility than can be lacking in other tools.

5.2 MediaPipe

A prominent aspect of a lot of sound installations is the movement of the visitors. It can be their movement through the space, or a specific gesture they can perform to produce, or alter some sound. We wanted to incorporate this into the framework as well.

A tool of choice is MediaPipe, a series of artificial intelligence (AI) and machine learning (ML) solutions developed by Google [53]. MediaPipe provides a Python library, which makes it easy to integrate into our current system, since OSC is easily implemented through the OSC library [54]. This essentially makes Python a communication device between MediaPipe and Pure Data.

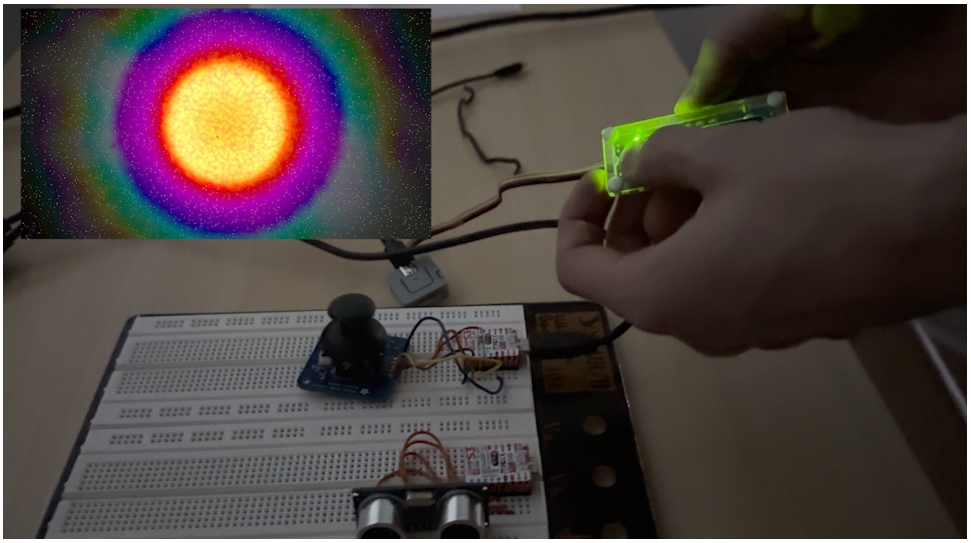


Figure 9: Use case 1

Examples made for this project include the MediaPipe Hands solution and the MediaPipe Pose solution. Each solution is a pre-trained ML model that can identify parts of the human body and track them through space. It then provides landmarks, which represent joints or relevant points on the body part. The entire program runs in an OpenCV [55] loop, where a Python library that allows video handling provides MediaPipe data to process. For further explanations of the feature see appendix 13.1.1

It should be noted that the MediaPipe feature was not tested and evaluted for this project, as it has not been implemented in any use case.

5.3 Other tools

A core strength of the framework is the modularity, which provides the option for extendability. The OSC protocol is used by a vast amount of software, so if any user feels more comfortable with other software, a lot of the same principles can be applied to those. Software such as QLab could be relevant for more performance-focused use-cases, or VCVRack if the artist wishes for the audience to interact with a live synth patch, or if they just feel more comfortable with the software.

5.4 Use Cases

For the project, two use cases have been made to showcase ways in which one could create a sound installation using the framework. This was done to help highlight the modality of the system.

5.4.1 Use Case 1: Spaceship

The first use case is called 'Space Ship' and is an interactive audiovisual interface. The sensors that control the sound are attached to a breadboard to showcase how just a few sensors can interact with the sound 9. The sensor data is fed into Pure Data, wirelessly through OSC. The data collected is used to control various parameters of the synthesized sound. Lastly, the data it is out from the Pure Data patch into Touch Designer, which reads the incoming OSC data as different channels. These data channels are then fed into the network that resides inside Touch Designer.

5.4.1.1 Hardware

The spaceship use case utilized three ESP microcontrollers. One as the host and two as senders, each of them sending the data from each sensor. The sensors used in the spaceship is a thumbstick and a touch slider. By utilizing all wireless connections, we are able to scale the system both in physical size and connected sensors in order to make it adjustable to various use cases or various versions of the same use case.

5.4.1.2 Pure Data

The Pure Data patch for the spaceship experience can be divided into four sub-patches, responsible for aspects of the sound design. The intention for this patch was to have the sound of an engine firing up, the dissipation of the engine, then the explosion and speed sending the user into warp speed, and the a steady hum off a spaceship coasting through space.

- Engine
  - Uses FM synthesis to create abstract sounds that resemble that of a futuristic engine through a collection of differently tuned oscillators (both sine and square waves). All modulated by another set of oscillators. These come together with an additional oscillator (providing a clear distinguishable tone) and a noise object. Filters (high pass and low pass) are then used to model the sounds in the frequency domain and a tremolo that affects the time domain. Lastly, sliders are connected to various parameters within these objects, affecting the tremolo, pitch and modulation, simulating that of an engine firing up. See figure 10

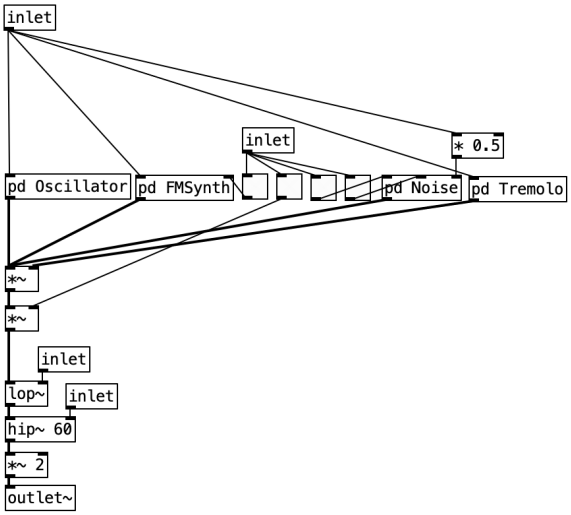


Figure 10: Engine patch in Pure Data

- Take Off Noise
  - Built around a noise object, which runs through a set of highpass filters this subpatch becomes audible once a bang is sent to the subpatch. This bang also affects every other subpatch mentioned in this section triggering envelopes that either cause sounds to fade in or out. This subpatch provides a very high frequency sound that serves as the moment between when engine has been fully charged and take off.
- Impact
  - This subpatch has three subpatches that come together and create the impact sound that is meant simulate the sound of launching a space craft into warp speed. The Hit subpatch is bascially modeled as a kick drum to provide that initial thump. The Tone subpatch consist of a single oscillator to fill out some space in the mid range

of the frequency domain. The Bass subpatch provides information in the low end by combining a sine and square wave oscillator and acts as a tail for the initial impact of the Hit subpatch.

- EngineHum
  - Once the impact is triggered the all other sound will fade out and the engine hum is activated. This subpatch then provides a steady chord simulating an engine maintained at warp speed gliding through space. It consists of a collection of five oscillators precisely tuned to form a chord combined with a noise object. These are all affected by a tremolo and run through the rev2 object (Pure Data's reverb object). See figure 11

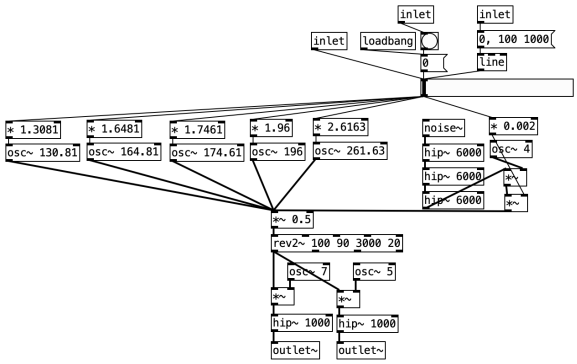


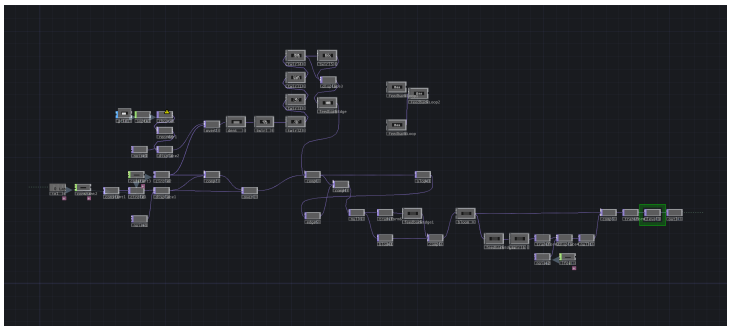
Figure 11: Engine Hum patch in Pure Data

The patches developed in Touch Designer are designed to give an example way of getting OSC data streams from either sensor or Pure Data or both. This data-driven approach makes it possible for the sound or sensor to change, and then having the visuals react instantly.

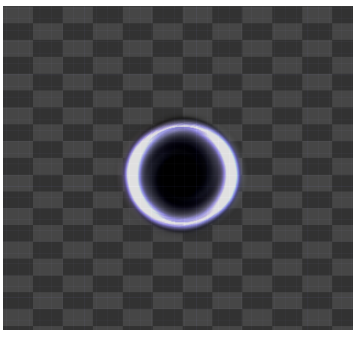
5.4.1.3 Touch Designer

The black hole visualization was created by displacing two circles with some noise. One circle represents the black hole, and the other represents the outline of the black hole. Then, feeding in lines into a twirl effect, we get this effect of the black hole "bending" the light around it.

The Twirls objects are animated over time on their rotation, making the black hole have this continuously looping movement.



(a) Black hole network

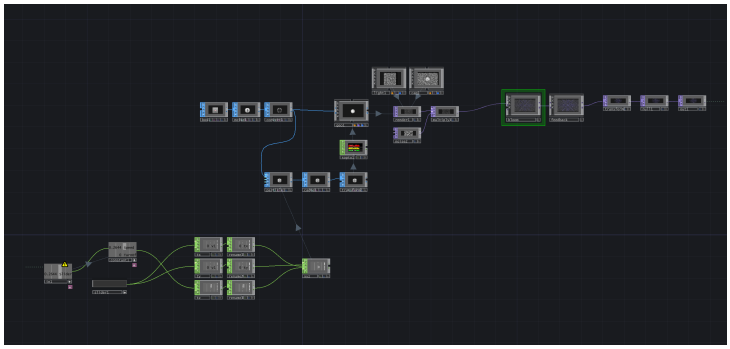


(b) Black hole visualization

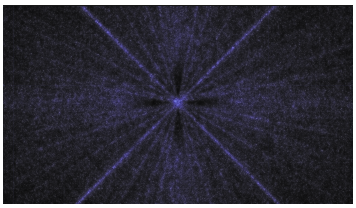
Figure 12: Black Hole Touch Designer

The hyperdrive was made using instancing within Touch Designer. This is a function where you

can manipulate and render geometry with the GPU instead of the CPU. Three axes are defined that control a particle sphere, which is instanced to create geometry. This geometry is then multiplied by a noise and is animated on the z-axis. Post-processing, like bloom and feedback, was done to help amplify the visual elements.



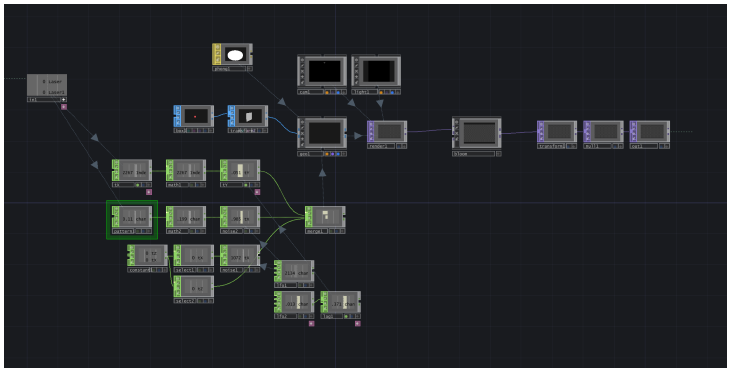
(a) Hyper drive network



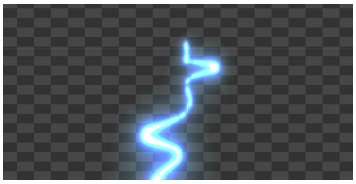
(b) Hyper drive visualization

Figure 13: Hyper Drive Touch Designer

The Laser is also done using instancing. Noise was added to the x-axis of the laser, creating the bending effect. Furthermore, two LFOs change the values of the x and y axes, essentially animating the geometry of the laser.

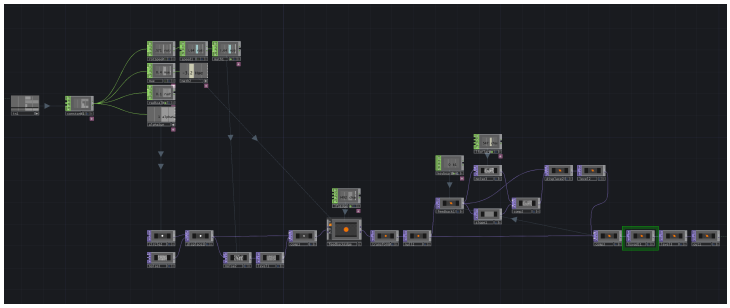


(a) Laser network

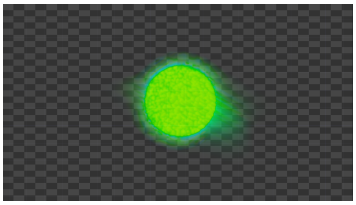


(b) Laser visualization

Figure 14: Laser Touch Designer



(a) Sun network



(b) Sun visualization

Figure 15: Sun Touch Designer

The sun was made using noise displacement techniques combined with circle geometry, which created the textured surface of the sun. This was fed into a feedbackedge which layers the previous frames with the current frame, creating an edge glow that simulates natural solar glow, as well as the base color of the sun's surface. This was further animated by an additional noise layer into a displace that created a more dynamic and organic look to the sun, mimicking solar flares.

This use case displays the framework's modularity, in its ability to communicate with various programs. It utilizes different types of sensors that were flexible in which kind of parameters they were manipulating. This demonstrates the capabilities of the system in different areas such as hardware, audio, and visuals.

It's important to note that the use case also served as a project for the group to learn to develop with the framework, as well as debugging and testing all aspects of it.

5.4.2 Use case 2: Ballin'

The idea behind the second use case was to create a more tangible approach, where we create a physical object that the audience can interact with. This would work as a sort of token, with which the audience can pass around. We selected two shapes: a ball and a box, in which an accelerometer and a gyroscope were installed. The audience is encouraged to then throw and pass the ball. The accelerometer then captures the data based on its motion. This data is then sent to further alter the music. These two components would create a dynamic and constantly evolving musical feedback loop for the participants. See figure 16 and 17.

5.4.2.1 Hardware

This use case employs the same ESP-32 microcontroller as in the previous use case, one for each distance sensor, one for the ball, and one for the access point.

The ball/box is utilizing the BNO-055 board from Adafruit that is based on the Bosch BNO-055 IMU (inertial measurement units) [56]. It's a system in a package solution that integrates multiple sensors (accelerometer, gyro, and magnetometer) and a microcontroller to give easy access to precomputed movement in quaternions, Euler angles, and vectors, releasing the user from computing all the math. Since the ball was to be wireless as well as running on a rechargeable battery, a prototype was built consisting of an ESP-32S2 thingplus, a Li-ion 18650 rechargeable battery, a battery charge controller, and the BNO- 055. A 3D-printed battery case [57] was made which assembled the device as compactly as possible.

The system mainly uses the same base code that handles the wireless connection, both in terms of sending sensor data and OSC as described in section 5.1.1.2, only the structure of the OSC package was changed on the access point to comply with the IMU data struct.

The IMU code is handling the BNO-055 board, where built-in functions are utilized to get the linear acceleration vector. The linear acceleration is used since the gravity is not needed, but the relative position and movement of the ball

The code below is for the linear acceleration function that prints the myData struct as X,Y,Z.

```
1    void ReadLinearAcceleration()
2
3    \{
4        //code to read the acceleration Vector
5        imu::Vector<3> acc = bno.getVector(Adafruit\_BNO055::VECTOR\_LINEARACCEL);
6
7        myData.x = acc.x();
8        myData.y = acc.y();
9        myData.z = acc.z();
10   \}
```

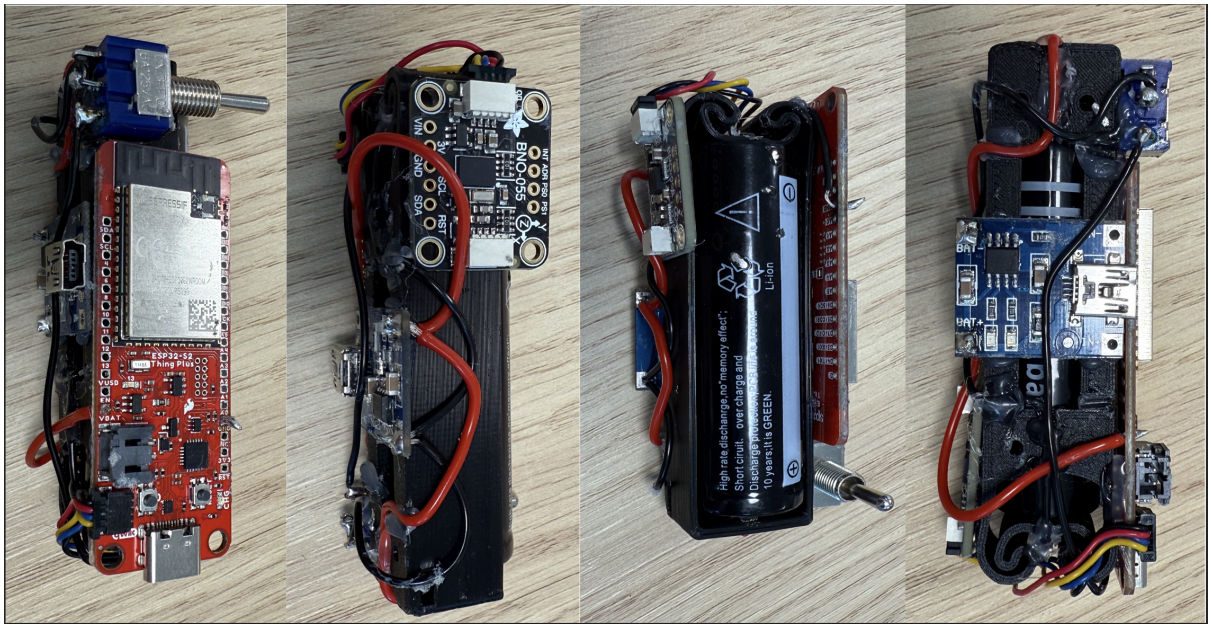


Figure 16: Prototype design of the ball sensor

Figure 17: Usecase 2 with the acces point and IMU sensor unit and the ball to place the sensor into

To map effects to the ball depending on how it is thrown, a single variable derived from the linear acceleration is needed. Therefore the magnitude of the acceleration vector is calculated as:

$$\text{Acceleration Magnitude} = \sqrt{x^2 + y^2 + z^2}$$

In the code below, the X, Y, Z variables from the myData struct are used to calculate the acceleration magnitude, and adds the value to the myData struct as a new variable:

```
    // Calculate magnitude of acceleration
  myData.Acceleration = sqrt(myData.x * myData.x + myData.y * myData.y + myData.z * myData.z)

  Serial.print("X: "); Serial.print(myData.x, 2);
  Serial.print(" Y: "); Serial.print(myData.y, 2);
  Serial.print(" Z: "); Serial.print(myData.z, 2);
  Serial.print(" | Accel Mag: "); Serial.println(myData.Acceleration, 2);
```

5.4.2.2 Pure Data

The pure data patch revolves around a simple granulator that cycles through a total of four predetermined samples. A total of three sample banks are configured within the patch but more can be added or subtracted from it. These samples can be replaced by the user through the operating system's file handling interface. The main parameters affected by the gyroscope's axes are the sample's playback speed, grain size, and grain repeat rate. Before the signal reaches the output, it passes through a selection of effects which can either be coupled or activated individually. Namely, a reverb, tremolo, delay, and distortion. Lastly, the signal reaches a sub patch capable of panning the signal left or right, which is also controlled by the gyroscope's Z-axis. The path can be seen in figure 18.

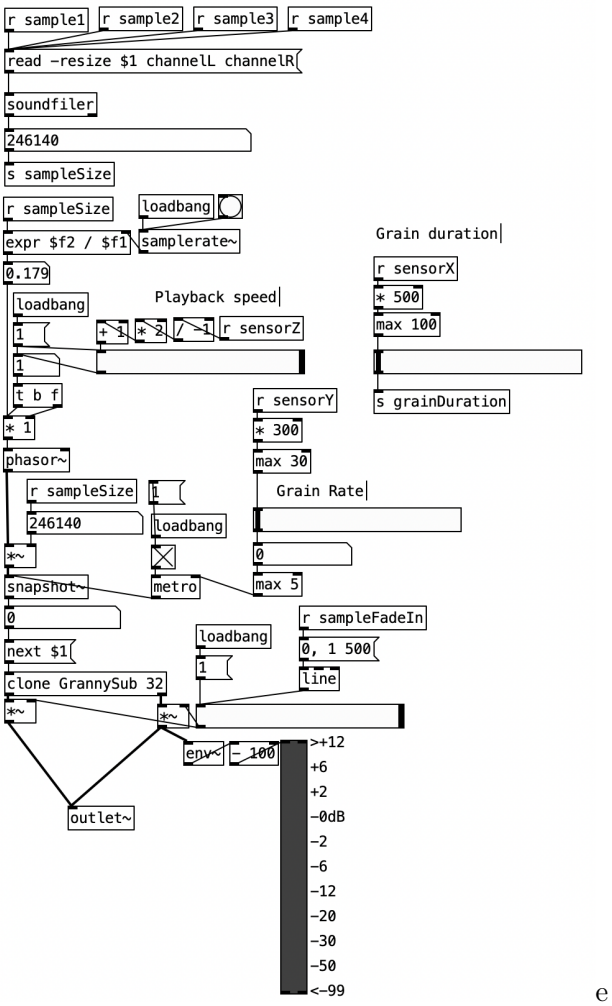


Figure 18: Granulator Sub Patch in Pure Data

All sensor data is normalized by using PureData's arithmetic objects and manipulated to fit the effect and granular parameters intervals. E.g., a filter would need to span the full audible frequency range (0-20000 Hz). Apart from the section of sub patches dealing with the signal path, a set of sub patches take care of sensor and TouchDesigner communication as well as other organizational tasks that ensure the main path's intended functionality. The "gyro" patch receives the OSC data and are able to be distributed to the rest of the main patch using send/receive objects. The patch for receiving sensor data can be seen in fig 19.

Another example of such an organizational sub patch is the "samplePicker" patch. In this instance, the sub patch is responsible for cycling through the samples chosen to be used in the

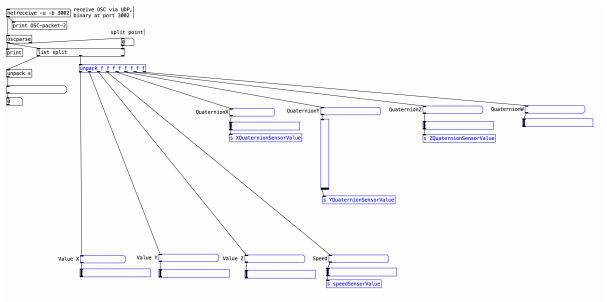


Figure 19: gyro Patch in Pure Data

granulator. Picking which set of samples the patch should play is determined in the UI, created for this specific use case.

The UI accommodates for both use case 2 and 3 and consists of visual indicators (sliders) for the effect on the gyroscope's axes and distance sensors. Additionally, a set of toggles controls a variety of settings. E.g., whether or not the signal from the granulator is allowed to pass through the corresponding effect. Aside from the intractable components, the UI features a visualization of the waveform of the current sample loaded for both the left and right channels.

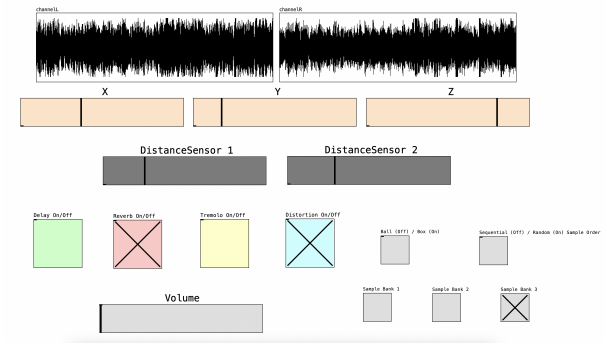


Figure 20: Granulator UI in Pure Data

5.4.2.3 Touch Designer

Visual feedback were created with Touch Designer. Data parameters sent from Pure Data through OSC was hooked up to various visual elements. The x, y, and z axis was taken from the gyroscope and data from the two distance sensors were also sent. The visuals were inspired from a tutorial [21]. The patch was made with two separate noise texture operators that are passed through various effect operators. These include edge, blur, displace, mirror, luma level, bloom. Lastly, to help give the effects a more dramatic look, composite operators were used at different node junctions.

The data parameters sent from Pure Data was hooked up as follows. The X-axis was set to a period within one of noise texture operators. The Y-axis were set to an UV-weight of a displacement operator. The Z-axis were set to interpolate between two different luma level operators.

Figure 21: Touch Designer Fluids

5.4.3 Use case 3: What's In the Box

The third use case is very similar to the second. Instead of a ball, the gyroscope/accelerometer is placed inside a wooden box, aligning the axes of the sensor with those of the box in the hopes of creating a more intuitive experience. Additionally, distance sensors are introduced with new parameters to alter. Minor alterations were made to the PureData patch and TouchDesigner program to accommodate this new use case. A series of two filters, high-pass and low-pass were added to the audio signal path and the ability to control of the hue were added to the visuals. One distance sensor controls the low-pass filter and the amount of blue hue and the other controls the high-pass filter and the red hue. The sensors can be seen in figure 22.

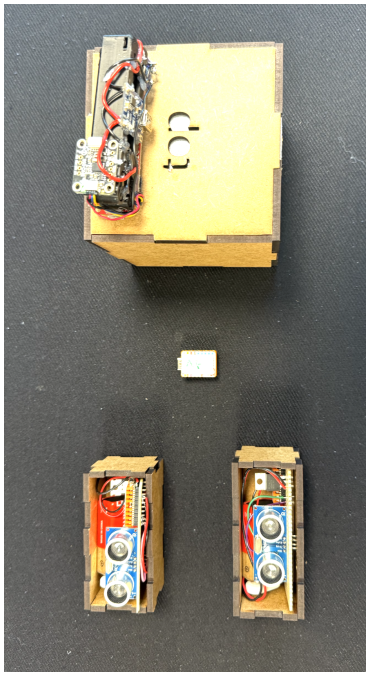


Figure 22: Use case 3 with the box and two distance sensors

6 Iterative Process

The initial brainstorming of this project led to a great deal of ideas surrounding sound. Ideas such as an open-source synthesizer, with the possibility of developing your own synth plugins, or an interactive window installation, with a focus on auditory feedback, when moving about or touching the windows. See appendix 13.2 for brainstorm ideas.

Our development followed a process where we during the project had three online meetings with our stakeholders (Tina and Lars). Demo videos were shown or sent prior to the meetings, as discussed, and feedback was given throughout the meetings. This was then taken in, and the product was reevaluated for the next meeting.

6.1 First meeting - 18/02-2025

The first meeting served as an introductory meeting, where we were presented with the stakeholders. We presented the first idea, which was to create an art installation/street installation with the use of transducers on windows. Lars, one of the stakeholders, saw potential in the idea. Both of the stakeholders saw a lot of potential in creating interactive installations or performances where users/audience could interact with sound.

During the period after the first meeting, multiple discussions were held in the group room. The group decided on creating a sort of tool-kit that would help sound installation artists. This later developed into the framework, which is described within the report.

6.2 Second meeting - 27/03-2025

The second meeting was held with Lars and Tina. Here, a demonstration of how the framework works was presented. This involved showcasing the first use case5.4.1 , as well as showcasing the possibilities of using MediaPipe for various interactions. What caught their interest was the modularity of the framework, which was the use of OSC.

After the meeting, Use case 1 was polished and served as a prototype. The development of use case 1 ultimately served as a way for the group to get a deeper understanding of how various interactions and sensors were viable and how to showcase the strengths of the framework. This led to the development of a first draft of use case 2 5.4.2. The group conceptualized an idea revolving around using distance sensors mounted to the ceiling in a grid, which could to used to create wave tables from various parameters, taking the height and position of people within the grid.

6.3 Third meeting - 10/04-2025

The third meeting was held with Lars. At this point, the framework was fleshed out as we had worked and finished the first use case. This meeting was primarily used to shape and flesh out our final second use case, as well as explain more in-depth to Lars what the system could do, so he could get a better understanding of the usability/possibilities of the framework. With this information, Lars introduced the idea of the audience being co-creators of the music by having a token, which is what we used as inspiration for our second use case.

The group had the idea of combining the grid of distance sensors with the previously mentioned suggestion from Lars. The idea of a token that functions as an interactive medium for the audience emerged. This would enable them to control and have direct influence on the music. It was decided that a ball, taking inspiration from the state-of-the-art3.7, containing an accelerometer and gyroscope, would fit this function. The grid, however, evolved through multiple idea iterations. Through lack of resources, inconvenience, and mostly the potential hazards of ceiling-mounted objects, the idea evolved into what would become a circle of sensors encapsulating the participants and thereby creating a play-stage for the installation.

6.4 Final iteration

Though the use case was heavily inspired by the meetings, throughout the development, the final use case in testing, turned out different than what was originally planned. The circle of distance sensors became two units that the users could hold and move around to use as inputs, where one controlled a low pass filter and another the colors of the visual representation. They instead became part of a use case three with a box instead of the ball in order to get a better translation of the audio representative feeling to the movement of the x,y,z axis, and was taken out of use case two so the ball would stand alone. This gave us 2 iterations with the same IMU sensor but with different experiences when adding the distance sensors.

7 Stress test

7.1 Latency test

As part of the stress test of the framework, we wanted to test the latency between the input from a sensor to when the sound is manipulated or played. To do that, we created a setup where we used a piezo placed on top of the built-in microphone of a MacBook. The idea was to send a trigger signal the same way as in the framework over ESP-now and OSC and record the timing of the received message and compare it with the recorded audio from the microphone. This time it was sent to Ableton Live instead of Pure Data. We did that because we had the opportunity to record on tracks and zoom in on the timeline to see the difference in milliseconds. When the piezo was hit, a cowbell sample was played.

By comparing difference on the the two timestamps from the cowbell sample and the piezo hit sound, we could determine the latency relation and thereby the system's latency. (See figure 23) A screen recording of the test in Ableton is available online [58].

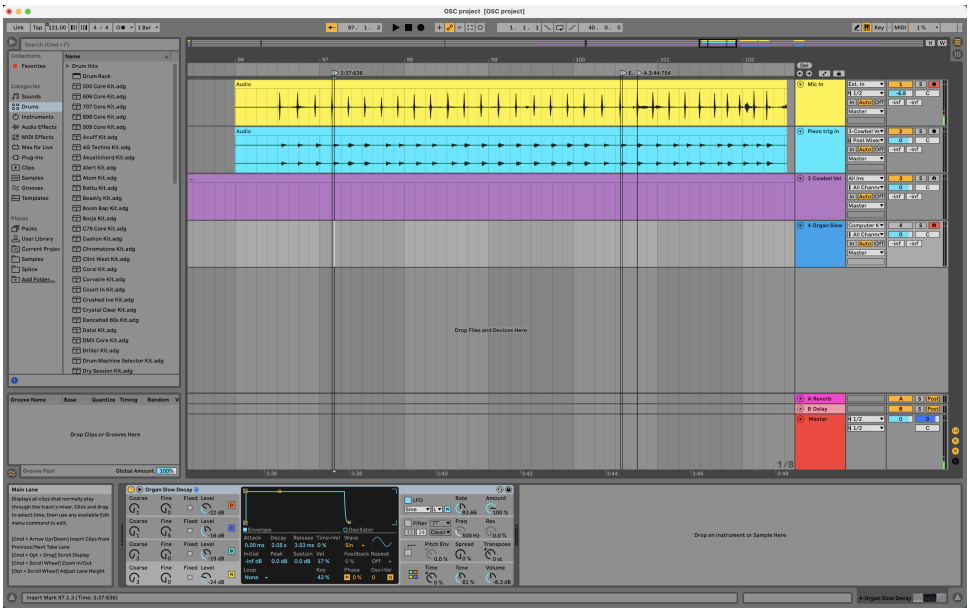


Figure 23: Latency setup Ableton live

While this setup gave us an indication of how the system performed. It was not a very precise way of testing it, and our results ranged between 7 and 121 ms with an average latency of 44 ms (see Appendix 13.1.1.4). Compared to the theoretical latency of ESP-NOW, which is as low as 1 ms for data packages around 1 byte, [59] our system is not performing optimally. This could be due to multiple factors. First of all, our system is not ESP-Now only. In order to send OSC wireless to a Mac/PC we utilize UDP, which is part of the Wi-Fi protocol that accordingly to the same study, has a latency of around 3.3 ms. Furthermore, UDP is known for being prone to

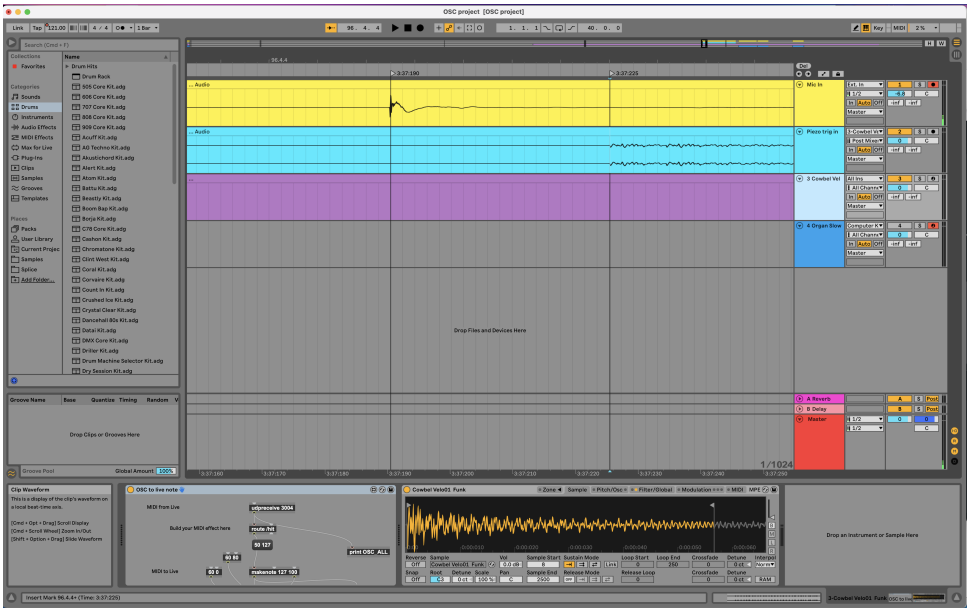


Figure 24: Latency setup Ableton Live zoomed in where we can see a latency of 35 ms

congestion, where the data sent is either dropped, not received in the sent order, or has variable latency because of jitter in the Wi-Fi signal [25]. This is even true for small packages that are sent at fast rates. Another reason could very well be code that is not optimized, resulting in unwanted latency. Lastly, the system we tested on had some latency as well. The computer used for the testing had to record the analog sound, converting it through the internal DAC while also playing the sample. We did a small test on the computer using the keyboard to play a MIDI note and the mic to record the hit, and that showed the latency to be around 10 ms.

While these mentioned potential reasons show some of the latency, it does not give a precise explanation to the latency issues and further investigation on the subject would be advisable on future work with the framework, one solution to try could be to put the receiving ESP on a wired Ethernet connection to the computer or using a USB-cable to send OSC to the computer eliminating Wi-Fi and UDP entirely using the OSC Slip library.[60]

7.2 Range

Since our framework is based on an all-wireless connection, the range in different installation situations is important. Wireless signals encounter a barrier effect where signals can be disturbed by different building materials and surroundings, which can result in severely affecting the RSSI(Received Signal Strength Indicator) negatively. A Wi-Fi-crowded space with a lot of searching and connected devices can also impact the performance negatively. We tested our framework by creating a sender with an ESP32 S3R with a screen showing the current RSSI on a predetermined Wi-Fi network and the access point used in the framework. We then placed the receiver at a location on the Aalborg University campus and walked away with the sender and took five samples at different locations on campus within range of the access point. The location of the access point can be seen as the red dot on figure 25. The blue numbers refer to the measuring locations. We did the test two times, once before lunch with relatively few people and once at lunch with a lot of people in the canteen. Finally, we did a line of sight test where we tested the range in clear sight.

The test showed us that the surroundings had a negative impact on the signal, and especially windows, made the signal attenuate almost 20 dBm (decibels milliwatts). This, however, contradicts the findings by Eridani [59] where they did not find glass to interfere with Wi-Fi signals;

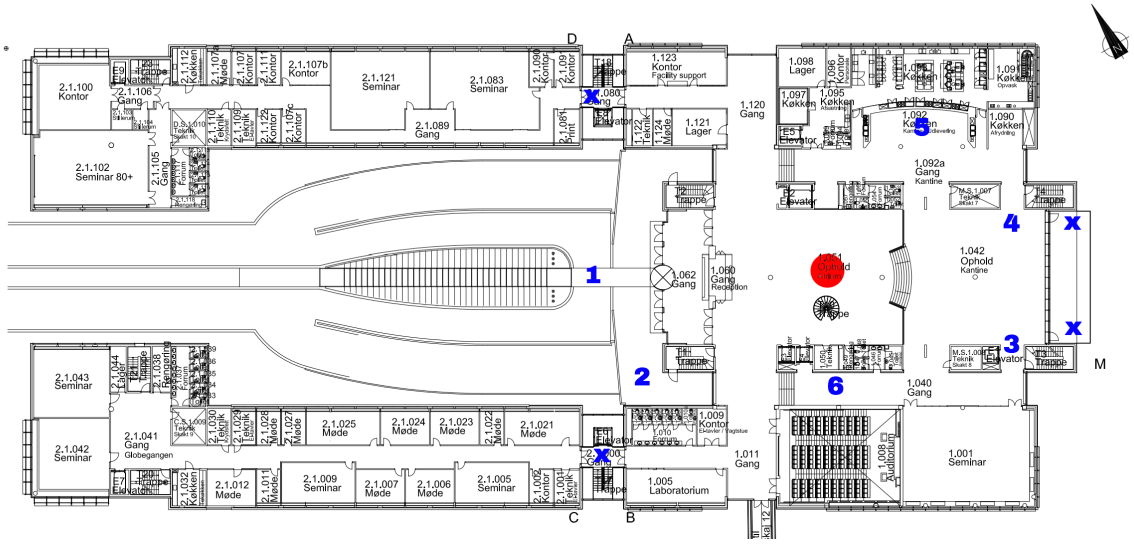


Figure 25: Plan drawing of tested area

other factors such as metal frame of the window and surrounding walls could be the culprit here. The test results from the test before lunch and at lunch did not show a noticeable effect on the signal strength, except for position two, where it got better by around 12 dBm, which we can't explain. According to the article, [61] humans walking through the line of sight could have a negative impact on the RSSI. Therefore, theoretically, if enough people were present at the canteen, we should have been able to see an attenuation on the RSSI. However, the weather was good and a lot of people were eating outside, and the eating area is "below" the Access point location, so they might not cross the line of sight.

The line of sight test showed us a connection around 250 meters, which is well above the stated in the [59] , which is 84 meters for Wi-Fi and 185 meters for ESP-now. However, we did not send data over the connection while testing, so we would not know the actual practical range of the system; this counts for the indoor test as well.

The overall experience and the range of the Wi-Fi were found to be satisfying within the use cases of this project. But if a different use case over a large area with many people and connected devices is needed, further testing, including data transmission, is advisable.

Signal strength (RSSI) Before lunch						
	1	2	3	4	5	Avg
Pos 1	-87	-90	-89	-91	-90	-89,4
Pos 2	-75	-73	-71	-71	-79	-73,8
Pos 3	-78	-79	-78	-78	-76	-77,8
Pos 4	-66	-65	-63	-72	-63	-65,8
Pos 5	-80	-77	-78	-79	-79	-78,6
Pos 6	-79	-76	-75	-77	-70	-75,4

Signal strength (RSSI) During lunch						
	1	2	3	4	5	Avg
Pos 1	-87	-88	-90	-88	-90	-88,6
Pos 2	-60	-63	-65	-60	-59	-61,4
Pos 3	-75	-76	-75	-75	-77	-75,6
Pos 4	-68	-67	-66	-68	-68	-67,4
Pos 5	-75	-82	-81	-84	-82	-80,8
Pos 6	-73	-76	-73	-78	-77	-75,4

RSSI (Received Signal Strength Indicator) - Closer to 0 is better

8 Evaluation

8.1 Methodology

The goal of the evaluation is to answer the final problem statement of the study 3.9. The following sections will describe the process.

8.1.1 Sampling

Purposive sampling was used for the evaluation test. It is a sampling method where the decision to choose participants lies solely in the hands of the researchers. It is also known as judgmental sampling, as the researcher chooses the sample based on whom they think is relevant and appropriate for the study [62]. This sampling method was used as there was a limited number of relevant individuals with enough expertise that would be appropriate for the evaluation. For the pilot test, a broader sample group was targeted.

8.1.2 Procedure

This study employs a combination of different techniques to collect qualitative data. The steps the participants will go through are firstly an explanation of the framework with a visualization of its modular aspects (see table 16). This is then followed by a demonstrations of use case 2 (see section 5.4.2) and then a semi-structured interview.

Sound source	Effects	Sensors	Output
Live sound	Tremolo	Touch	Auditory
Sample	Reverb	Distance	Visual
DAW (Any)	Granulator	Acceloremeter, Gyro	Other
Other	EQ	Body detection (ML)	
	Distortion	Hand detection (ML)	
	Other	Other	

Table 16: Modularity visualization

The first two steps of the test serve as a way to inform and familiarize the participant with the system. The last step, being the interview, is where data is collected. It will follow a semi-structured guide, which allows for exploration of occurring themes that might seem interesting.

8.1.2.1 Interview guide:

1. Did the demonstrated use cases inspire you creatively?
2. Would the framework be useful in your own artistic or professional projects?
   (a) If yes, how so?
   (b) If no, why?
3. How might you integrate this framework within your own work context?
   (a) What functionalities or aspects do you feel are missing or could be improved?
4. What do you consider the key strengths of the framework?
5. How would you envision the framework evolving to better meet your needs?
6. Could this framework streamline your workflow or accelerate your prototyping process?
   (a) Why or how could it facilitate improvements?
   (b) What might prevent it from being helpful?

The interview guide aims to gather the following information from the participants:
Relevancy: Does the framework inspire them, and do they see its application in their work?
Functionality: Is there any functionality they may feel is missing or lacking?
Improvements: What could be improved?

8.1.3 Data analysis

To interpret the data collected in the interviews, traditional coding will be done to identify patterns and thematic occurrences. The coding will divide the data into defined categories,

showcasing example quotes from each category. Traditional coding is a common procedure within qualitative evaluation research [62].

8.1.4 Reliability & Validity

Reliability means the consistency or dependability of the instrument or measurement strategy, and this is a necessary prerequisite for validity [63, p.413]. To improve the reliability of this evaluation, inter-analysis will be implemented, which is "*The extent of agreement or consistency among two or more independent observers, interviewers, or document reviewers-recorders*"[63, p. 421].

For the data analysis phase of the evaluation, multiple group members will be coding the transcriptions of the interviews, and only thereafter compare and discuss the results. The overlap between the results would then theoretically be the most reliable and reproducible result.

The validity of a study's findings refers to how true the claims in the study are, or how accurate the interpretations are [64]. To improve the validity of the findings within this evaluation, some of the eight validity strategies, as described by Creswell [65, p. 314-315], will be implemented:

Member check: A reflection on the participants of the evaluation, to account for whether their participation is relevant, and if there would be other, more ideal candidates.
Rich, thick descriptions to convey the findings.
Clarifying bias: Potential biases will be discussed that may influence the results.
Inclusion of negative and/or discrepant information: Any findings that may contradict the themes found within the data will be presented and discussed.

8.2 Pilot test & Findings

To test the method of our final test procedure, a pilot test was conducted. According to Baker, a pilot study is the pre-testing or 'trying out' of a particular research instrument [66, p. 184]. Teijlingen and Hundley mention that conducting a pilot study does not guarantee success in the main study, but it does increase the likelihood [67].

The pilot test aims to test the method and procedure currently planned for the final test, and to evaluate whether the desired data is gathered as described in the Methodology section (see section 8.1). To accurately evaluate the primary tests, the pilot test participants need to represent the target demographic as closely as possible to best emulate the final test scenario. The pilot test conducted included 2 participants, both of whom had experience creating music, but not any experience with interactive sound installations.

The framework was explained to the participants, followed by an introduction to use case 3. The participants engaged with the use case and were afterwards interviewed.

It was found that the modular aspects were not properly explained to the participants, as they understood the use case as the product, and not the framework. This is a critical issue, as improper explanation of the system limits the feedback we can get from the user. The interview guide was difficult to evaluate properly, as the pilot test participants did not accurately represent the target demographics. (See section 9.1.1)

8.3 Final test procedure adjustments

To tackle the concern found in the pilot test, adjustments were made to the testing procedure. In addition to use case 3, the participants will be introduced to use case 2, displaying the modular aspects and general capabilities of the framework. This iterative refinement aims to ensure that participants focus on evaluating the framework itself rather than the use case.

8.4 Findings

The following section is a presentation of the final test's findings. The section presents the findings as themes found throughout multiple participants' interviews. Each theme is described and supported by a table of quotes, comprising the theme. Note that some quotes have been translated as two interviews were in Danish. See appendix 14 for the complete, untranslated transcriptions.

8.4.1 Theme 1: Creative, playful exploration

When experiencing the use case presented to them, all participants showcased a certain interest in dissecting the inner workings of the installation. The specific interactions in the use cases seemed to invoke a curiosity within the participants, which led to a creative exploration. Lars and Simon began playing with the ball as a football, and Tina almost began choreographing a dance, exploring the options and the amount of control she had over the sound. Lars also described a playful aspect of the experience and expressed how he wanted to show the installation to his children, to see how they might interact with it. See table 17.

Participants	**Theme 1: Creative, playful exploration quotes**
Simon	"An artistic exploration automatically arises because there's something you don't fully understand, no matter your standpoint. And then you're sort of forced to, at least from my perspective, analyze your way forward a bit." *(Translated from Danish)*
Tina	"And even from just a person dealing with it, the fact of investigating what is going on is already a creative process. Like you are curious. How is this? What is happening? Basically. Because you are not told exactly but you realize something is going on"
Lars	"Probably also because we're in prototype territory, I become very aware of the technology. And I get fascinated by trying to understand it. But because it's also so stripped down, it actually feels like you get a bit on the inside of all the things you surround yourself with in everyday life." *(Translated from Danish)* "[...] It worked... Partly playful. The ball is clever, because it makes it playful. [...] Yeah. For me, it's mostly something playful. Because I think it's exciting to be in it. And I want to bring my kids into it too. And see, what the hell do they do in it?" *(Translated from Danish)* "Well, it was exciting to see Tina in it, because she sort of... Already there, she approaches it choreographically and finds a slower pace. She kind of challenges the more football-like approach I have to a ball." *(Translated from Danish)*

Table 17: Quotes regarding the exploration of the framework

8.4.2 Theme 2: Confusion regarding the framework's capabilities

Generally, the participants had trouble understanding the system's precision and how they might apply it in their own work. Simon wanted to explore the framework's capabilities further and would like a simplified version of the framework, comparing the idea of learning the framework with the feeling of learning and exploring a new instrument. Tina and Lars voiced a need for having softer and more controllable sound output, as they felt the use case sounded choppy. Overall, they described a need for precise control of the interactions' output and the ability to decode the consequences of the interactions as an audience member, as they had trouble understanding the framework as presented. In this vein, Lars and Tina expressed how they felt, or tried to figure out if the floor was involved in any way, which it wasn't (See table 18).

Participants	**Theme 2: Confusion regarding the framework's capabilities**
Simon	"Well, I think mostly what I said before about simplifying it... yeah... is the thing I'd definitely latch onto first, and then see how it works. Mm. Mm. I don't really think I can imagine anything that's missing. Uh... yeah. Mostly I think, like, make a simpler version and then see what that leads to." *(Translated from Danish)*
	"...as I said before, make a simpler version and then have it available so you have the opportunity to just play with it almost infinitely, because it can quickly become... or it feels a bit like an instrument you've never tried before." *(Translated from Danish)*
Tina	"But it was a bit confusing to me to experience in the beginning with these like distance sensors. Took me a long time. So I'm just saying. That the clarity of what's going on is quite important tool to have at your availability. If I was to use it creatively. Because if I'm using it creatively. And I want to cause that people don't get it. Then I would just play with timing. I would just delay it. So that I can be deliberate"
	"I mean, quite specifically I'm super curious on how could I make, for example, the rolling of the ball into a soundscape that is easy to perceive even for a child. I mean that was quite rough and there was a lot of like dakadakadaka, a lot of different, uhm, impulses?. But something that is actually soothing"
	"I think one development that I would like to do, there's these squares on the floor, so I was trying to figure out if there is a spatial orientation towards where the ball is. Or is it velocity only or is there also. something about where in the grid is it?"
Lars	"At the moment, the music is very chopped up. Yeah. And it sounds awesome. But you could also have it control some parameters where... where it reflected that softer movement more." *(Translated from Danish)*
	"But there was also a lot going on with the floor. You could feel that there were some... some very distinct shifts in the floor. Yeah. Which affected this sample... which I knew really well. But which was... like... elevated into something completely new." *(Translated from Danish)*

Table 18: Quotes regarding confusion

8.4.3 Theme 3: The social possibilities of the framework

When discussing possible use cases, all participants mentioned socially oriented ideas, allowing for interaction between the audience themselves, rather than with the installation or the artist. Lars thought of rolling a ball between audience members to highlight a social perspective, and Tina mentioned a project she is working on with disabled children, where this ball idea could provide an alternative to dancing, while still feeling a part of it. Tina expressed that the element of detection is a key strength of the framework for her, and that this could be used for an audience to generate something with intention. Simon saw the potential of audience members with no connection suddenly interacting with each other within an art performance. See table 19.

Participants	**Theme 3: Social possibilities of framework quotes**
Simon	"But as quickly became clear in our demonstration, a sense of play emerged among people. And I think it's incredibly exciting that art, in that way, can become more inclusive. Instead of being something you stand and observe quietly." *(Translated from Danish)* "It invites... something... like an art experience that is more engaging. And more active. And somehow... can serve as something that also brings people together. Like, for example, if it's something more audience-participatory. Mm. Where audience members who don't know each other... yeah... suddenly find themselves throwing a ball to one another. Yeah. So that's one of the aspects I think is super cool." *(Translated from Danish)*
Tina	"The key strengths for me in this framework is the fact that it, it detects. [...] for me as an artist that is super interesting. Because it becomes [...] something that can be generated. Something that can be generated with intention by a player. Being generated by intention by an audience. In an object. This is really nice. For me that's super strength. Strong. And interesting. And inspiring. That's my key strength thing for it." "[...] this specific project called Hear the Dance, Feel the Sound. Is dedicated to children. I was quite curious about the element of the playfulness inside it. Where the movement of a ball also became an image, right? [...] because these are children that are not necessarily have all the full functions of their bodies. So to ask them to dance is a different thing, right? But maybe to move an object is another way. Which could then be translated into hearing the movement.[...] It could be a toolbox for trying to translate for example movement into sound.
Lars	"If the ball could control a high pass, a low pass, and then [they] could sit and roll the ball to each other and feel that it's a social perspective, which also sounds really exciting." *(Translated from Danish)*

Table 19: Quotes regarding the inclusive nature of the framework

8.4.4 Theme 4: Flexibility of the framework

When discussing the different use cases of the framework, all participants saw its application in different fields rather than necessarily applying it to sound installations. Simon mentioned a multitude of applications that extend beyond the framework's original intention, such as incorporating it into a concert or even using it as a creative mixing tool. Generally, Tina saw that the framework provided multiple choices, and mentioned its advanced nature compared to previous tools she had worked with before. She also mentioned an idea of using the framework to create an art piece involving a dancer. However, Lars mentioned how the number of options would make him struggle to keep focus.

See table 20.

Participants	**Theme 4: Flexibility quotes**
Simon	"Well, I see quite a high usage potential for it specifically in various forms of performative art experiences, whether it's a concert or a dance performance."
	"Maybe it should actually be more like, if you think in a DAW context. [...] I could actually imagine something joystick-like. Yeah. Something that could help you mix a piece of music in a slightly freer way than what a keyboard and mouse can." *(Translated from Danish)*
Tina	"You have multiple choices, right? Which is good. I think this is something that is different and more advanced than what I've been working with before."
	"As it is right now, it's a super fun tool to have in a lab where you can explore things. And I can totally imagine an art piece, for example, being developed with this toolbox in that room. You have an artist in there, a dancer, you map out some different parameters, you sit together, you code it. I'm sure it could become an excellent, interesting work that we could exhibit."
Lars	"Basically, I'll keep thinking it over. Um... It's still quite... As you said, it's a framework. [...] It has the huge advantage that I can explore many avenues. And it also carries the weakness that I can... uh, struggle to sharpen my focus." *(Translated from Danish)*

Table 20: Quotes regarding flexibility of the framework

8.4.5 Theme 5: General inspiration

The dominant theme throughout the interviews was a sense of inspiration for the participants. They expressed a variety of both concrete and vague ideas, often put in the perspective of their own projects, which are already in development. Generally, they found aspects of the use cases interesting and wanted to explore some of these concepts further. Tina saw inspiration in trying to incorporate a soundscape made for children. She also expressed wanting to play with velocity, closeness, and orientation in space. Simon also noted this orientation in space and how he wanted to take the experience beyond the movement of the ball itself from use case 2, but making the physical space itself shake. Lars saw potential in both concert and art gallery settings, and just in general expressed seeing a lot of ideas being available. See table 21.

Participants	**Theme 5: General inspiration quotes**
Tina	"Quite specifically I'm super curious on how could I make, for example, the rolling of the ball into a soundscape that is easy to perceive even for a child."
	"So the part of the velocity and the closeness, but a sense of orientation in space, that could be an interesting development... Yeah, so the orientation in space could be something that I, would actually be needing to really use it I think."
Lars	"If there's a sphere that could look like the Earth, or like the Sun, or just like a ball... but one you can actually influence... you could imagine that being... uh, aesthetically exciting. You could also... conceptualize the excitement you could, I think... I can really see that working in an art-gallery context." *(Translated from Danish)*
	"You've seen so many balloons and all that crap. But if they could actually play a role — if the audience suddenly controlled something. That's the concert we haven't heard yet. That's something some people find exciting." *(Translated from Danish)*
	"There's a sea of possibilities." *(Translated from Danish)*
Simon	"That it could be... super cool to take it even further. Yeah. Uh... so that you could really, for example with the ball, if... now, I didn't quite figure out whether something also happened when you brought it down toward the floor. Yeah. As opposed to holding it up in the air. But if you could get like... almost everything to just shake. Yeah. Because you could get such deep bass from bringing it down to the floor. So that in some way it also... like, becomes a physical experience, beyond just the movement you're making yourself." *(Translated from Danish)*

Table 21: Quotes regarding general inspiration

9 Evaluation Review: Outcomes, Methods, and Validity

The following section is an in-depth discussion of the results from the evaluation, the overall test methodology, potential bias, and other relevant factors.

9.1 Discussion of results

Since the participants aren't technically aware of what the framework's underlying system is, and is capable of, it could be argued that the capabilities of the framework they speak of and have in mind might not exactly align with the framework of this project. It quickly became apparent during the interviews that the participants were not properly introduced to the modularity of the framework, and were also not informed about the underlying software and technology that made up the framework. Therefore, it is difficult for them to speak on the capabilities of the framework, as they were shown a use case utilizing it, rather than the framework as a system. This point comes from the participants not having a strong technical understanding.

> *"I'm not a technical person. So I can't talk into those things...*[*In reference to the framework*]*"*, Tina

Therefore, a lot of - but not all - the responses seem to latch on to the use cases presented and the ideas with these, rather than the framework. A lot of the findings will therefore be interpretations of the participants' responses, put into the perspective of the framework.

The first theme about creative playful exploration (see section 8.4.1) is related to the participants' experience with the use case. Their answers have been interpreted as audience members of an installation rather than experts. The rest of the findings are interpreted from their perspectives as experts for the following themes. For the use cases presented, the participants described them as playful and fun to explore.

> *"An artistic exploration automatically arises because there's something you don't fully understand, no matter your standpoint"* - Simon.

It shows that the framework can be used to create a successful interactive installation, since all participants expressed their enjoyment. Highlighting the fact that the framework does work to create interactive sound installations that engage the users. It should, however, be noted that the playful elements that the participants experienced and expressed in the subsequent interviews were partly due to the playful nature of the use cases. Namely, the ball from use case 2.

Moving on to the second theme regarding confusion (see section 8.4.2), when the participants were asked about the ways in which the framework could be implemented in their work, all participants mentioned the desire for the possibility of simplifying the output. As the test only afforded the participants to view the framework through the lens of a set of use cases, the confusion expressed by the participants wasn't necessarily a critique of the framework. But from the confusion, ideas emerged that could be implemented in a future version of the framework. Such as incorporating the floor, or somehow providing a sense of direction and placement within a sound installation:

> *"I think one development that I would like to do, there's these squares on the floor, so I was trying to figure out if there is a spatial orientation towards where the ball is. Or is it velocity only or is there also something about where in the grid is it?" - Tina*

However, this confusion also led the participants to want a simpler version of the framework, to play around with:

> "*Mostly I think, like, make a simpler version and then see what that leads to.*", Simon

The simplicity referred to is tied to both the audible and tangible experience. While curiosity also helped drive the interaction, it seemed the participants desired more control and understanding of their interactions. The short experience with the framework already led the users to realize this, as reflected in the following quote:

> *"But it was a bit confusing to me to experience in the beginning with these, like distance sensors. Took me a long time. So I'm just saying. That the clarity of what's going on is a quite important tool to have at your disposal."*, Tina

For the third theme about social possibilities of the framework (see section 8.4.3), we found that all the participants saw a potential for inclusiveness in installations. Meaning, it provided the potential of multiple people interacting not only with the sound installation, but with each other as well:

> *"If the ball could control a high pass, a low pass, and then* [*they*] *could sit and roll the ball to each other and feel that it's a social perspective, which also sounds really exciting."*, Lars

This social aspect could be applied to different fields as well. Perhaps as part of the introduction rounds in schools, getting to know each other, or as part of a game in a sports class. It could perhaps help encourage a social aspect in art performances, such as Vår Dag [68], where the interaction between the dancers and the audience is a crucial element. Their comments suggest that the framework could potentially help encourage social interaction in certain scenarios or amplify existing systems.

The fourth theme on flexibility of the framework (see section8.4.4) relates to the framework's potential across different settings beyond the field of just sound installations.

When participants were asked about how they saw the framework might be applied, all of them mentioned scenarios that were quite different in nature. While this framework was developed to create installations with an audience in mind, and the interaction between audience and installation, the participants mentioned instances where a performer would be incorporating it into their performance. In this way, the performer would be using the framework as an artistic tool for themselves to interact with rather than the audience. Simon noted:

> *"Well, I see quite a high usage potential for it specifically in various forms of performative art experiences, whether it's a concert or a dance performance."*

As for the framework's use in a concert context, while the framework might encourage audience interaction, which could pave the way for a more unique concert experience, it could also be used to create a specialized tool for the performer(s) to use on stage. Simon also noted how he could see the framework's use in his mixing process while creating music, leaving out the audience entirely:

> *"Maybe it should actually be more like, if you think in a DAW context.* [...] *I could actually imagine something joystick-like. Yeah. Something that could help you mix a piece of music in a slightly freer way than what a keyboard and mouse can."*, Simon

This application does not involve an audience at all, only the artist. These comments suggest that the framework's application purposes extend beyond traditional interactive sound installations, or perhaps its definition could be expanded upon. But this vastness of opportunity is a double-edged sword. As Lars mentioned:

> *"It has the huge advantage that I can explore many avenues. And it also carries the weakness that I can... uh, struggle to sharpen my focus."*

Giving the user the possibility to explore many different avenues can be a hindrance to their

creativity and can feel overwhelming. Suggesting that the framework, as it is, may be too unfocused in what it's trying to achieve and could benefit from a narrowed-down vision. Perhaps expanding its definition by, paradoxically, adding rules to the system, would limit the possibility of creating overly complex systems.

One way to achieve this could be to limit the number of components from each category and the number of connections between them. This could function as a suggestion to the user, rules can be broken, and it wouldn't inhibit freedom of expression.

Lastly, the prominent theme throughout the evaluation was the inspiration that the participants seemed to gather (see section 8.4.5). This inspiration permeated their responses in all aspects. While the previous themes focus on specific aspects of their suggestions and thoughts, a lot of the same responses could be categorized within this theme, to showcase the inspiration that emerged from their interaction with the use cases. Generally, they seemed to see potential in the framework and its general application.

As a lot of this inspiration stemmed from the use cases they were presented with, a lot of their ideas revolved around these concepts, such as the ball from use case 2.

> *"Quite specifically I'm super curious on how could I make, for example, the rolling of the ball into a soundscape that is easy to perceive even for a child." - Tina*

While this inspiration is great, it also highlights our inability to properly communicate the modular aspect of the framework, as discussed in earlier sections. Some inspiration even stemmed from an experience they had, with a feature that was not implemented, as discussed for theme 2. Despite this, the creative inspiration is undeniable, and it could be argued that a deeper understanding of the system from the participants' perspectives would perhaps inspire even further.

9.1.1 Test methodology

While the final test only partially achieved its goal of assessing the framework, the themes reveal valuable insight into what the participants found appealing (flexibility, social interaction) as well as what they found lacking (clarity, control).

A recurring problem throughout the test was that the participants could seemingly not conceptualize what the framework was. They had a hard time evaluating the framework as the technology it is, but rather talked about its artistic potential in relation to the use case. This issue primarily stemmed from our testing methodology not clearly conveying the framework's purpose, but rather showing a finished version of a use case. As the participants were artists, and the test involved an art installation, they were inspired artistically, which was predominantly reflected in the interviews. Therefore, the evaluation prejudice did not go as expected. However, it could be argued that the framework is meant to provide artistic inspiration, and therefore, the test did not necessarily fail, though it might have provided some results and themes that were unexpected and didn't match what we were aiming for.

If more time had been afforded to evaluating, this test could have, in hindsight, served as a pilot test. In a new iteration of the test, the methodology could be altered to ensure the testing of the framework as a technology. To do this, an expansion of the modularity visualization table 16 could be utilized. Rather than showing and explaining it briefly, it could be integrated as part of the test. The participants could pick and choose the sensors, sound sources, outputs, and effects and combine them in their desired way. Essentially, they would build an installation which we would then realize by making a working prototype for them on the spot, thereby showcasing the framework's capabilities.

Another way of making the participants review the framework as a tool, instead of reviewing the use case as shown, would be to make them come up with their own installation ideas. This could

be done, in addition to the demo use case, by moving them to different environment settings (e.g. Street, AAU Bridge, Studio, Theater), and having them brainstorm ideas for each setting. This would force them to think about the capabilities of the framework and how they would use it in different contexts, thereby also exploring the flexibility of the system.

The method of diary studies could also be considered for future testing. This would allow the participants to use the framework themselves over a period of time and note their thoughts and feelings during the process. They would gain hands-on experience with it and could provide proper feedback as artists utilizing the framework. This method would help the artists gain a better grasp of the framework, as they could get a proper sense of its strengths, weaknesses, and features.

There was some potential bias due to the stakeholder-centric development process, which pushed the project towards their specific needs. Furthermore, the stakeholders evaluated the framework themselves, therefore, acquiescence bias is also applicable from the data that was collected during the evaluation.

Different aspects of the test could have been changed to combat this bias. First of all, the interview guide could have been reevaluated to strike a balance between positive, negative, and neutral loaded questions. Additionally, it wasn't explicitly expressed that we needed both their positive and negative opinions, which might have had an influence on the way they answered, perhaps making way for acquiescence bias. Furthermore, having an external tester could have reduced acquiescence bias. Adding to this, more people should have been tested to minimize the potential bias in the overall themes. Tina and Lars, as of now, are 2/3 of the test participants, and therefore, having more participants would ensure the data is more valid instead of being potentially skewed by a few participants.

Reliability and validity

To yield a higher reliability within the evaluation, further precautions could have been implemented. Such as an intra-analysis, where the data was coded multiple times to look at the consistency between the former coding sessions, both across the team members, and also a single analyst's ability to consistently identify and categorize the same data. Additionally, the consistency/repeatability of the results has not been researched for this project, as participants might not produce the same results over multiple sessions.

In terms of validity, reflecting on the participants for the pilot test, some clear issues were present, as the participants only had one point of relevance, being that they had experience with creating music. They were not ideal participants for the pilot test, as the interviews subsequently didn't shed light on the issues we later experienced with the testing methodology of the final test. This was partly an issue of time, as our attempt at acquiring relevant pilot test participants was unsuccessful. As we were getting closer to the final test date, and a pilot test felt critical, we ended up convenience sampling a couple of participants in our vicinity, who were as close to our target demographic as possible, but conclusively not close enough. The pilot test ended up feeling close to pointless, and only provided a single point of issue, which was not dealt with sufficiently for the final test, as we saw the final test participants not fully grasping the modular nature of the framework.

Reflecting on the participants of the final evaluation, it should be noted that Tina and Lars, being our main stakeholders, were close to being ideal candidates. The argument for them not being ideal participants is the influence of bias from the collaborative aspects of the project, as the ideas were partly taken from our meetings. Simon, being from the same space as Lars, was also a good candidate, having a relatively stronger technical background, and he gave us insight into some technical needs that he found relevant. Ideally, candidates for the final evaluation test would have been sound artists with experience in creating interactive sound installations

that had no preconceived notions or test bias that would affect the findings in a notable way. Snowball sampling through the connection with Lars and Tina could have provided ideal test candidates; however, poor scheduling ultimately hindered this from being feasible.

While these validity strategies help strengthen the validity of our findings, other strategies could have been implemented. Strategies described by Creswell include 'Triangulate', the process of examining evidence from multiple data sources, other than just the interviews, to further support the themes. This could have been an observational study of the participants or perhaps a diary study. Cross-examining these could improve the validity of the presented findings. In addition to the member check, the themes uncovered and described from the interviews could have been presented back to the test participants to have them validate the findings. Creswell also suggests that peer debriefing, or an external auditor to review the project, would also benefit the validity of the project as a whole. Lastly, Creswell suggests spending a prolonged time in the field to develop an in-depth understanding of the participants and their settings, improving the validity of the findings.

These strategies were not implemented, mainly due to poor scheduling. These strategies would have increased the workload to a point that would have jeopardized finishing the project on time.

The overall validity of the findings is debatable. As described earlier, as the modular aspect of the framework did not seem to be properly conveyed to the participants, their understanding of the framework is skewed and/or incomplete. While an attempt has been made to interpret their thoughts regarding the use cases and their idea of the framework, against the actual framework, it is difficult to make conclusive statements regarding the framework's desirability as a tool for the participants. Generally, we did not quite receive the data we set out for, impeding the validity to some degree. As previously mentioned, the final test would perhaps better suit as a pilot test for another iteration of a new final test.

10 Project Review: Process, Outcomes, and Limitations

This section will discuss and review the process of the project, going through the process and how it could have been improved.

10.1 Process consideration

As the project approached the testing and evaluation stages, hindsight considerations emerged and sparked group discussions about the early project decisions. One example that could have led to a more qualitative approach for designing the framework would have been to implement card sorting earlier, with complementing interviews. This could have given us a more defined target group and a better understanding of various necessities within the framework. An argument to be held is the fact that most sound installation artists and what they need are heterogeneous. This would then require a more in-depth analysis to consider and choose the crucial features that should have been implemented. The project was done in collaboration with and more or less catered towards our stakeholders.

10.1.1 Iterative process

Use case 2 was gradually changed throughout development without the changes being explicitly discussed. The lack of group discussion and making a concrete decision on this does not necessarily reflect a problem with the process, as projects naturally evolve during development. However, if a decision to only use two sensors had been more explicit and taken earlier, they might've served a different purpose.

10.1.2 Team communication

When working on both use cases, there was a lack of communication when considering the technological requirements of the different systems between the development teams. The discussions

and processes of deciding what to develop lacked the specific technological details on how each piece of software and hardware should function and intertwine. This was something that definitely slowed down the development of the framework, as each part was individually considered "finished" but then required further development time to integrate with the other. To avoid this, the technical aspect should have been discussed in detail to avoid any wasted development time as well as missing or misaligned interactions/features.

10.2 Limitations

The framework in its current state has both technical and practical limitations. A practical limitation is that adopting and implementing the framework in the current state requires a high degree of technical understanding of the underlying systems. Meaning that in order to successfully adopt the framework to a working interactive sound installation, the user needs to have knowledge of sensors, Pure Data patches, and Arduino programming. This could be improved upon by providing extensive documentation on the framework and the underlying systems. Additionally, had there been time, a GUI (graphical user interface) could've been developed to easily program the ESP32 boards and route their data.

During our stress test, we learned that the technical limitations of the framework depend on the use case and the environment it is deployed. As mentioned in the stress test section 7. The latency of the framework in the current state is at an average of 44 ms. Though higher than anticipated, it is not mentioned in the test results as a source of confusion. This might have to do with the specific use cases not demanding a need for latency lower than the average. Another technical limitation is the range of the wireless connection, both on ESP-Now and Wi-Fi. This is also an environmental parameter that should be taken into mind when designing the specific use case for the framework.

11 Conclusion

"Can we create a framework for sound artists to create and perform sound installations?"

As the participants predominantly saw the framework through the lens of the use cases, it proved difficult for them to view the framework as a tool and separate it from the use case itself. Their response was positive but inherently difficult to put in the perspective of the framework. The feedback primarily revolved around the specific use cases and less of the framework in its entirety. However, the thematic analysis indicates that the participants recognized a creative potential within the framework as professionals. Their positive response from their experience as an audience, also shows the framework's potential for creating interactive sound installations successfully.

The project aimed to create a framework for sound artists to develop interactive sound installations. As testing was flawed, it did not put the actual framework in the hands of the user. Even so, the idea of using the framework to create with no assistance from other actors, such as the framework developers, did not seem plausible for the participants and would require some form of collaboration. This however, does not inherently hinder the artist from using the framework for creating and performing.

Ultimately, the answer to the final problem statement is yes, the framework is capable of creating interactive sound installations. As for the requirements, each of them were met and assured the blueprint for the functionality demanded by the framework. The framework's use, however, is limited to artists that are tech competent or have colleagues/collaborators that are, thereby limiting the scope of potential users. Testing showed that there was a desire to work with physical and digital components to create tangible, visual, and audible experiences, and while test participants were not necessarily going to create these systems with their own hands, they saw what it was capable of and felt inspired.

12 Future Work

The framework in it's current state would not be ready for commercial use by professionals. Therefore, if further resources were spent on the project it could be developed into a usable framework. This could be achieved by making ready-made enclosures containing sensors and micro controllers powered by batteries. Additionally, more types of sensors should be available and ready to use within any setup as it would make the framework more flexible and modular, and allows artist more freedom for what to use the framework for. Furthermore a solution to the high latency should be approached and implemented.

Expanding on the previous, the development of a graphical user interface (GUI) would greatly increase accessibility. It would allows potential users who aren't tech-savvy to customize the framework to their needs by routing sensor inputs and programming the controllers through an easy to use GUI. Another improvement could be to update the framework with in depth documentation, on how the system is set up, as well as technical detail on the system. This would open up for more people to understand the system and subsequently be willing to implement their own systems. The framework could allow for different types of connections for receiving and sending data. The users could configure the devices to use Wi-Fi, Bluetooth or wired according to preference and use-case.

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13 Appendix

13.1 Sound design

Sound design is distinguishable in the sense that sound design refers to the creation of specific sounds, while SID, as mentioned earlier, refers to the design of interfaces and perceptions. Creating an engaging sonic interface and experience requires a good understanding in how users act based on certain sounds in real time. Key principles to help shape a good sound design is:

- **Immediate real time feedback:**

Interactive sounds should respond immediately to any input the user makes, maintaining a tight connection between the action the user does and perception of what is happening[8]. Interaction such as this will make the system feel more natural and immersive.

- **Audiotory affordance:**

Like how visual cues can suggest actions to the users, so can sound invite the user to act certain ways or use product certain ways. A certain timbre or rhythm can maybe encourage tapping, or a pitch rising might suggest to the user to move something quicker. Sound is a fundamental property of everyday interactions and contributes to how we perceive an object's uses [69].

- **Meaningful and expressive feedback:**

Every sound in the interface should carry some meaning to the user or relevance to the action of the user's action or the system's state. Having random bleeps, might not suggest well enough to the user what is happening. One approach is to use auditory icons or metaphorical sounds that resembles real-world events, for instance a trash-can "crumbling paper" sound to signify deleting a file[69].

13.1.1 Mediapipe

13.1.1.1 `main.py`

`main.py` is the script the user runs when they wish to use a MediaPipe solution. The entire Python implementation is built modular, splitting sections of the code into different files, allowing for a better overview, improving readability, and easily allowing for extending the functionality by implementing your own code. This leaves the `main.py` script as the knot through which it all is executed. The script loads arguments from a parser, begins the OpenCV loop, and then checks for which model to use. The model that the user wishes to use can be specified as a command-line argument, as the argparse module has been implemented. (See section args.py 13.1.1.3)

13.1.1.2 `osc.py`

The OSC communication is set in its own file, to easily add functionality if you need to add some extra logic, such as formatting. Presently, the script includes setup of a UDP client, a function to send data to an address, and lastly, a function specific to MediaPipe data, which iterates the landmarks of the models and sends them individually to an address.

13.1.1.3 `args.py`

Since this is meant to be used by anyone, for different use cases, with different setups, some variables within the code will need to be changed. Even something as small as choosing between the built-in laptop camera and an external camera, something needs to be changed. To keep it neat, the file `args.py` gathers all relevant global variables.

They are set up using `argparse`, which allows for arguments to be generated in other scripts. The parser also allows for variables to be changed using command-line arguments when running the script, which allows for easy alterations for scenarios such as testing. The user would simply

need to execute the file in the terminal and add a relevant argument, such as the camera choice to be the external camera instead of a laptop's built-in camera. For this, a user would write:

```
py3 main.py -cam 1
```

The `args.py` file then also contains the default values of all relevant global arguments, such as IP address, output port and so on. If the user finds themselves needing a new default, they would change the values in this script, instead of every script where the argument is used.

13.1.1.4 Model implementation

The goal of the MediaPipe implementation is to extract the normalized location values of the landmarks and send them through OSC to Pure Data - this data could be sent to any device that can communicate through OSC, but for this project, Pure Data will be the primary receiver. This data can then be used in Pure Data to map it to audio effect parameters, or in Touch Designer for visual feedback.

However, besides mostly raw data, a decision was made to calculate and extract some additional data for the MediaPipe Hands model, inspired by Instagram user pepepepebrick [70], who posted a video [71] of them using a MediaPipe plugin for TouchDesigner[72] developed by Torin Blankensmith [73]. In the video, the distance between the index fingers and thumbs, and the distance between their hands, is used as data to control parameters in VCVRack[74], which provides some fun and interesting interactions. This data is also extracted for this project.

For the general file setup, each MediaPipe model has its own dedicated file, where the landmark data and any additional calculated data are extracted. From their respective scripts, the function that formats and sends the OSC message is called.

The current code setup and file structure provide an easy overview, giving the user a structured file system, allowing for extending the functionality of the current solution. And since Python, as a programming language, is widely used, other types of input can be implemented to be extracted and sent via OSC if the user so pleases. As this is meant for artists of all skill levels, the documentation provides a simple user guide, displaying how to install dependencies and afterwards run the program in the command line, avoiding the clutter of dozens of lines of code.

Stress test Latency

13.2 Brainstorm

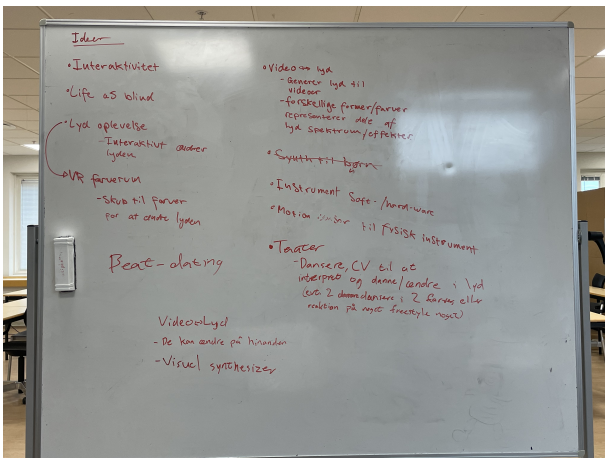

Figure 26: Brainstorm

Audio time	Esp time	ms latency	Median	Average
36.358	36.406	48	41.922	44
36.773	36.792	19		
37.190	37.225	35		
37.586	37.638	52		
37.968	37.983	15		
38.356	38.363	7		
38.749	38.867	118		
39.129	39.169	40		
39.515	39.579	64		
39.903	39.948	45		
40.310	40.408	98		
40.687	40.712	25		
41.087	41.115	28		
41.494	41.503	9		
41.906	41.922	16		
42.333	42.344	11		
42.717	42.743	26		
43.113	43.124	11		
43.508	43.524	16		
43.926	43.983	57		
44.346	44.392	46		
44.754	44.761	7		
45.120	45.212	92		
45.499	45.620	121		
45.869	45.931	62		
46.217	46.235	18		
46.568	46.648	80		
46.870	46.882	12		
47.158	47.259	101		

Table 22: Audio and ESP Times with Latency Measurements

14 Transcriptions

14.1 Simon transcription

00:00 - 00:26 SPEAKER_01

Først vil jeg spørge om tilladelse til at optage, og om vi må bruge navn i rapporten?

SPEAKER_00 Yes, det må du gerne.

SPEAKER_01 Okay, fedt. Spørgsmålene er på engelsk, men du må gerne svare på dansk.

SPEAKER_00 Foretrækker du engelsk?

SPEAKER_01 Det er hvad end du foretrækker. Så må jeg bare sige, at dansk er fint, ja. Så her. Did the demonstrated use cases inspire you creatively? How so?

00:26 - 01:08 SPEAKER_00

I would say, nu tager jeg den på dansk. Der opstår automatisk en kunstnerisk undersøgelse, fordi der er noget, man ikke som uanset punkt forstår. Og så bliver man jo nødt til at, altså i hvert fald fra mit perspektiv, analysere sig lidt frem. Og i og med, at der er et output hver gang man laver en ændring, så bliver den kunstneriske udfoldelse ligesom bare en del af min analyse. Ja. Og jeg kan virkelig godt lide tilfældigheder. Nu ved jeg godt, at det selvfølgelig ikke er som sådan en tilfældighed, hvad der sker, men hvad jeg gør med objektet er lidt en tilfældighed. Ja. Ja.

01:08 - 01:10 SPEAKER_01

Ja, okay. Would the framework be useful in your own artistic or professional projects?

01:17 - 01:50 SPEAKER_00

Det tror jeg. Altså, jeg kan virkelig godt lide det interaktive aspekt af det. Ja. Og det som man kunne se i vores demonstration hurtigt blev til en ... Øh, jeg har sagt, øh, whatever. Dansk er fint. Men som det også hurtigt blev synligt i vores demonstration, at der opstår en leg blandt folk. Og det synes jeg er vildt spændende, at kunsten på den måde kan blive mere inkluderende. I stedet for at være noget, man står og beskuer, mens man siger stille.

01:50 - 02:06 SPEAKER_01

Ja. Ja, selvfølgelig. Øhm ... Og så ... How might you integrate this framework within your own work context? Og hvis du så husker, at det her med dig ... Med det her papir, du så, hvor der var alle de her muligheder og forskellige måder...

02:06 - 03:04 SPEAKER_00

Altså, jeg tror, jeg ville ... Jeg ville forsimple det ret meget. Mm. Så man i højere grad får fornemmelse af, hvad man gør og hvad det udløser. Ja. Altså, det virkede ... Nu ved jeg godt, vi ikke har brugt mere end 5-10 minutter. Men i hvert fald for mit eget vedkommende er det lidt afgørende, at jeg i lidt høj grad kan afkode, når jeg gør det her, så sker det her. Når jeg gør det her, så sker det her. Mm. Og så kunne man måske lave større detaljegrad af hver variation. Ja. Så man fra side til side, f.eks. med bolden, når man ruller den til en side, så sker der egentlig kun én ting. Ja. Men det kan så ske i ... Ja, med højere detaljegrad på en eller anden måde. Ja. Men jeg har svært ved at regne ud, er der både delay, distortion, panorering, ja, andre ting, der spiller ind. Så bliver det også lidt forvirrende. Ja.

03:04 - 03:10 SPEAKER_01

På en eller anden måde. Så noget med, at det måske ville være lettere at afkode, hvad det var, der skete som råd.

03:10 - 03:55 SPEAKER_00

Ja. Og muligvis at lydkilden, det der ligesom er samplet, udgangspunktet ... Ja. ... enten er noget, man har præsenteret i ren form først ... Mm. ... eller man ved, hvad er det for en lyd, der er på spil, og hvilke variationer. Har den indbygget i sig selv? Ja. Eller bruge en lyd, der er nærmest uden variation, så det er interaktionen, der skaber al variation. Mm. Og igen er det

lidt tilbage til mit behov for at i lidt højere grad på at afkode. Fordi man kunne bare forestille sig, at hvis man havde én tone, der bare kører konstant, så ville det være nemmere at vide, at hver variation er noget, jeg skaber. Mm. Og ikke nødvendigvis noget, som ligger indbygget i samlet eller lydkilden.

03:55 - 04:08 SPEAKER_01

Ja. Okay. Mm. Det kan jeg mene i. Øh ... Hvilke funktionaliteter eller aspekter af dette framework føler du, kunne være forbedret, eller ... altså ikke er til stede? Mangler der?

04:08 - 04:39 SPEAKER_00

Øh ... Jamen jeg tror mest det, jeg sagde før med sådan at forsimple det ... Ja. ... tror jeg er den ting, jeg i hvert fald ville gribe fat i, og så se, hvordan det fungerer. Mm. Mm. Jeg tror ikke helt, jeg kan forestille mig noget, der mangler. Øh ... Ja. Jeg tror mest det, altså sådan lave en simplere udgave, og så se, hvad det fører med. Ja. Så kan det godt være, der opstår noget, man tænker, ah okay, det kunne godt bruge det her eller det her.

04:39 - 04:46 SPEAKER_01

Ja. Okay. What do you consider the key strengths of the framework?

04:46 - 05:00 SPEAKER_00

Helt klart ... Øh ... at det ligger op til ... noget ... altså en kunstoplevelse, der i højere grad er inddragende.

05:00 - 05:01 SPEAKER_01

Ja.

05:01 - 05:21 SPEAKER_00

Og mere aktiv. Og på en eller anden måde ... kan agere noget, der binder folk sammen også. Altså for eksempel, hvis det er noget mere publikumsinddragende. Mm. At publikum, der ikke kender hinanden ... Ja. ... lige pludselig står og kaster en bold til hinanden. Ja. Så det er et af de aspekter, som jeg synes er super fedt. Ja. Ja.

05:21 - 05:23 SPEAKER_01

Okay. Fedt.

05:23 - 05:29 SPEAKER_01

Øhm ... lad mig se ... How would you envision the framework evolving to better meet your needs?

05:29 - 05:35 SPEAKER_00

Mmm ... vil du lige sige det igen? Det skal jeg lige ...

05:35 - 05:48 SPEAKER_01

Ja, sådan. Jeg kan prøve at sige det også på dansk her. Øh ... hvordan ville du forestille dig, at det her framework kunne udvikle sig ... Ah. ... så det bedre ville tilpasse dine behov i din profession?

05:48 - 05:55 SPEAKER 00

Altså, jeg tror helt sikkert, at det er noget med at få ... altså igen, som jeg sagde før, lave en simplere version, og så have det til rådighed, så man har mulighed for bare at lege med det i

en uendelighed nærmest, for det kan hurtigt blive ... eller det føles lidt som et instrument, man ikke har prøvet før.

06:12 - 06:13 SPEAKER_01

Mm.

06:13 - 06:29 SPEAKER_00

Og man vil gerne måske have noget tid med det instrument, før man kan finde ud af, hvad er sådan mulighederne i det. Ja. Øh ... Så det er helt klart et aspekt. For simple det. Ha' adgang til det. Og bare lege med det. Øh ...

06:29 - 06:31 SPEAKER_01

Ja.

06:31 - 06:47 SPEAKER_00

Der er et eller andet i ... den sådan, altså sådan, for mit vedkommende, tror jeg, sanse-oplevelsen ... af hvor, lad os sige, spændet fra, hvor dybt gæt det er. Ja. Og hvor lyst kan det blive, og hvor stille kan det blive, og hvor højt kan det blive.

06:47 - 06:48 SPEAKER_01

Mm.

06:48 - 07:23 SPEAKER_00

At det kunne være ... super fedt at kunne højne det endnu mere. Ja. Øh ... så man virkelig f.eks. med bolden, hvis ... nu nåede jeg ikke helt at regne ud om, der også skete noget, når man tog den ned mod gulvet. Ja. Modsat at have den op i luften. Men hvis man kunne få sådan ... altså nærmest det hele til bare at ryste. Ja. Fordi man kunne få så dyb bas af at tage den ned til gulvet. Så det på det en eller andet måde også ... altså bliver en fysisk oplevelse, ud over den bevægelse, man selv har. Ja. Øh ... ja.

07:23 - 07:48 SPEAKER_01

Ja. Det var faktisk det sjove, du nævner det. Det var faktisk noget, vi gerne ville have lavet med bolden. Ja. Men vi havde ikke lige tid, for det ... det var jo begrænset, det data, man får fra det der axelometer. Så det var matematisk ret svært. Ja. Men vi havde klart gjort det, hvis vi havde haft mere tid. Ja, Fordi det kune være at mega fedt. Ja. Og ligesom kunne mærke forskel på højde, og ikke kun bevægelse og rotation.

07:48 - 08:42 SPEAKER_00

Ja. Jamen det synes jeg er jo mega fedt, at jeg kunne vide. Altså jeg ved slet ikke, hvor meget der ligger inde bagved jo. Men jeg tænker netop, altså sådan jo højere detaljegrejde, man kan få med egentlig bare ét element, der ændrer sig. Mm. Og det vil i høj grad ligesom højne, hvor meget man ... hvor meget detalje, man selv kan få ud af at lege med det. Ja. Altså hvis man kan virkelig få følelsen af, okay, når jeg bevæger det en centimeter, så sker der noget. Ja. Når jeg så bevæger den en meter, så sker det gange 100. Mm. Altså så er det virkelig bare sådan, okay shit, man kan stå lige så stille og bevæge den og føle, at der er en forandring. Men man kan også kaste den til en, og så siger det bare . Ja. Så det er en ... en stor forskel. Ja. Og det kan jo fornemme, at der er ... altså selvfølgelig er der det i det nu. Øhm ... Ja.

08:42 - 09:01 SPEAKER_01

Ja. Okay. Øh ... var der ... udefra det her papir, du så, og så eksemplet, du så, var der så nogle typer interaktioner, som du ligesom fik idéer til, eller som du blev inspireret af til, at ...

09:05 - 09:12 SPEAKER_00

Ja, helt klart. Ja. Altså måder man kunne bruge det på, eller mere om jeg kunne ... det der stod på papiret, om jeg ligesom kunne se, at det var i spil, når man så trådte ind.

09:12 - 09:15 SPEAKER_01

Øh ... nej, nej mere i at måder du kunne bruge det på.

09:15 - 10:32 SPEAKER_00

Ja, klart. Øh ... Altså jeg ser ret høj anvendelse af det i netop forskellige former for performative kunstoplevelser, om det er en koncert eller en danseforestilling. Og det der med ... Altså med det definerede felt, synes jeg var virkelig fedt. At det er ... Øh ... At der på en eller anden måde er en arena, det udspiller sig i. Om det er ... Øh ... Nu stod der også stået, altså sådan hvad ... hvad lydkilden kunne komme fra, om det var fra en DAW, eller om det var fra en anden type program. Øhm. Jeg tænker sådan, DAW er jo oftest noget man bruger til sådan indspillet materiale, og sidder og bearbejder indspilninger. Og jeg tror på en eller anden måde, at de programmer, i hvert fald de fleste, men de er så sindssygt komplekse i sig selv, at det ville være ... Hvad jeg ligesom har af fantasi. Sådan lidt for ukontrollerbart at hive det derover. Øh ... Øh ... Men jeg kan virkelig godt se det i en koncertsammenhæng. Ja. Eller netop, eller mere sådan en performancekunst sammenhæng. Øh ... Hvad var det man der stod i længere hen? Øh ... Jeg har ikke lige taget papiret med mig. Vil I lige prøve at hente dem?

10:32 - 10:33 SPEAKER_01

Jeg henter det lige...

10:49 - 11:27 SPEAKER_00

Ah ja, selvfølgelig. Ja, så jeg sagde jo egentlig før, at det med feltet, der var defineret. Ja. Altså det er vel både den der hedder body detection og måske distance sensor. Selvfølgelig også accelerometeret. Men altså sådan touch-delen kunne jeg virkelig også godt se ... ... have en fed effekt i en eller anden sammenhæng. Men igen, så ser jeg i mit hoved i hvert fald, så er det touch-sensoren måske alene. Ja. At man har et objekt, man kan gå hen og røre. Og hver lille bitte ting kan et eller andet. Og en stor berøring, eller hvad man kan sige. En mere kraftig berøring gør noget mere.

11:27 - 11:28 SPEAKER_01

Ja.

11:32 - 12:08 SPEAKER_00

Joystick. Det skulle måske faktisk mere være, hvis man tænker sådan i daw sammenhæng. At de ville kunne hænge sammen. Ja. Nu hvor jeg selv arbejder rigtig meget i en daw, så blev det meget tastatur og mus. Og det ... Det er veldig praktisk, men det har ikke den der leg over sig, som jeg synes det her, det kan have. Ja. Så jeg kunne egentlig godt forestille mig noget joystick-agtigt. Ja. Som kunne hjælpe en med at mixe et stykke musik på en lidt mere fri måde, end hvad et tastatur- og mus kan.

12:08 - 12:09 SPEAKER_01

Ja, okay.

12:09 - 12:24 SPEAKER_00

Øhm ... Men så den ser jeg nok mindre i sammenhæng med noget live, der foregår. Ja. Men det er jo lidt i sammenhæng med noget computerarbejde på en eller anden måde. Ja. Ja.

12:24 - 12:25 SPEAKER_01

Okay.

12:25 - 15:04 SPEAKER_00 (Looking at paper)

Øhm ... Og jeg kan virkelig ... Altså de der to, synes jeg egentlig ... Hvad for nogle? At output'et er både noget visuelt og noget hørbart. Mm. Er på en eller anden måde ... Jeg ved ikke ... Altså jeg tror godt ... Jeg tror den lydlige del kunne fungere for sig. Ja. Den visuelle del kunne helt sikkert også fungere for sig. Og så sammen, så højner de jo på en eller anden måde bare hinandens udfoldelse på en eller anden måde. Ja. At jeg kunne mærke ... Det var også det, jeg startede med at sige, at jeg kunne mærke, at jeg brugte det meste af tiden på faktisk at sådan lidt analysere, hvad er det, der foregår. Mm. Hvor den visuelle del var måske lidt nemmere at afkode ... Ja. End den ... Den lydlige. Ja. Og så herovre i effektdelen ... Altså, vi vil jo få det her. Altså, reverb synes jeg er fedt. Granulator delen synes jeg giver vildt god mening. Distortion giver vildt god mening. EQ kan ... Synes jeg også godt kunne give mening.

Det var måske særligt det, vi snakkede om med, hvis man har et objekt, man kan tage op og ned til jorden, at det så på en eller anden måde styrer. Ja. Jo længere du har den nede, jo mørkere bliver lyderne, jo længere du tager den op, jo lysere bliver det. Ja. Mm. Og der kunne helt sikkert også være nogle sådan ren ... Ja. Speciale effekter. Mm. At man sagde, når ... Altså, hvis man igen har feltet, når objektet så er tæt på en højtaler, så centrerer alle lyden så derovre. Ja. Så man, hvis man stod fire i hvert hjørne og kastede bolden til hinanden, så flyttede lyden så ligesom med boldens bevægelse. Ja. Så bolden på en eller anden måde bliver ... Hvad fanden skal man sige ... Ja, så bolden bliver sådan ... Det bliver symbolet på lyden. Ja. Det bliver sådan lydkilden på en eller anden måde. Ja, præcis. Ja. At det er næsten som om, at lyden kommer ud af bolden. Ja. Det tror jeg kunne fungere super godt. Ja.

Og igen, så tror jeg, det ville være så stærkt i sig selv, at man skulle passe på med at blande for mange ting sammen med. Ja. Fordi så bliver det sådan lidt sværere at afkode, er det mig, der gør det? Sker det bare lidt tilfældigt? Mm. Kan jeg ... Kan jeg lære at styre det så godt, at jeg kunne bruge det mere? Altså, hvis man siger, det er en performancekunstner, der har det her, som står ... Og det ikke er publikumsinddragende, men personen står og performer med et af de her objekter. Så er der også et element af, at publikum gerne skal forstå, hvorfor sker det der, når du gør det der. Mm. I hvert fald personligt. Altså, har jeg det sådan, at ... Hvis man siger et band med lidt for meget backingtrack, kan det godt være ... Altså, jeg har klart haft et problem med at afkode sådan, hvem gør hvad? Ja.

15:04 - 15:20 SPEAKER_01

Ja. Ja. Mm. Det er super god mening. Fedt. Fedt. Så har jeg et spørgsmål mere her. Could this framework streamline your workflow or accelerate your prototyping process?

15:20 - 16:02 SPEAKER_00

Uh. Altså, i sådan ren ... Altså, som jeg nævnte, sidder mixemusik. Mm. Så tror jeg, det ville kunne accelerere noget. Mm. Fordi det ville kunne gøres mere intuitivt. Og i stedet for 50 klik med en mus, så kan det være en bevægelse med et eller andet objekt eller med et joystick. Så det kan bære meget mere information med sig i én bevægelse end hvad 50 smutseklik ville kunne gøre. Ja. Øh. Og så sidder man i prototype og accelererer your prototype process. Mm. Den tror jeg ikke, jeg lige har noget relevant at svare til.

16:02 - 16:15 SPEAKER_01

Nej. Ja. Ja. Det er også helt fair. How could it facilitate improvements in your work? Mm. Hvis det, hvis det kan.

16:15 - 16:59 SPEAKER_00

Ja, selvfølgelig. Øh. Men jeg tror især, altså hvis vi snakker den der mixing del, sidde lidt alene med en computer. Mm. Så ville det helt sikkert kunne, øh, ja facilitere at det også bliver en mere levende proces. Og ikke så stillesiddende en proces. Mm. Og lidt mere legende. Og i den performative del, kunne det helt sikkert, altså er det meget det der med at rive idéen op. Nogen der står på en scene, rive det lidt op med rødderne og sige, øh, altså en koncert eller en, noget performance kunst. Kan også være meget mere fysisk blandt mennesker og eventuelt inddrage publikum.

16:59 - 17:00 SPEAKER_01

Mm.

17:00 - 17:01 Undetermined speaker

Ja.

17:01 - 17:08 SPEAKER_01

Ja. Øh. Og så sidste spørgsmål her. What might prevent it from being helpful?

17:08 - 17:15 SPEAKER_00 Øh. Det tror jeg ville være gennem, altså forvirring. Ja. At der sådan er, der sker for mange ting på en gang. Ja. Okay.

17:15 - 17:16 Undetermined speaker

Ja. Øhm, det var egentlig det sådan. Mm. Ja. Af spørgsmål, der var forberedt.

17:16 - 17:26 SPEAKER_01

Ja. Ja. Har du andre sådan tanker eller pointer eller?

SPEAKER_00 Altså jeg er mega nysgerrig på, altså fordi, nu kan du også høre at jeg går sådan lidt i analyse mode af hvad der foregår der. Ja. Altså så jeg havde i, hvor, hvor er alle de her effekter i spil nu? Øhm. Jeg er ikke sikker på hvad det er. Jeg stopper bare lige optagelsen her for nu. Ja.

14.2 Tina transcriptions

00:00 - 00:22 SPEAKER_00

No problem. Like that. And of course there are a lot of questions, you can't answer wrong. Just answer as it fits you. There are no bad or good answers. Just answer the ones you feel are right for you. Did the demonstrated use case inspire you creatively?

00:22 - 01:25 SPEAKER_01

Yes. It did inspire to movement the way that I perceived it. And for me that is also creativity since I work with dance and choreography. And yes it is inspiring in terms of creativity because it somehow calls for an investigation on the dialogue that you have with an object. So in that way there is a relation going on. And for me the creativity always happens in some sort of a relation. So in that way, yes it inspires by creativity. It does. And even from just a person dealing with it, the fact of investigating what is going on is already a creative process. Like you are curious. How is this? What is happening? Basically. Because you are not told exactly but you realize something is going on. Is that a sufficient answer? Or should I delve a bit more?

01:25 - 01:49 SPEAKER_00

Perfect. Like I said before, it is just whatever thing comes to your mind. Because it is what makes sense. If you start to think what the right answer is then it is not really. So to the next

question. Would the framework be useful in your own artistic or professional projects? If yes, how so? If no, why?

01:49 - 03:48 SPEAKER_01

So in a very concrete way it will be helpful. I have for example, I have a project that we call Hear the Dance, Feel the Sound. And this whole thing about translating let's say movement into either a sound or an image. So the sense of transferring whatever material. Material is produced by either children or artists and other into another form. Is a creative tool that I usually actually work with, has worked with many times. And I think in this one particularly because this specific project called Hear the Dance, Feel the Sound. Is dedicated to children. I was quite curious about the element of the playfulness inside it. Where the movement of a ball also became an image, right? Yeah. Or the movement of a ball that could also be because these are children that are not necessarily have all the full functions of their bodies. So to ask them to dance is a different thing, right? But maybe to move an object is another way. Which could then be translated into hearing the movement. If you understand. Yeah. So this would be like for example. The movement of the ball. The movement of the ball generated sound differences or it generated images changes. That would be a way of them to hear the movement. See the movement in different layers. So in that way very very much so. I mean concretely so actually. It could be a toolbox for trying to translate for example movement into sound.

03:48 - 03:49 SPEAKER_00

Yeah.

03:49 - 04:36 SPEAKER_01

It's exactly what I've been working with. With this project. I have done that in various other ways. And of course there's different ways of tracking movement and producing sounds. But I realized this has. I'm very interested in the turning aspect. I guess that's where the ball came in, right? So the sense of the velocity, the speed is another way of like it's a way of dealing with sound or movement. Transformed into sound. Transformed into sound or image in a different way. I haven't actually done that before. So that was actually quite interesting. Especially because it touches upon playfulness. Like and because I'm going to be working with children. And playfulness is the game. It's interesting. Very much so.

04:36 - 04:48 SPEAKER_00

How might you integrate this framework within your own context? What functionalities or aspect do you feel are missing or could be improved?

04:48 - 08:11 SPEAKER_01

Mm-hmm. I was spending. Okay. So what is missing? It's a bit difficult for me to detect whether what is missing is a matter of how the actual framework is set up. Or what it is that's put in there. I have a harder time detecting the differences in the movement and how it connects to the sound. Than I had to the way that it connected to the image. But this can just be me being more image driven. I'm not sure. So I think for the way that I understand that there is a level of recognizing what's going on. That's important. It was a bit tricky to do. Especially with the distance sensors. It took me a long time. So it could be an investigation. That's also interesting. But I would say. The recognition of what's going on is nice to be able to have in a way that is. You can play with it then after. To understand. Okay. If I go closer. This happens. If I go further. This happens. I think this is what the framework is set up to. But it was a bit confusing to me to experience in the beginning with these like distance sensors. Took me a long time. So I'm just saying. That the clarity of what's going on is quite important tool to have at your availability. If I was to use it creatively. Because if I'm using it creatively. And I want

to cause that people don't get it. Then I would just play with timing. I would just delay it. So that I can be deliberate. And when the interaction is very easy to understand. And when the interaction is not so easy to understand. So those are just tools that are important to me as an artist. And working with some sort of interaction through sensors. Does that make sense what I'm saying? So I want to be able to be very clear. When you go close. This happens. When you go far. This happens. But this can also just be about the inputs. And there were three different sensors in the room at the same time. So forth. So maybe that is already part of the toolbox. But I'm just trying to comment on this is important to be able to adjust with. Because for example. Let's say it was really clear. I understand immediately I go close. It goes red. I go far. It goes not red. I would figure that out after a while. So if I wanted to have a dialogue with this. Let's say it's a sentence that gets told. Like it generates a voice. Then I can play with the fact of how the timing would be of that. So let's say you train the audience. If you go there this happens. And then. If you want to surprise them. Which is what is good in performance of art. Is that you build up a expectation. And when you want to twist people and wake them up. You break that expectation. So that's kind of 90%. It's like building up the expectation. Then you break it. Because then you move somewhere else. So this is what I mean is important. For me as an artist. Maybe it's already integrated. And maybe I was just not easy for me to detect the first level. Especially of the emotions like distances. Like distance sensing.

08:11 - 08:38 SPEAKER_00

As the framework. Or this specific use case we had now. It was just a use case. Like we tried to say in the beginning. It's like whatever you want to do with it is exactly what you do with it. So and this is. We really. It was important for us to try to say that. This is just a use case. You can do whatever with it you want. You can map whatever with it you want to. So that's basically the idea of it.

08:38 - 08:39 SPEAKER_01

Yeah.

08:39 - 08:58 SPEAKER_00

I don't think I should say more though. But like especially because of the questions and stuff. I hope I didn't ruin it now. But what. Let's go to the next question. What do you consider the key strengths of the framework?

08:58 - 09:59 SPEAKER_01

The key strengths for me. In this framework. Is the fact that it. It detects. I'm really into the velocity thing. And all of this. Because it's new to me. Like the idea that it. It detects. How to say. Speed. And turn. In the way that it does. Because it's just new to me. I haven't really done that before. I've done a lot of distance sensing. But not this velocity sensing. For me this is a framework. I'm not a technical person. So I can't talk into those things. But for me as an artist. That is super interesting. Because it becomes something that is. Maybe in space. Something that turns. Something that can be generated. Something that can be generated with intention by a player. Being generated by intention by an audience. In an object. This is really nice. For me that's super strength. Strong. And interesting. And inspiring. That's my key strength thing. For it.

09:59 - 10:28 SPEAKER_00

And if you thought like. Away from the whole. Like IMU sensor. The accelerometer. Like. Is there anything else. That you think. Is. A strength of it. Like. Do you think. Like. You mentioned the IMU now. Or the accelerometer. Like. Do you think something. Dif like. The

framework itself. Has strength. Or is it. Like. Is it more. The accelerometer. You think is. Interesting.

10:28 - 10:45 SPEAKER_01

Well. I seem. To me. That there seems to be some sense of. It's being quite. Like, sturdy? I don't know, it seems to be quite solid somehow? Like is it dependable? Or what do you mean by strength? Like in terms of like?

10:45 - 10:47 SPEAKER_00

Like. In terms of like.

10:47 - 10:50 SPEAKER_01

Like. Just. Like.

10:50 - 10:55 SPEAKER_00

What are. Multiple sensors. Many kinds of sensors. Is also a strength.

10:55 - 11:22 SPEAKER_00

I mean. The strength of. Strength of the framework, is like, what is, the. How would I... Another way to say it is: What do you think makes this framework stand out from anything else you've seen? Like the framework itself? With the ESP now and the sensors. and different sensors you can choose and different use cases you can think of, like, would that make this framework. easier to, like, if you had to choose between-

11:22 - 11:24 SPEAKER_01

Different frameworks to do motion sensing of some sort?

11:24 - 11:29 SPEAKER_00

Exactly. Like. Would you think, that it was like.

SPEAKER_01:

What is the strength?

SPEAKER_00

Exactly.

11:29 - 11:59 SPEAKER_01

The strength for me. I mean. I think that the multiple - I think there is more different ways, like kinds of sensors. You have multiple choices, right? Which is good. I think this is something that is different and more advanced than what I've been working with before. So. I can only talk from my experience [laughing]. So, so, in that way that there are different kinds of sensors, both the sense of the velocity and the distance sensors. That I think is a key strength for me.

SPEAKER_00

Perfect. How. Would you envision the framework developing to better meet your needs?

12:12 - 12:25 SPEAKER_01

Again I would I very fast turn into, how I can see it used artistically, right?

SPEAKER_00 That's perfect.

SPEAKER_01 Is that what you want? And that's so far, because I won't be able to say anything about the technical side of it.

12:25 - 12:36 SPEAKER_00

No, no. We, I don't want to put your - the answers in your mouth, as a professional, because then it wouldn't be like-

SPEAKER_01

Yea, as an artist.

SPEAKER_00

-as an artist, how you would use it, as a professional?

12:36 - 13:12 Undetermined speaker

What. I would want to do is to... Uhm... I mean, quite specifically I'm super curious on how could I make, for example, the rolling of the ball into a soundscape that is easy to perceive even for a child. I mean that was quite rough and there was a lot of like dakadakadaka, a lot of different, uhm, impulses?. But something that is actually soothing, and something that is... How do you say..

SPEAKER_01

So less jitter. Or-

13:14 - 14:09 SPEAKER _00

Yes, or more something that is maybe more sort of like gets an inspiring inside a child's mind. I'm trying to figure out what that is, something more, gentle maybe? But this is also about the aesthetics of the sound. So that is one thing that i would want to do. And then, uhm, I would want to... Hmm, what else would I do? I'm very curious about the, how the velocity and the detection. I think one development that I would like to do, there's these squares on the floor, so I was trying to figure out if there is a spatial orientation towards where the ball is. Or is it velocity only or is there also. something about where in the grid is it?

14:10 - 14:12 SPEAKER_00

The grids are not part of it. But if you wanted that-

14:14-14:29 SPEAKER_01

That would be an interesting development in terms of performing arts for example, because there is a lot about "where are you in space?". So if that's an add-on, that could be added too, then that would be one.

14:30-14:31 SPEAKER_00 Mm

14:32-14:52 SPEAKER_01 Like to try to understand, where am I? Now it's a grid on the floor, it doesn't have to be a grid, but where is it in space? If the ball is here, if it runs over there. That would be an interesting thing. So the part of the velocity and the closeness, but a sense of orientation in space, that could be an interesting development.

But that's one thing. But now you asked me what i wanted to do with it, right? Or what was the question?

14:52-14:59 SPEAKER_00 Just what you would envision the framework evolving to better meet your needs, which could be one of them. So what you just said is basically it.

15:00-15:14 SPEAKER_01 Yeah, so the orientation in space could be something that I, would actually be needing to really use it I think. Besides the fact that i think it is interesting with the, you know, the motivation to move something.

15:15- 15:25 SPEAKER_00 Yeah. And the last question, could this framework streamline your workflow or accelerate your prototyping process? Why or how could it facilitate improvements?

15:26 - 16:56 SPEAKER_01

If it's easy to access and use, yes. If it's complicated and requires a lot of expert knowledge from the outside, it's more difficult, because it requires, you know, economy [laughs]. Uhm, and I'm not saying that it shouldn't require expertise, but uhh, easy access, - I haven't seen the interface as well - what is the interface like, who can use the interface, is it somebody, a professional within let's say a technical person that is used to already light work and stuff, is it something a person like that could access? Or do you need expert knowledge every time you use it? If you need expert knowledge every time you use, then it's of course more difficult, because it's more economically heavy but if you don't need expert and you actually can have an interface where you could use the sensors and you can apply it in a workshop for children where you set up at 9 30 in the morning the kids arrive at 10 and then you have a workshop you finish at 12 you have to be out at 12 30 like if that's possible then it would be massively useful. Like really, because nothing is that easy. I'm just trying to understand how easy is it or how not? I mean the accessibility and the sort of like okay plug and play element of it? Huge, in terms of if this is something that you wanted to, you know, send out in the world and make money on. I'm just saying, accessibility.

16:56 - 17:02 SPEAKER_00

And the second question is what might prevent it from being helpful?

17:02 - 17:19 SPEAKER_01

A lot of expert knowledge would be preventing it from being helpful it could be interesting maybe for a big theater that does musicals or something but they can afford to have an expert sit and do this specific but there's many frame things frameworks out there for motion sensing so i think if you wanted to stand out i think the easy access plug and play i think is it's a very good one.

17:19 - 18:00 SPEAKER_00

And it's a fair point and it's totally understandable. Right now as it is it's pretty technically heavy, we need to code all the sensors for each sensor we need to match it with the like different mac addresses from the other sensors so everything is kind of heavy now but i don't think it's impossible. Like if we use more time of now this is just a project so but if we use more time in the in the future or if we like literally handed it over to someone and said like - make this a thing - i definitely think it's possible because the sensors as long as they're just coded they just snap like if we pull out the batteries of any of them and put it back it's just just snaps back to wherever it was before

18:00 - 18:03 SPEAKER_01

So that could be good, easy presets actually.

18:03 - 18:43 SPEAKER_01

Yeah we can just you can code specific like frameworks or you can code specific sensors, saying this is a sensor and then you just take this code and put it in that sensor, and then literally that works. So the coding part is the part that could be a little heavy, but if everything is

just pre-made and you just change different parameters then it's it can be easy. So there is a possibility for it but with three months of project works it's like

18:43 - 19:27 SPEAKER_01

Of course, of course i'm talking to future things but it's also like what you what do you want what is the aim right so it is right now is super fun tool to have in a lab where you can investigate things and i can totally see an art piece for example work out with this tool box in that room you have an artist in there a dancer you put over some different parameters you sit together you code it i'm sure it could be an excellent interesting work that we could exhibit for example but it will require that somebody with the technical knowledge and somebody with an artistic vision sit together and do that then it's already there right possible but that is not a very um i say it depends a bit what kind of market you want to go into I suppose *19:27 - 19:43* SPEAKER_00

yeah and if if any market like at all at all yeah like i'm concerned that this is a project um i'm just gonna stop this now because we don't ——————————

14.3 Lars Transcription

00:00 - 00:12 SPEAKER_01

Okay, jamen først og fremmest, vil du måske bare lige fortælle mig lidt om den oplevelse, du lige har haft?

00:12 - 01:27 SPEAKER_00

Yes. Den kan jeg jo sådan dele i to. Så den, hvor der var de tre objekter, kalder jeg dem nu. Ja. Den, som jeg kan huske, du beskrev kort, der var en, der var afstandsafhængig. Så var der en, der var sådan et accelerometer, den store firkantede kasse. Og så var der egentlig jeg faktisk ikke noget at fange, hvad var. Og noget helt og aldrig at kode, hvad den var, ud over den... Hvis jeg satte hånden hen mod den, så tror jeg, at skærmen blev blå. Men jeg svært ved at kode, hvilken effekt den var koblet på. Og det, synes jeg, med afstandsbedømmelsen, som jeg tror, den der blev rød, også når man lukkede til på, den virkede til at være afhængig af nogle volumen, parametre. I hvert fald nogle steder. Og aktualometeret var helt klart den sjoveste og mest ukontrollerbare. Fordi den virkede til, at man både kunne dreje den og var afhængig af, i hvilken højde man havde den. Og også... Hvad skal man sige? Hastigheden, man bevægede den i. Så den var sådan... Den var intuitiv at have med. Og de to andre var mere sådan nogle mystikere, man skulle kode ind på. Hvad fanden var de for nogen?

01:27 - 01:30 SPEAKER_01

Jamen, det var rigtig nok med distance-sensorerne der.

01:30 - 01:34 SPEAKER_00 Var de begge to distance-sensorer?

01:34 - 01:48 SPEAKER_01 De var begge to distance-sensorer. Og de ændrede farven, ja. De ændrede hver deres farve. Og så var det faktisk low-pass og high-pass filter. Så det var mere eller mindre volumen.

01:48 - 01:50 SPEAKER_00 Volumen, ja. Klart.

01:50 - 01:53 SPEAKER_01 Okay, fantastisk.

01:53 - 02:27 SPEAKER_00 Og så var oplevelsen, hvis man skal gå ind i den del. Øh... Nok også, fordi vi er i prototype-land, så bliver jeg meget bevidst om teknikken. Og bliver fascineret af at prøve at forstå den. Men fordi det også er så strippet, så er det faktisk også sådan, at man kommer lidt på indersiden af alt det, man omgiver sig med til dagligt. Det var faktisk meget fedt. Man følte lidt, som om man kom... Ja, det ved jeg ikke, hvad det er. Det havde jeg det, Brinde. Det var en behagelig fornemmelse af at være på bagsiden af tech-verdenen.

02:27 - 02:29 SPEAKER_01 Ja, fedt. Ja, det tror jeg også godt, vi talte om med...

02:29 - 05:04 SPEAKER_00 Ja, med Nørregård. Ja, præcis. Det er rart, at man kan kode bare en smule af det. Ja. Øh... Så er der bolden. Som jo er en perfekt videreførsel på det, vi har talt. Altså har oplevet sammen bare med den der imaginære bold. Så det synes jeg bare for det første, at give credit for, at I har kredit for i har grebet den. Øhm... Og så virker det selv. Er det accelerometer? Accelerometer... Tingen, der på en eller anden måde er inde i den... Gætter jeg på. Øh... Den virker jo vildt intuitiv. Men der var også meget med gulvet. Man kunne mærke, at der var nogle... Nogle meget markante skift i gulvet. Ja. Som påvirker det her samplede... Som jeg jo kendte virkelig godt. Men som jo var... Sådan... Toppet op til at være noget helt nyt. Som også var meget spændende. Mm. At det ligesom ikke... At det havde en helt anden form. Øhm... Også en sådan sonisk kvalitet også. Ja. End det oprindelige. Øh... Det virkede... Ligedele legende. Det er smart med bolden, fordi den gør det legende. Men der er også noget i det, som er sådan... Trigger noget... Hvad skal man kalde det? Altså... Ja. Der er nok primært noget legende i det for mig. For jeg synes, det er spændende at være i. Og jeg har lyst til at få mine børn med ind i det også. Og se, hvad fanden gør de i det? Og så er der noget andet i det, som også bliver lidt sådan... Noia. Altså i... Hvad er det her? Og det er højt, og det virker nogle gange sådan lidt ukontrollerbart. Og man kan ikke helt forstå konsekvenserne af de bevægelser, som bolden har. Hvor man også godt kan være... Altså vi prøver jo... På tre forskellige måder at få kontrol. Og det lykkes os ikke. Vi forstår ikke, hvad vi er i gang med. Og det er selvfølgelig ubehageligt. Der er kontrolsab i det. Det er måske der, jeg skal hen. Men sådan et legende kontrolsab... For at nå at bruge et ord, der overhovedet ikke er særlig kodeagtigt. Øh... Det synes jeg var... Jeg ved ikke klart, den... Det var godt doseret, ja. Altså, vi sluttede med bolden. Fordi det er helt klart den... Ja. Der... Er lettest at forstå, og lettest at være i. Det er sikkert. Ja. Men det andet er jo også spændende, kan man sige. Giver det mening?

05:04 - 05:05 SPEAKER_01 Ja, det gør det. Det gør det i den grad.

05:05 - 05:41 SPEAKER_00 Øhm... Altså... Jeg ved sgu ikke. Der er noget med gulvet, som jeg... Bolden gjorde, at jeg afsøgte gulvet mere... end jeg gjorde i starten. Og det ved jeg ikke hvorfor... Jo, det er nok fordi bolden triller. Man fandt ud af, at der var nogle punkter, som... Når jeg havde objekterne i hånden, så havde jeg svært ved at... ... at forstå. Altså, jeg kunne se, at de havde mappet det ud. Men jeg havde ikke... Men jeg forstod ikke konsekvensen af at rykke mig rundt... ... så let, som jeg kom med bolden.

05:41 - 05:42 SPEAKER_01

Nej. Altså, nu...

05:42 - 05:44 SPEAKER_00

Men det er ikke nogen kritik, det er bare sådan en...sådan... ... og konstaterer

05:44 - 05:57 SPEAKER_01

Nej, nej, nej. ... . Men nu vil jeg sige, det er faktisk ikke os, der har mappet det ud. Er det rigtigt? Nej, nej. Der var faktisk ingen kontrol i gulvet.

05:57 - 06:00 SPEAKER_00 Så det der med, at der lige præcis var to punkter med bolden... ... hvor det panorerede helt vildt, har bare været tilfældet?

06:00 - 06:01 SPEAKER_01

Ja. Ja, det tror jeg, det har været

06:01 - 06:13 SPEAKER_00 Ej, det er jo endnu mere mærkeligt og spændende. Nå, der var sådan... Simon og jeg stod og driblede fra den ene side til den anden side... ... og jeg havde den

blå streg... ... og så panorerede det.

06:13 - 06:15 SPEAKER_01 Det har måske bare lige præcis passet med.. eller hvordan den har ligget inde i bolden.

06:15 - 06:16 SPEAKER_00

Ja, ja, ja.

06:16 - 06:41 SPEAKER_01

Nej, det er sjovt. For ting med kassen er jo, at den er... ... der kan du ligesom se... ... akserne er ligesom visuelle, ikke? Ja, det er det. Det er en kasse, så det giver lidt mere mening. Men inde i bolden, der ligger den jo sådan lidt et tilfældigt sted. Så den er jo ikke... den er aldrig helt præcis. Og det er derfor, at bolden er svær at styre, men den er lettere at lege med, ikke?

06:41 - 06:51 SPEAKER_00

Ja, det er det. Hvordan med..... oh nu tabte jeg tråden. Nå, pis. Nå jo, var der noget, der bevægede sig inde i bolden? Jeg følte, at jeg havde følelsen af, at den snurrede eller...

06:51 - 07:03 SPEAKER_01

Nej, det er der ikke, men jeg tror måske, at det der er sket er at dens tyngdepunkt er off. Fordi at sensoren ikke ligger helt inde i midten. Så jeg tror måske, at den kan føles lidt mere levende, end den egentlig er.

07:03 - 07:10 SPEAKER_00

Ja, klart. For jeg er sådan... sådan, okay, har I sat noget ind, der også gør bolden sådan sensorisk her?

07:10 - 07:11 SPEAKER_01 Det kunne have været rigtig fedt.

07:11 - 07:15 SPEAKER_00 Men det er jo også det, der er mange ting... Man kan jo blive ved med at bygge på og...

07:15 - 07:16 SPEAKER_00 Det er det. Det er det.

07:16 - 07:27 SPEAKER_01 Men skal jeg høre dig engang, om du fandt noget inspiration i den her demonstration?

07:27 - 9:50 SPEAKER_00

Øh, ja. Og nu er det jo sådan fem minutter efter, så så er det jo den respons. Og der skal jeg måske sige, at jeg er ret sikker på, at det kommer til at vokse på mig. Altså, jeg kommer til at tænke videre. Øhm... Det er jo stadigvæk et ret. Som I siger, det er et framework. Altså, det er sådan, det er råt i sit... Og det gør jo... Det har den gigantiske fordel, at jeg kan tænke i mange veje. Og det gør også den svaghed, at jeg kan... Øh, have svært ved at stille skarpt på sådan... Det er det, vi skal nu. Det synes jeg. Øhm... Så i den første del, der synes jeg jo, at... Det er godt. Og det er nok... Altså, right off, så er det sådan... Så er det bolden, jeg ummidelbart tænker, den er spændende. Den er spændende på... Altså, det var spændende at se Tina være i den, fordi hun ligesom... Allerede der går sådan koreografisk ind, og finder et langsommere tempo. Udfordrer ligesom den lidt sådan fodbold-agtige indgang, jeg har til en bold. Øh... Så der kunne jeg se noget sådan koreografisk. Virkelig spændende. Hvis man kunne få lyden til at blive... Altså, det er jo bare et spørgsmål om noget, jeg ikke ved, der er. Men hvis... Altså, lige nu er musikken meget choppet. Ja. Og det lyder fedt. Men det kunne også være, at man kunne sætte den til at styre nogle parametre, hvor... Hvor den afspejlede den der lidt bløde bevægelse mere. Øh... Måske var koblet op på noget, der var live. Og koblet op på nogle effekter. Det kunne man have lyst til at prøve. Men din forskning ville jo nok også lande sådan et sted her.

Hvor det ligesom... Hvor det er sådan... Næsten bitcrusher. Ja. Øhm... Så der er noget sådan et koreografisk materiale, som er spændende. Det der med at få et... Og det med at få en sådan professionel danser... Øh... Til at arbejde med det her, ville være spændende. Så jeg har også lyst til at høre, hvad kunne der ske, hvis man... Som jeg har skrevet en mail. Hvad sker der, hvis man forestiller sig, at bolden er stor? Så kan bevægesler blive langsomt Automatisk?

09:50 - 09:51 SPEAKER_01 Ja, så er der ikke andre valg.

09:51 - 11:37 SPEAKER_00 Ja, det er det. Man kan måske lære at bokse til den, når den bliver ret stor. Så går den måske mere over i noget, som har et sådan et installatorisk... Potentiale. Hvis der står sådan en bold, som måske kan ligne en jord, eller som kan ligne en sol, eller som kan ligne bare en bold, eller... Men som du kan ligesom påvirke... Det kunne man godt forestille sig ville være... Øh sådan æstetisk spændende. Man kan også godt... Konceptualisere det spændende, man vil også godt kunne... Det kan jeg se egentlig i sådan en kunstgalleriverden. Det er selvfølgelig sådan, at det skal snittes til. Og skal laves som en prototype. På en eller anden måde. Og så ligger der jo et andet potentiale i, at... For tiden er jeg meget ude ved sådan, som jeg også taler om flere gange, men sådan ret sårbare mennesker og arbejder med musik med dem. Og lige nu spiller vi jo på fysiske instrumenter, fordi de er et sted i livet, hvor de måske lidt har mistet kontakten til sig selv og til verden og til alt muligt. Så det er fedt at spille på et rigtigt instrument. Men igen, en bold, som.. fordi så tit arbejder jeg med, at der er en trumme, der står og spiller. Lyden kommer op af trummen, og de kan lægge objekter på den. Den er fysisk. Hvis bolden kunne styre et high pass, et low pass, og så side og trille bolden til hinanden og mærker, at det er et socialt perspektiv, som også hører vildt spændende, som jo også taler om det koreografiske med timen. Man tænker sig at have sådan et redskab i musikoprevisningen, at man også kan spille lyden, det vi oplevede med den usynlige bold. Nå, som du kan høre. Der er et hav af muligheder.

11:37 - 11:38 SPEAKER_01 Der er et væld af idéer.

11:38 - 12:28 SPEAKER_00 Og så er der selvfølgelig også et eller andet, man kan vel gå maten af. Prøv lige at vække af, at Mathias siger, at han er turmand for Carbock North. Jeg forestiller mig, at den type scene også ville kunne bruges, hvis der var nogen interesseret i noget galskab. Men jeg ved ikke helt, hvordan de ville tage den hen. Men det kunne jo være ret spændende. Man har set så mange balloner og er piss og lort. Hvis de kunne spille en rolle, hvis publikum lige pludselig styrede noget. Det er den koncert, vi ikke har hørt fra. Det er der nogen, der synes er spændende. Det er ikke sikkert, det er Carbock North, men jeg er ret sikker på, at man kunne finde nogen, der ville synes, det var rimelig fedt at gå ind i Altså, ja. Hvis man kan.

12:28 - 12:29 SPEAKER_01 Det kan man sikkert.

12:29 - 12:33 SPEAKER_00 Ja, det er det. Men det skal også være henne i jeres energi. I er bare sådan, okay, nu må jeg tage bolden og dribble med.

12:33 - 13:10 SPEAKER_01

Men der er jo et hav af muligheder. Men det var meget interessant, noget af det første, du lige sagde nu, var at, i hvert fald da jeg stillede dig spørgsmålet her, var at du kunne se en hel masse for dig, men at det her med at have så mange muligheder, også er en begrænsning så det bliver svært at finde ud af, hvor man skal stille skarpt.

SPEAKER_00 Ja, præcis.

SPEAKER_01 Så hvordan, i din egen proces, væk fra det her, navigerer du så i det, hvis du står over for en situation, hvor du har så mange muligheder?

13:10 - 14:46 SPEAKER_00

Øh, jamen jeg er jo en musiker, der improviserer, så jeg prøver det, vi gjorde der, er egentlig vejen ind til det. Altså at prøve noget af er vejen for mig, og så opstår der noget i det. Jeg tror jeg er meget påvirkelig af situationer, så det vil sige, at prøve det sammen med Tina, sætter én ramme, havde vi taget Mads Nørgaard med ind, havde vi tænkt noget andet, så det er også, vil ofte være en del af min proces, hvad sker der, hvis jeg tager den her type komposition ind, i et meget kunstagtigt område, eller med nogen, der er på et værested, så jeg A, B, C, D tester idéer, i forskellige rum. Så det vil jeg nok også gøre her, hvordan vi gør det hér, kan man dét, kan man dét, kan man dét, og så er der ligesom noget, der materialiserer sig, og en anledning, der sådan står, altså ja, så opstår der en mulighed, fordi man ligesom søger den også. Så vejen videre er vel, altså man får lyst til at, at det her kan blive tilgængeligt, på en eller anden måde, altså sådan en lab oplevelsen.

SPEAKER_01 Ja, bare herinde? [Taler om settingen nede i AugLab som vi havde stillet op]

SPEAKER_00 Ja, præcis, bare herinde, og så finde ud af, kan vi få det, altså ja... I har jo sådan præcis lagt et framework, for noget, man har lyst til at videreudvikle på.

14:46 - 14:56 SPEAKER_01

Så vil jeg høre, om det er noget, du tror, vil være brugbart i din egen proces?

14:56 - 15:38 SPEAKER_00

Ja. Det, der står i vejen for mig, det er jo, jeg kan regne ud, at det her er et forskningsprojekt, altså, et studierelateret projekt, så hvordan trækker man det ind i noget, hvor det jo stadigvæk er et udviklingsprojekt, det vil sige, det er svært at, ja, der begynder at opstå sådan nogle, sådan noget praktikaliteter med økonomi, og sådan noget inde i mit hoved. Men det må man jo løse, hvis ilden er der, kan man sige, men hvis man kan komme ind i den, og hvis man kan få løst det, så kan jeg se mange muligheder, kan man sige. Men det kræver nok lige nogle runder mere i sådan et fælles udviklingsrum.

15:38 - 15:45 SPEAKER_01

Ja. Hvor i den proces, sådan, ser du din rolle?

15:50 - 16:05 SPEAKER_00

Det er jo det, at man kunne kalde, tror jeg, ved det musikfaglige, og måske også det at placere den i en, altså i en kontekst. Altså have et netværk, der kan få den ud. Den idé. Præsentere det for nogen, som kunne have lyst til at udstille den, eller anvende den, ja, den her ting. Det er det, jeg tænker. Og så tænker jeg jo, det er ret vigtigt, at det vil være et samarbejde. Det er det, jeg synes, der er det mest spændende, altså, eller mest spændende, det synes jeg er mindst lige så spændende, hvis det kan blive sådan et potentiale for, at man udvikler det her helt sammen, hvor det ikke er en teknologi, som er open source, som alle kan bruge, men at det faktisk mere er noget, som I og os, eller nogen af jer og os, kan, har sådan egerskabet på sammen. Egerskab både forstået som sådan idéen, men også sådan det æstetiske say, at vi ligesom arbejder som et hold, for jeg tror i det fællesskab sker der noget spændende. Ja. Så jeres inputs er jo, altså indenfor musikken, er jo helt vildt fede, fordi I har en indblik i den der verden [tech agtige computer verden]. Og man har jo oplevet, hvor mange umulige opgaver, jeg kan stille jer, fordi jeg ikke ved noget om, hvad jeres backend er. Den vender også sådan for mig. Ja, det er jo også sådan for mig, at det er fedt for mig at høre, hvad I tænker i musik, og hvordan, og det er det trigger noget i jer, kan man sige. *17:32 - 17:56* SPEAKER_00

Og hvordan har du forholdt dig til ligesom os, eller hvis du overhovedet har det sådan, og, og, hvad skal man sige, for vi har jo ligesom haft, haft tanker om sådan, du ved, hvor du ligger henne, hvor din kreativ proces, og hvad dine evner ligesom er. Har du gjort det samme, synes du, i forhold til os, og sådan tænkt ind i vores sådan, hvad skal man sige, tilgang?

17:56 - 18:03 SPEAKER_00

Jeg har jo ikke kendt jer så godt, og I er også en større flok. Så på den måde, så er det mere sådan, det er en gruppe. Hvor jeg så alligevel har, altså fordi dig og Mathias har ført ordet med os, så har jeg oplevet, at det er jer har talt mest til, ikke? Ja. Øh. Altså så næste trin er jo egentlig det der med, at drikke noget mere kaffe sammen, og finde ud af, altså for eksempel, hvad er det for et hold, vi kan etablere omkring sådan et projekt her? Og måske trække det ud af noget, som er sådan, udelukkende i studiet-regi, vil jeg sige. Jeg ved ikke, om jeg svarer på det spørgsmål der, men...

18:36 - 18:51 SPEAKER_01

Jo, jeg tror mere, at det jeg tænkte på var, om sådan, hvad skal man sige? Ja. Ligesom vi har prøvet at sådan tilpasse vores tankegang til dig.

18:51 - 20:18 SPEAKER_00

Ja. Jo, jeg har prøvet, Ja, okay. at forstå jeres setting, og måske jeg også synes, det var det, der var på et tidspunkt svært, altså hvordan er det, at vi får forventningsafstemt, på en måde, så I får relevant feedback. Det har jeg ligesom skulle vende og dreje nogle gange, sådan så alle fik mest muligt ud af, af det her projekt. Det har ikke klart været første gang, jeg har lavet den her type, sådan en samarbejde, så det skulle jeg lige forstå, hvor er I? Jeg tænker, vi fandt en form, hen og vejen, men jeg husker som om, vi havde et møde, et andet møde eller et eller andet, og der kom så mange bolde i luften, at det var slet ikke det, I havde brug for. Og det har nok været, fordi jeg ikke har forstået, premissen af den ene eller den anden, eller den tredje årsag, altså enten jeg ikke havde fattet det, eller det ikke var mødet klart nok ud, eller hvad det er. Det, der var helt klart et møde, anden møde, tog jeg derfra og tænkte, "øh, det var, det var for kaotisk for alle parter", ligesom rammen var ikke sådan helt skarp nok. Så skrev vi sammen, frem og tilbage, altså også fordi jeg ærgede mig, mig over det, og skrev mange mails, der kom sådan en mailstorm fra mig, som jeg husker det, og så fandt vi derfra lidt ind i et spor, og fik sådan afstemt. Når det er sagt, så er der jo noget i, hvis man inviterer sådan, nok især sådan en som mig, tildeles også sådan en som Tina ind i det, så er det jo et, et rum, der er ret bevægeligt, altså sådan et udviklingsrum. Så der er selvfølgelig også noget der, man skal lære hinanden at kende, hvor kan vi bare lige sådan sige, hvad med en bold, eller hvad med en... Sådan er det. Altså der må, I jo også lære, sådan nogle som os og vores fagligheder at kende, at vi er vant til at arbejde og tage nogle ret store skifte nogle gange, og også nogle gange uden at kende, sådan de tekniske muligheder, og begrænsninger. Altså i sådan en teater, eller musikproduktion, jeg har arbejdet i, der kan man selvfølgelig godt tage nogle ret store twists, sådan nogle gange. Så det er jo det vi er vant til også. Man kan pludselig finde ud af, okay det her, det holder ikke den her, den her forestilling, det er ved at lave, det her album det her holder ikke, vi gør noget andet. Og det er lidt det der skete i den her proces også, hvor jeg lige mærkede, der blev vi udfordrede alle sammen. Og det tror jeg også, kunne jeg også mærke, I var vant til at have en, at finde en plan på første møde, og gå efter den. Og vi var stadigvæk ret mobile inde i vores, ja. Det kunne, det kunne til en anden god gang. Den kunne vi bare have forventningsafstemt. Det ved jeg til næste gang, det ved jeg, at den vil jeg stille skarpt på. Ja, det håber jeg ikke har været for frustrerende for jer,

22:21 - 22:31 SPEAKER_01 Nej, nej, nej, nej, der er, det har været, det har været helt fint. Det har også, det har også været noget vi skulle lære. Ja, ja, præcis. Og det har ofte sådan har det jo været, det kan vi bare ikke lige og sådan.

22:31 - 22:36 SPEAKER_00 Vores forbindelse har også været, Dan, som vi jo også har, det er også en komponent i det her, ikke. Det har både været en styrke, den forstand der er kommet en ind, der har været en imellem os til, altså med at facilitere det. Og så har den er, at der er ingen af os i gruppen, og Tina og jeg, der har kendt hinanden. Mm. Så vi har skulle lære

hinanden, og projektet at kende på samme tid. På Zoom.

SPEAKER_01 Øh, nu er det det sidste spørgsmål her. Øh. Hvordan tror du sådan et system her, bedre kunne, kompensere for din måde at arbejde på, og dine evner, og, og din proces?

SPEAKER_00 Altså, hvis man forestiller sig, at I har, eller nogen af jer, eller hvordan I nu, hvis man forestiller sig, at det her produkt, ligesom bliver løst, så er det, udtræder fra, det studiemæssige. Øhm. Er det sådan, er det den kontekst, vi er i så?

SPEAKER_01 Ja, lad os bare sige det.

SPEAKER_00 Ja. Jamen, det vil jo være en, nogen man kunne, enten lave et projekt, sammen med, og sige, i gang i det her, og i adgang af det her, skal vi lave, noget sammen og etablere sådan en ramme for det, på alle mulige måder. Og den anden vej ville jo være, at sådan en som mig, ved, at i er i har gang i det her, og har en idé, og så køber jeg ind, til at løse, den idé. Ja. Det er vel sådan, de to veje, jeg lige umiddelbart ser. For jeg tror ikke, det går den anden vej rundt, at i har en god idé, og tænker, vi har brug for noget musik, til den. Den situation, den ender ligesom blindt, så.

SPEAKER_01 Could this framework streamline your workflow, or accelerate your prototyping process?

SPEAKER_00 Ja, det er et god spørgsmål Ja, øhm, to streamline, strømligne en proces, øhm... nu er det fordi, jeg slår over i dansk, jo, at det bliver en, øh, jo, strømligne forstået på den måde, at det kunne sætte en retning, for et konkret projekt, øh, 100%. Det vil være sådan, konceptet, øh, kernefortællingen i, øh, den forestilling, eller den udstilling, eller den, det er sådan en concert gadget, eller hvad vi nu er på vej ud i, ja. Så vil det helt klart være meget definerende. Tit er tech jo en lidt farlig ting, altså sådan lidt en, det kan godt blive en, eller en "farlig ting", men det kan godt, fjerne nærvær, men det her er jo interaktivt, vi ligger jo et lag, på musikken, så jeg tror, det er det der tiltaler mig, specielt med bolden, det bliver, håndgribeligt.

26:45 - 26:49 SPEAKER_01 Er der nogen måde du tænker, det kunne være en forhindring, i den proces,

26:53 - 27:00 SPEAKER_00 Der er jo virkelig meget udvikling i det, så det vil være kræve, at man er, sindssygt dygtig til, at blive ved med at afstemme, det, det er jo, det er en udfordring, en forhindring, ja, det er det sikkert, er det ikke?