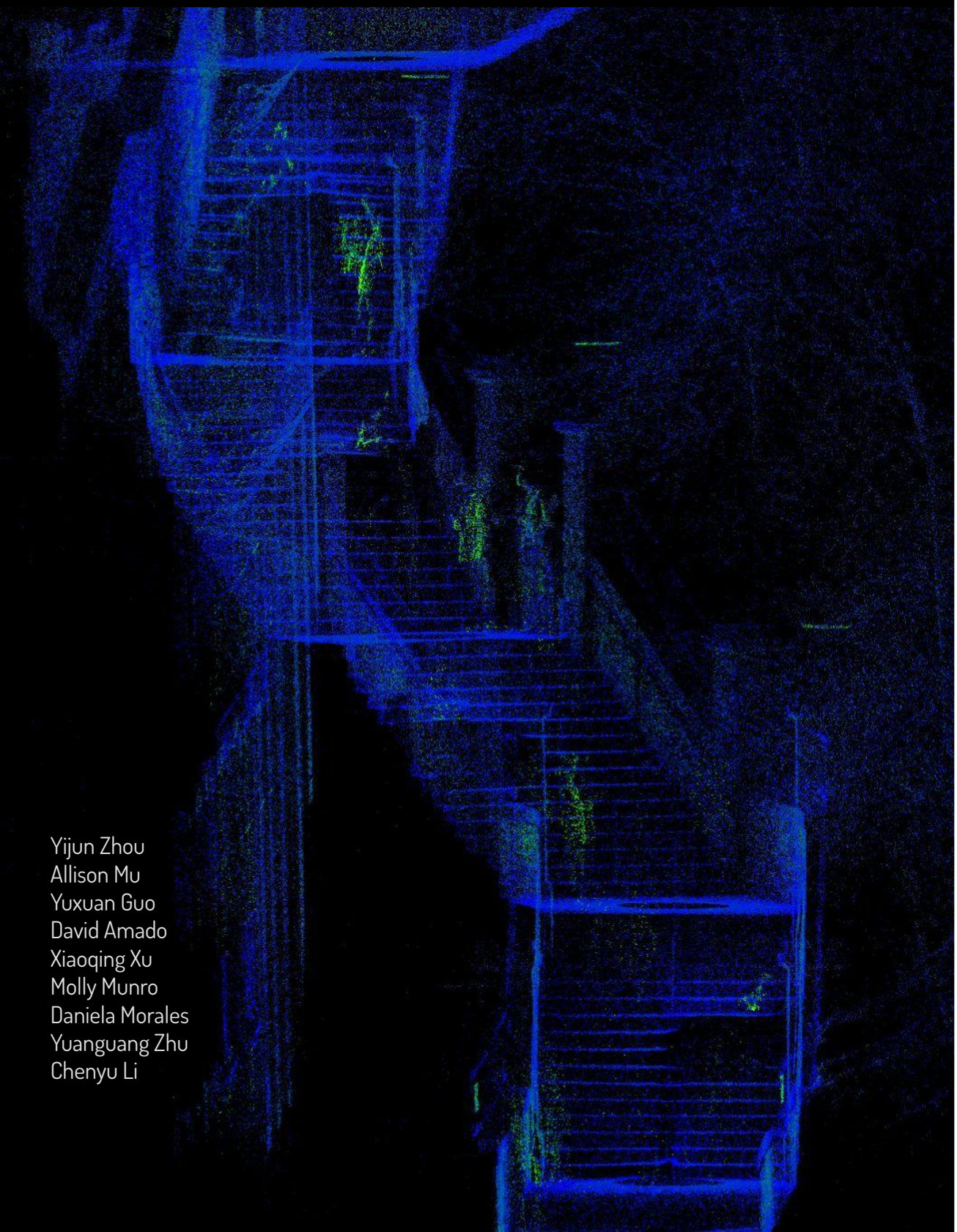
Echoes & Absences



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DIGITAL MEDIA STUDIO PROJECT: PLACE

.2023

Abstract

This report explores the boundaries of human perception by investigating the existence of places and non-places beyond our traditional senses. The authors aim to reveal the material and immaterial experiences that develop in the process by considering the interaction between tangible components and abstract information in the siege of algorithmic computation. The project utilises various methods, including LiDAR scanning, photogrammetry, 360 images, and field recording, to create high-resolution spatial datasets of local, site-specific environments throughout Edinburgh, Scotland. The report discusses "Echoes and Absences," an immersive exhibition designed to explore the emotional connection people have with a liminal place, The News Steps in Edinburgh's old town, by utilising LiDAR technology. The report explores the theoretical research of quantifying the concepts of Immersion and Presence, Place and Non-Place, and the possibilities of a digital exhibition. Overall, this will walk through the project as a whole, including the admin of team meetings and roles, to the technical specifications of this complex installation. We conclude with a summary of the day of exhibition and personal reflections.

This report contains a breakdown of this project. Most sections contain one to two paragraphs of context, followed by the link to the blog post that discusses that topic in more detail. The decision to organise this report in this way was made to allow for a coherent and structured reading and understanding of this project..

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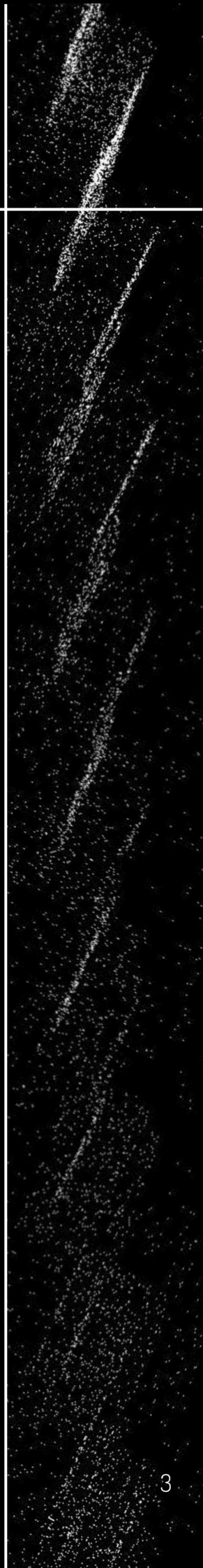

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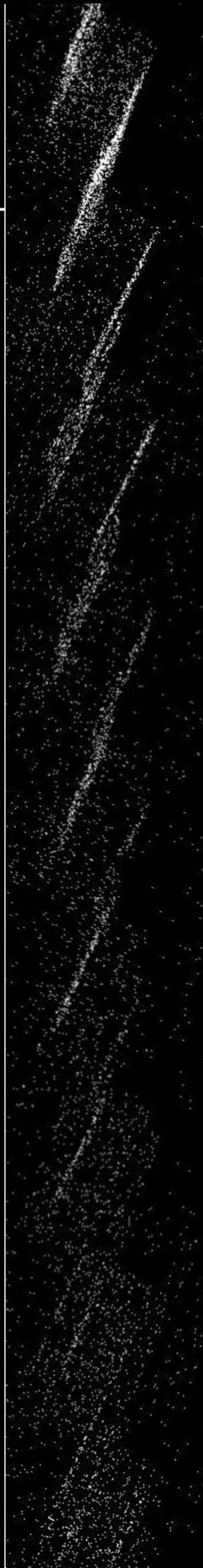
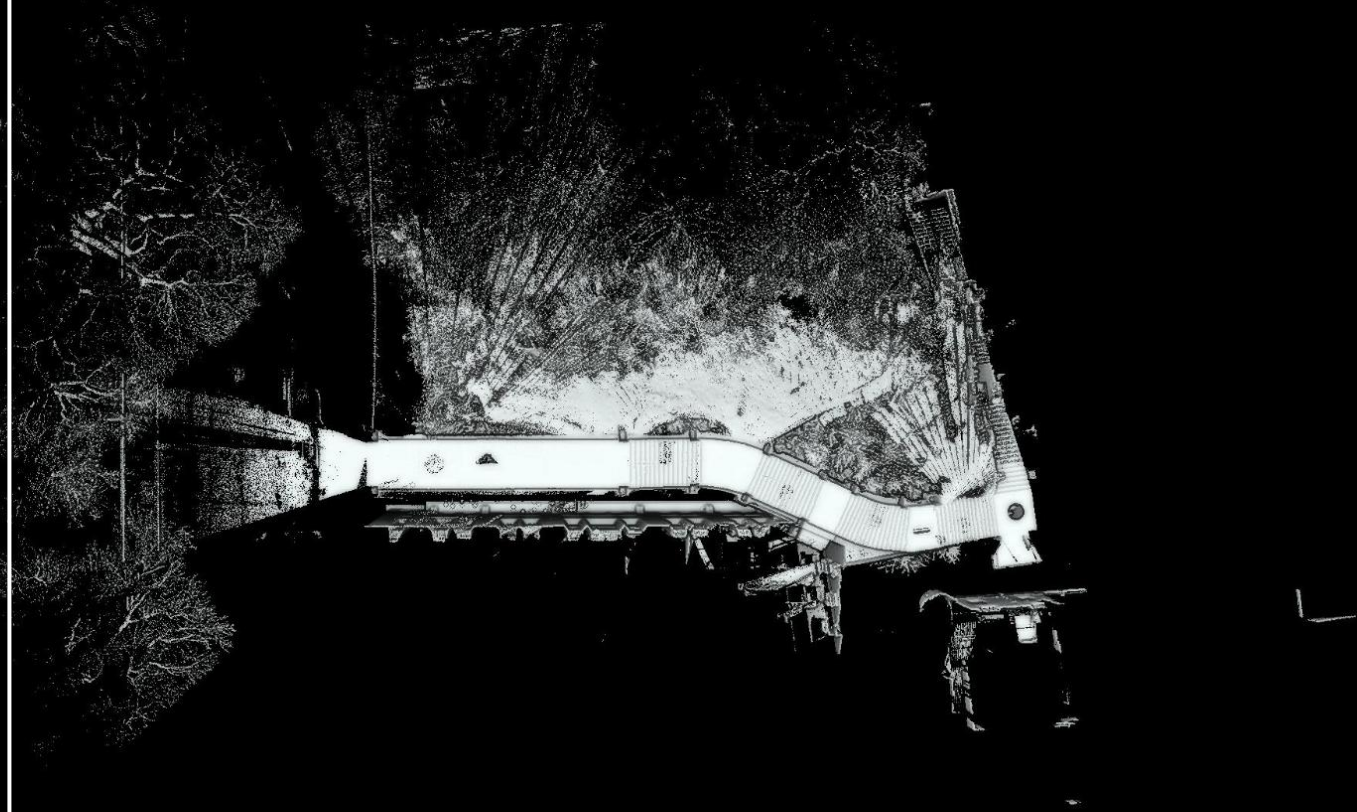


Background and context



From blog post: Background

The project for this course explores the boundaries of human perception to look into the existence of places and non-places outside the limits of our traditional senses. We want to unveil the material and immaterial experiences that develop in the process before collapsing into certain oblivion by taking into account the interaction between tangible components and abstract information in the siege of algorithmic computation. Through various methods of recording, rethinking, reshaping, remaking or remixing place, we seek to uncover the liminal, cultural, ecological, and industrial aspects of environments, whether they are speculative, fictitious, or factual, emotive, informative, or rhetorical.

Our ability to register local, site-specific environments throughout Edinburgh, Scotland, as high-resolution spatial datasets that expose and activate the spatial, temporal, and cultural properties of place is made possible by the project's advancements in the use of remote sensing and design informatics to enhance perception and extend audition.This approach involves LiDAR scanning, photogrammetry, 360 images, and field recording. The learning outcomes of this project include methods for capturing spatial data, ways of presenting and interacting with spatial data, and critical discourse around space, aesthetic, narrative and culture.

Project Aims and Objectives

By creating a unique and immersive experience that allows the user to experience a sense of presence, the teams aims are as follows:

- Explore the connection and transition between a liminal place and the audience.
- Create an enjoyable, interesting and intriguing experience for the audience.

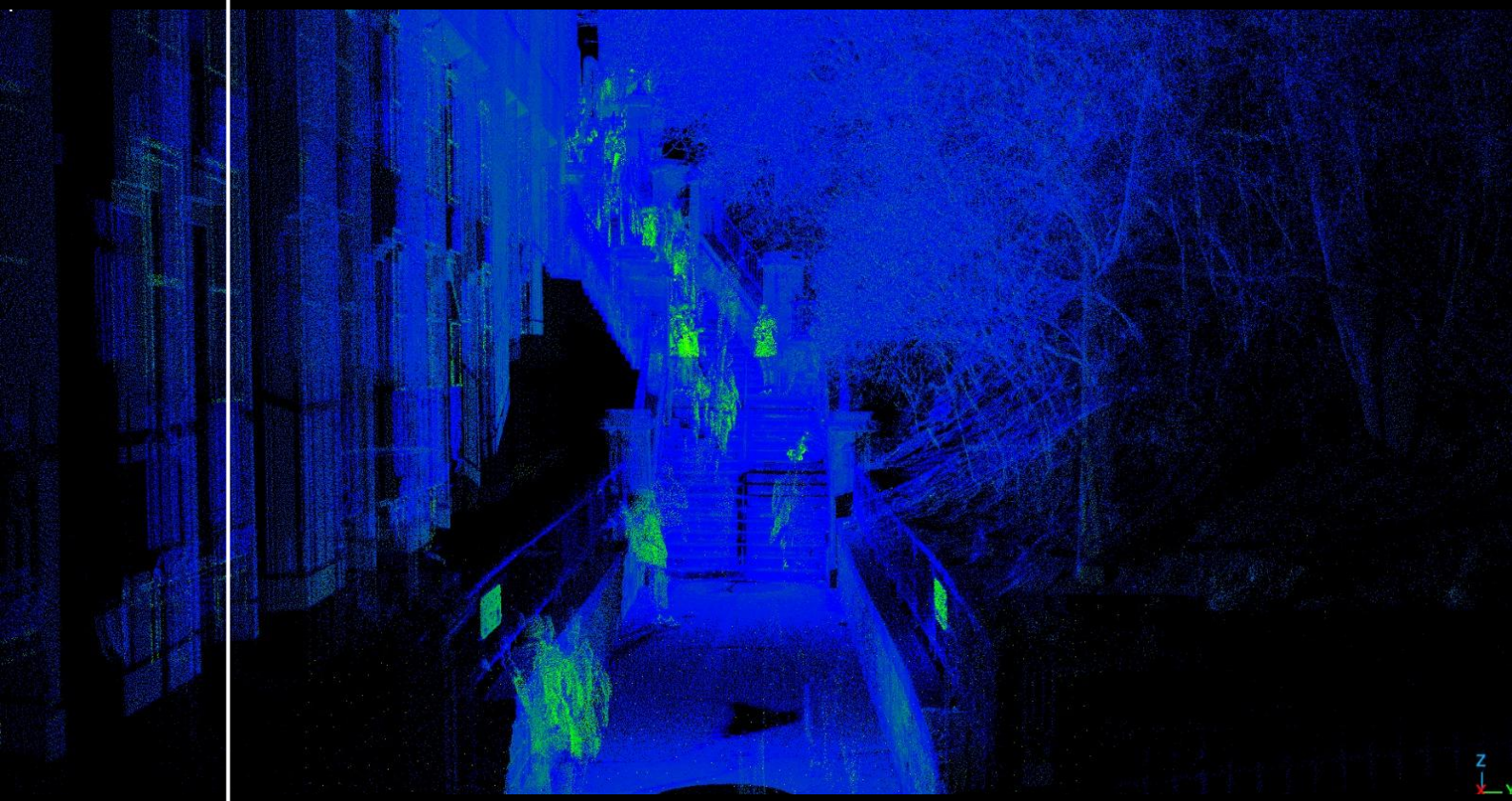
The described aims will be achieved by collecting data through LiDAR scans, field recordings, Arduino systems and AI-generated content. Process and synthesis will be performed through cloud point visualisation software, Max/Msp and C# scripts. Finally, presented through means of multi-dimensional projection and surround sound displacement.

What is LiDAR?

LiDAR stands for Light Detection and Ranging, and it is a remote sensing method that uses laser light to measure distances. The technology works by emitting a laser beam that reflects off the target and returns to the sensor. By measuring the time it takes for the laser to return, the LiDAR system can calculate the distance between the sensor and the target with high precision.

LiDAR technology has advanced rapidly in recent years, with smaller, more affordable sensors becoming available. This has led to increased adoption of LIDAR in a range of industries and applications

Concept



From blog post: Echoes and Absences Concept

Echoes and Absences is an immersive exhibition designed to explore the emotional connection people have with a liminal place, The New Steps in Edinburgh's old town. The exhibition utilizes LiDAR technology to create an immersive environment that stimulates the senses and transports the user to a different world. The aim is to create an engaging and thought-provoking experience that leaves a lasting impression on the user and contributes to ongoing discussions around the use of technology in art and cultural experiences, as well as the concept of place and how it shapes our experiences and emotions.

Approach to the Brief

The brief for this project is stated in the page: Background

We depart from J.G Ballads story, The Sound Sweep, where the author writes "The 'place' of strange echoes and festering silences, overhung with a gloomy miasma of a million compacted sounds, it remained remote and haunted, the graveyard of countless private babels".

As the brief mentions, "It is in the hushed soundscape, in the inaudible where a place manifests.". We extended from this by delving into the concept of how the sounds of a liminal non-place can be altered, morphed and warped by its physical counterpart.

The project was said to utilise remote sensing and design informatics to enhance perception and broaden auditory experiences, resulting in the creation of detailed spatial datasets of local, site-specific environments throughout Edinburgh, Scotland. These datasets uncover and stimulate the spatial, temporal, and cultural characteristics of each location.

We challenged the brief on these aspects by taking the data sets and creating an interactive element that gives the user the power to create their own unique interpretation of the place. whist simultaneously conducting their own symphony of temporal sound.

Through theoretical research, we explore what it means to quantify the concepts of Immersion and Presence. Undertaking a more detailed examination of Place and Non-Place, in addition to exploring possibilities of a digital exhibition.

Immersion and Presence

From blog post: Immersion and Presence

Is what we are achieving in this project immersive? How are we able to convey a sense of presence for the audience? Slater and Wilber (1997) define immersion as a description of a technology, and describe the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant. The sense of presence, defined by Gruter and Myrach (2012) describes "the subjective experience of feeling present in a non-physical space".

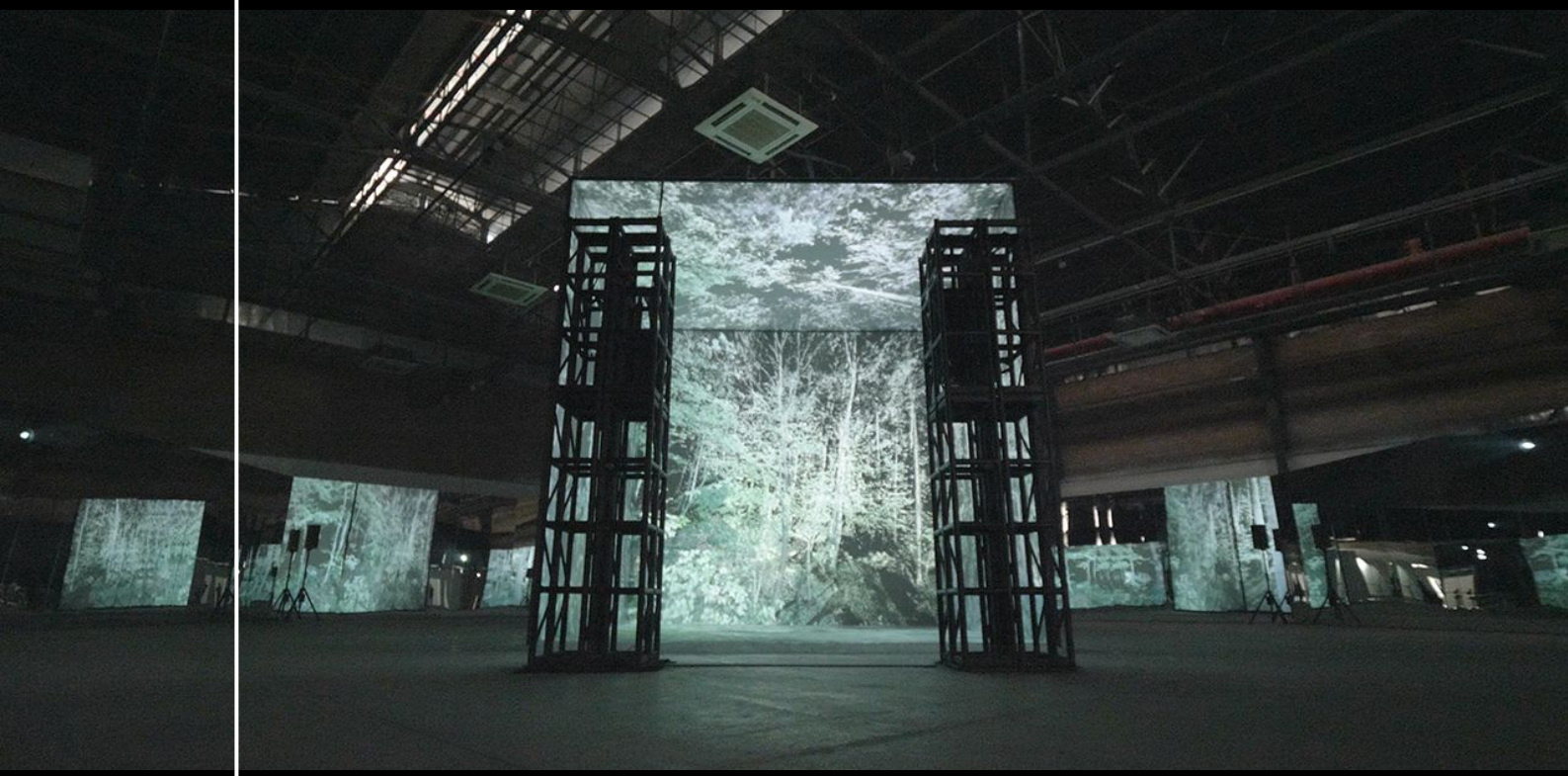
We are aiming to create a surrounding and vivid illusion of reality that, when combined with audio sensory input and the added interaction being a physical movement, will allow users to be immersed in the exhibition. For the sense of presence in relation to this project, we are giving the user the option to control their experience through the physical interaction.

Place and Non-Place

From blog post: Place and Non-Place

Our relationship with place is subjective and shaped by individual experiences. A "place" has a distinct identity and significance, while "non-places" lack a distinctive identity and do not foster a sense of community. Our relationship with place is evolving to include digital spaces. It is important to consider how these spaces shape our experiences and explore new ways to foster a sense of belonging in both physical and digital places.

Digital Exhibitions



TOPYS. (2020) OCT-LOFT Creative Festival. Available at: https://www.ryoichikurokawa.com/project/saw.html (Accessed 20 April 2023).

From blog post: Research on Digital Exhibitions

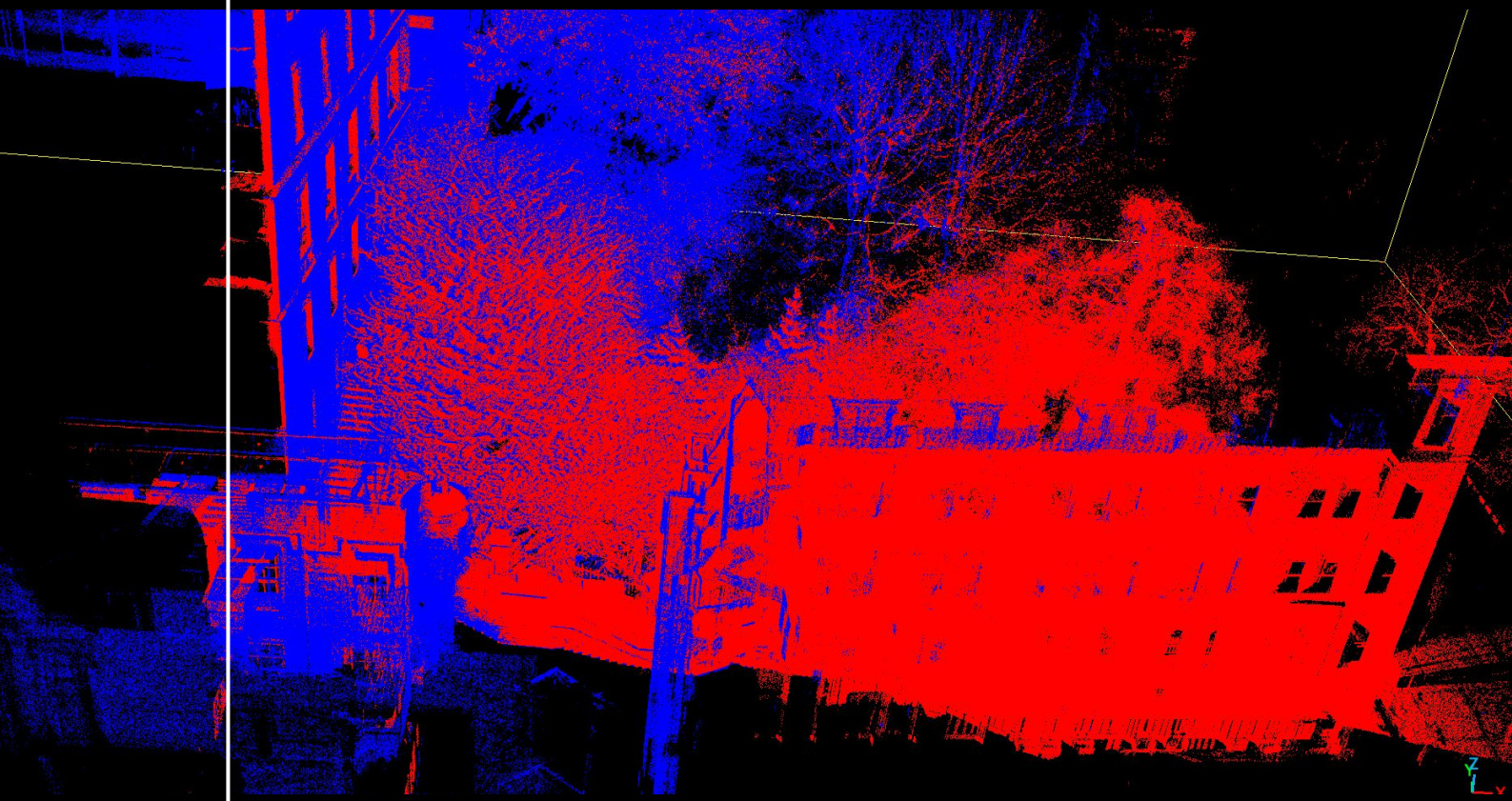
A definition of digital exhibition:

"A digital exhibition is the presentation of moving images to the audience, either live or prerecorded, in public spaces, via digital distribution and projection" (Walker, 2012)

Lev Manovich (2006) argues that augmented space presents an opportunity for cultural institutions to play a more active role. While many video installations already serve as experimental sites for exploring novel image configurations within a space, institutions can leverage their physical spaces to foster the creation of fresh spatial forms of art and moving images. As artists and curators move beyond the boundaries of the picture frame and into the physical space of the white cube, walls, and floors, they should also view this space as layers of data. Manovich posits that it is through the interplay of the physical space and data that some of the most remarkable art of our time is being produced.

Mathias (2022) explores the emergence of immersive digital exhibitions (IDE) within the broader context of society and the experience economy. The public demand for such experiences is linked to the expansion and popularity of the experience economy, a phenomenon that has long been recognized as a significant factor in the global economy (Pine, Pine and Gilmore, 1999). Miles (2020) suggests that experience has become "the new ideological terrain of consumer society," while Schulze (1995) argues that modern life, particularly in the post-WWII era, has become increasingly experience-driven.

Chaos and Places



From blog post: Chaos and Places

In the case of this project, we question how spectators can be shown the chaos of the world we are living in? How the places we inhabit change by the very own nature of the world, and by our own interaction with it in a non-linear way. How the steps passing through time keep changing, evolving the environment they are surrounded and are part of, and the way they are keeping up with the changes of the city and the people who pass through time and space. We want to create a representation of this, the chaos of the world, and the transformation it has over time and space. In our exhibition, the digital animations of the scans will be representing this evolution of the new stairs, while at the same time will be showing a new unexplored dimension.

The New Steps

From blog post: The New Steps Research

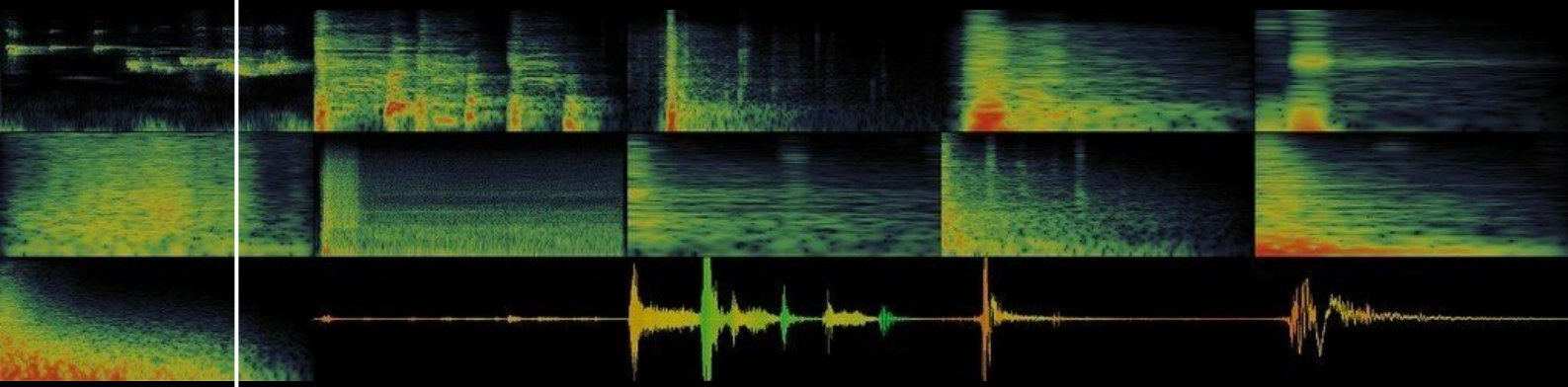
With limited official information available about the history of The New Steps in Old Town, Edinburgh, we turned to the National Library of Scotland for assistance. Using their resources, we were able to locate the steps on old city maps dating back to 1892 and came across a comment on a tourism blog suggesting that they were built in 1869. While we could not confirm this information, we did find an unverified account that in 1928, The Evening News building was extended, causing the steps to be realigned. Seeking further confirmation, we reached out to a librarian who unfortunately was unable to provide much additional information on the steps.

Team Roles

Visual and General Roles

- Field Scanning: Daniela, Molly, Yuxuan, Yijun
  - Responsable for scanning News Steps by LiDAR and exporting the data
- Visual Elements Designer (Interactive): Yuxuan, Yijun, Allison
  - Responsible for making an animation using Touch Designer
- Visual Elements Designer (Non-interactive): Molly, Daniela
  - Responsible for creating supporting visual videos with Blender and iMovie
- Interaction Designer: Allison, Yuxuan, Yijun
  - Responsible for programming and designing the workflow of the interactive portion of the project
- Prop Making: Daniela
  - Responsible for making physical model of the stairs with 3D printing along with promotional prints
- Documentation: Daniela, Molly
  - Responsible for documenting group meetings notes for blog posts and project reports. Also includes organisation of files and compiling reports.
- Interviewers: Allison, Yuxuan, Yijun
  - Responsible for interviewing the audience members during the exhibition.
- Video Creation and Editing: Allison
  - Responsible for compiling all recorded media and creating the exhibition trailer video and the behind the scenes documentary video.
- Gear Manager: Everyone
  - Responsible for booking equipment and keeping track of the usage and return date

Sound Roles



From blog post: The Sound Task Force

- *Soundscape Capturing - Chenyu Li*
- *Place Sonification - David Ivo Galego*
- *Interactive Sound - Xiaoqing Xu*
- *Installation - Yuanguang Zhu*

Soundscape Capturing

- The soundscape contributes to our perception of a place.
- The soundscape creates a sense of identity and atmosphere.
- Capturing and reproducing the soundscape plays a critical role in shaping perception and understanding of the presented place.

Interactive Sound

- Users will interact through a control system that takes in a relatively simple gesture (stepping up or down)
- The gesture presents multiple sets of data: outcome A; outcome B; similarity to a past outcome; dissimilarity to a past outcome
- These parameters can be represented by quantified data and be sonified through Max/MSP

Place Sonification

- The project's core concept is to capture a location into point cloud data.
- Data sonification is an aspect of sound art that involves transforming data into sound to make it more accessible and enhance its representation
- Point cloud data can be turned into quantifiable formats such as XYZ and RGB and exported into an XML file.
  Through computational sound composing, data can generate a meaningful sound-art piece that represents the recorded place.

Installation

- The project proposes an immersive experience
- The "immersive" label narrows down the installation options but demands innovative and creative solutions
- Installation plays with various factors that must be planned, measured, tested, and improved
- The installation must be thought out early in the project and improved along the project developments.

Team Meetings

From blog post: Meetings

Brainstorming: Miro board

At the beginning of the project, we made a conscious decision to maintain a comprehensive log of all our meetings. To achieve this, we utilized Notion to document all the important points discussed during these meetings, ensuring that we had a clear and detailed record of each one. This proved immensely beneficial, as it allowed us to easily track the project's progress over time by reviewing our notes from previous meetings.

First Sound Meeting

One Drive: DMSP Sound meeting

On the 23 February 2023, the first Sound department meeting took place. All parts of the sound team attended the meeting and took part in its content. The session was structured across each sound task, as mentioned in the latest sound post. Each team member had the opportunity to catch up and show individual progress on their coordinated task. A collective effort also allowed for planning the future steps of each job.

The meeting took place in the following and played out in the following order:

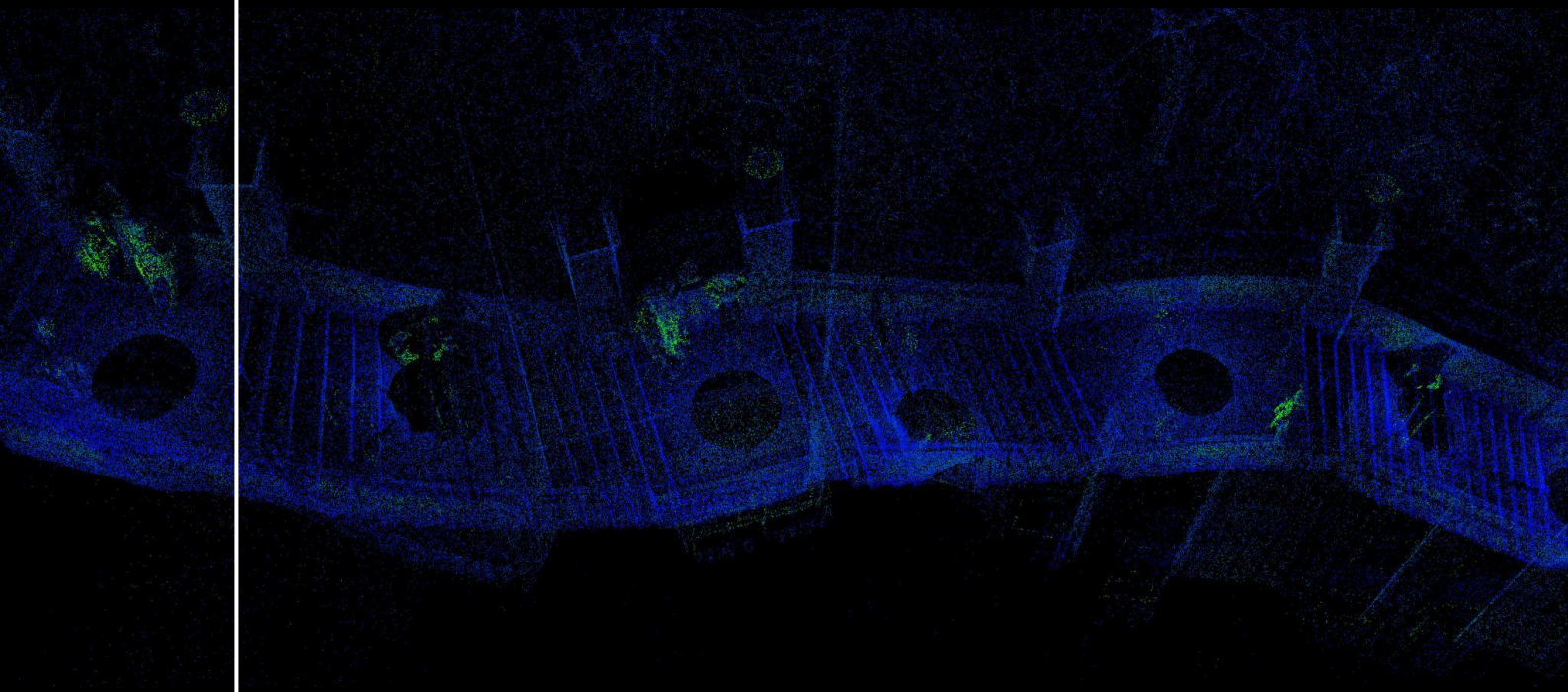
- Soundscape Capture with Chenyu Li – Proposal and Planning;
- Place Sonification with David Ivo Galego – Data-Reading method demonstration and future Creative approaches;
- Sound Installation with Yuanguang Zhu – Proposal Review and further planning;
- Interactive sound with Xiaoqing Xu – Resources overview.

Gantt Chart

From blog post: Gantt Chart

To better manage our project and ensure that everyone on the team understood their tasks and timelines, we created a Gantt chart. We identified all the different stages and tasks required to complete the project and mapped them out in a sequential order, taking note of each task's duration and dependencies. This helped us determine the critical path for the project and ensured that everyone was on the same page with regards to the timeline and milestones. Using the Gantt chart, we were able to optimize our workflow and improve overall project management.

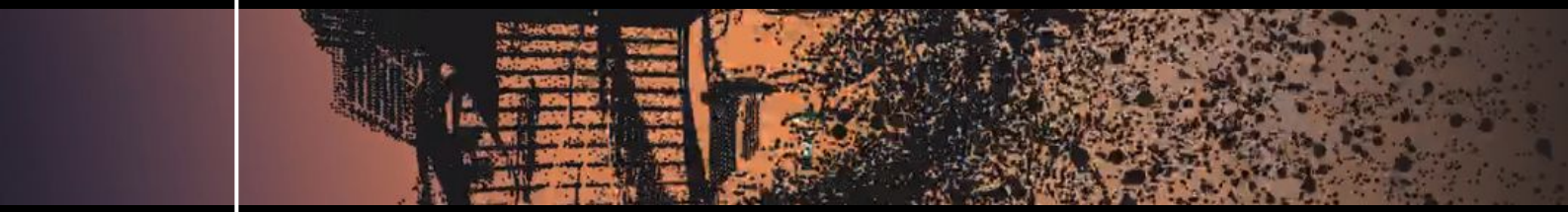
Design Methodology



From blog post: Design Methodology

For this project, we adopted the Double Diamond methodology, which is a strategic approach to design that involves four stages: discover, define, develop, and deliver. During the discovery phase, we researched the concept of place and LiDAR technology, identifying our opportunity and ideating potential project ideas. The definition phase involved filtering our ideas and selecting the most promising one to pursue, which led us to create an immersive, interactive exhibition with The New Steps. In the development stage, we built our concept and continuously iterated it based on feedback from our tutors. Finally, during the delivery phase, we conducted several tests to ensure everything worked well, and successfully solved any problems that arose on the day of the exhibition. Overall, our use of the Double Diamond methodology allowed us to follow a rigorous and iterative design process that led to the creation of an engaging and immersive exhibition.

LiDAR Scanning



Data Collection

From blog post: LiDAR scanning The News Steps

In order to be certain that the decided upon place of The News Steps was feasible for our project, it was important to test how the scanner responded to the environment. There was also the worry of space on the landings, if there was enough room for the scanner and the public to pass for example.

Daniela, Molly, and David conducted a successful scanning session in the late evening on the steps. We took advantage of the darkness to test the scanner's flash and capture detailed points. Despite differences in height, the scans aligned well, and we found that there was enough room and light to produce a good amount of points even in the dark.

From blog post: The Day(s) of the Lidar Scans

The loaned device was the Leica BLK360 pro 3D, a LiDAR scanner described by many as one of the smallest and most intuitive of its kind. However, its size and simplistic design deceive the user on a first glance. This device is capable of capturing full-color panoramic images overlaid on a high accuracy point cloud, showing accuracy on distances up to 60 metres, and capable of capturing HDR images, even in low-light settings thanks to a small integrated LED. To sum up, small but powerful, simple but full of potential.

Friday 3rd March from 6am - 10:30am

During the first day of fieldwork, at 6am, we planned to take one scan on every landing of the steps, but discovered we were missing information from the middle of the steps. We adjusted one of the legs of the tripod and placed the scanner in the middle space between the landings. With concerns about the expensive scanner being accidentally kicked, one team member acted as a bodyguard. After the sixth scan, we ran out of storage and battery and had to find somewhere to charge and work. We went to the New College and settled in Rainy Hall, where we exported the scans and manually aligned each one. We finished scanning the four places we were missing and processed the data in Alison House. Despite some setbacks, we were excited about the amount of data we had gathered and looked forward to experimenting with it.

Tuesday 7th March from 1:30pm - 7pm

We did the first batch of scans from 1pm to 3pm to record the mid-day rush. We discovered there was more movement on the steps than we expected, and we helped tourists who appeared lost. We returned at 4pm to do a couple of scans for the evening, and then waited in a coffee shop until sunset. We finished the final part of the scans at around 6:30 pm, creating over one billion points of data. Processing the data was difficult due to the sheer amount of it, but we managed to create different versions for different uses, including for the sound team to process using MaxMSP.

Sound Recording

From the post: Field recording report

An unforgettable and amazing experience of setting off at 5am, simultaneous with LiDAR scanning. After meticulous planning and many times of preparation and testing, the sound designers used two pairs of stereo microphones and a shotgun microphone to record the sound environment of the News Steps - one of the most important characteristics of that "place".

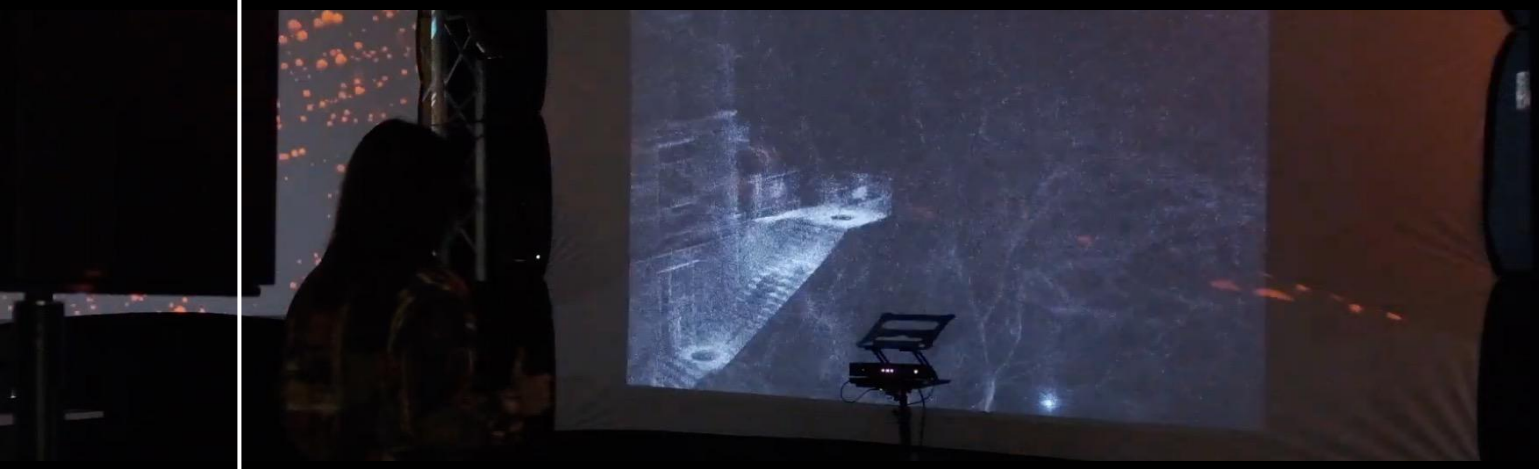
Friday 2nd March from 4pm - 7pm
After get our equipment, we tried to do a test record and found out some problem might affect our formal recording. We do not have windproof for the mics, but we found some things that work as the windproof. We also check the audio files after recording to make sure the formal recording is smooth.

Friday 3rd March from 6am - 11:00am
During the first recording we captured the sound from the early morning to noon. The environment was more complex than we thought, the truck and birds in the morning, the communication of the pedestrians, the bell of the rail station under the road. We set up the system together, after this, some students stayed here to record and monitor, while others helped to buy breakfast. After that, the recording also alternated in turns.

Tuesday 7th March from 1:30pm - 7pm
We captured a more lively sound field this time — there are more people walking through the steps. We can also hear the busy kitchen sound by the restaurant nearby. We got some real windproof this time from the lesson we learned from the last time. We can tell the difference of the sound field with the time passing by, the sounds in different times are quite diversified.

After the recording, the audio files are processed and edited in to exactly ten minutes and delivered to the other sound designer groupmates for the next steps.

Interaction Design



From the post: Arduino 1st Stage

As we venture into the realm of Arduino sensor testing, the objective is to utilize a specific sensor to initiate the playback of various videos as audience members interact with our innovative physical step model. Given that Arduino lacks its own video library, it is imperative to integrate it with other programming platforms, such as Python, Max/MSP, and Processing, to attain the desired outcome.

To achieve a dynamic video playback experience, I establish two thresholds that dictate when a video transition should occur. These thresholds, defined within the programming environment, are dependent on the light sensor data received from Arduino. As the audience interacts with the physical step model, the light sensor readings fluctuate, triggering video transitions when they surpass or fall below the predetermined thresholds.

From the post: Arduino 2nd Stage

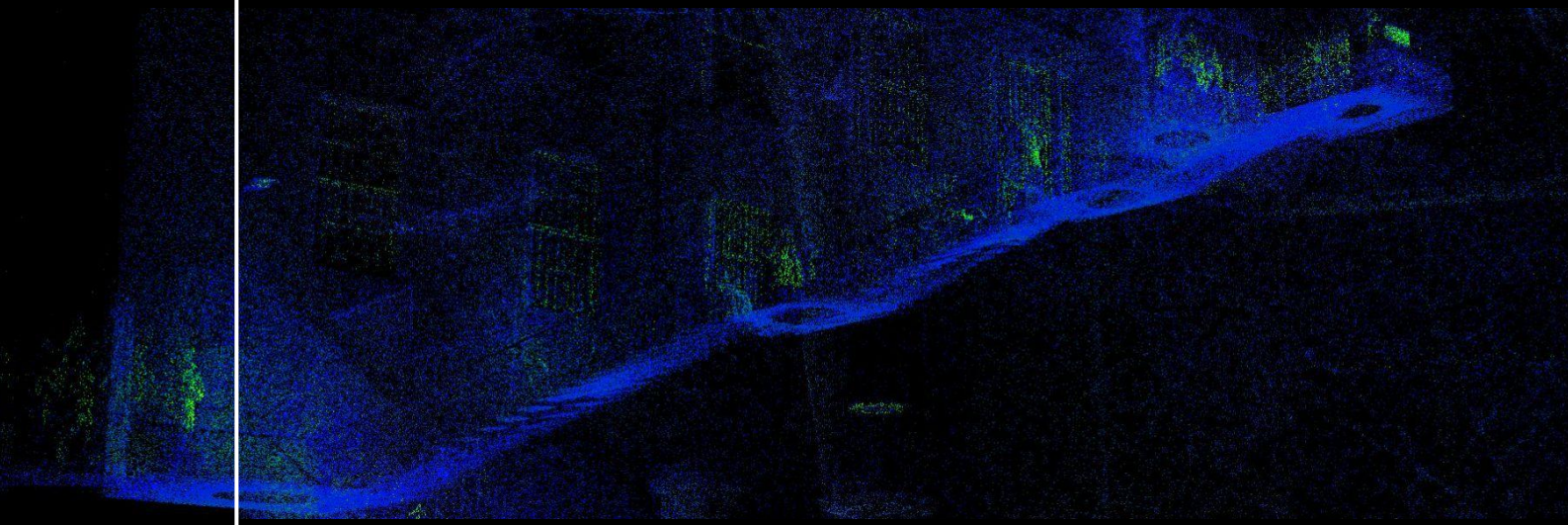
As our project evolves, we have decided to adopt an ultrasonic sensor in response to the feedback received during our recent presentation. To prioritize safety in the exhibition, we have chosen to forgo the use of physical steps. Instead, we will rely on distance sensors to detect audience movement, which will in turn, control the video swapping mechanism.

To enhance collaboration with the sound design team, we have delved into the intricacies of connecting Arduino sensors to Max/MSP. This exploration has led to the exciting discovery of new approaches, while also reinforcing the fundamental principles of serial port communication. Regardless of the specific form in which serial ports are displayed, the central concept remains consistent: utilizing a shared port and transforming the data into a format that Max/MSP can interpret.

From the post: Arduino 3rd stage – Connecting to Touchdesigner!

After several practice sessions with Arduino, our team is ready to progress to the next stage of our project, as previously outlined in our blog posts. The goal is to detect the movement of audience members in order to trigger the playforward or playback of an interactive animation. Ideally, we would directly connect all the sensors with the software used for creating visual elements, such as TouchDesigner or Unity. Although we initially devised a backup plan to trigger recorded video through Processing, the results were not optimal, warranting further exploration of our primary option.

Handling Point Clouds and LiDAR



Data Collection

From blog post: From Raw Data to Unity

The LiDAR scanner to Unity pipeline is, in theory, quite straightforward. However, in practice, there are many individual elements and constraints that need to be taken into account.

LiDAR iPad to Cloud Compare/Cyclone360:

The .e57 files that had to be exported individually, outside their bundle, had to be imported and manually aligned in Cyclone360. The scan could then be exported as a bundle and brought into cloud compare. The afternoon and morning scans could then be aligned in that software to complete the scan of the staircase.

Cloud Compare to Blender:

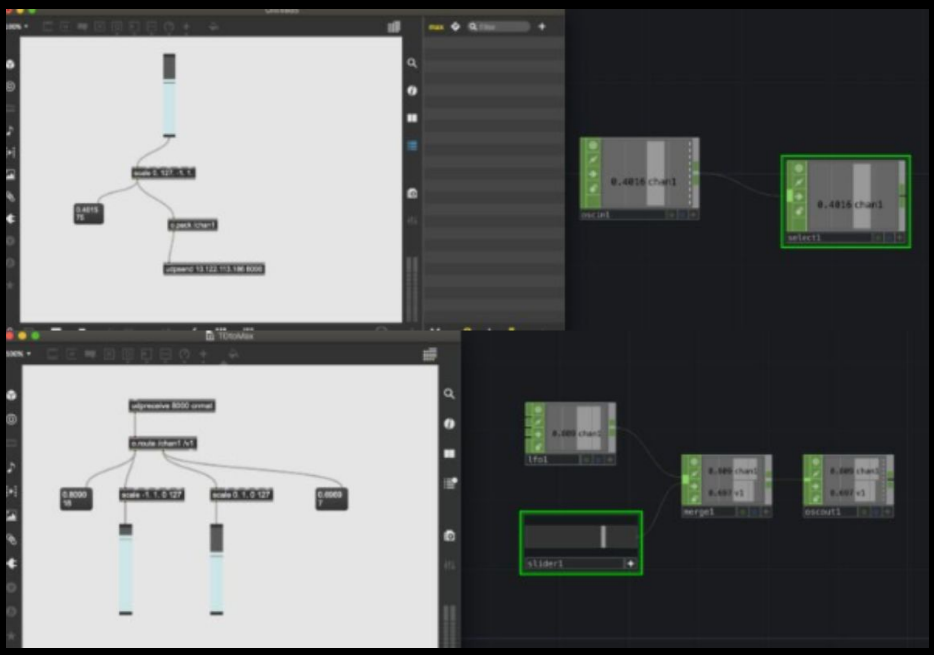
The in between step to resolve this is to export the scans (after subsampling to 100,000 points!) to .ply format and bring it into Blender. Working with Geometry Nodes and then assigning a texture to it.

Blender to Unity:

Two options to go from Blender to Unity here: Export as FBX or just drag and drop the Blender file into Unity. I found that the Blender file was better accepted by Unity with faster importing and more options available for edits, such as textures and lights.

Kinect, Touchdesigner and Max MSP

From the blog post: : Kinect, TouchDesigner and Max data transfer



Use the Osc protocol to transport the data between Touchdesigner and Max

- Kinect > Touchdesigner > Max: to achieve the sound triggered by the audience's movements.
- But since our sound was already rich enough, we didn't end up triggering the sound by this method.
- Max > Touch Designer: We have used Max and ultrasonic sensors to precisely implement the interactive sound that is triggered whenever the audience goes up and down the steps, so we can use these triggered sound effects (use a snapshot to get the level between ±1) to control the speed of the video in Touch Designer.

Sonification Data

```
point Numbe r;X;Y;Z;Rf;Gf;Bf;Af;Intensity
62767;3.3316803;46.28307343;34.78308868;0.309804;0.317647;0.435294;1;0.08204
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47681;2.5660553;45.71753693;32.08362961;0.278431;0.266667;0.376471;1;0.08219
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From the blog post: Sonification #1 – Data Collection, Treatment and Processing

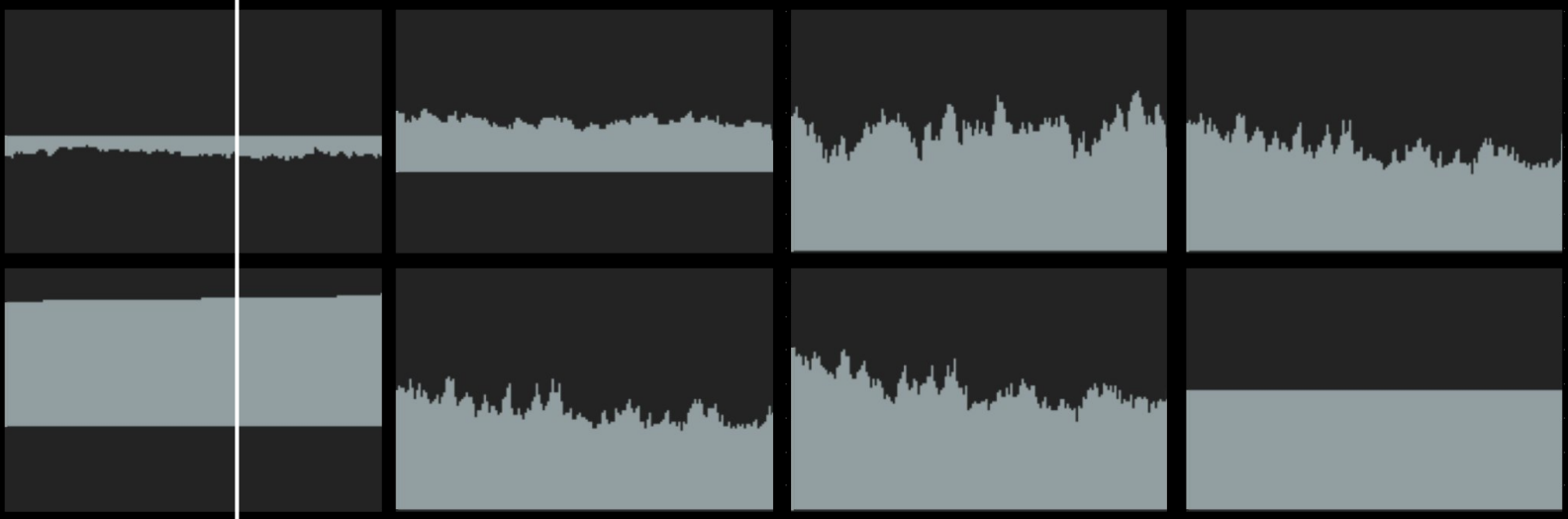
Sonification is understood as the use of sound to convey information or data. It transforms data, such as numbers or measurements, into sound signals or musical notes the listener can hear and interpret. As such, a rich and representative data set had to first come into place to develop the actual "sonifying" procedures further.

Data Collection: A point cloud scan based on a LiDAR scan, in its essence, is a recording of individual distance points from the source (the scanner) that are then correlated and represented together in space within a digital domain. (...) Through CloudCompare software, we managed to understand that this set of properties corresponds to positional (XYZ) and colour (RGBA) coordinates, as well as an "Intensity" value that seems to correlate with the reflectiveness of the surface. While in cloud compare, we also learned ways to export the aggregate data set into its text format, which meant that the point cloud data could easily feed a Max/MSP system.

Data Treatment: The ability to import this data set into excel allowed two crucial aspects, it allowed to create/calculate new variables and also allowed to organise data in a more meaningful and readable form. Both the text and the excel format presented a structure where each line composed a point, and with a total of 8 variable rows: X; Y; Z; R; G; B; A; Intensity. (...) Since the sonification means focus on the spatial qualities of the capture, the data set was re-ordered over the z-axis from top to bottom. (...) However, at first, to monitor the re-ordering operation, all of the lines were previously numbered, creating a point number variable. This new variable seemed interesting due to its rich uncorrelatedness to any other variables when ordered on a specific axis, so it was kept and later sonified.

Data Processing: The last aspect of the data treatment came from later learning the memory thresholds of the designed max patch. Through trial and error, we found that the max patch could only hold an approximate maximum of 100.000 lines (txt. file).(...) The original file size could never be processed through the methods used and the available resources. Luckily, CloudCompare provides downsampling tools that reduce the points evenly across the model to a desired amount, providing sonifiable-sized data whilst conserving the model's integrity. Therefore the entire data collection and reorganising process described until now had to be performed for a downsample of 100.000 points.

Data Interpolation

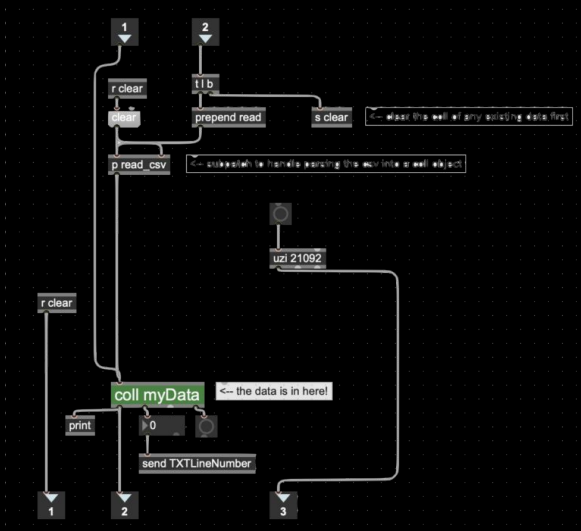


From the blog post: Sonification #2 - Interpolation and Data Flow

Where there is an oscillating variable, there are sonic opportunities. As such, the first goal within the Max/MSP domain was to have a discrete set of variables flowing over time, maintaining their representative interpolation. A Max/MSP patch for the data reading purposes of this project was envisioned to have the following capabilities:

- Allow the upload of single text files and hold memory, respectively;
- Provide some data flow over time;
- Disaggregate and isolate variables into individual domains;
- Provide control over the data flow rate;
- Provide navigation across the interpolation of the uploaded data set;
- Define a loop over the reading of the uploaded file;
- Display monitoring visualization;

Thanks to Dr Tom Mudd's creative coding resources, provided in the academic year of 2021/2022, a Max patch was already available and up for use. This patch covered the first five topics described above. This patch surrounds a coll system that, when messaged "next", outputs the aggregate data of an individual line (point) of the uploaded text over its integral order (in this case, z-axis top to bottom); in other words, reads the text file line by line. The triggering of "next" messaging can be rated through a metronome that provides a simple and rather easy control over reading-rate. This coll object is also aware of line count, both inputting this data for navigation purposes and outputting it monitoring and with little work to trigger a loop back to the first line after reaching the 100.000th and last line (number of points in the file). The aggregate line data is then unfolded into individual domains with an "unpack" object, providing the desired variable isolation to proceed with their respective sonification.



5. Computational Pipeline

Integrated Sound Triggering System

—— The function and structure of MAX/MSP

From the blog post: Integrated Sound Triggering System #1 The function and structure of MAX

The interactive sound component of the device is designed to receive data from the sensors and map the real-time sensory data generated by the tester to the expected sound samples in Max.

Therefore, in this part of the concept, my goal is to translate the state of a simulated human climbing a step into triggered and random sound events for the tester within a certain threshold range. The functions of the MAX/MSP patch that triggers the interactive sound part of this project are as follows:

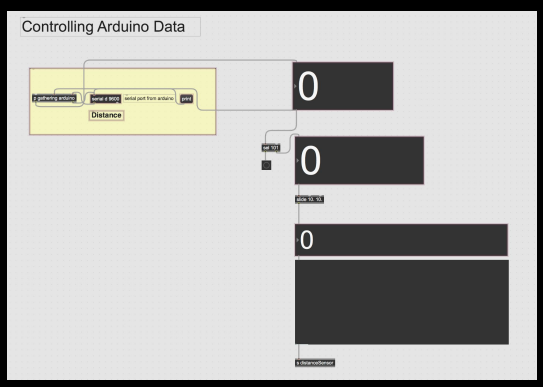
- Threshold control
- Random sound containers
- Transitions and connections for sound playlist switching
- Intuitive and flexible sound transition
- control

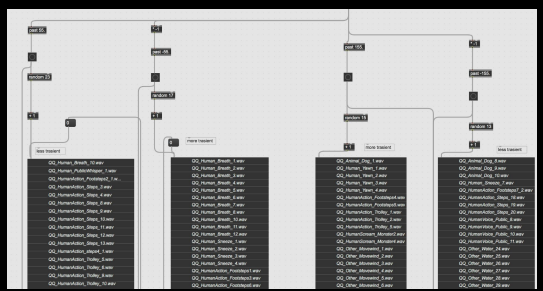
The Max patch uses distance sensor values from the Arduino to track a person's position on the stairs and triggers sound playlists based on two thresholds. It simulates stair climbing states and adjusts sound playlists accordingly for a diverse auditory experience.

When a person is climbing the stairs, sustained sounds play. When returning to the intermediate state, transient sounds play for a rapid response. This applies to both ascending and descending stairs, with specific sound characteristics for each direction.

Smooth transitions between different sound sample playlists are required since the observer is constantly moving. In the Max patch, "gate" and "slide" objects are used to manage this process. The gate object receives threshold values and determines if the input value is above or below the threshold. The slide object controls the transition duration, which is mapped to the appropriate range for playlist transitions.

The transition duration is based on the team's listening experience and tests, and loadbang and metro objects are used to trigger the transition at the appropriate time. This part of the Max patch ensures smooth and seamless sound playlist transitions based on changing sensor input values.





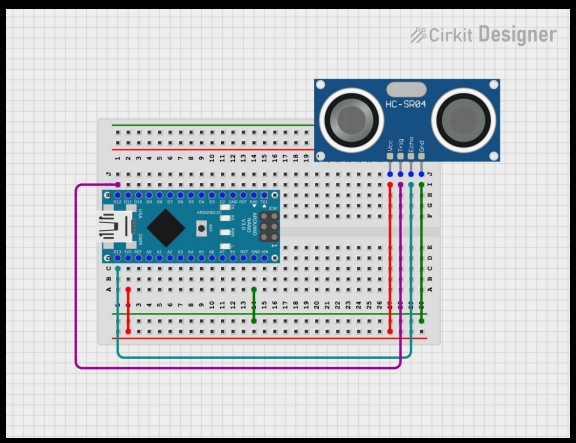
Integrated Sound Triggering System

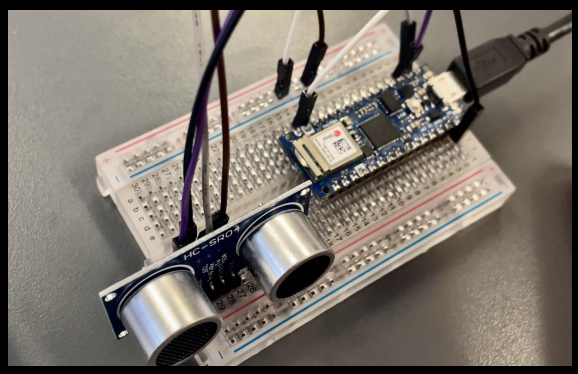
—— The function and structure of Arduino

From the blog post: [Integrated Sound Triggering System #2 The function and structure of Arduino]

The Arduino plays a vital role in an interactive sound triggering system by connecting the distance sensor to the Max patch. It reads sensor data and sends it to the Max patch using serial communication. The Max patch processes the data, generating a sound when the sensor value crosses a specified threshold.

In summary, Arduino serves as the primary interface between the distance sensor and the Max patch, enabling an interactive sound response based on user actions.





Our team considered pressure, distance, and photosensitive sensors. However, pressure and photosensitive sensors were found to be inaccurate or influenced by the environment. The distance sensor was chosen as the most sensitive and suitable option for detecting movement. To address potential errors caused by clothing material, a smooth plane with a certain area was used to improve real-time sensing data accuracy.

The test process is recorded as follows:

From the blog post: [Integrated Sound Triggering System #4]

Cloud Compare

From the post: Point cloud data processing with CloudCompare #1 - Editing

The study area under investigation encompasses The New Steps in Edinburgh, a locale that features a staircase with a 90-degree angle, a wooded region, and a building adjacent to the staircase.

To facilitate integration with other software applications, the scene was divided into three distinct segments: an isolated wooded area, the first half of the staircase with adjacent buildings removed, and the second half of the staircase with the adjacent buildings intact.

The segmentation process necessitated the use of the Segment Tool in CloudCompare. Upon selecting this tool, the user is able to draw a polygon on the screen, which can subsequently be mapped onto the 3D scene where the point cloud is situated. The user is then given the option to eliminate all points either within or outside the delineated polygon boundaries. Following several iterations, the three separate scenes were successfully extracted.

Touchdesigner & Kinect

From the post: Designing interactions with TouchDesigner #3
From the post: Touchdesigner visual part 1

In a previous discussion, we outlined the division of the original point cloud data into three segments: Staircase 1, Staircase 2, and Forest. The current objective is to enable interactive transitions between Scene 1 and Scene 2 while maintaining a fixed forest segment.

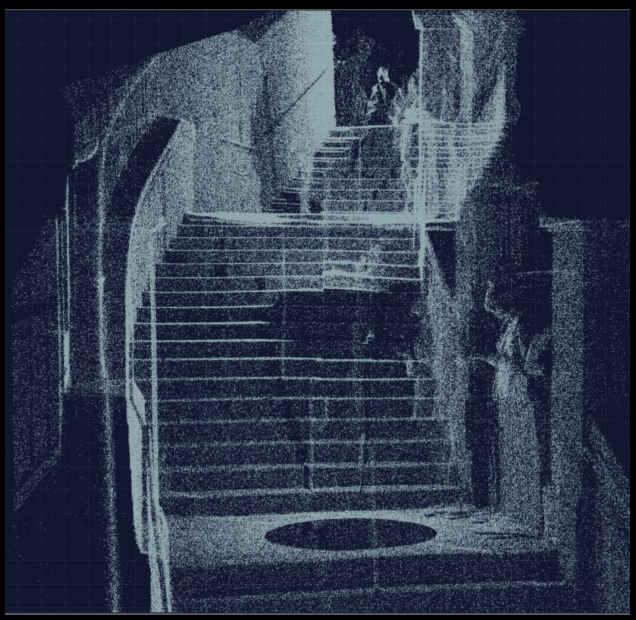
To ensure a seamless transition between the two scenes, we employed the Cross TOP and Reorder TOP to facilitate the transition by scrambling the points in one scene and subsequently reconstructing the second scene. Furthermore, the Noise TOP can be utilized to introduce noise to each axis individually, allowing for point cloud alterations in specific directions.

From the post: Touchdesigner visual part2 - Noise node
From the post: Touchdesigner visual part 2 – Noise node and thresh node
From the post: Touchdesigner visual part3 - color and photographic composition

Most of the effect is achieved by using noise node, such as distorting the entire scene, or spreading and offsetting particles. These effects are all linked to the sound part. Because the sound is recorded on site, we believe that sound is also a part of the environment. It affects people's impression of the place. So, we use technology to visualize how sound shapes and influences the environment.

In addition, we have adjusted the colours and the composition to make the picture more beautiful and harmonious.

Touchdesigner & Kinect



From the blog: TouchDesigner Point Cloud Camera Animation#1
From the blog: TouchDesigner Point Cloud Camera Animation#2

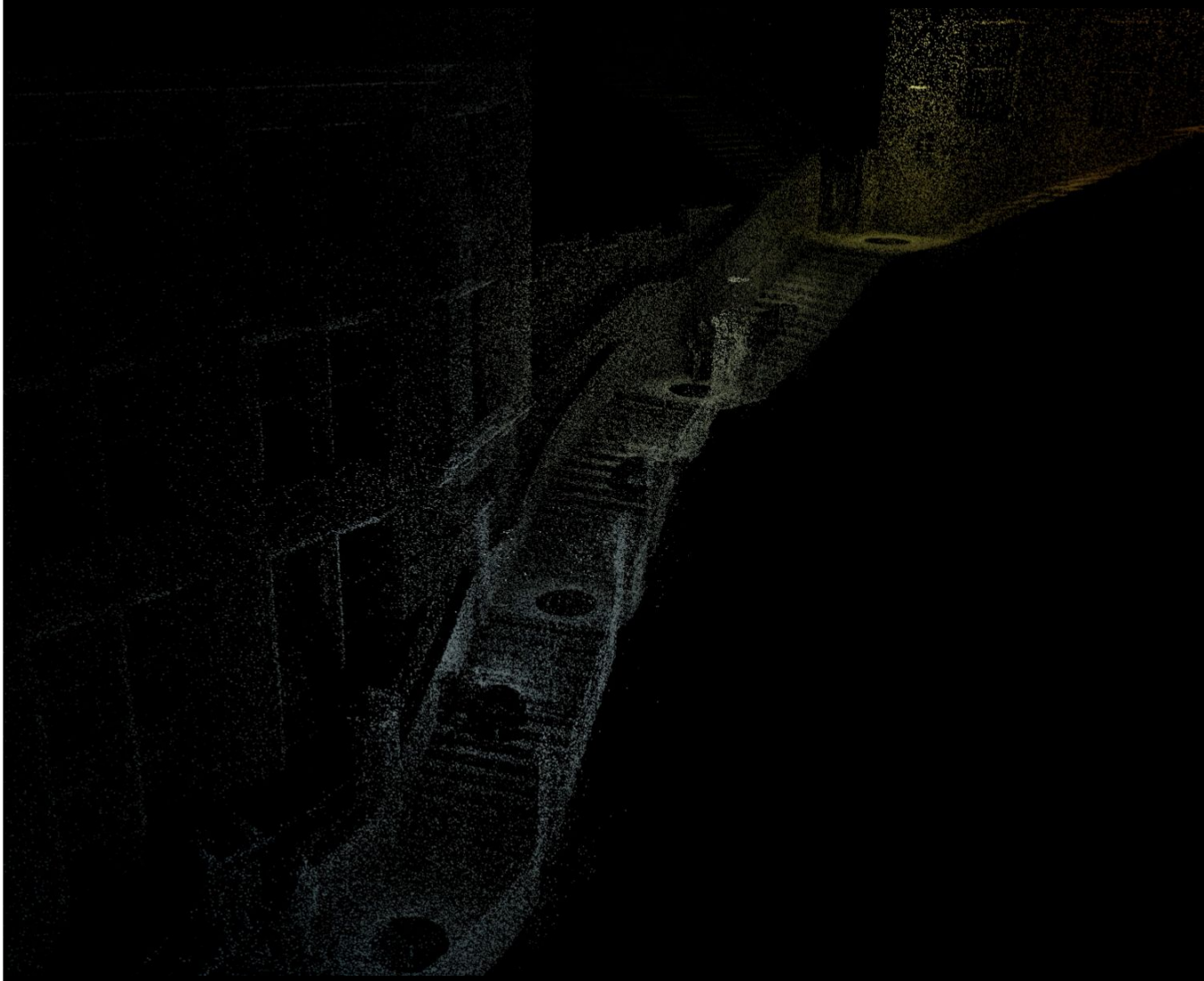
We have decided to slightly modify the visual representation of the New Steps project from our original plan. Rather than creating one animation moving up to the top while another presents one step down, we aim to develop two animations from distinct perspectives: first-person and third-person views. This fresh approach offers various possibilities for point cloud scanning, allowing the audience to experience the visuals from multiple angles. The first half of the stairs are very winding, and we hope to use this climbing stimulation to bring a sense of familiarity to the audiences. The second scene would more focus on the overall visual presentation of the stairs, with the camera focusing on different people.

From the blog: Kinect Phase 1
From the blog: Kinect Phase 2

In our recent exploration of TouchDesigner, we identified Kinect as a promising tool to offer audiences increased freedom and opportunities for interaction with on-screen visual elements.
As noted by Jamaluddin (2021), Kinect was initially designed for gaming purposes, but its application has expanded into other fields. The release of Microsoft's SDK has enabled its use in medical, robotics, and other sectors through academic research projects, showcasing its adaptability and potential for innovation.
By incorporating Kinect into our TouchDesigner workflow, our design team can utilize the motion data captured by Kinect to generate interactive and responsive visuals. Kinect's real-time data can be seamlessly processed and manipulated in TouchDesigner, enabling the creation of more captivating point cloud effects based on audience movement.mera

We use Kinect to capture the audience's hand movements. By detecting changes in the distance between the two hands, the scene can be influenced. These interactions can help the audience better understand the relationship between the environment and people, as well as the impact of the environment on people.

Blender



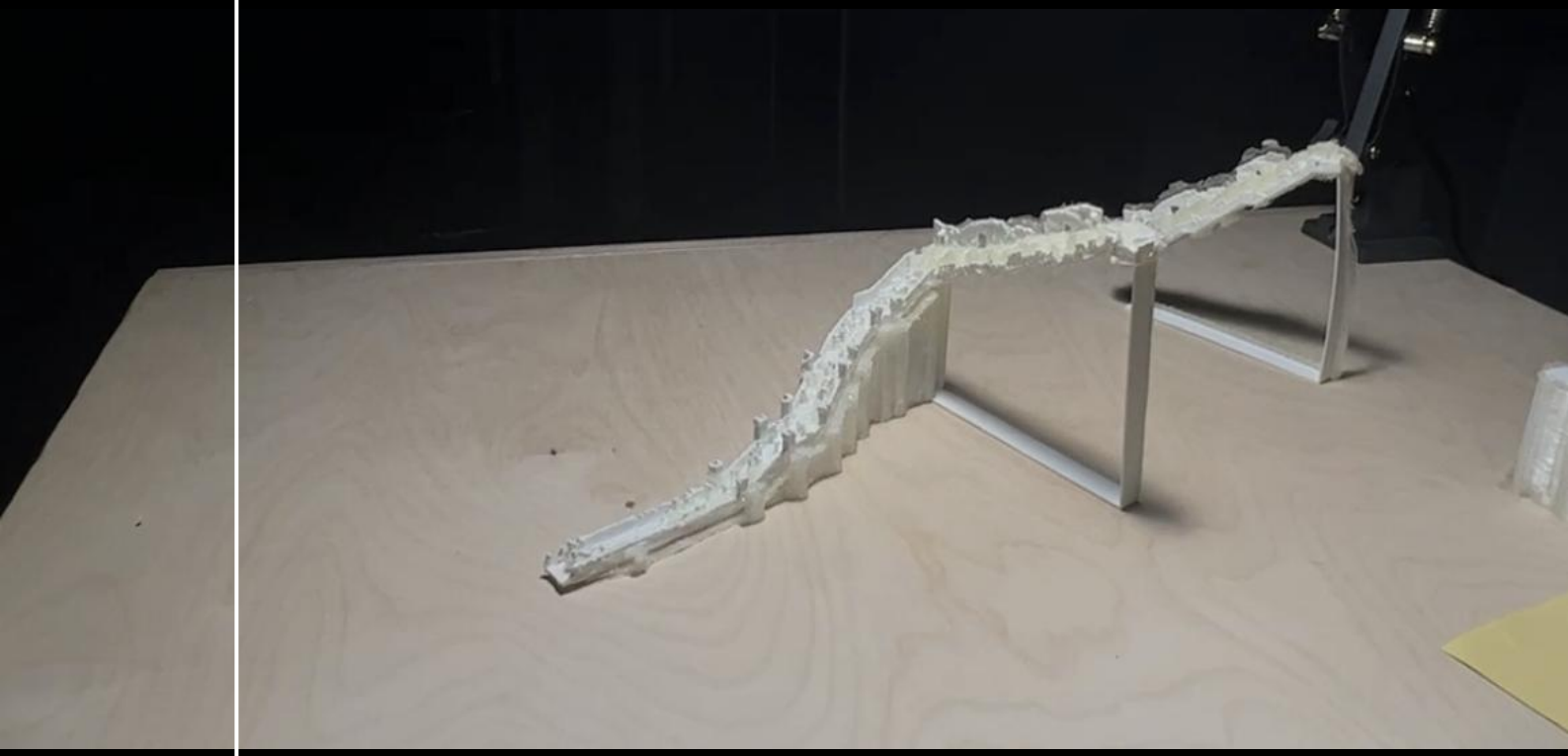
Molly MUNRO (2023) Blender Staircase: [Screenshot of Render]

From blog post: Blender Animations and Renders

As discussed in the initial brief for this project, the interactive space consists of three projection screens. The one directly in front of the user is occupied by the Touch Designer interactive imagery. The screens on either side of the user were originally planned to be connected to the Touch Designer project and have all three images be synced, however, as the weeks progressed, it was found that this feature would need more time to develop.

Therefore it was decided to revert to our backup plan of manually animating a camera moving up and down the virtual 3D model of the stairs and simply rendering and exporting this as a looping animation. Blender was the chosen application to be utilised to achieve this task.

3D Model



From blog post: The New Steps 3D Model

We wanted to explore the transformation of a physical space into a digital one and then back into a physical model using 3D printing. We started by collecting cloud points from the new steps and worked the data in Cloud Compare to create a 3D model in Blender. We then sliced the model and used PrusaSlicer software to prepare it for 3D printing. Initially, they encountered problems printing the model due to its complex geometry and the fact that they were printing it in one piece.

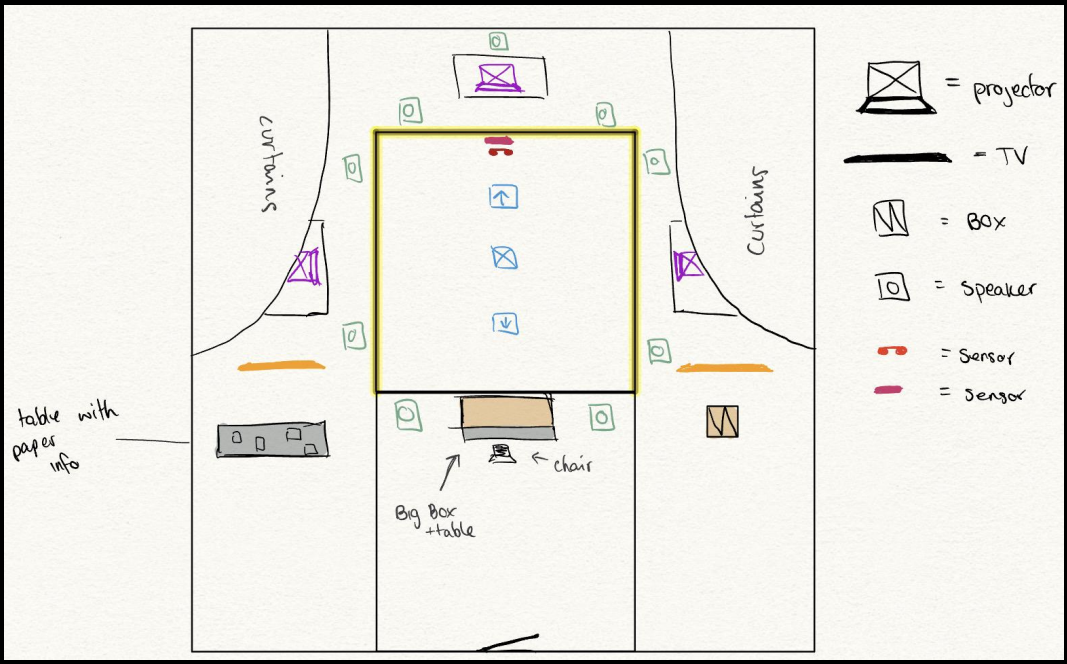
We received feedback from the head of the 3D printing department at uCreate and decided to create a mesh and split the model into two pieces, which saved material and made printing easier. The first part of the stairs printed well, but we had trouble with the second part due to calibration issues. After several failed attempts, we were finally able to print the second part and joined both pieces together.

Behind the Scenes Slideshow Video

From blog post: Behind the Scenes

As part of our exhibition, we included a video compilation of clips, images, and sounds from our creative process. Displayed on a screen, it gave the audience a unique behind-the-scenes look and provided an immersive experience that generated interest and inquiries about our project. The video added value to the exhibition, bringing depth to the overall experience.

Designing the Physical Space



From blog post: [Building the Space #2]

Since submission 1, and upon feedback and suggestions from tutors, we decided to add more elements to our project so that it felt like more of an exhibition that you might find in a museum. The exhibition can be divided into three areas:

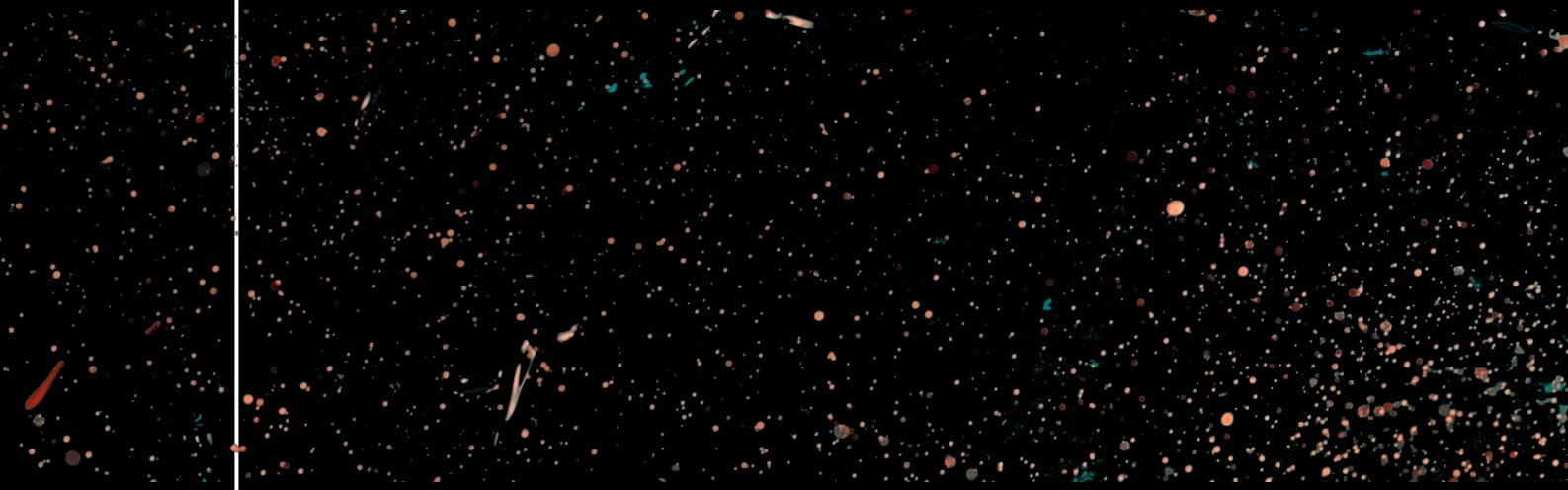
1. Middle: Main interaction and visual zone
2. Right side: 3D model and behind the scenes video
3. Left side: Sound project visualisation and promotional material.

The layout of the exhibition was carefully designed to consider audience flow, and the placement of projectors, speakers, and multimedia elements. The "interaction zone" had to be aligned with the space, and other elements were integrated to create balance and encourage exploration of the space. The process was iterative and took place over several weeks.

Here is a list of the equipment used in the space (not including sound equipment).

Projectors	1 Optoma Short throw projector and 2 Sony short throw
Screens	2 small, 1 large fabric projector screen
Lighting	2 clamp desk lamps
Cables	6 HDMI cables, 5 Extension leads, 3 USB-c to HDMI adaptors
Computers	3 MacBooks, 1 Windows desktop
Sensors	Arduino Ultrasonic Distance sensor; Kinect sensor.
TV	2 smaller tv screens, 1 large.

Granular Synthesis



From the post: [Sonfication #3 - Sonified Granular Synthesis]

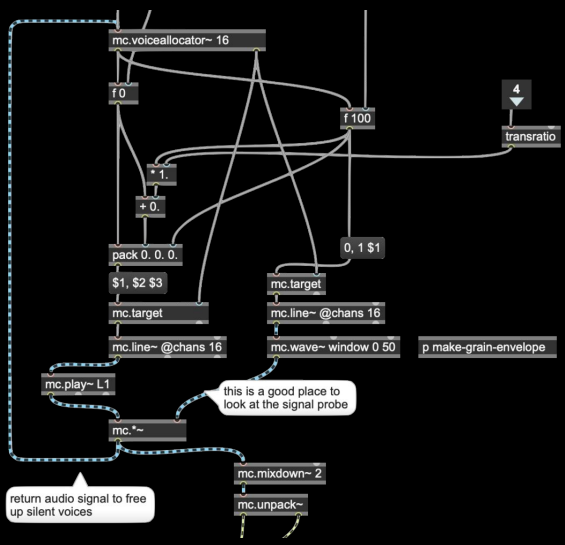
The performed data export out of this format into text values allowed us to understand the genesis of a point-cloud file and break down its meaning: a collection of points with a set of spatial coordinates (XYZ), colour coordinates (RGBA) and an Intensity value (Reflectiveness). This understanding closely reminded the painting technique of pointillism. This technique uses single strokes or dashes of paint, each with characteristics (e.g. position on canvas, colour and texture) to paint the bigger picture.

The idea of a complex texture made of repeating the same gesture, yet each with different characteristics, naturally fell into the sonic granular synthesis technique. The sonic nature of granular synthesis seemed to fit the sculpting method of a point cloud better while also providing an exciting set of sonifiable parameters. It could also use the actual soundscape of the LiDAR recorded place, which seemed meaningful since this meant that the entirety of the sonification would come from recorded data of the defined site (the News Steps).

The granular system bases itself on a Max/MSP patch provided last year by Dr Tom Mudd following the means of the Creative Coding course's academic tools and resources up for grabs and further developments. This patch provides a way to trigger an audio buffer or a snipped-off while allocating this to a separate voice, collecting a max polyphony of 16 voices. This patch also provides a transposition factor (in semitones). Once triggered fast enough using a metronome, a sonic texture is formed.

These four granular parameters were then assigned to be sonified by the flow of some of the available data fractions from the previously described point-cloud database in the following way:

- Rate of grain playback ↔ Point Number
- Starting sample point ↔ Z coordinate
- Grain length ↔ B coordinate
- Transposition ↔ Intensity



Sonified Processing

From the post: Sonification #4 - Sonified Processing

By the stage of granular synthesis, the sounding result is a texture with spectral qualities that feel similar to the high-fidelity soundscape capture but granularly rearranged, providing a first sense of acceptance and normality, followed by disorientation and pattern unrecognition when listening actively—a result of the interest of its own, and presented in the final result as such. However, further resynthesis and processing were desired, a linear variable that could morph between this first scenario and one other that felt otherworldly, hollow, and with an "upside down" feeling. This linear variable was achieved by designing a parallel crossfaded signal flow, with heavy processing between a delay line loop and a parallel reverb.

A delay system can be achieved in Max/MSP by simply using a ~tapin and a ~tapout together, (...) in a signal loop with a multiplier factor between the value of 0 and 1 built into it, known as the "Feedback Amount".(...) By allocating other types of processing inside this loop, the effects will also get repeated accordingly. When these processing block's parameters behave dynamically, things get interesting. This way, we no longer solely loop an audio signal but also the effect of the processing blocks over time. In this project, three processing blocks are set with their respective parameters: A low-pass filter — Cut-off frequency; A pitch shifter — Pitch; And a tremolo/ring-modulator — Modulating frequency and Ramp Time;

Having this set-up settled, this dynamic behaviour that shapes sound in such interesting ways is provided by the method of sonification by assigning the fluctuations of the variable by the flowing data set and its factors (previously described in the past blog posts). After some experimentation and careful tuning over scale a smoothening, the sonification reflects over the following connections:

Delay Time --> R coordinate;

Feedback Amount --> Intensity;

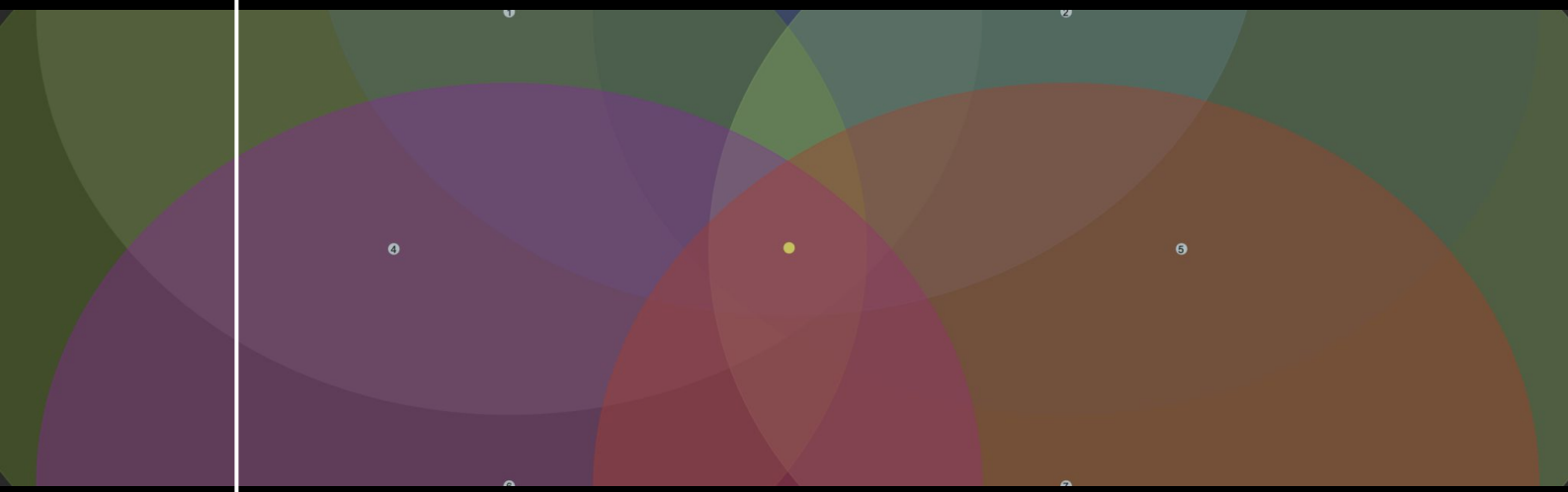
Cutoff Frequency --> G coordinate;

Pitch --> B coordinate;

Ring -Modulation modulator frequency --> X coordinate

Ramp time Ring -Modulation --> Y coordinate.

7.1 Panning



From the post: Sonfication #5 - 7.1 Panning and Surround Sound Layout

The concept of "7.1 surround sound", not only describes the number of discrete output channels needed for this set-up but also includes a notion of spatial relationships between the qualities of these eight channels and the nature of their respective audio signals.

It has been mentioned in previous documentation how the recording techniques (2 pairs of A-B, facing opposite directions) used in this project defined a set of fixed positions, all with the same orientation. For each moment of the "stepped" recording, four positionally related audio files were produced together (Front-Left, Front-Right, Rear-Left and Rear-Right). Now the distribution across the eight channels of the 7.1 layout followed as such:

Front-Left → Recording: Front-Left

Front-Right → Recording: Front-Right

Centre → Recording: Front-Left + Front-Right (MONO)

Side-Left → Recording: Front-Left

Side-Right → Recording: Front-Right

Rear-Left → Recording: Rear-Left

Rear-Right → Recording: Rear-Right

Subwoofer → Recording: Front-Left + Front-Right (MONO)

Although the audio source layout was thought to be as described above, such a solution would still feel unnatural due to the discreetness per output channel. It would cause too harsh of a distinction between the different audio content.(...) For a better solution, some 7-channel panning had to be designed to successfully mix gain values for each signal channel into correctly panned-out ones. As such, the design found a suitable answer by using node panels that can quickly provide a mix of values according to the relative position of a pointer, a solution found research on Cycle'74 Forums (Woodbury 2016). These panning systems were created for each of the 7.1 outputs using the same node layout with a respective pointer position, and input the respective audio-file channel, and split into seven tracks of this audio signal with the correct gain values for each speaker position, providing an accurate, correct, smoother panned mix.

Once tuned to the room and the speaker set-up, this layout provided a surround sound environment emphasising a wide sonic front while keeping surrounding panoramic qualities with two dedicated rear channels. The output of these discrete channels was achieved using a [~dac 1 2 3 4 5 6 7 8] object, followed by dedicated volume faders.

Interactive Sound

From the blog post: [Integrated Sound Triggering System #3]

The installation's design concept explores various states and possibilities of people and systems. The sound library focuses on diverse human interactions, featuring samples from different age groups, social roles, and conversation types. It also includes non-verbal sounds and noises from everyday actions like dragging a suitcase or carrying a bicycle. In summary, the sound library captures a wide range of human-centered auditory experiences, highlighting the diversity of human interactions and behaviors.

During sound editing, multiple versions of each sample were created by adjusting various aspects such as time, frequency, and layering. These versions represent intermediate steps in user decision-making from ResultA to ResultB, combining multiple sound states and triggered transitions.

The post-production goal was to create contrasting sound versions using the realistic samples, such as combining grainy techno and ethereal echo effects or sharp, transient tones with layered soundscapes. Logic Pro and Reaper served as the primary DAWs for this process. In summary, the project involved creating diverse sound variations through editing, field recordings, and post-production techniques, resulting in a rich and engaging sonic experience.

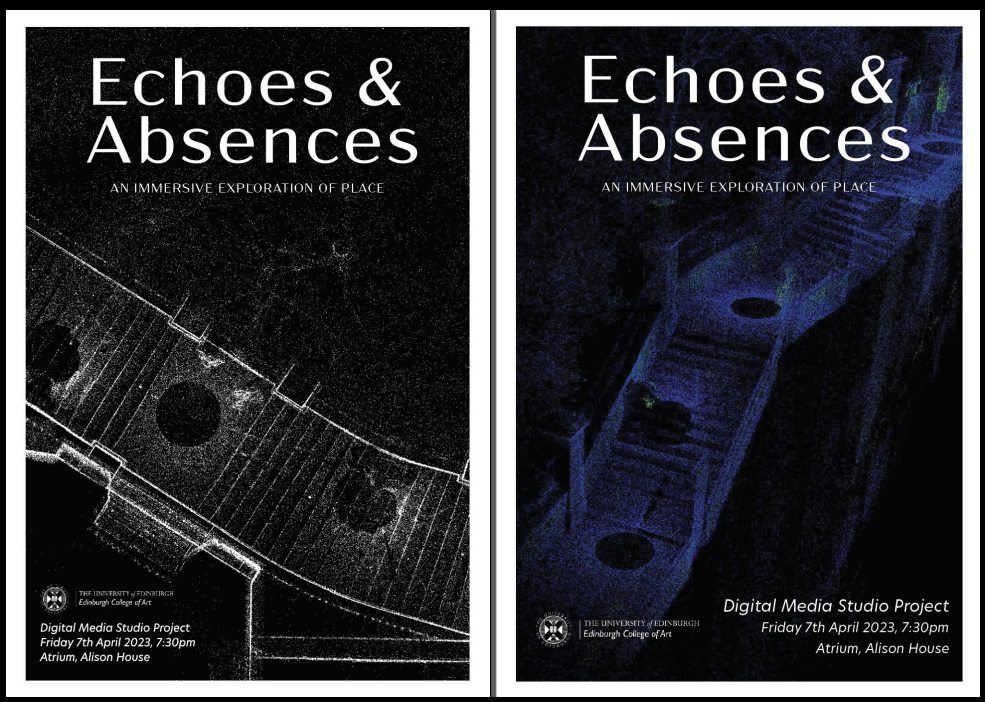
Sound production techniques are as follows:

- Time stretching and pitch shifting
- Distortion and Saturation
- Layering
- Reverb and Delay
- Frequency shifting
- Resample
- Automate Effects
- Experimental processing
- Grain Synthesis
- Reverse
- Flanger
- Bitcrusher

Promotional Material

From blog post: Graphic Identity

When designing the promotional materials for the exhibition, we opted to use the rawest form of visual data available to us, which were the images generated through cloud compare when working with the cloud points. We experimented with various iterations of these images, selecting those that best previewed the essence of the exhibition. Our focus was on visually conveying the core concepts of the project in a way that would be easily accessible and engaging for potential visitors.



Echoes & Absences

Echoes and Absences presents a multi-modal encounter with the New Steps in Edinburgh, Scotland. The work re-composes a local place as a forensic-grade precise swarm of point clouds with up to a billion details using light detection and ranging surveys and cutting-edge data sonification techniques. Each computational-controlled audiovisual grain is either an echo or an absence, navigated through algorithmic cameras and interactive gestures. The resulting tensions constitute the epicentre of a multi-faceted territorial work characterised through algorithmic and sonic ordering of geospatial data. The work altogether partakes, to chime in a phrase from the feminist philosopher Elizabeth Grosz, in creating "The sensation from chaos through the entwined relationship between body and the universe, entwined in mutual concavity/convexity, floating/falling, folding/unfolding are directly touched by that outside now enflamed, creating sensation from their coming together." The result is a multi-dimensional work, perceptualising place at the numeric threshold of echoes and absences.

Digital Media Studio Project 2023

Allison Mu . Chenyu Li . Daniela Morales . David Amado . Molly Munro . Xiaoqing Xu . Yijun Zhou . Yuanguang Zhu . Yuxuan Guo

Sound Installation Setup in Exhibition

From blog post: Sound Installation Setup in Exhibition

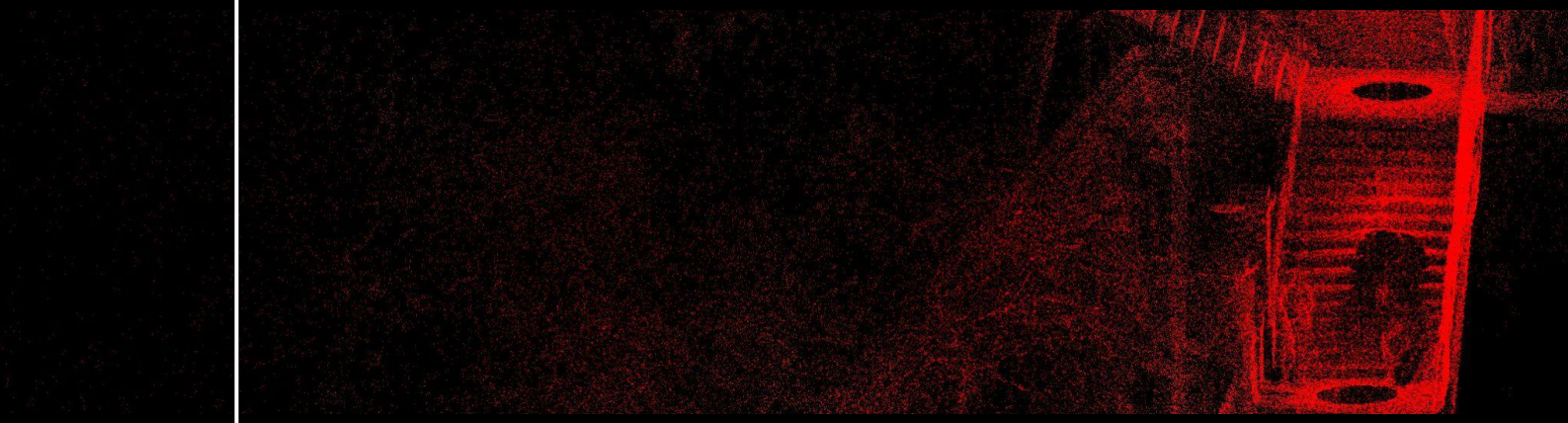
The surround sound installation in this exhibition provided a great immersive sound experience for many audiences. From talking to the audience, I found that there was a high level of interest in the sound installation and how it should be set up, so I would like to explain the idea of the sound installation and how it was set up in the exhibition.

For the sound installation in the exhibition, I initially set two plans, and I think the best sound installation plan would be the one I mentioned in my previous blog, Plan A. Firstly, the digital mixer DiGiCo SD11 and DiGiCo UB MADI Audio Interface would reduce unnecessary cables for the connection between our audio equipment and the audio channels. Secondly, the digital mixer would provide us with the greatest convenience in solving the gain level of the live sound without worrying about overloading live sounds and other unnecessary problems; finally, the digital mixer could provide some internal digital effects for live sound adjustment or live presentation to provide more options for the sounds of our project. Therefore, we learned about the SD11 in the early planning stages. Of course, the use of digital mixer in a live setting without the addition of a spare digital mixer confirms that there may be a certain risk to live presentation. Unfortunately, I was unable to use the digital mixer on the day of our presentation for a variety of reasons, which I felt slightly upset.

In sound installation setup Plan B, we replaced the digital mixer with an analogue console, the MIDAS Venice F, and changed the sound interface from a MADI sound card to an RME FireFace UCX. To some extent, this would reduce the efficiency of the live sound installation setup. However, this plan may be more reliable than Plan A, and may be slightly less rich in internal features than Plan A. This would mean that other members of the sound team may need to do more post-production work when designing the sound to ensure that the live sound could be perfect for the audience. Ultimately, Plan B could not be realised for a variety of reasons.

Our final solution in the live setting is to have the computer demonstrating the sound directly connected to a sound interface with ten output signals for live sound reinforcement. In the live test phase, we mainly did the following settings in terms of speakers connected to the sound interface, the front left speaker connected to the first channel of the sound interface output, the front right speaker connected to the second channel of the sound interface output, the front centre speaker connected to the third channel of the sound interface output, the left speaker connected to the fourth channel of the sound interface output, the right speaker connected to the fifth channel of the sound interface output, the rear left speaker connected to the sound interface output sixth channel, the rear right channel speakers connected to the sound interface output seventh channel, the front subwoofer connected to the sound interface output eighth channel. The live sound control was primarily controlled by the computer demonstrating the sound. During the live test phase, we also set a standard setting on the level of all the speakers and tested all the channels to see if the sound went smoothly. This plan would require relatively more audio cables as far as Plan A was concerned.

Obstacles and challenges



Each of the team wrote a blog post about their experience of the day of exhibition, Below are the obstacles and challenges we encountered and how we overcome them.

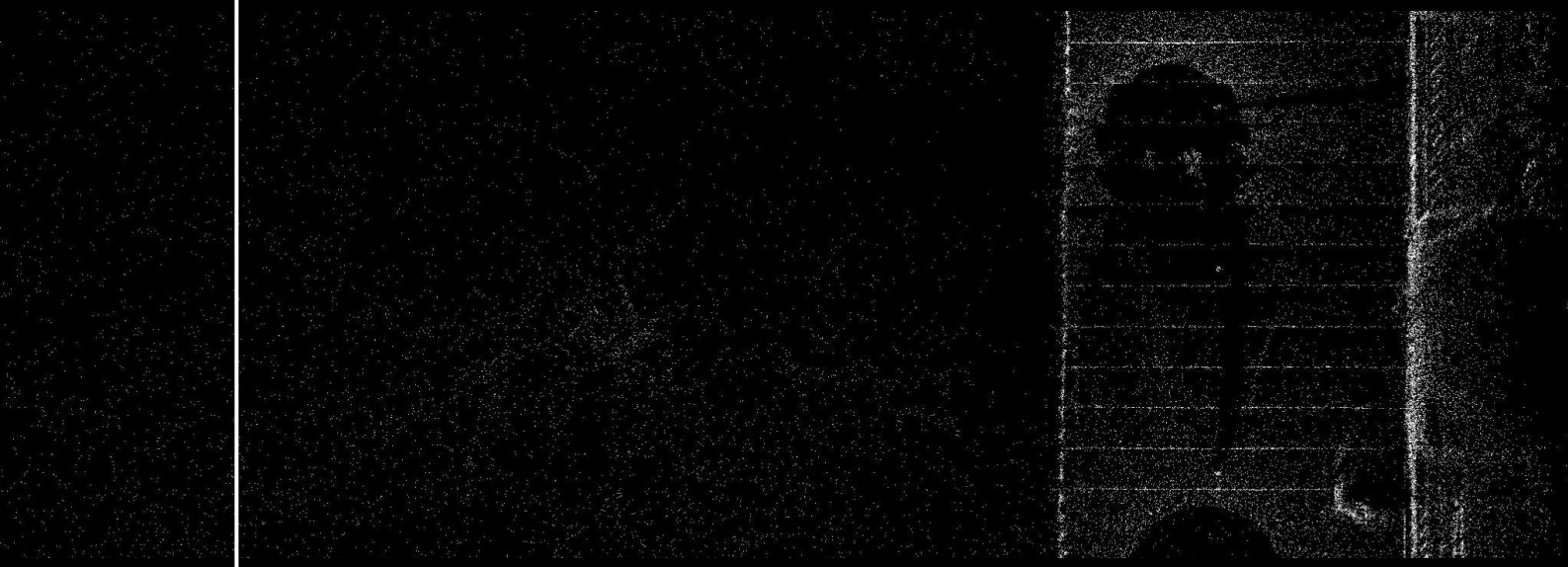
Exhibition Day – Allison
Exhibition Day – Yuxuan
Exhibition Day - Yijun
Exhibition Day – Xiaoqing
Exhibition Day - Chenyu
Exhibition Day - Daniela Morales
Exhibition Day - Zhu Yuanguang
Exhibition Day - Molly Munro

Despite our best efforts, we faced several last-minute challenges with this project, including unexpected technical issues. Although we shifted to a PC for increased power to run TouchDesigner, the performance did not meet our expectations, with glitches appearing frequently. There were some miscommunications in our previous discussions, which resulted in slight differences in the triggering settings between the sound and visual components. This caused the sound and image to be out of sync. When we attempted to fix the settings, we encountered some bugs in our code, but fortunately, we were able to resolve them in the end.

Additionally, using Kinect interfered with the ultrasonic sensor triggering and disrupted the audio. When users manipulated the point cloud with gestures, the ultrasonic sensor below the Kinect was affected, sending incorrect data to MAX. Ultimately, we decided to disable all Kinect effects to prioritize overall performance. Another problem was (Chenyu) failed to connect the screen with my computer, and finally found out it was because the hdmi port of the adapter was broken. (Chenyu) was very anxious and stressed at that time but finally we found the question out and solved it.
In order to prevent the speakers from falling off accidentally, we also reinforced each speaker with tape. The cables were not allowed to pass through the audience experience area in order to reduce the risk to the safety of the audience and the safety of the installations.

Due to a slight miscommunication between groups, the specific projectors that we wanted to use had been returned and booked out by someone else. The solution was to get in touch with them and collect the correct projector right after they had finished and we were about to begin. It wasn't the exact brand that we wanted, but we solved the problem that day and made it work! Some of the light fixtures that we wanted to use, were not set up properly, but with a bit of creativity, we changed the setup slightly to make it work. In our installation, after testing and comparing, we chose to use a smooth iron plate as a prop in the observer's hand to interact with the sensors. However, based on our observations, the transient response of this method was not as agile and fast as we would have liked during our testing. The reason for this could be due to the fact that the sensor response speed was delayed and accumulated throughout the display, thus causing our system settings to interfere with each other.

User Experience



From blog post: Usability in the Exhibition

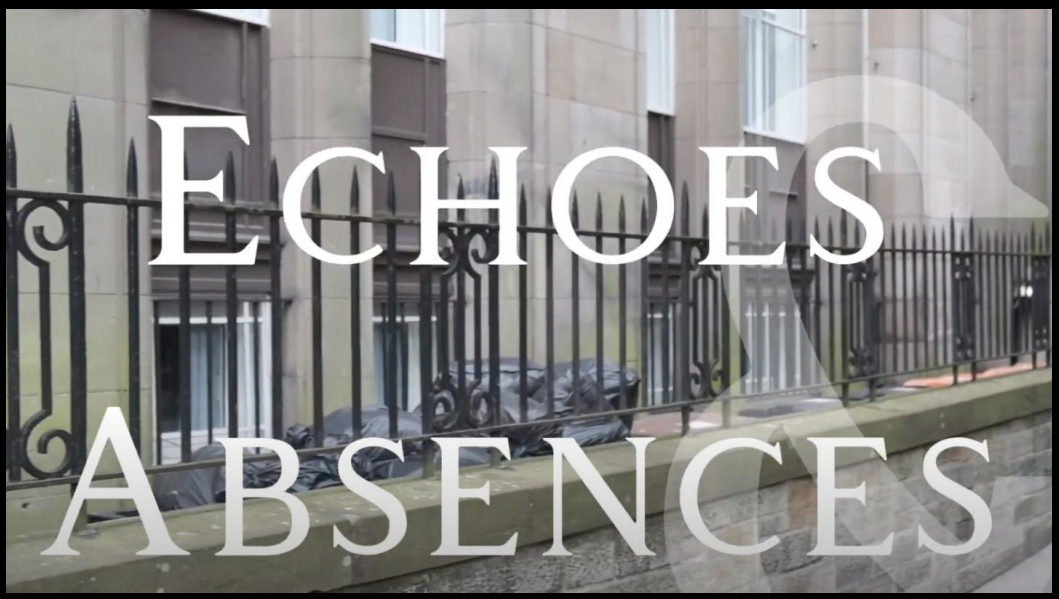
Widjono (2020) explores the usability of virtual exhibitions as a product of interaction design. Though our exhibition is in person, these still apply. To be usable, the "product" should follow these criteria:

1. Usefulness
2. Efficiency
3. Effectiveness
4. Learnability
5. Satisfaction

How our exhibition did in relation to the criteria:

UX Principles	**The Exhibition**
Useful	User able to freely move around the space and explore multiple pieces of content
Efficient	Users took 1-3 minutes per interaction, meanwhile, waiting users could be entertained by the other multimedia pieces surrounding the interaction.
Effective	Users were engaged, immersed and be present in the space. Interested in discovering and exploring the space, creating their own unique experience
Learnability	Once one user was shown what to do, as the others observed, the primary skill needed to interact was learned
Satisfaction	As seen in interviews with users in the audience - very satisfied and moved by the imagery and sounds they were experiencing. Additional material was good to see in addition to the main interaction.

Project Videos



Echoes & Absences: Documentary

Echoes & Absences: Exhibition

Individual Reflections

Personal Reflection: Allison
The "Place" group has been a remarkable learning experience, characterized by effective collaboration and communication among team members throughout the project's development. Working within a large group, I learned the importance of time management and task organization, skills that are deceptively difficult to implement.

Personal Reflection: Yuxuan
I feel very fortunate to have taken the DMSP course and the Place theme this semester, which has been an unforgettable journey for me. Not only have I learned how to use LiDAR and TouchDesigner, but I have also worked with exceptional teammates to create an impressive project.

Personal Reflection: Xiaoqing
The implementation of the Place project has been a novel and rewarding experience for me. I learnt that the granularity of sound makes for a unique and infectious presentation, and I overcame many new problems in this learning process with the help of the team.

Personal Reflection: Yijun
In this team project, I deeply realize the importance of teamwork and the role of sound design in interactive media projects. Everyone is like a part of a machine, efficiently completing their own work.

Personal Reflection: Chenyu
The most valuable gain of this practice is that I realized how to be flexible and adaptable to solve problems. In a word, through this valuable experience, I not only gained knowledge, but also broke through and gained friendship.

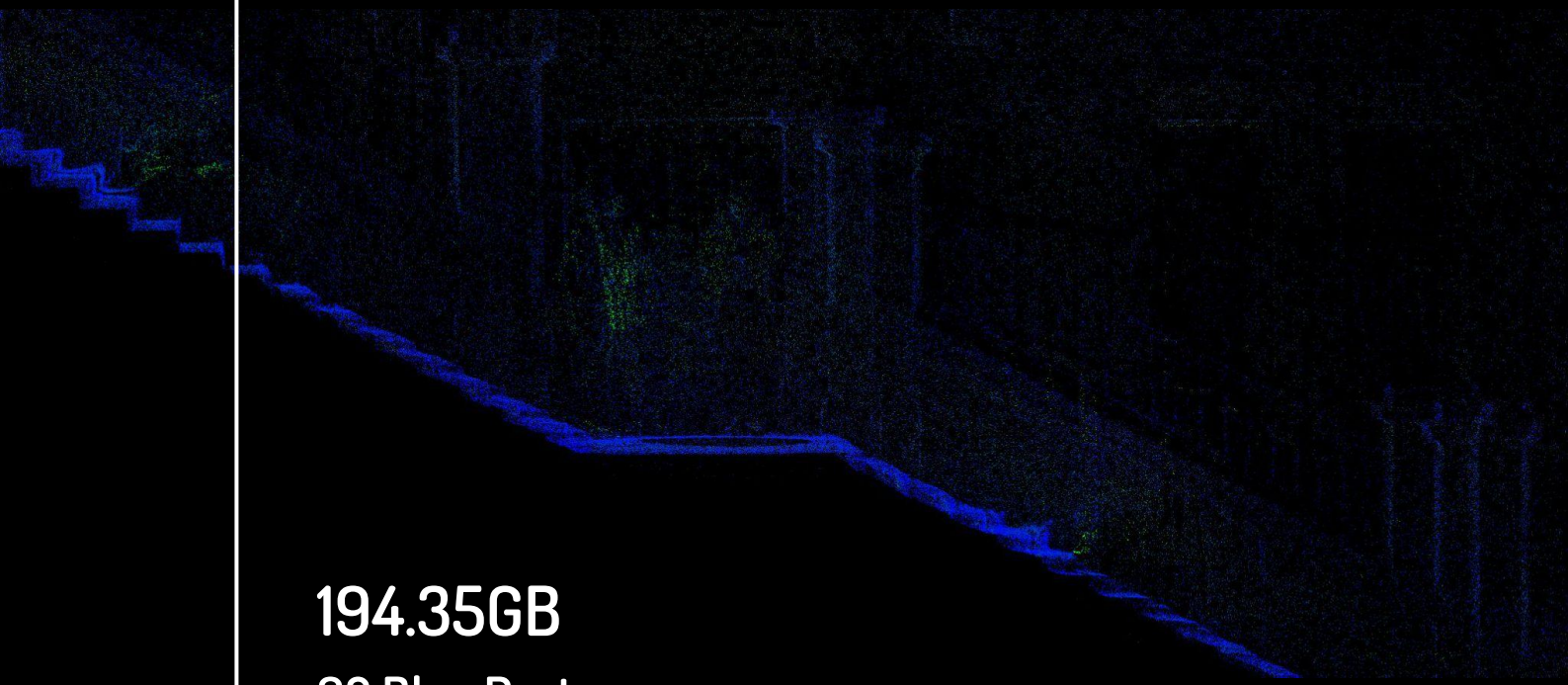
Personal Reflection: Zhu Yuanguang
I believe that with better support, the live sound installations for our project would be more logical and efficient, and would provide a better sound environment for the audience to experience.

Personal Reflection: Molly Munro
This project has only increased my drive to aim high as we were able to achieve an amazing result that I am so incredibly proud of. I would happily present this project again with all the new updates and fixes that are possible to make it even more impactful.

Personal Reflection: Daniela Morales
I learned a great deal working with a multidisciplinary team, as it was my first time creating such a complete project with other disciplines. While my knowledge about sound was nonexistent before the project, I have now learned useful information that could help me in future projects.

Personal Reflection: David Galego
While observing the users' behavioural patterns, some interesting improvement points came up (...). Users would very commonly tilt, flip and explore the position of this plank instead exclusively of their own (...) Such a natural reaction led to re-thing a solution for future exhibitions, where instead of placing the Arduino system in a fixed position facing the user, put it on this plank.

Final Conclusion



194.35GB

92 Blog Posts

Aside from the project itself - What would make this report better? It would have been beneficial to have some of the more technical diagrams and screengrabs labelled with simple titles for explanation. Calculating the computational processing power could have been interesting to see too.

Our interdisciplinary project successfully pushes the boundaries of human perception, unveiling the complex interplay between tangible components and abstract information in various environments. Through the combined efforts of our sound and visual design teams, we have crafted an immersive experience that explores the emotional connections people have with liminal places like The New Steps in Edinburgh's old town.Utilizing LiDAR scanning, we have captured high-resolution spatial datasets that reveal the intricate spatial, temporal, and cultural characteristics of each location.

Our project, Echoes and Absences, demonstrates the power of teamwork and creative collaboration, as it artfully combines cutting-edge technology with innovative approaches to create an engaging and thought-provoking experience.The success of our exhibition lies in its ability to foster public conversation around the concepts of place and non-place. We have achieved our initial goals by providing an interactive space for users to explore their own unique interpretations of these environments. As a result, our project has not only contributed to ongoing discussions surrounding technology, art, and cultural experiences but has also given people a chance to actively engage with the complex relationship between the physical environment and digital translation.

In conclusion, our project serves as an innovative exploration of the liminal, cultural, and ecological, aspects of environments, bridging the gap between the physical and digital worlds while fostering a deeper understanding of how they shape our experiences and emotions. The teamwork and dedication of our sound and visual design teams have been instrumental in creating an immersive exhibition that resonates with audiences and sparks meaningful conversations.

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