ual: creative computing institute

MSc INDIVIDUAL PROJECT

UNIVERSITY OF THE ARTS LONDON

CREATIVE COMPUTING INSTITUTE

Silica Seas: Echoes of the Anthropocene

Design Integrating Digital and Physical Interfaces for Immersive Artistic Creation

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November 22, 2023

Abstract

This study investigates the integration of data communication between software within the context of artistic practice, synthesizing the application possibilities of physical interactive devices and digital art design installations. It explores how integrated new media technology creates immersive interactive experiences in artistic creation. It has been demonstrated that data communication linkage between software is a viable approach for immersive artistic creation, enabling interaction between virtual reality and physical installations, and achieving diversity in visual and experiential aspects. However, the varying data communication methods accepted by different computer systems and software present a challenge in terms of unification. Through continuous testing and adjustment, this paper outlines the methods of creating integrated interactive new media art via real-time data communication among Unity, Arduino, and Touch Designer on a MacOS system. The author has crafted the artwork "Silica Seas: Echoes of the Anthropocene" through the interlinking techniques between these three software platforms. This project expresses the author's nihilistic view of the current Anthropocene based on the incident of Japan's discharge of nuclear wastewater into the ocean, while also looking forward to the era of silicon-based life forms from a positive nihilistic perspective.

Acknowledgements

Over the course of this year, I have absorbed a wealth of new knowledge, and the fast-paced curriculum has continually pushed me to surpass my own limits. I am delighted to have had this phase of joyful and rapid growth in my life. The tutors at the Creative Computing Institute have been cheerful, optimistic, and erudite, serving as beacons of knowledge and guiding me further than I could have imagined. I am grateful for the companionship of all the teachers and classmates. As a modular student, I owe thanks to every course leader who has shown me the applications and potential of creative computing across various fields. I have gained distinct knowledge and skills from each course, propelling me significantly forward in my academic journey. I am thankful for my supervisor, Adam Cole, who always provided me with patient and incisive guidance and encouragement. My gratitude extends to the college's technical team—Matt Jarvis, Chris Bull, Lexin Zhou—for their advice and help with the structural support, construction, laser cutting techniques, and Arduino technology for physical devices. And I am thankful to Lieven van Velthoven for enlightening me on the logic of using OSC data in Unity.

Contents

Chapter1

Introduction

1.1 Motivation

At first, no one cared about this disaster, it was just a mountain fire, a drought, the extinction of a species, the disappearance of a city until this disaster was relevant to everyone.
---The Wandering Earth[1]

1.1.1 Incident

On August 24, 2023, Japan began the reckless discharge of nuclear wastewater[2], compelling us to refocus on marine issues. How must marine species evolve to survive in this future geological era dubbed the "Anthropocene"? Could everything devolve into a Darwinian nightmare? Japan's release of nuclear wastewater into the ocean may not be the largest issue, but the stakes are high regardless. Our oceans are limited, and once a quantitative change triggers a qualitative one, the damage inflicted may be irreversible. If this trend continues, in my extreme extrapolation of the future[3], marine life will also evolve into silicon-based entities[4] according to evolutionary ecology and human remediation, beginning to detest human proximity and resist it. Creating this project, I hope to raise awareness that this is happening. However, during the process, I've been continually sinking into negative nihilism[5], feeling that my actions and efforts seem unable to achieve a real purpose or value, and that individual power is insufficient to halt the reality of Japan's nuclear wastewater discharge. I question whether my creation is akin to "Waiting for Godot"[6]?

Since the incident occurred in Asia, my extensive research showed that the awareness and feedback on this event were quite pronounced among the people in Asian countries like China, Japan, and South Korea[7]–[10]. In contrast, online videos of street interviews from Western countries[11] show that there is a lack of widespread awareness about this event among the people. Perhaps I'm powerless to change the facts, but this gives a special significance to completing a project on this theme while I'm in the UK.

Figure1.1: South Koreans march in protest.[7]

1.1.2 Species research

1. Coral

The impact of nuclear-contaminated water on marine ecosystems is widespread and complex. While some organisms may exhibit a certain degree of tolerance to low doses of radiation[12], this does not imply they can safely thrive in a highly contaminated environment. High doses of radiation can damage the DNA of marine organisms[13], leading to genetic mutations, diseases, and death. When discussing marine issues, the significance of coral is undeniable. Coral reefs are among the most abundant and diverse ecosystems on Earth, akin to the tropical rainforests of the sea[14]. They provide habitat, food, and breeding grounds for thousands of marine species, which are a vital component of global fisheries, providing food resources and livelihoods for billions of people. Increasing evidence suggests that ocean acidification and warming are rapidly degrading the ecosystems required by coral reefs, with the result being that those dead or dying reefs have become ghostly, gigantic white skeletons[15]. It is an indisputable fact that human activities are causing ocean acidification[16], and the destruction of coral reefs is global, resulting from a combination of natural and anthropogenic disturbances.

2. Tentacles

In the book's [15]first demon—the Spider (an alias for the octopus), I believe the spider, tentacles, or octopus all point to the idea that "everything is connected to something," meaning there is a correlation between things. Thus, the connection between the biological world and human society is indivisible and real.

"From the blood dripping from Medusa's severed head came the corals in the western hemisphere's oceans, turning into rock... She is part of a symbiotic system comprising tentacled cnidarians and photosynthetic algae known as zooxanthellae, making up coral-like sea fans and sea whips." [15]

This is one of the reasons why I chose jellyfish, a creature with tentacles, as the physical embodiment of the installation. Another reason is that jellyfish are composed of about 95% to 98% water[17], making them nearly completely transparent in water (hence the use of transparent acrylic sheets). As the oceans are being eroded by nuclear-contaminated water, jellyfish as a species will breathe and be exposed to this contamination to the greatest extent.(see Figure 1.2)

Figure 1.2: Both images are illustrations from the book 'Staying with the Trouble'[18], created from left to right by Marley Jarvis[19] and Shoshanah Dubiner[20].

3. Effects of nuclear radiation on living things

Numerous research papers have tracked the biological responses near Japan's Fukushima and Russia's Chernobyl following nuclear power plant explosions. Cases of damage highlighted include: i.) The Pale Grass Blue, a common butterfly in Japan, suffered physiological and genetic harm[21]; ii.) Wild boars in Fukushima have shown resistance to mutations resulting from chronic low-dose radiation exposure[22]; iii.) Perch in lakes near Chernobyl are more sensitive to radiation than cockroaches, leading to delayed gonadal maturation and the existence of several undeveloped phenotypes[23], among others.

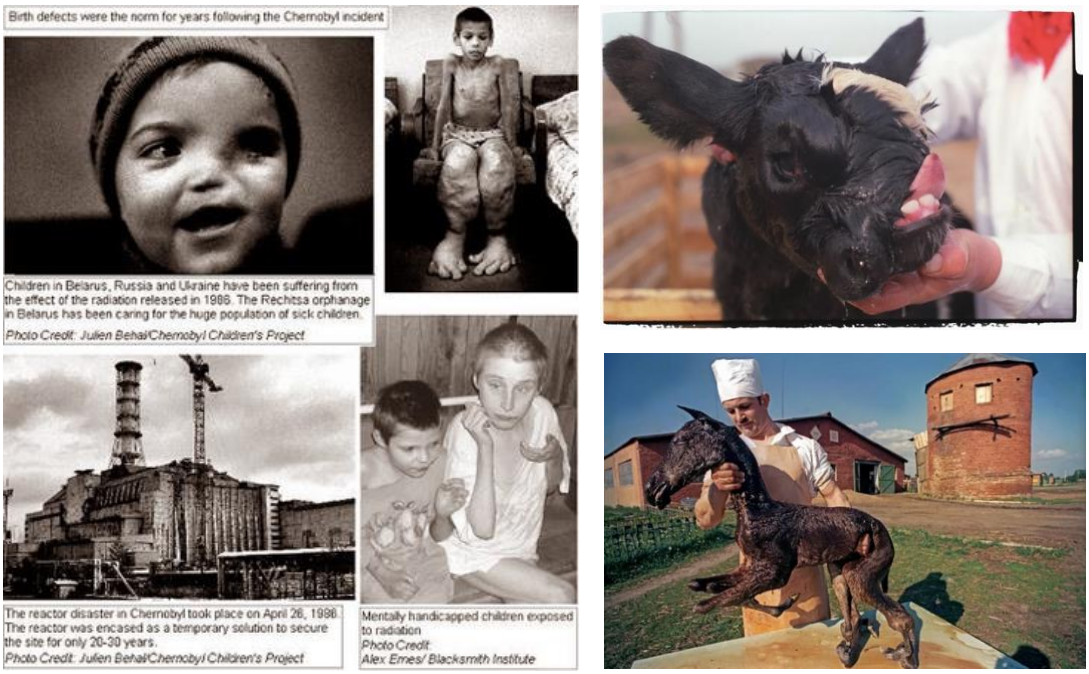
Assessing how Japan's release of nuclear wastewater into the sea will affect marine life is an extremely complex and difficult process. On some level, prolonged exposure to radiation does indeed damage DNA molecules and may lead to mutations. Musso and his team found tumors, cataracts, and damaged sperm in birds in high-radiation areas of Chernobyl, as well as impacts on biodiversity near Fukushima. Studies on carp near Fukushima found abnormal growth in the structure of the spleen, kidneys, and liver of some fish (scientists are still investigating these cases).[24]

Tokyo Electric Power's Advanced Liquid Processing System can remove highly radioactive substances such as strontium and cesium from the water, but it cannot filter

out tritium, a radioactive isotope of hydrogen, which coastal nuclear power stations typically dump into the ocean along with water. Shaun Burnie, a senior nuclear specialist with Greenpeace Germany who regularly visits Fukushima, says "Dilution does not avoid the problem."[25] Hence, Japan's claims that the discharged nuclear wastewater is safe are likely to be misleading.

4. Consult

The literature all provides evidence that previous nuclear radiation exposure disasters in human history have directly led to species mutations and significant deformities. Despite the diversity of environmental factors affecting these outcomes and the scarcity of evidence due to the need for scientists to track and collect data over many years, the results are often inconclusive. However, the documentary "An Inconvenient Truth" critiques by stating "Scientists are forced to alter academic content, simply because it is inconvenient."[26] This starkly questions the authority of academia in the modern world. Therefore, I also question the authenticity of the research materials available to me. Studies conducted by Japan on the reactions of serval species to nuclear radiation often conclude with insignificant findings, which I am skeptical of. The photographs post-Chernobyl nuclear power plant explosion in Russia illustrate the vast damage of nuclear radiation on species (see Figure 1.3). Although I cannot judge their authenticity, perhaps I can only assume the worst, because this is not good, and even extremely bad—we are all trapped in an information cocoon[27].



Figuer 1.3: From left to right, Radiation effects on humans after the Chernobyl accident[28], radiation effects on organisms from nearby farms[29].

Overall, the main factors of coral death are ocean acidification and thermal effects, whereas moderate thermal stress can promote the selection of heat-resistant genes in coral populations[30]. Which leading to theories of creative evolution. Badiou

emphasizes that life possesses innovativeness and freedom, able to adapt freely to environmental changes[31]. Nietzsche's positive nihilism also solidified my motivation for creating this theme, as he said, "Faced with a meaningless world and a meaningless life, one should stand firm in reality, confront the absurdity of meaninglessness, and dance with a strong life instinct, creating value in the process of living." [32]

Thus, my motive for creation is to bring attention to the issue of Japan's release of nuclear wastewater into the sea and to raise awareness among people, not expecting to change it with individual power, but hoping to awaken the consciousness of some viewers through artistic creation. Motivation in terms of creative methodology I describe in the next step.

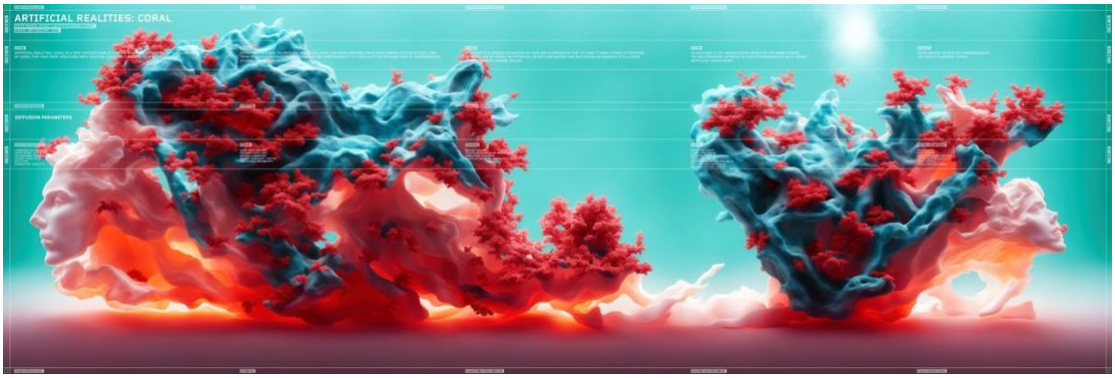
1.1.3 Reference

Ecological conservation and positive nihilism intersect in certain forms of artistic creation, particularly in works that delve into the relationship between humans and nature, environmental crises, and reverence and concern for the natural world. For instance, Andy Goldsworthy's land art (see Figure 1.4), where he uses natural materials to create ephemeral art within natural settings, underscores the connection between humans and nature as well as the transitory and impermanent nature of the environment. Numerous documentary films have explored environmental issues and conservation efforts, such as "An Inconvenient Truth" and "Oceans." These films call for action to protect the planet by showcasing the beauty and vulnerability of the natural world.

Figure 1.4: Both of these images are land art by Andy Goldsworthy's.[33]

Moreover, the digital art project "Artificial Reality: Coral," (see Figure 1.5) which leverages computer technology to address environmental themes, has served as a reference for me. The project aims to transform a vast array of real marine flora and fauna images into virtual coral AI data sculptures through machine learning, thereby displaying the beauty and fragility of corals within the marine ecosystem. By creating

an artificial marine environment, the artist seeks to draw attention to the urgent environmental reality of climate change's impact on coral mortality. I feel that digital media has many unique charms and advantages over physical installations, such as the ability for creators to create creative spaces without boundaries through computers, and



to construct virtual environments and experiences that cannot be realised in the physical world. This provides almost unlimited possibilities for creative expression.
Figure 1.5: Artificial Realities: Coral presents Refik Anadol Studio's ultimate visualization of years-long research on compiling a comprehensive dataset of coral images with the aim of raising awareness about climate change through art. [34]

However, physical installations also have their own irreplaceable value and impact, such as providing the audience with multi-sensory physical interaction, as well as creating a unique atmosphere and sense of reality in a particular space. Thus, digital media and physical installations, as complementary forms, extend the boundaries of art and expression. The works of the following artists have given me a taste of physical installations, or the fascination of creating a combination of digital media and physical installations.

Filip Custic's work investigates the influence of digital technology on our conscience and sense of identity, integrating art, technology, and humanity. Alex Werth's Garden series explores human-environment interactions and touches upon grid systems closely associated with industry and infrastructure. Neri Oxman's work is equally inspiring; her team conducts research at the intersection of computational design, digital fabrication, material science, and synthetic biology, applying these insights to interdisciplinary, cross-media, and multi-scale design. (see Figure 1.6)

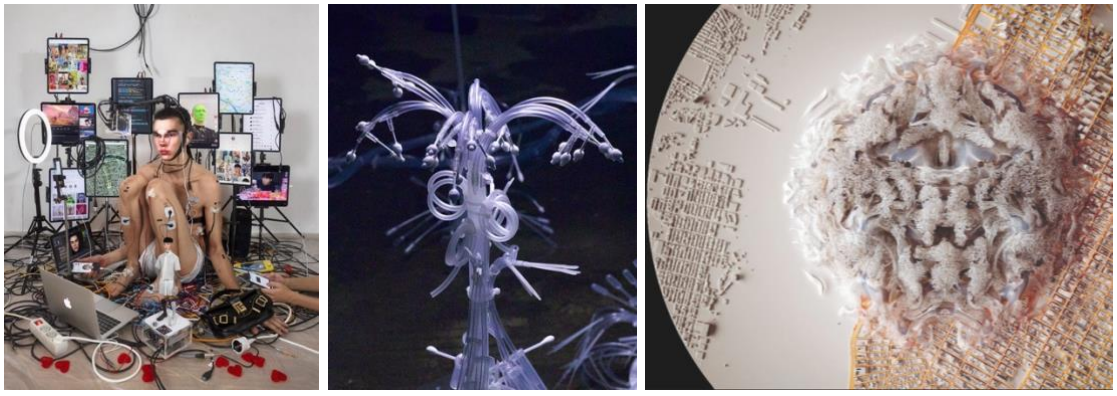


Figure 1.6: From left to right, images of the work of Filip Custic[35], Alex Werth[36] and Neri Oxman[37].

These artistic endeavors, employing various media, evoke a consciousness of ecological conservation and highlight the individual's connection and responsibility to the natural world. In particular, the works that utilize diverse creative computing technologies to realize creation have sparked my interest in integrated new media artistic creation.

I decided to adopt an integrated digital and physical interface approach in my creative approach, investigating how to create immersive artworks by integrating digital and physical interfaces.

1.2 Research Goal

My goal is based on the design applications of how integrated new media technology can create immersive experiences in artistic creation, is to figure out how to appropriately combine the unique qualities of different technological mediums and software to realize the artistic theme I intend to create. This is rooted in the contemplation of a nihilistic future for the Anthropocene based on the backdrop of Japan's nuclear wastewater discharge event, as well as reflective creation of the life forms in a post-creative evolutionary Cthulhu world with silicon-based marine organisms. Through research, I will utilize data communication technology between software to create original interactive art pieces that express a critique of the Anthropocene's inaction towards ecological conservation. Multi-party communication of digital and physical interfaces to achieve immersive interactive art creation is also a key feature of this research.

Chapter2

Background

2.1 Arduino

2.1.1 Continuous Rotation Servo and Servo Driver

1. Servo Motor and Continuous Rotation Servo

A servo motor is a type of closed-loop control system capable of precisely controlling angle, speed, and acceleration. They are commonly used for precise position control, such as in robotic arms or control surfaces of airplanes. Control is achieved by receiving a control signal (pulse-width modulation signal) and accordingly adjusting the position of its output shaft, but they are limited to 180 degrees of rotation. In contrast, a Continuous Servo can rotate continuously, 360 degrees, and is used in applications that require continuous rotational output, like wheels or rollers. （see Figure 2.1） It receives the same pulse-width modulation signal, but not for position control. Instead, the signal controls the motor's rotation speed and direction, and these motors typically do not have position feedback.[38] Therefore, Continuous Servos are more suitable for applications requiring continuous rotation, such as the wheels of a mobile robot or other scenarios requiring controlled rotational speed. I will be using a Continuous Servo in my physical device to control the continuous rotation of jellyfish tentacles.

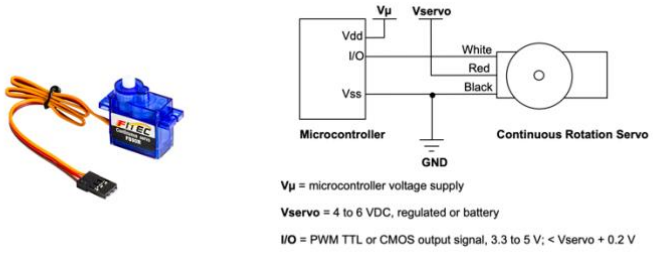


Figure 2.1: From left to right, the FS90R Continuous Rotation Servo product diagram[39] and circuit schematic[40].

2. Servo Driver

In this study, I employed Arduino's PCA9685 Servo Driver to control multiple Continuous Servos（see figure 2.2）. This module, based on the PCA9685 chip, is commonly used for driving servo motors and can control multiple servos simultaneously. It is particularly popular in robotics, automation, and DIY projects as it offers a simple and efficient way to control several servo motors. It communicates with Arduino or other microcontrollers via the I2C bus, a widely used serial communication protocol that allows multiple devices to communicate over two lines (data and clock lines). This is particularly beneficial for applications requiring control of numerous servos as it reduces the number of control pins needed. The PCA9685 controls servo motors using pulse-width modulation (PWM) signals[41]. PWM is a method to modulate the strength of electronic signals by altering the duty cycle of the signal, thereby controlling devices like the angle of servo motors (see Figure 2.2). Additionally, this module typically requires an external power source to drive the connected servo motors, as the power demands of the servos might exceed what the Arduino board can provide (see Figure 2.2).

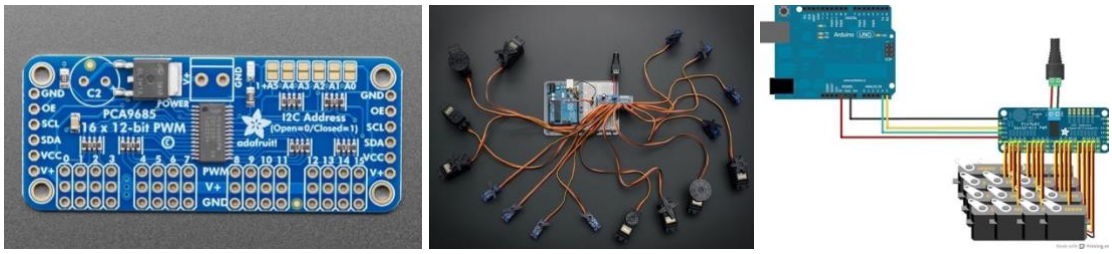


Figure 2.2: From left to right, the PCA9685 Servo Driver product diagram[42], an example of how it connects to multiple servos[43], and a schematic of the circuit connections[42].

2.1.2 LED Ring

In my project, I have implemented Arduino's NeoPixel Ring-12 x 5050 RGB, which is a ring-shaped light source based on LEDs, consisting of 12 colored RGB LEDs. Each LED can independently control its color and brightness. The NeoPixel LEDs are based on the WS2812 or similar integrated circuits, with each LED incorporating a small controller that allows individual control of each LED's color and brightness through a single data line. [44]These LEDs use a simple serial communication protocol, enabling data transmission through a single Arduino pin. Each LED receives color data and then passes the remaining data to the next LED, allowing me to achieve a series connection effect between multiple LED rings through the interconnection of the OUT and IN pins. These LED strips typically require a 5V DC power supply, and there are certain demands for the quality and stability of the power supply, especially when connecting plenty of LEDs. Therefore, I also need an external power source for this part of the project.

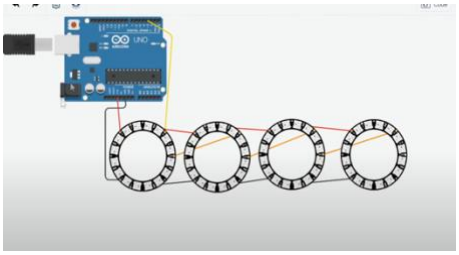



Figure 2.3: From left to right are the LED ring commodity schematic[45] and the LED ring series circuit connection example diagram[46].

2.1.3 Mini Pump

In this project, I utilized the Mini Pump ZR320-02PM DC 4.5V as an air pulsator (see Figure 2.4). Its operating voltage of only 4.5 volts makes it particularly suitable for projects powered by batteries or small power sources. It features a centrifugal pump design, where the motor rotates the impeller, using centrifugal force to push water or air from the center of the pump towards the periphery, and then out through the exit. However, this type of pump usually cannot precisely control the flow rate. The flow rate is proportional to the motor's speed, so adjusting the motor's voltage and current

Rated voltage	DC:3.0V	DC:4.5V	DC:6V	DC:12V
Use voltage	DC2.2V~3.7V	DC3.0V~4.5V	DC5.2V~6.5V	DC10.8V~13.2V
Load current	< 650mA	< 580mA	< 500mA	< 280mA

Note: The above load current refers to the current value when the rated voltage supply air pump is used to inflate to the highest pressure in a 100ml container.

can somewhat control the flow rate.[47]

Figure 2.4: The legend shows, from left to right, the Mini Pump 4.5V product diagram[47], and the voltage schematic.[47]

2.1.4 Ultrasonic Distance Sensor

The HC-SR04 ultrasonic distance sensor for Arduino is a widely used non-contact distance measurement device (see Figure 2.5). It calculates the distance to an object by sending ultrasonic pulses and receiving the pulses reflected[48]. While need to measure the specific distance from sensor, this can be calculated based on this formula:

D = S * T D = Distance

S = Speed T = Time

Total distance is measured as = (343* Time at HIGH ECHO)/2

Note: '343' in the above formula indicates the sound speed in air medium considered at room temperature.

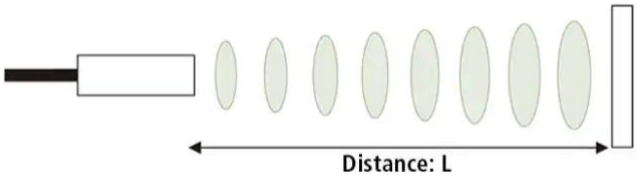


Figure 2.5: From left to right, the ultrasonic sensor merchandise diagram and the distance measurement example diagram are shown[49], [50].

Due to its accuracy, stability, and low cost, it serves as a data input module in my project. The HC-SR04 provides four pins: VCC (power), Trig (trigger input), Echo (echo output) and GND (ground). Among them, the Trig and Echo pins are connected to an Arduino or other microcontroller for transmitting and receiving signals and require a 5V DC power supply[48].

2.2 Touch Designer

Touch Designer is a highly flexible and powerful visual programming tool, extensively used in the creation of interactive media, visual arts, real-time video processing, and VJ performances. It offers a real-time, node-based interface, enabling artists, designers, and programmers to intuitively create complex interactive projects[51].

Touch Designer utilizes a node-based workflow, where each node represents an operation or effect. Users can create complex visual effects and interactive experiences by connecting these nodes (see Figure 2.6). Given its software features, Touch Designer supports a variety of input and output formats, including audio, video, MIDI, and sensor data:
1. Multi-platform compatibility: Touch Designer is compatible with multiple operating systems, including Windows and macOS.
2. Strong integration capabilities: It can integrate with other software and hardware tools, such as Ableton Live, Arduino, and various VR/AR devices, providing a wide range of creative possibilities.
3. Custom programming: Although Touch Designer offers many preset nodes, users can still customize and control deeper layers through Python scripting.

Figure 2.6: These two schematics are from left to right from The NODE Institute[52] and Ultraviolet.to[53].

Users can incorporate these data types into their projects, creating dynamic and interactive visual presentations. Therefore, I will be using Touch Designer as a component in my integrated media creation application.

2.3 Unity

Unity is a widely used game engine and real-time development platform, utilized by developers for creating 2D and 3D games, as well as other real-time interactive content like simulations, training applications, and visualizations. Its high scalability and cross-platform capabilities make it a popular choice for game development and interactive content creation (see Figure 2.7). Unity is based on the C# scripting language, enabling developers to easily write game logic and interactions. It employs a component-based architecture, where game objects can be enhanced by adding various components[54].

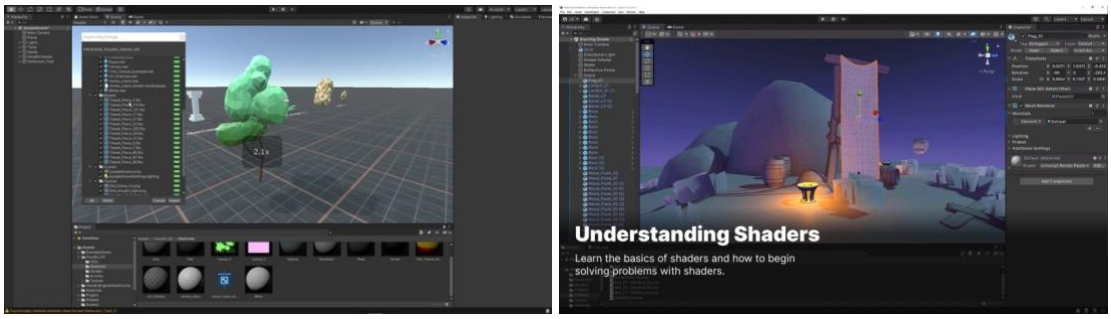


Figure 2.7: Both schematics, from left to right, are Unity interface schematics[55], [56].

Its software features include but are not limited to:
1. Cross-platform support: Unity supports multiple platforms, including Windows, macOS, iOS, Android, WebGL, PlayStation, Xbox, and more, allowing developers to create games and applications for various platforms.
2. Integrated Development Environment (IDE): Unity offers a comprehensive IDE, including a powerful editor for scene building, asset management, debugging, and performance analysis.[57]

Therefore, I use Unity as the virtual reality output component in my integrated application.

2.4 OSC Data

OSC (Open Sound Control) is a network communication protocol designed for communication between modern computing devices, especially in music and multimedia applications. Due to its flexibility, openness, and ease of use, OSC has become a widely used communication standard for multimedia artists and developers in real-time audio, video, and interactive systems. OSC employs a text-based addressing mode, like URLs, allowing for the transmission of complex data structures. This format makes data transfer intuitive and easy to understand[58]. OSC messages can be sent via various network protocols, such as UDP and TCP:

1. High compatibility: OSC is compatible with various software and hardware, including music software, digital audio workstations, sensors, controllers, etc.
2. Easy integration: Many modern music and multimedia software (like Ableton Live, Max/MSP, Pure Data, Touch Designer) natively support OSC, simplifying integration.
3. Flexibility and expandability: The openness and flexibility of the OSC protocol allow users to customize messages and address formats to meet specific application needs.[59]

In this project research, I will use OSC data communication to connect Touch Designer and Unity and implement data communication between them. Based on my research, in addition to using the OSC data communication protocol to achieve interactivity between Touch Designer and Unity, you can also directly set up "Spout in" and "Spout out" within Touch Designer to transfer screens directly, which is more convenient and faster. However, this method is only supported on the Windows system, which is a technical pain point for creators who can only use the MacOS system. Additionally, there are very few research application cases on the internet about how to use OSC data communication to achieve interactivity between Touch Designer and Unity. Therefore, this is both a technical challenge and a distinctive feature of this project's research.

Chapter3

Methodology

To ensure that each component operates independently and yet remains interconnected, I will introduce in this chapter how each individual module is tested, constructed, and operated, as well as how they communicate with one another. The results of each phase encompass the operation of the physical device, digital art, and virtual world, allowing for the assessment of the effectiveness of interlinking between modules based on the efficacy of data communication. With this experimental approach, I aim to progressively advance and complete the creation of the integrated interactive art installation "Silica Seas: Echoes of the Anthropocene."

3.1 Physical installation jellyfish

3.1.1 concept

Based on the "tentacle thinking" mentioned above, the element of "jellyfish" is indispensable. It serves as the embodiment of the concepts "the origin of everything" and "everything is interconnected," playing the initial role in my overall artistic creation. That is, the ultrasonic distance sensor acts as the input module, with data first affecting the jellyfish and then sequentially passing downwards.

Therefore, in this phase, while contemplating the form of my jellyfish physical installation, I utilized the Midjourney tool to generate a series of conceptual images by continuously adjusting input words and reference picture forms (see Figure 3.1).

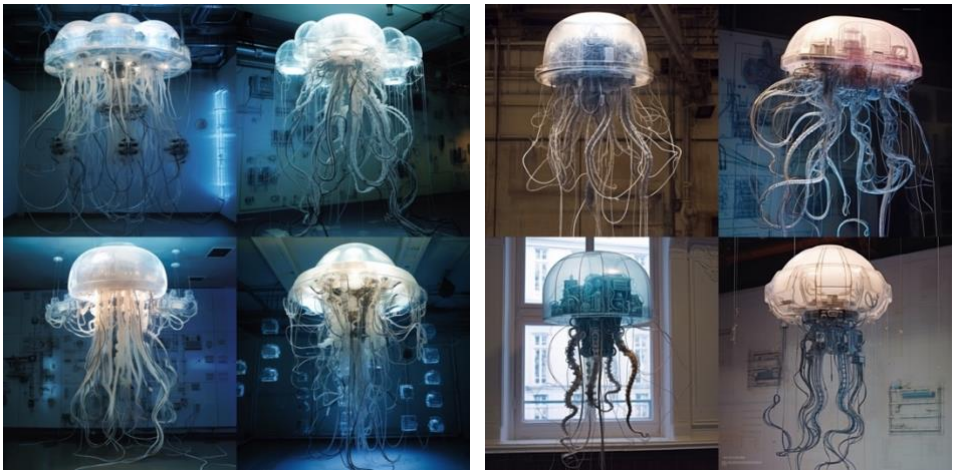


Figure 3.1: The above images were generated in Midjourney using keyword commands.

When I aim to create a physical interactive device, challenges include structure, materials, installation, transportation, and stability testing. Considering these factors, the functionalities it needs to achieve are:
1. It needs to be suspended, so its structure must be capable of bearing weight.
2. The tentacles of the jellyfish need to be able to rotate (achieved through a certain number of Continuous Servos).
3. As a representation of a "silicon-based lifeform," its "life" requires other dynamic parts for expression. Breathing LED lights are an excellent visual element, so its body structure needs to have circuits and fixtures reserved for LED arrangements.
4. It should be easy to disassemble, install, and transport. Given that a jellyfish's body is composed of 95% water, I have chosen transparent acrylic sheet slices as its main material and structural form.

Based on these considerations, I have drawn a conceptual sketch. (See Figure 3.2)

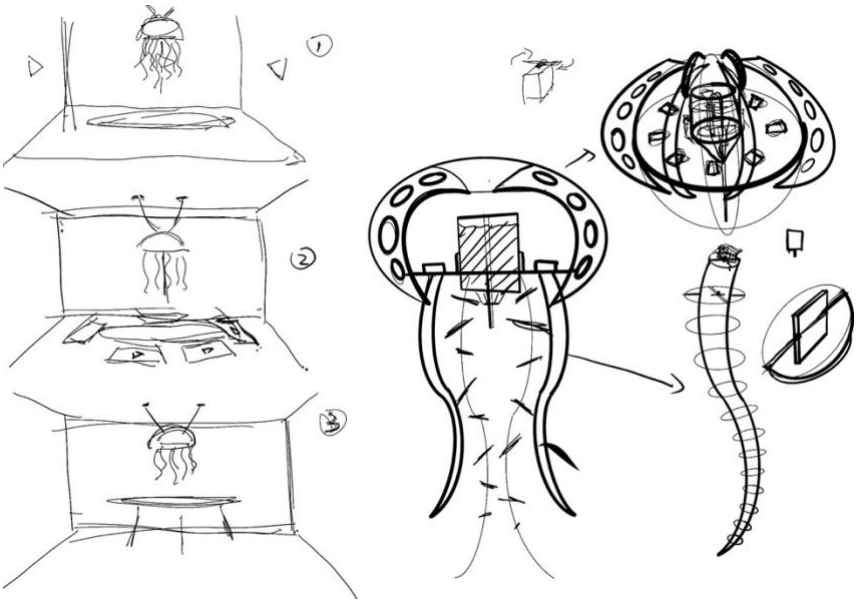


Figure 3.2: Conceptual sketch of the structure and installation

3.1.2 Structure with Arduino

As the first "demon" (referencing the book's mention of "the blood dripping from Medusa's severed head turned into corals forming rocks in the western hemisphere's oceans"), when contemplating the structure and the number of parts, I adopted the symbolic "6-6-6" concept. Thus, my physical jellyfish will be supported by six petal-like acrylic plates, have six tentacles, and utilize six Continuous Servos and six LED rings.

Based on the following structural experiment, I created its structural model in 3D modeling software Rhinoceros (see Figure 3.3). Given the sturdy and flat characteristics of acrylic sheets, I opted for a slot-in structure.

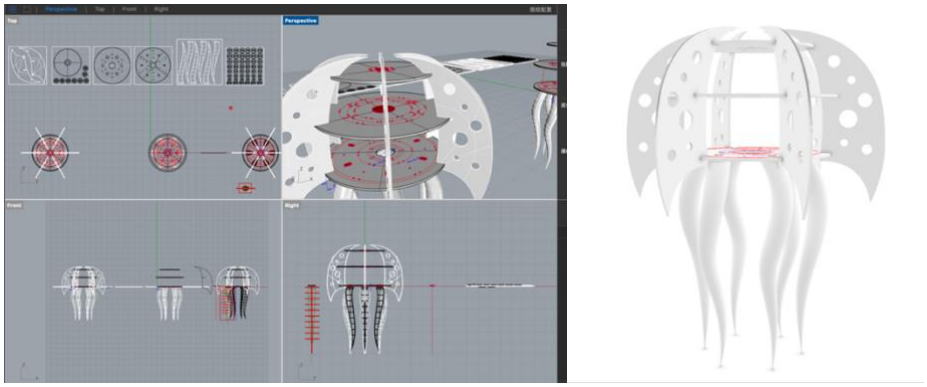


Figure 3.3: The above screenshot of the Rhino software interface shows the iterative process of modeling

Regarding the acrylic structure and the distribution of the Arduino components' circuits, I made the following detailed structural adjustments:

1. I designed slot positions based on the size of the FS90R servo to fix the servo onto the acrylic plate. (See Figure 3.4)
2. Considering the load bearing, I used 3mm thick acrylic sheets for non-load-bearing structures and 5mm thickness for load-bearing parts (like the circular slices on the tentacles, cross-section in the middle of the body).
3. I designed fixing slots for the six LED rings, facilitating the later fixation of LED components onto the acrylic plates.
4. For the connection between the acrylic tentacles and the servo, I designed a ring piece with slot holes for attachment. (See Figure 3.5)

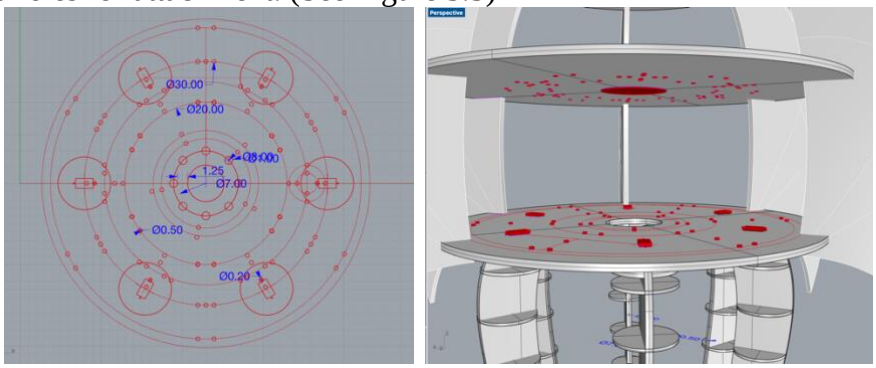


Figure 3.4: The figure above shows the holes reserved for the model

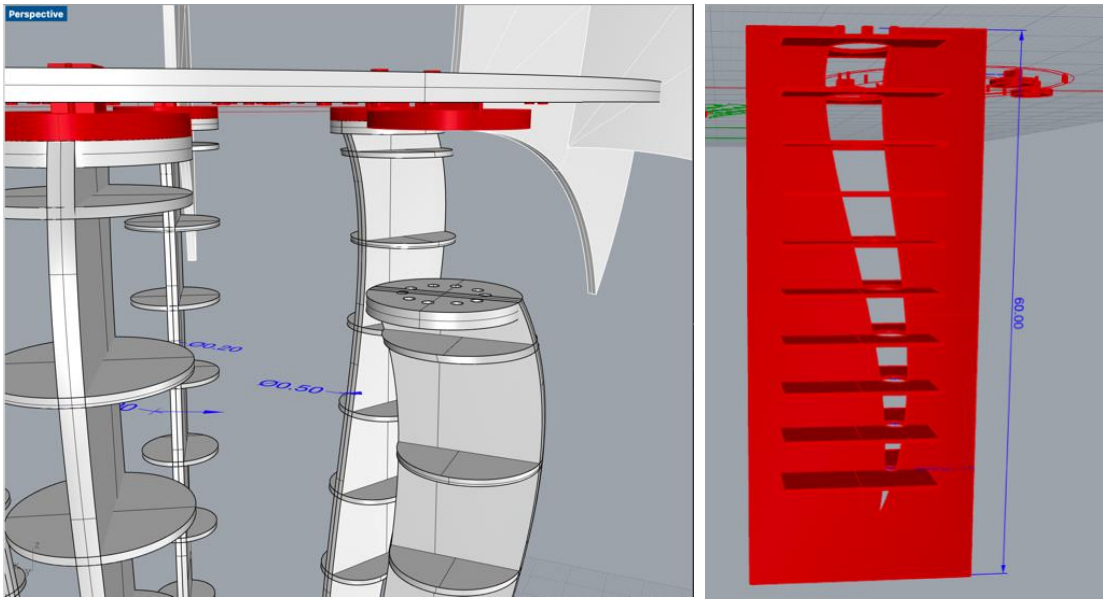


Figure 3.5: The screenshot shows the modeling process and method for slicing and assembling the antenna structure of jellyfish

After completing the 3D structural modeling, I arranged all the component plans in Adobe Illustrator for laser cutting (see Figure 3.6). In this process, I designed some peripheral flat elements on the acrylic sheet parts (ultrasonic distance sensor box, mutated coral keychain, nuclear radiation pendant) for promotional purposes at the exhibition. (See project's GitHub for full AI files)

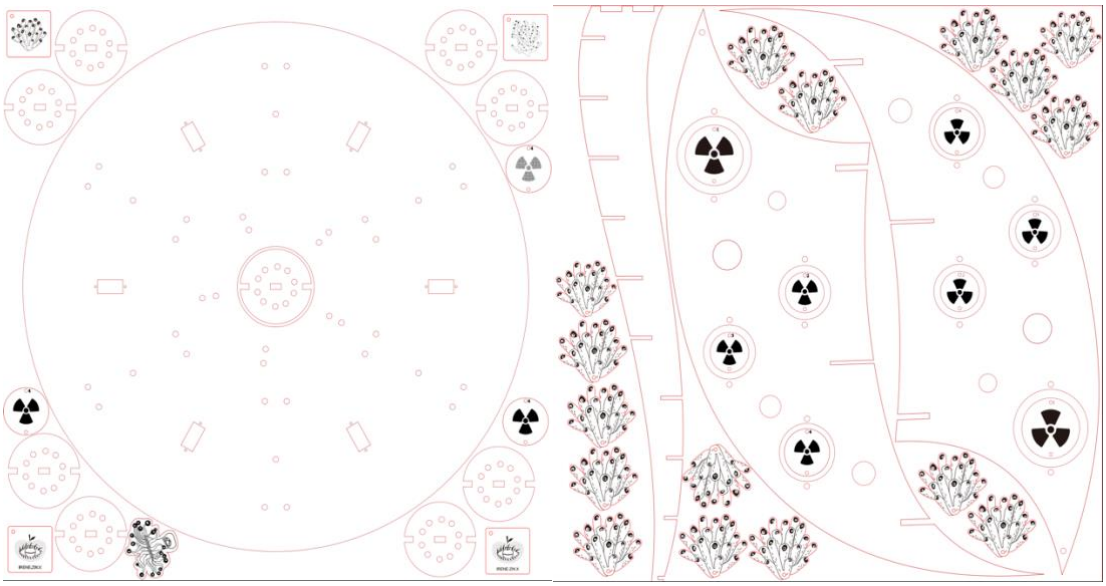


Figure 3.6: The image above shows a laser cutting file for a 50 × 100cm, 5mm thick acrylic sheet.

3.1.3 Series Connection and Test

After successfully completing the cutting of all the acrylic sheets, I tested the Arduino I needed for the operation of each module, my logic diagram (see Figure 3.7) visualizes the logic of the operation of this part. The core components of the project include an HC-SR04 ultrasonic distance sensor, a PCA9685 servo driver for controlling continuous servos, six Continuous Servos, a Mini Pump, and a series of NeoPixel Ring-12 x 5050 RGB for visual effects. The HC-SR04 ultrasonic sensor is the primary input device. It measures the distance to objects by emitting ultrasonic pulses and calculating the time taken for the echoes to return. This data is crucial for triggering subsequent operations in the installation.

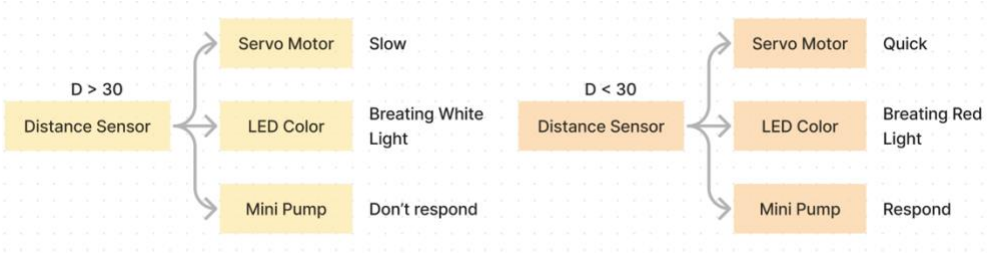


Figure 3.7: The picture shows the response logic of each Arduino component

The PCA9685 servo driver is used to control multiple continuous servo systems. These servos are essential for the moving parts of the installation, and I utilized the driver to precisely control the movement and speed of multiple servos. (see Figure 3.18 A series of interconnected RGB LED rings add visual effects to the installation. I used functions such as "fadeToBright" and "fadeToDim" to create gradual lighting effects on the LEDs.（see Figure 3.8）

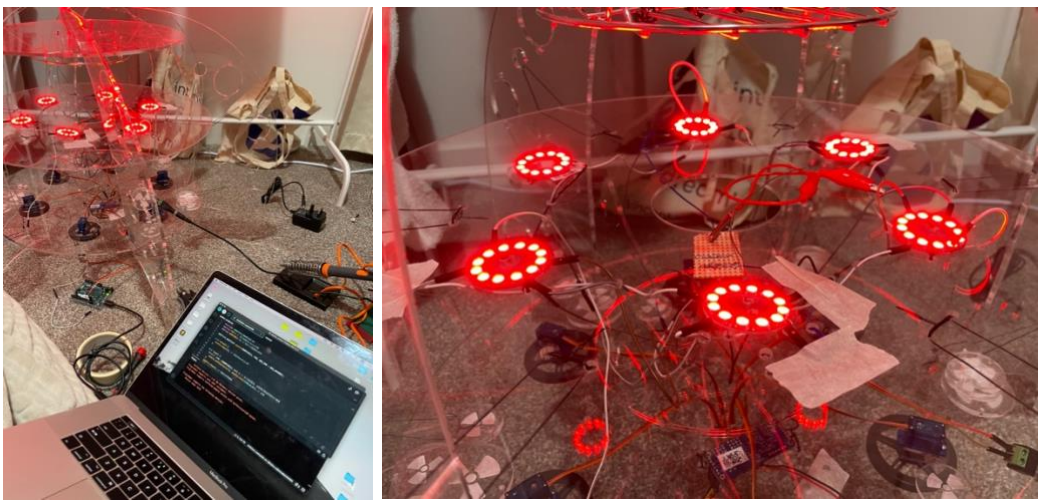


Figure 3.8: The pictures show the process of assembling and commissioning the physical installation

I coordinated the functionality of these components by writing code in the Arduino IDE. My code starts by initializing each module and setting the required parameters. The main loop of the code continuously reads the distance measured by the ultrasonic sensor.

Based on this data, it adjusts the positions of the servos and changes the color patterns of the LEDs. For example, if an object is detected within a certain distance range, the servos might move to a predefined position, and the LEDs might light up in a specific color pattern.

In summary, the integration of sensor input, mechanical movement, and visual feedback forms the core of the interactive experience provided by the physical installation. The Arduino, through its code, acts as the brain of this operation, coordinating between the different modules based on real-time input and predefined algorithms. (The overall running code is included in the attachment.)

3.2 Touch Designer Test

In this step, I made several different types of Touch Designer models for testing, both 2D and 3D, and I have selected two of them for brief description here：

1. Dynamic coral generation (see Figure 3.9):

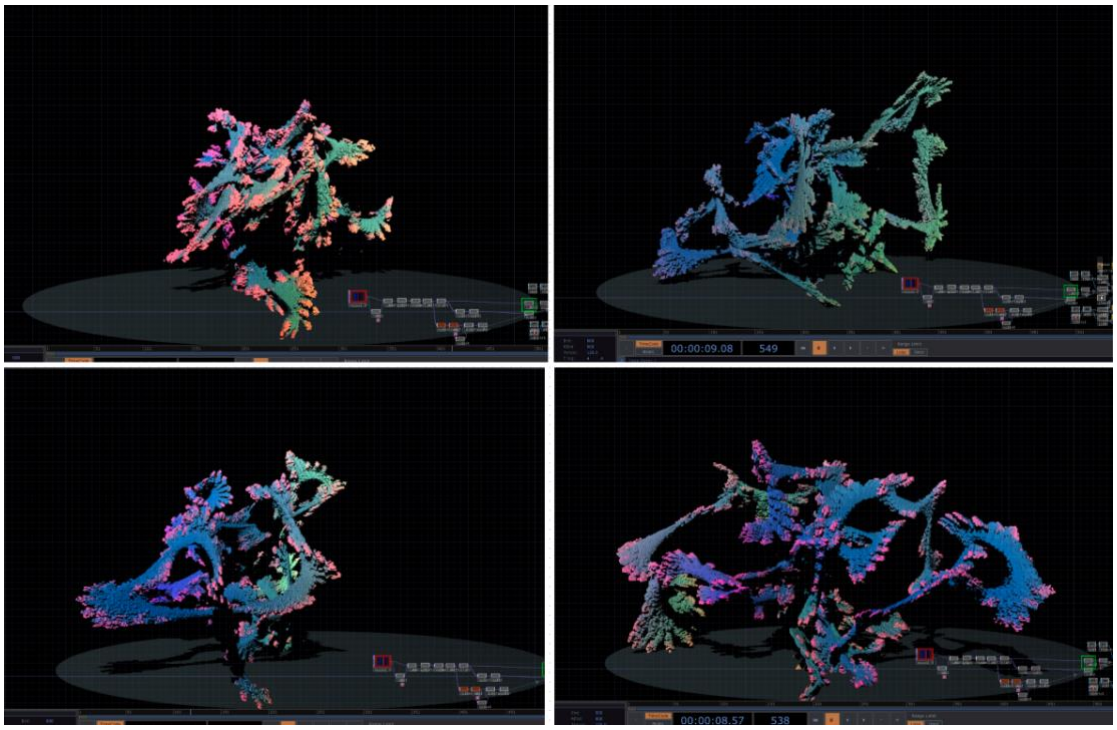


Figure 3.9: The above images are screenshots of Dynamic coral generation.

The creative concept behind these images is rooted in the emulation of natural coral forms through algorithmic patterns. By leveraging the procedural capabilities of Touch Designer, I created a generative model that simulates the organic growth processes of coral. This approach allows for the exploration of complex shapes and vibrant color palettes that evolve over time, providing a digital metaphor for the biological phenomena observed in coral reefs. This dynamic representation emphasizes the

delicate and interdependent nature of coral ecosystems, highlighting the beauty and complexity of marine life.

Advantages:

a. The real-time aspect of the visualizations ensures that each experience is unique, reflecting the ever-changing conditions of natural environments.
b. The use of procedural generation allows for a high degree of complexity and detail, which would be challenging to achieve manually.
c. Touch Designer's node-based environment enables live adjustments and iterations, providing me with immediate feedback and the ability to fine-tune the visual output.

Disadvantages:

a. The computational intensity required for real-time rendering of complex structures may require robust hardware capabilities.
b. The randomness inherent in procedural generation can sometimes produce unexpected or less desirable results, necessitating additional controls or constraints.

Overall, these generative coral structures in Touch Designer represent a blend of art and technology, demonstrating the potential to create complex, organic, and responsive visual ecosystems in a digital context.

2. Multimodal Coral Sea (see Figure 3.10)

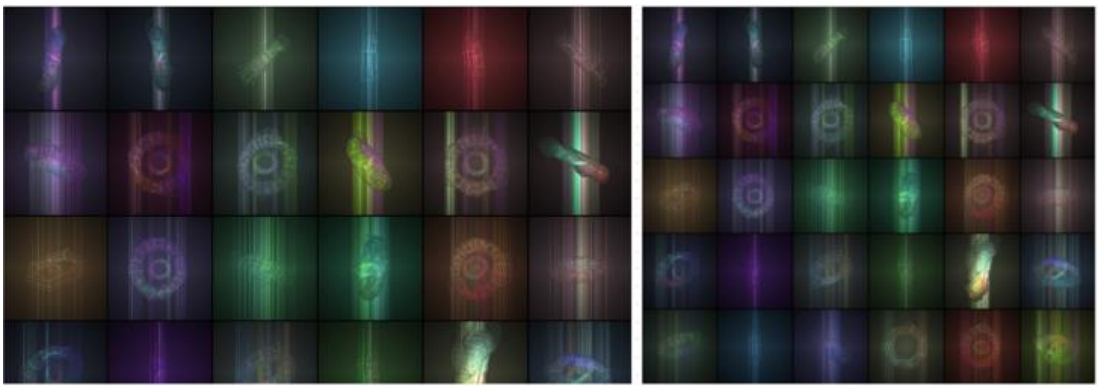


Figure 3.10: The above images are screenshots of Multimodal Coral Sea.

This screenshot shows a series of complex 3D visuals I created using Touch Designer. Using Touch Designer's replicator component and python commands, I generated several different mesh models, each with varying colors and brightness based on the randomness of the noise module, providing a rich visual exploration. Through the symmetry and repetition of these debugged images, I wanted to metaphorically represent digital evolution in some way.

Advantages:

a. The variety within the series demonstrates the vast potential of procedural generation to create unique yet coherent designs.
b. The use of lighting and color within a dark background effectively conveys a sense of three-dimensionality and focus on the central figures.

Disadvantages:
Depending on the rendering processes and the detail within each structure, the images may demand significant computational resources.

Overall, this test exemplifies the power of Touch Designer as a tool for creative expression, enabling me to construct a digital display that blurs the line between technology and art.

In summary, both tests had their pros and cons for me, with test 1 "Dynamic coral generation" causing my computer to lag too much, so the next test with the Arduino will be focused on implementing it through test 2 "Multimodal Coral Sea".

3.4 Arduino->Touch Designer

To achieve data communication from Arduino to Touch Designer, you need to make necessary settings in Serial module in Touch Designer: (see Figure 3.11)

1. After connecting the Arduino board to the computer and successfully uploading it, find the port address in the Tools of the Arduino IED, which needs to be synchronously set in the Port of Touch Designer.
2. Similarly, the "*Serial.begin(9600)*" set in "*void setup*" in the Arduino code should be consistent with the Baud Rate of Touch Designer.

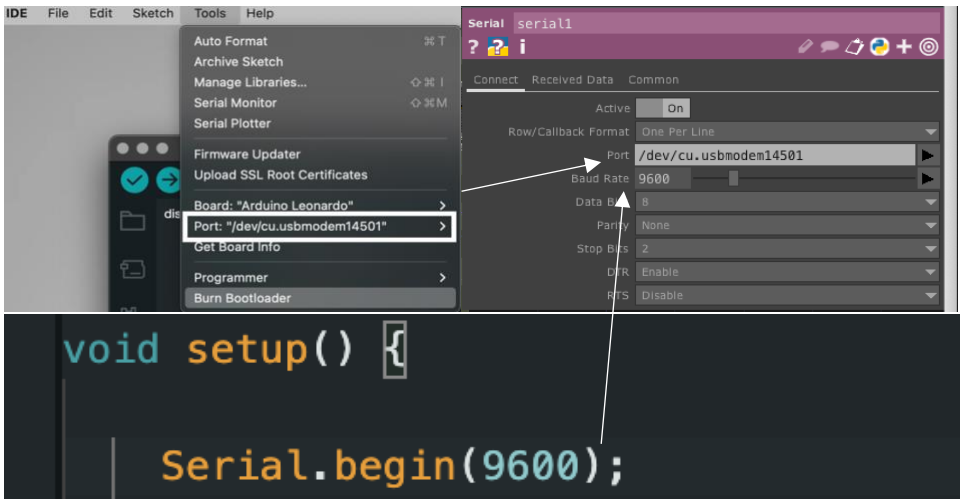


Figure 3.11: This legend is an indication of how to correctly set the port in my project

In my project I only need to transfer the distance data from the ultrasonic distance sensor, so I just need to add the distance print command to the "*void loop*" to successfully transfer the distance data to the Touch Designer. Note that the distance data can only appear on one port, so you can't open the Serial Monitor of the Arduino IED, it will take up the Serial port of the Touch Designer.

Once the distance data had successfully bounced around Touch Designer's Serial module, I selected out the latest updated distance data (see Figure 3.12) via a node

connection for controlling the rotation and size of the model in Touch Designer, and one of the OSC data that was later transferred to Unity.

Figure 3.12: The image is the connection method for processing access data in Touch Designer in this project

The testing up to this point went very well and can be seen demonstrated in my test image Figure 3.13. I will replace the circle model with a 3D mutant coral model in subsequent steps.

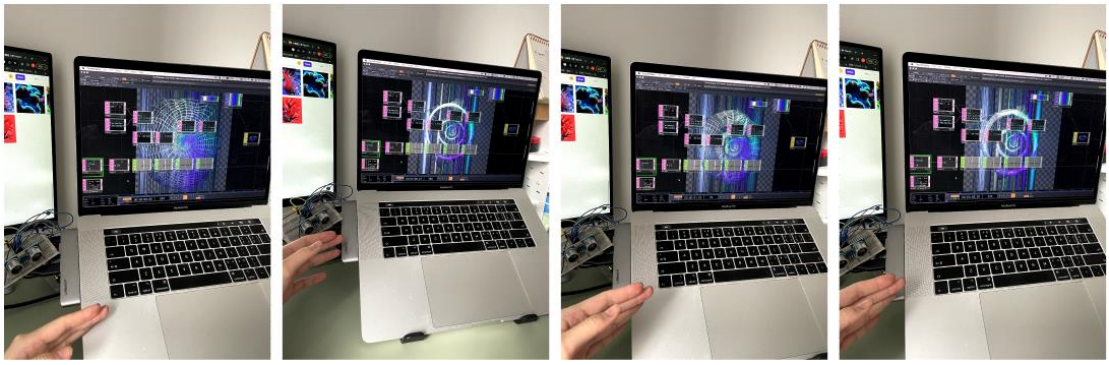


Figure 3.13: In above pictures, the author was testing the interactive effect of the distance data detected by the ultrasonic distance sensor of Arduino in Touch Designer

3.5 Blender->Unity

3.5.1 Concept

As coral reefs are vital to the oceans and to the planet, coral also occupies an important part of the virtual world that I will create, "with the blood that dripped from Medusa's severed head for the rocky coral in the oceans of the Western Hemisphere", they are the part to which the intention of "Tentacles" connects. They are the parts that are connected by the intention of the "tentacles". So when I created the 3D coral, I used Open AI's DALL-E tool to generate a series of images of cnidarian corals based on debugging keywords as a reference. (see Figure 3.14)

Figure 3.14: The above images were generated in DALL-E using keyword commands.

Building on my extreme extrapolation logic of the Anthropocene (see Figure 3.15), I hope to envision a series of mutated silicon-based coral reefs. These will not only reflect the potential future adaptations of marine life but also serve as a visual commentary on the synthetic augmentation of natural forms—a blend of organic evolution and human-induced change.

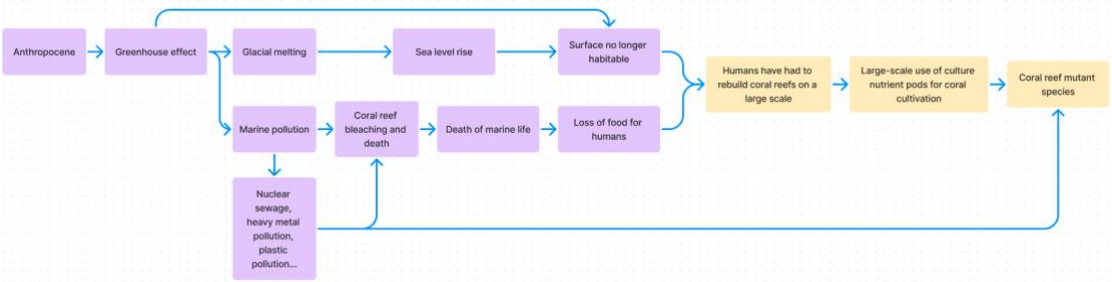


Figure 3.15: The picture is the author's reasoning logic diagram

The references for these mutated corals extend beyond Midjourney (see Figure 3.16) to include installation art, illustrations of mimicry in evolution, digital composite gardens,

camouflage studies, deep-sea phobias, and surrealism (see Figure 3.17). These inspirations will be synthesized to create representations that are as evocative and thought-provoking as they are aesthetically diverse, contributing me to a narrative that questions the boundaries between natural evolution and technological interference. Through this, I hope to provoke reflection on the fragility of marine ecosystems and the ripple effects of human activity, encapsulated in a digital art form that is as haunting as it is beautiful.

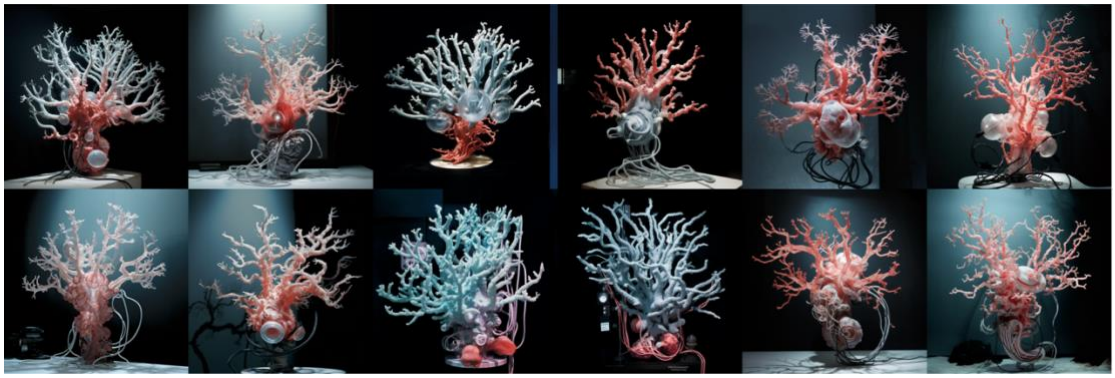


Figure 3.16: The above images were generated in Midjourney using keyword commands.

Figure 3.17: From top to bottom, the 4 images on the top are screenshots from the movie Fantastic Planet[60], and the 2 images on the bottom are screenshots from the exploration short animation film Reef[61]

3.5.2 Blender Creates 3D Models

Based on the above reference, in this step I used Blender to complete the creative coral and scene modelling. (see Figure 3.18)

Figure 3.18: The image shows how I created the alien coral and virtual world model in Blender

I reveal a complex underwater landscape fuse natural marine life with technological elements, reflecting the intricate interplay between the natural world and human-induced changes characteristic of the Anthropocene era.

The scene is meticulously crafted, with attention to the detailed textures and forms that suggest a deep-sea environment altered by the pervasive influence of silicon-based life forms. The use of light and shadow creates a sense of depth and volume, emphasizing the contours and structures of the coral-like entities and the mechanical components that intertwine with them. These elements together evoke a sense of a future where nature and technology have converged in unexpected ways, challenging the viewer's perception of life and evolution.

The title "Silica Seas" suggests a narrative where the oceans have become a crystalline realm of silicon-based organisms, a direct nod to the potential future outcomes of current environmental and technological trends. "Echoes of the Anthropocene" further implies that the artifacts within this virtual world are remnants or consequences of the human epoch, resonating with the ongoing dialogue about our impact on the planet and its ecosystems.

I want this virtual world serves much more like a poignant artistic commentary. It invites contemplation on the profound and potentially irreversible imprints humanity leaves on the Earth's geological record, all while providing an immersive aesthetic experience that merges the boundaries between the real and the imagined, the organic and the artificial.

3.5.3 Set up Component in Unity

1. Coral models reduction and texture painting

Continuing from this step, employing the Nomad software allowed for the reduction of polygons, hand-painting textures, and baking textures onto all coral models. Decimating the models significantly reduces the computational load, ensuring smoother operation and visualization during real-time interactions. This technical consideration is crucial for installations that demand high levels of detail and complexity, like "Silica Seas: Echoes of the Anthropocene."

Hand-painting textures onto the corals brings a personal touch to the virtual environment, infusing the models with a unique aesthetic that software-generated textures cannot replicate. This method grants me the freedom to explore and embody the envisioned peculiarities of silicon-based coral life. Each brushstroke adds to the narrative of a transformed sea, one where the corals are not just biological entities but also carry the story of their evolution in the Anthropocene.

The texture baking process locks in the intricate details of light and shadow, allowing these textured models to maintain their visual integrity across different platforms and rendering environments. Through this careful and artistic process, the corals in "Silica Seas" become more than mere digital constructs; they are imbued with a sense of history and purpose, serving as a metaphor for the symbiosis between organic evolution and the synthetic reality of their new silicon-based existence.

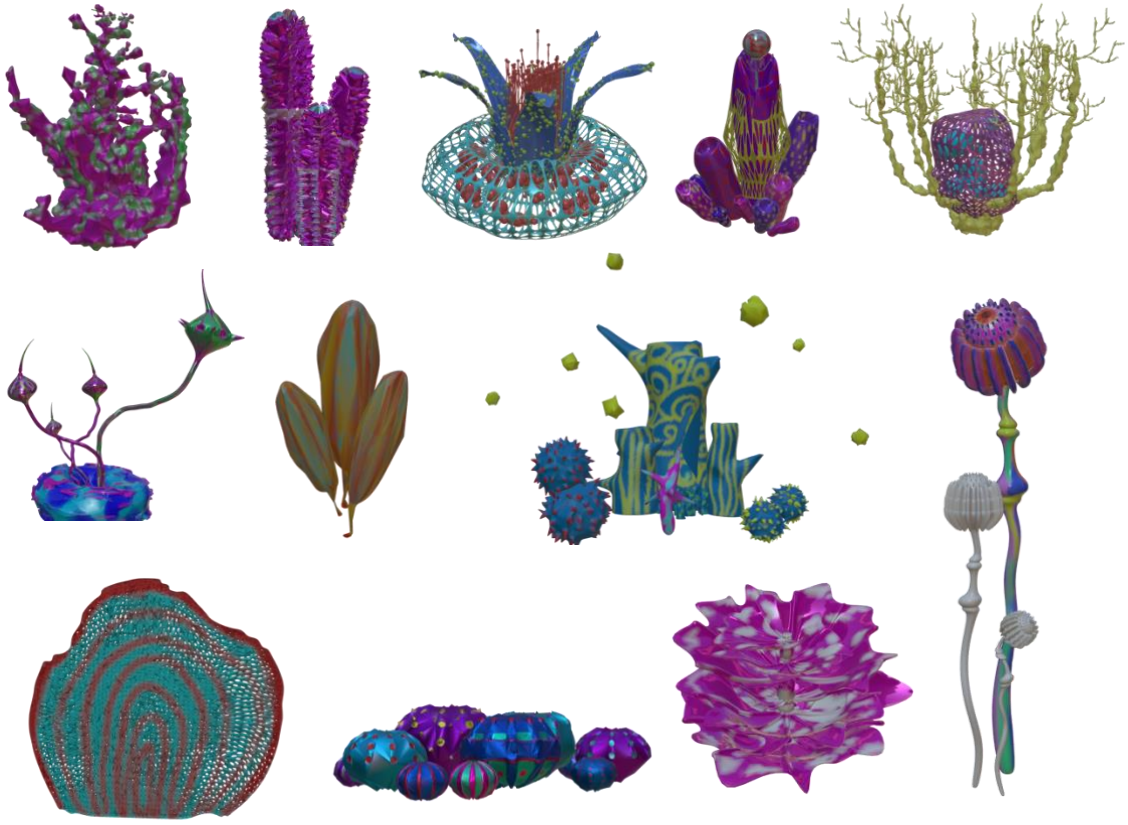


Figure 3.19: The image shows the effect of each coral species after mapping and model reduction

2. Unity Scenes

The scene I constructed in Unity presents a vision of a hellish virtual world, a striking tableau that combines the bio-luminescent allure of a deep-sea environment with a dystopian twist. In this realm, the corals, and marine structures, imbued with vibrant yet ominous colors, seem to pulse with an otherworldly life. The utilization of particle effects adds a layer of complexity and dynamism, with particles that could represent plankton or perhaps embers, reinforcing the infernal aesthetic. (see Figure 3.20)

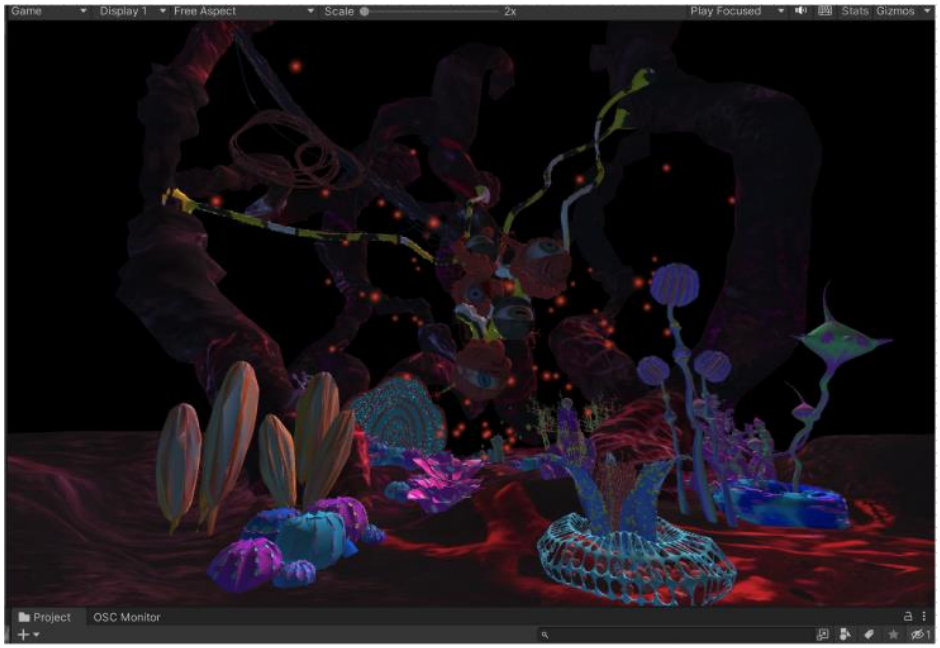


Figure 3.20: Screenshot of the "Nuclear" scene after lighting, material allocation, particle system Settings, camera animation effect

Camera animations sweep through this underwater hellscape, revealing the intricate details of the corals and the sinuous forms that dominate the space. The camera's movement is carefully choreographed to capture the scope of the environment and to guide the viewer's eye through the rich textures and forms that make up this digital abyss.

The inclusion of eyeball animations introduces a disquieting element of surveillance, suggesting a world where everything is watched. This could also symbolize the self-awareness of this digital ecosystem, aware of its viewers and responsive to their presence.

The overall effect is immersive and unsettling, inviting the viewer to contemplate the consequences of human activity on oceanic life forms. This virtual environment, with its hellish overtones and interactive elements, makes a bold statement on the current and future state of Earth's oceans, underscoring the potential for beauty and horror to coexist in the Anthropocene epoch.

The second scene that unfolds within the Unity environment presents a stark contrast to the first, though it shares the same set of 3D models. Here, I made it as a skeletal seascape, a chilling representation of the ocean floor transformed into a silent mausoleum by nuclear contamination. (see Figure 3.21) Where the first scene might have depicted a chaotic vision of a futuristic abyss, this one stands as a grim prophecy of what may come to pass — an aquatic necropolis borne of human recklessness.

Figure 3.21: Screenshot of the "Basic" scene after lighting, material allocation, particle system Settings, camera animation effect

The somber tones and the skeletal appearance of the corals and marine life evoke a haunting stillness, the kind that might follow an environmental cataclysm. The stark yellow signs of biohazard scattered across the sea floor serve as a morbid reminder of the source of this desolation. They are not just decorative elements but symbolic warnings, marking the intrusion of toxic legacies into the sanctum of marine life.

This scenario aims to crystalize the theme of the work, rooted in the real-world event of Japan's controversial decision to release nuclear wastewater into the sea. It's a world not shaped by the fires of infernal imagination but by the cold, hard consequences of ecological disregard. This undersea tableau is not just a digital creation; it is an artistic manifesto, an urgent call to recognize the paths we tread and the futures they lead to. Through this visualization, the message is clear: the echoes of our choices resound long after the initial ripples fade, and it is our responsibility to heed their call.

At this point, my initial scene setup in Unity is complete.

3.6 Touch Designer->Unity

3.6.1 Touch Designer Output

When considering Touch Designer's output, I imported a 3D coral model I created earlier into Test 2 of Touch Designer via File in Chop (see Figure 3.22). This completes the visualization of my digital art in Touch Designer, align with the ocean theme.

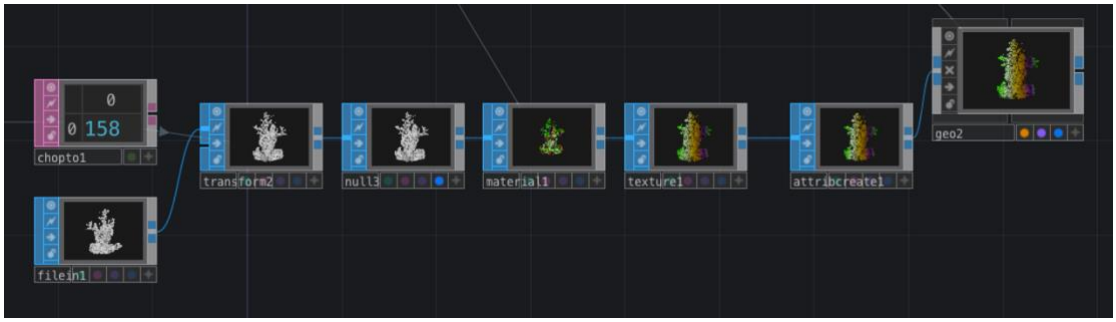


Figure 3.22: The screenshot shows how to access the connection method of the self-created model file in Touch Designer

As a little art piece "Staging Area" for my creation process, I set up two OSC Out Chops in Touch Designer, the first one, "oscout1", is planned to use to transfer the distance data from the Arduino directly to Unity, and the second "oscout2" is planned to use to transfer the real-time changing RGB color data of the 3D model due to the rotation to Unity. (see Figure 3.23)

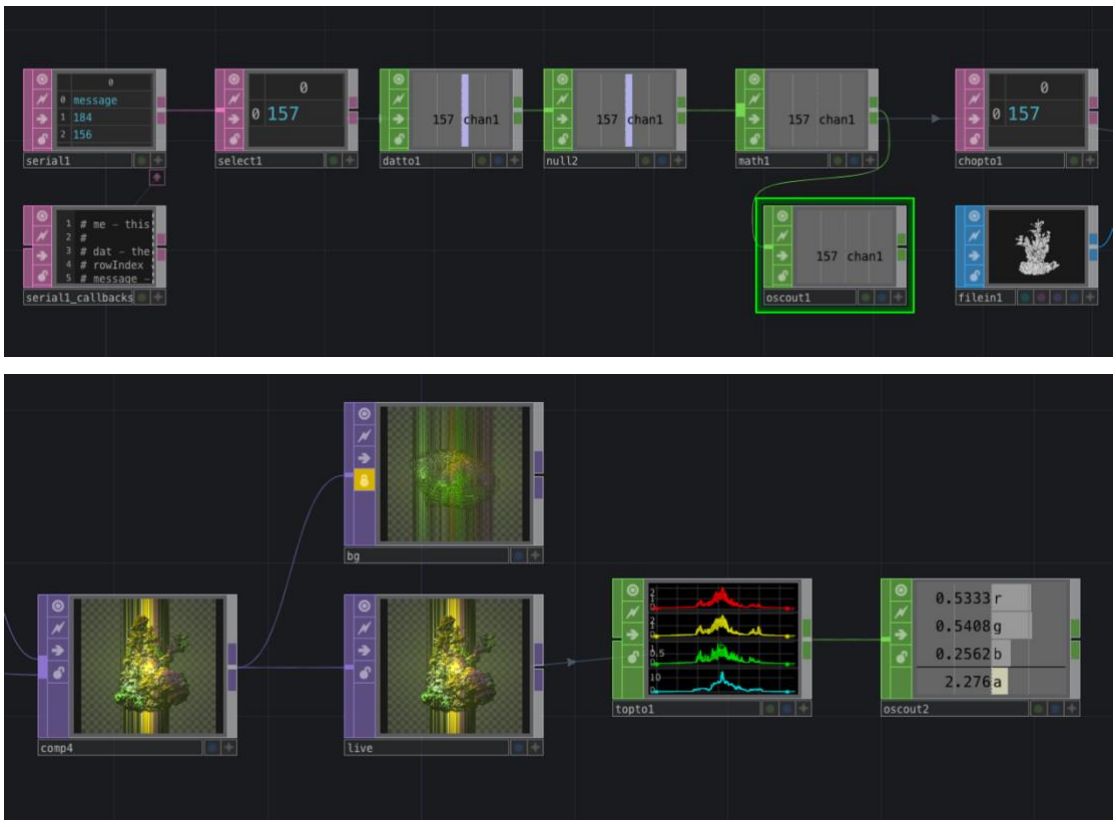


Figure 3.23: From top to bottom, the screenshot shows how to set two OSCout connection methods in Touch Designer

Regarding data communication, the OSC out Chop module in Touch Designer needs to make sure that the "Network Port" and "Local Address" are the same as those in Unity so that the data communication can reach Unity effectively. (see Figure 3.24)

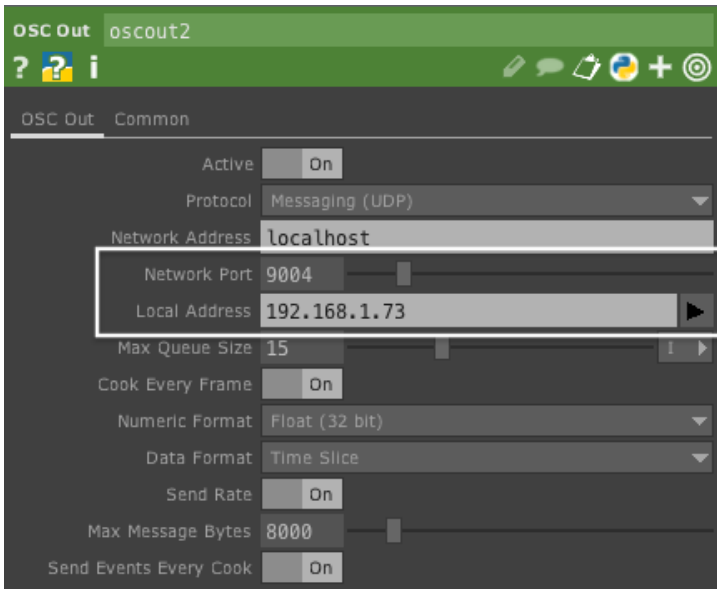


Figure 3.24: How to set up custom port and address indication methods in oscout in Touch Designer

3.6.2 Unity Input

Using the OSC data communication protocol in Unity requires importing external resources, and I used Keijiro's open source ‘OSC Jack’[62]. OSC Jack is a lightweight C# implementation of OSC (Open Sound Control) server/client, aiming to provide OSC support to Unity, which allows for the import and export of data, and in the case of this project, Unity is the last part of the integrated media, and only needs to be used for the data reception part of the functionality.

In this step, I planned to use the distance data "/chan1:" transmitted by "oscout1" to switch between the two scenes. The color data "/argb" from "oscout2" controls the color of the material sphere. All OSC data successfully transferred to Unity can be seen in the OSC Monitor. (see Figure 3.25)

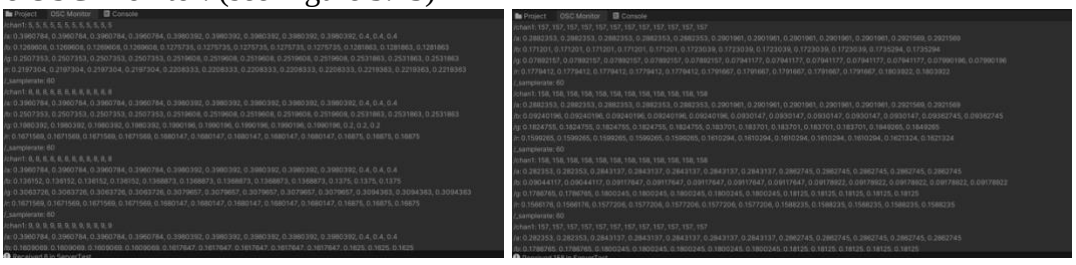


Figure 3.25: The screenshot shows two oscout data types being received in Unity

To invoke OSC data in Unity, commands need to be executed within a Script. In this project, the OscJack library[62] is used to receive OSC data and change the color of a material on an object in Unity. This is done by listening to specific OSC message paths, such as "/r", "/g", "/b". I declared several private and public variables using "public"

and "private" to access the game object's renderer component, store the current color value, and mark whether the color has been updated. An important method is the use of the "AddCallback" method to set callback functions for "/r", "/g", "/b", respectively. These callbacks are triggered upon receiving OSC messages for the corresponding color components. Thus, when OSC data is sent over the network to the Unity application, this script listens for the "/r", "/g", "/b" paths on a specified port, receives the color component values, and updates the material color of the game object in real-time. In this way, the color of objects in Unity can be dynamically controlled from Touch Designer. The script "ServerTest.cs" can be found in the GitHub repository of this project.

After completing the code invocation part of the script, there are two more steps to attach the script to objects in the scene. Drag the material onto the objects that require color synchronization and drag the "ServerTest.cs" script onto them. Then create an empty object, which I named "Receiver1" in this project. Add the "Event Receiver" script to the empty object's "Inspector", which is part of the OscJack library. In it, set the details of the materials that need linked color changes. With this, the method will successfully allow the colors of objects within the scene to change in real-time.

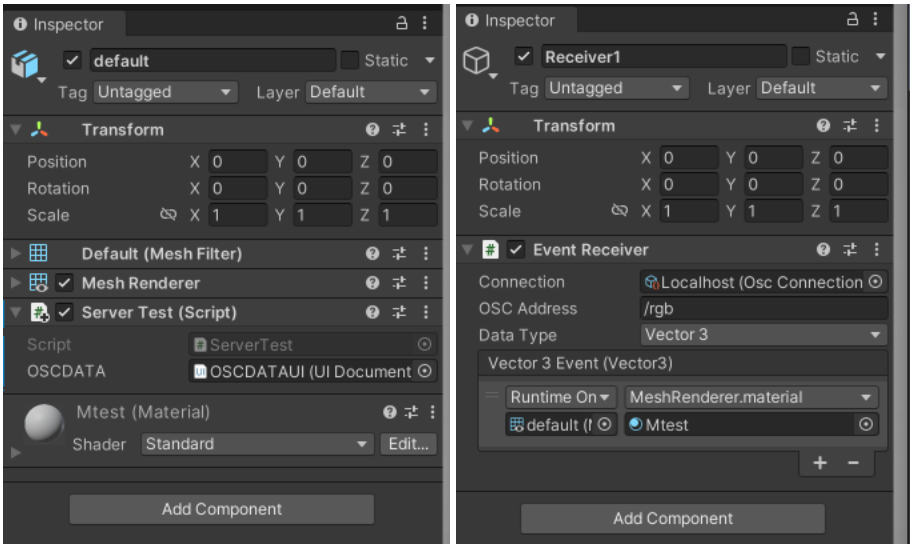


Figure 3.26: From left to right, apply the object object setting method for this item in the same component, and the empty object setting method

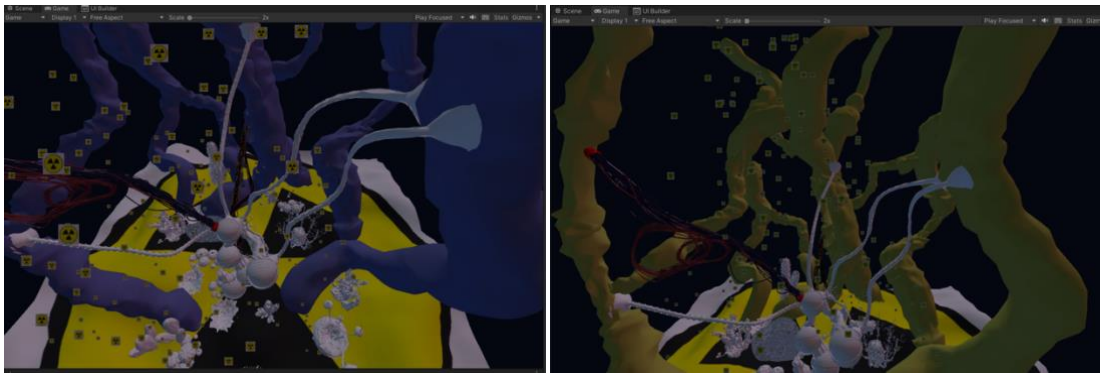


Figure 3.27: The screenshots are the effect of changing the color of the material based on osc data in real time

The aforementioned method is the result of various trials and debugging that I have summarized, and I won't detail the trial-and-error process here. This method effectively demonstrates how to apply the OscJack library and utilize Unity's internal components to achieve data communication.

In this step, I abandoned the idea of using distance data from "/chan1:" to switch between two scenes. During the debugging process, I found that due to the sensitivity of the distance data and the complexity of the virtual worlds in both scenes, frequent switching led to a confusing experience for the audience, preventing them from watching the animations of the two scenes in their entirety and grasping the theme I intended to convey. Therefore, I created another script, "SceneSwitcher.cs", to alternately switch between the "Basic" and "Nuclear" components at fixed intervals. In this setup, only the world pillar in the "Basic" scene changes color according to the OSC data. The script " SceneSwitcher.cs " can be found in the GitHub repository of this project.

3.7 Integration testing

In this step, I completed a 3-part connection test where I focused on debugging the communication and operation between the different modules to achieve the desired experience. (see Figure 3.28)

Figure 3.28: Above pictures are I was testing the effect of 3 parts linkage

During the debugging and testing phase, I considered the following issues:

1. Seamless Integration: Check if the data flow between the ultrasonic sensors, servo systems, LEDs, air pumps, Touch Designer, and Unity is smooth and uninterrupted.

2. Responsiveness: The system should quickly respond to human proximity, achieving minimal latency between physical interactions and digital responses.
3. Consistent Performance: Ensure that the interactive behaviors are consistent across multiple tests, indicating the system's stability.
4. Accurate Sensing: Ultrasonic sensors should accurately detect distances and trigger appropriate responses in both the physical and digital realms.
5. Aesthetic Coherence: Whether the visual and auditory outputs from the physical and digital components create a cohesive aesthetic that reinforces the artwork's theme.

However, I also encountered the following difficulties:

1. Complexity in Calibration: Ensuring that sensors and actuators are finely tuned for consistent performance can be challenging.

2. System Overload: The digital system (Touch Designer and Unity) must handle the incoming data without significant performance drops. However, this is quite pronounced in my Touch Designer, which experiences noticeable system overloads leading to monitor stuttering on my computer.
3. User Experience Variability: Different users may have varying experiences based on their approach and interaction with the installation, which may not always align with the intended outcome.

My next step for these issues is to collect feedback from test users during the evaluation phase. Consider the reliability of the setup, the attractiveness of the interaction, and whether the installation meets the artistic goals I aim to achieve. By carefully examining these aspects, I can refine my installation to ensure it not only functions as intended but also conveys a powerful message and an evocative experience to the audience.

Chapter4

Final Work

In this phase, my goal was to create an immersive art interactive work that transcends a single physical or digital art experience by utilizing the various software mentioned in this paper, as well as the communication techniques and rules between them, to present the Japanese nuclear sewage dumping incident in the environmental context of the Anthropocene and to express the theme of positive nihilism in the future age of silicon-based life. The final artwork described below uses Arduino as the physical device component, Touch Designer, and Unity as the digital media component, and responds to a distance sensor to achieve an integrated physical-digital combination of multi-sensory immersive interactive artwork. Video footage of the artwork can be found in Appendix A.

In this piece, the approach of a human triggers an apocalyptic struggle that bridges the physical and the virtual realms. Technically, I employ ultrasonic sensors for proximity detection, and continuous servos, RGB LED rings, and a Mini Air Pump act as the output modules of the physical installation. They emit danger signals and exhibit frantic movements when someone comes within 30 centimeters. The lights, shifting from white to red, flicker in alarm, their intensity modulating with the urgency of escape. Tentacles spin in panicked motion, and the air pump emits the sound of churning water, signaling a struggle, a desperate attempt at flight. As distance data is transmitted to Touch Designer, the digital corals react, contorting in place, unable to flee. With the OSC communication relaying their twisting motions and the RGB color signals to Unity's virtual seabed world—a world already bleached into a skeletal landscape by nuclear wastewater—the pillars of this realm begin to release mechanical warnings, unanswered by any form of life.

Eventually, the era passes, and the scene transitions to the next epoch, the age of Cthulhu, where the ocean of silicon-based life is fraught with danger and aggression. The seas no longer subdued, reign as the era's dominating force. The communication between physical and digital media becomes a natural yet ironic and reflective connection, suggesting an inevitable link between two infernal virtual worlds. This serves as a dire warning—a signal that resonates with foreboding.

Chapter5

Evaluation

The outcomes will be evaluated on two fronts: their technical proficiency and impact dissemination value. Here, technical proficiency refers to how successfully I have harnessed my command of various software technologies for artistic creation, and the successful design of 3D models, scenes, and physical installations that align with my theme. The impact dissemination assessment will take a more comprehensive view of the work, measuring whether the criticality of the piece and the implied expressions of the event have been successfully conveyed and received by the audience.

5.1 Technical Evaluation

5.1.1 Software

In the aspect of 3D modeling, I utilized Blender to create silicon-based corals and scenes, and Rhinoceros to construct the engineering model for the physical jellyfish installation. These models demonstrate my adept technical control in crafting 3D models, successfully fulfilling my vision for virtual world creation and physical installation structural design.

In terms of digital media creation, I employed Touch Designer to craft the Multimodal Coral Sea, which reflects my proficiency with the software to a certain degree. I consider my mastery of this software not entirely sufficient, yet in my project, it does not serve as the main element but rather as a bridge or conduit. My self-assessment for this part is neutral; it looks acceptable for me but could be improved. Furthermore, I used Unity to create the final two scenes, where I applied the software’s particle system, animation system, and scene transition commands, etc. Judging from the outcome, I rate my proficiency with Unity above average. Given Unity's powerful and extensive capabilities, I believe there is significant room for improvement and learning in mastering this software.

Regarding the use of Arduino, I combined different components to realize my concept for the physical jellyfish installation. From the final results, I successfully achieved the intended interactive feedback on the input and output modules that I needed it to perform.

5.1.2 Data communication

Data communication, as a technical highlight of the project, has been the focus of my research efforts. The successful interactive feedback between the three modules in the final work meets the challenges posed by my technical concept. However, based on my current research, I believe that my application of OSC data communication in Unity is not yet thorough and comprehensive. Although for my project concept, I only needed to apply a portion of the capabilities, and its implementation also broadly involves Unity system standard settings, communication protocols, and other aspects. Thus, while successful data transmission is one aspect, effectively invoking OSC data in Unity to execute a variety of different interactive commands is an area I have not yet fully mastered.

5.2 Communication Impact Evaluation

5.2.1 Questionnaire survey

A total of five people participated in the survey. Before starting the survey, two of the participants watched and interacted with the work on site, and the other three participants watched the video of the project. After the survey, they were invited to provide additional feedback.

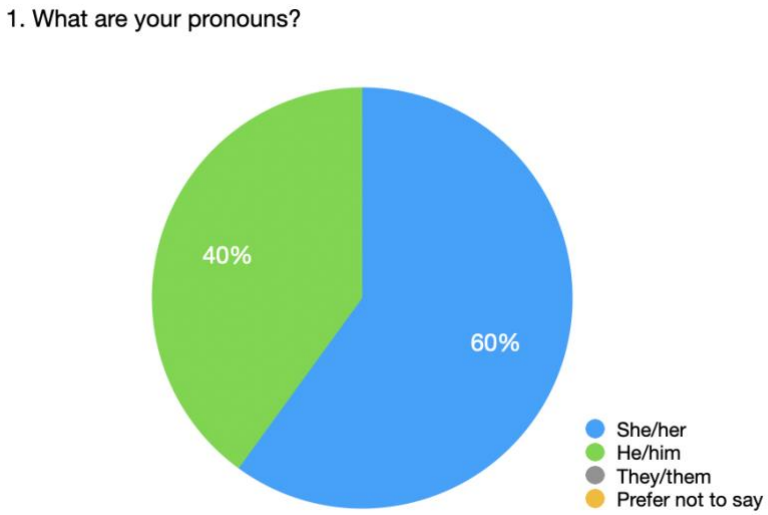


Figure 5.1: Question 1

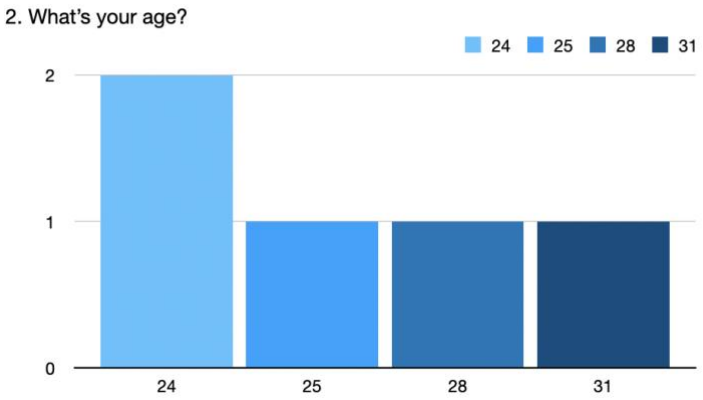


Figure 5.2: Question 2

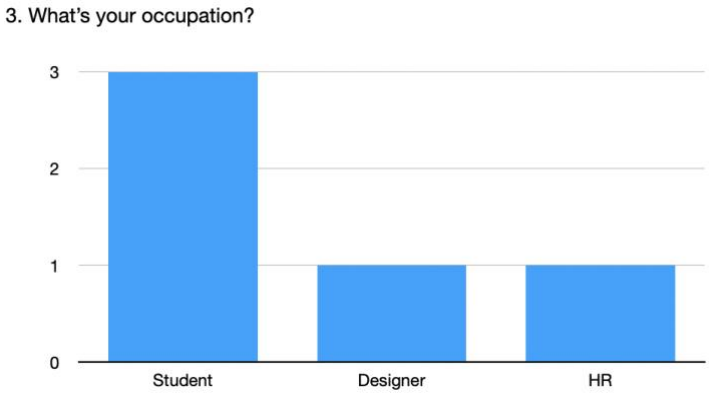


Figure 5.3: Question 3

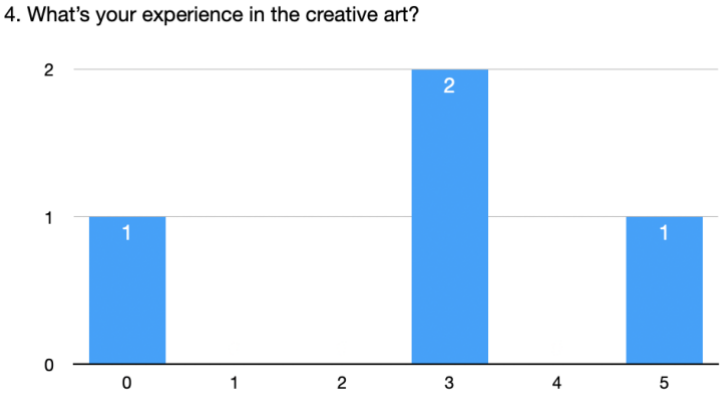


Figure 5.4: Question 4

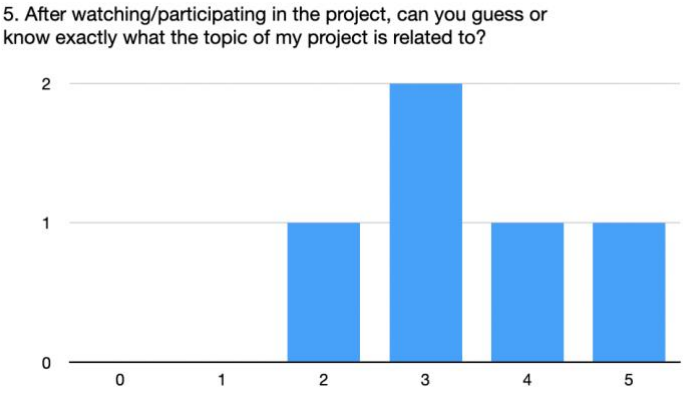


Figure 5.5: Question 5

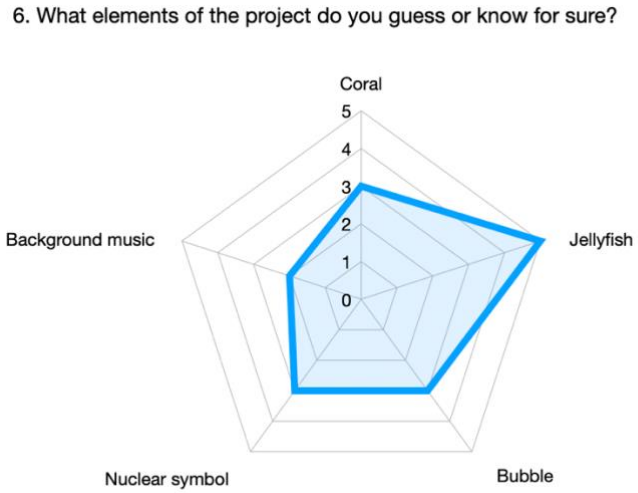


Figure 5.6: Question 6

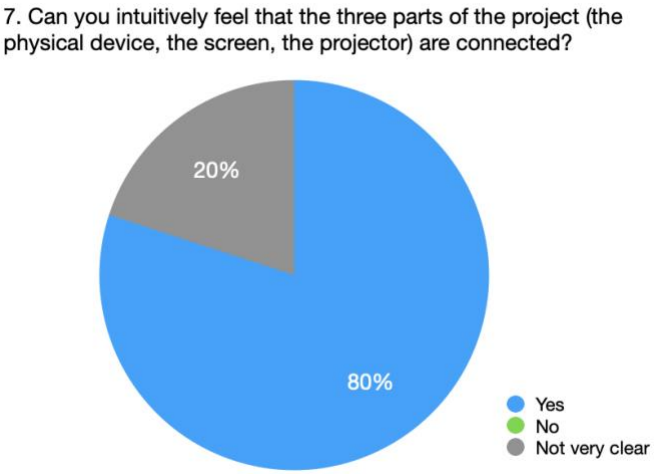


Figure 5.7: Question 7

5.2.2 Interview the participants

Q1: What do you think of the effect of this multi-faceted art installation? How was the experience?

Dairun Z: It can bring me a sense of immersive interactive experience.
Kaicheng W: The physical installation and the digital media can complement each other to express the theme, but I think each part is sufficient, so it is difficult to distinguish the order of primary and secondary relationships.
Tingting P: I think it can make me feel the harm of nuclear pollution to the Marine environment. The author expressed his feelings about nuclear pollution through the interactive device, which aroused my attention to this event.
Ran R: I saw the relationship between the interactive device and the projection screen, the relationship between the screen and the projection screen, but without the author's explanation, I still don't quite understand how the interaction between the three of them happened.
Qianyun C: I can clearly and intuitively understand the author's intention through the installation, and these interactions make me feel very interesting.

Q2: After experiencing the project or watching the project video, what can you think of in terms of interactive experience or technical optimization of the project?

Dairun Z: No at present
Kaicheng W: For me, I feel that there is a little less interaction with people, only a distance sensor, and more interaction as if it happens between the three parts of the project itself. In addition, I think if the distance sensor is placed on the jellyfish, it will better reflect the idea of "people close, jellyfish flee".
Ran R: I think the technology looks particularly strong in this project, so the optimization aspect that comes to mind is the interactive experience of the audience. For example, from the perspective of narrative, we should consider how to guide the audience to watch this work, whether there is a sequence, whether it appears at the same time, whether it opens different experience angles of the audience successively, or whether it highlights key areas.
Tingting P: Good technique.
Qianyun C: I think the technical aspect is very impressive, but I think the lack of guidance on the audience experience process may be related to the placement of the three parts.

5.2.3 Summary

The survey results mainly show the understanding of a project's topic, and their perception of the connection between different parts of a project. The experience in creative art varies, with most indicating a mid-level experience rating of 3 out of 5. However, participants' understanding of the project's topic is not very clear-cut, with the most common response being a neutral score of 3 out of 5, the average value is 3.25. Even though this value is higher than 2.25, but still indicating some ambiguity or diversity in the interpretation. Knowledge of marine elements such as jellyfish and bubbles seems certain, while background music and coral are less recognized, and a nuclear symbol is the least to be recognized in the project. After the interview, it was learned that some participants who did not select the nuclear symbol did not know that it was a warning sign of "nuclear radiation". In the end, a significant majority (80%) feel that the three parts of the project (physical device, screen, projector) are connected, indicating successful communication of the project's integration or a cohesive experience.

The data suggests a diverse yet somewhat homogeneous group in terms of demographics and a generally positive reception of the project's cohesion. However, there's ambiguity in the understanding of the project's content, as seen in the mixed responses regarding the project's elements and topic. This feedback could be valuable for refining the project's presentation and clarity.

Furthermore, from the two interview questions and the participants' responses, I can draw some insights into the effects of this art installation and the interactive experience or technical optimization of the project. Participants generally believe that this art installation can provide an immersive interactive experience. While some feel that the physical installation and digital media can complement each other to express the theme, each part is also independent enough, making it difficult for them to distinguish the primary and secondary relationships. Some participants felt the harm of nuclear pollution to the marine environment through this interactive device, and this event aroused their attention, which to some extent indicates that the author's creative purpose has been achieved. However, there were also some participants who stated that without the author's explanation, they did not fully understand how the interaction between the three occurred.

In terms of interactive experience and technical optimization, participants raised the need for more interaction with people, noting that apart from the distance sensor, there is little interaction with individuals, and more interaction seems to happen between the three parts of the project itself. From the feedback, while the technical aspect was impressive, there was a lack of guidance in the audience experience process. These feedbacks are valuable for future project improvements, especially in enhancing audience participation and improving the narrative quality of the work.

Chapter6

Discussion

6.1 Technical Contribution

In this article, I outlined a series of creative methods involving physical installations, digital media, and virtual worlds, and how they are interconnected to achieve an immersive exhibition experience. However, feedback from five participants suggests that there is room for improvement and adjustment in the work. Technically speaking, the current results were achieved through repeated fine-tuning through my research and practice. To create high-quality, cohesive art installation works through digital communication methods still requires extensive practical research, particularly in terms of the sequencing of time responses in various software, data calls, and the sensitivity and prominence of interactive feedback. Moreover, the techniques outlined in this article are not comprehensive; the OSC data communication method discussed is only for artists who create using the Mac OS system for data communication, although it is also possible on Windows systems. However, on a Windows system, one can directly use Touch Designer’s "Spout out" and "Spout in" to interface with Unity, a method superior to OSC data communication as it can directly transfer images without the need for OSC communication protocols and subsequent data call commands in a Script. The technical pain points described in the article are also based on this.

Moving forward, I aim to delve deeper into the intricacies of OSC within Unity to leverage its full potential for interactive applications. This will involve exploring more advanced features, like bidirectional communication and real-time data manipulation, which can enhance the interactivity and responsiveness of the installation. By advancing my understanding and application of OSC, I can enrich the user experience and create a more sophisticated and nuanced interaction within my work, thereby pushing the boundaries of what is possible in the convergence of technology and art.

6.2 Influence Contribution and Discussion

One of the aims of this article is to communicate the severity of Japan's dumping of nuclear wastewater into the ocean through the social exhibition of the installation. This

demonstrates my activism[63] on the issue to a certain extent. I hope that through my work, participants will become aware of this ongoing issue and be spurred into action. Since there has not yet been an exhibition, I rely on feedback from samples of five participants I invited, and according to them, my goal has been achieved. However, these efforts alone are not enough. I believe further action can be taken by:

1. Creating an educational website that compiles and disseminates information about the dangers of nuclear radiation, and updates on news about this event.

2. Proposing and organizing protest marches.

3. Sharing the website link for a petition to "Stop Japan's Nuclear Wastewater from Entering the Ocean" as a united front, like the global movements inspired by Greta Thunberg's climate change activism. [64]Just as Thunberg has said, "I want you to act as if our house is on fire because it is." We need to approach this nuclear issue with the same urgency.

4. Engaging with local and international environmental advocacy groups to amplify the message.

The intention is not only to raise awareness but also to create a ripple effect of activism that can lead to tangible change.

Chapter7

Conclusion

This article opens with a critique and introspective reflection on the contemporary world's inaction towards ocean conservation. It explores the creation of immersive art through the synthesis of real-time interactive technologies that meld the physical with the digital. Underpinning this is an assumption that physical installations and software can be interconnected through data transmission, allowing for reciprocal interaction—an assumption that is systematically tested and validated through my research.

During my studies, I have established a communicative synergy between the three original modules detailed in the paper, culminating in an immersive art piece that encapsulates my critical stance on the chosen theme. This creation serves as a dual-purpose vehicle: on one hand, it is a clarion call to the public to recognize and respond to Japan's flagrant discharge of nuclear wastewater into the oceans; on the other, it exemplifies how artists can harness computational tools to integrate physical and digital media in their craft.

This process has been a journey of both discovery and expression, where the intertwining of sensors, servos, and software not only forges a tangible experience but also manifests a commentary on environmental issues. As the artwork evolves, it invites viewers to engage with the narrative of ecological crisis, leveraging the power of art to illuminate and challenge the status quo. It represents a confluence where technology does not merely serve art but joins it in a unified voice that speaks to the urgency of the present and the possibilities for the future. Through this work, I underscore the artist's role not only as a creator but also as a conscientious provocateur and innovator in the dialogue about our planet's well-being.

Appendix A

Links to installation display video

https://youtu.be/PdnhBmvn9JI

Links to project's GitHub

https://github.com/xuezewen2333/MSc-Advanced-Project

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