[Andy]
JinranYe

DESIGN
ENDOWS TECHNOLOGY
WITH WARMTH

Jinran Ye | Portfolio 2024

CONTENT

Live-Diffusion #AI Image Generation; Real-time Interaction; Multimodal Perception

Live-Diffusion is a real-time multimodal AI image generation system that can dynamically respond to various user interactions. This project is designed to expand creative possibilities by bridging the accessibility gap for zero AI-knowledge users and integrating multimodal sensation of the physical world.

Aegis: Space Maintenance Drone #SpaceTechnology; SatelliteMaintenance; IONPropulsion

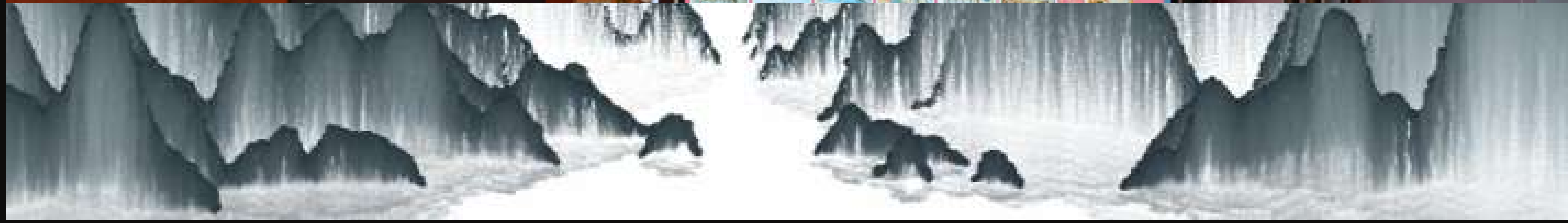
Aegis is a space maintenance drone designed to repair space satellites, extending their operational lifespan. It integrates surgical robot controller and arms for precise operations by either astronaut or remote operation from earth. The drone uses an ION propulsion system to ensure its sustainability and continuous servicing in space.

Gaudi-Vision #AI; Cultural Heritage; Image Transformation; Art and Technology

Gaudi-Vision is an interactive project that transforms user uploaded images into Gaudi's aesthetic. The project utilizing AI technology to provide an alternative solution to the population and preservation of culture heritage.

Beyond Ink-wash #Generative Art; Digital Ink-wash; Creative Coding; Culture Heritage

Beyond the Ink-wash is an interactive digital system that recreates the elegance of traditional Chinese ink-wash paintings through modern programming technologies. The project empowers users to draw a personalized ink-wash artworks though body interaction, offering an interactive experience with the traditional ink-wash paintings.



LIVE DIFFUSION

AUG 2024

Real-time Interactive AI Image Generation System

> The Live-Diffusion project aims to enhance the interactivity of current image-generation AI by integrating a multimodal sensory system. The system can dynamically respond to various user interactions and environmental data. By integrated user-friendly interface, the system can also expand creative possibilities by bridging the accessibility gap for zero AI-knowledge users and receiving multimodal sensation from the physical world.

IMA Gallery

NYU SHANGHAI 上海纽约大学

Shanghai Frontiers Science Center of Artificial Intelligence and Deep Learning

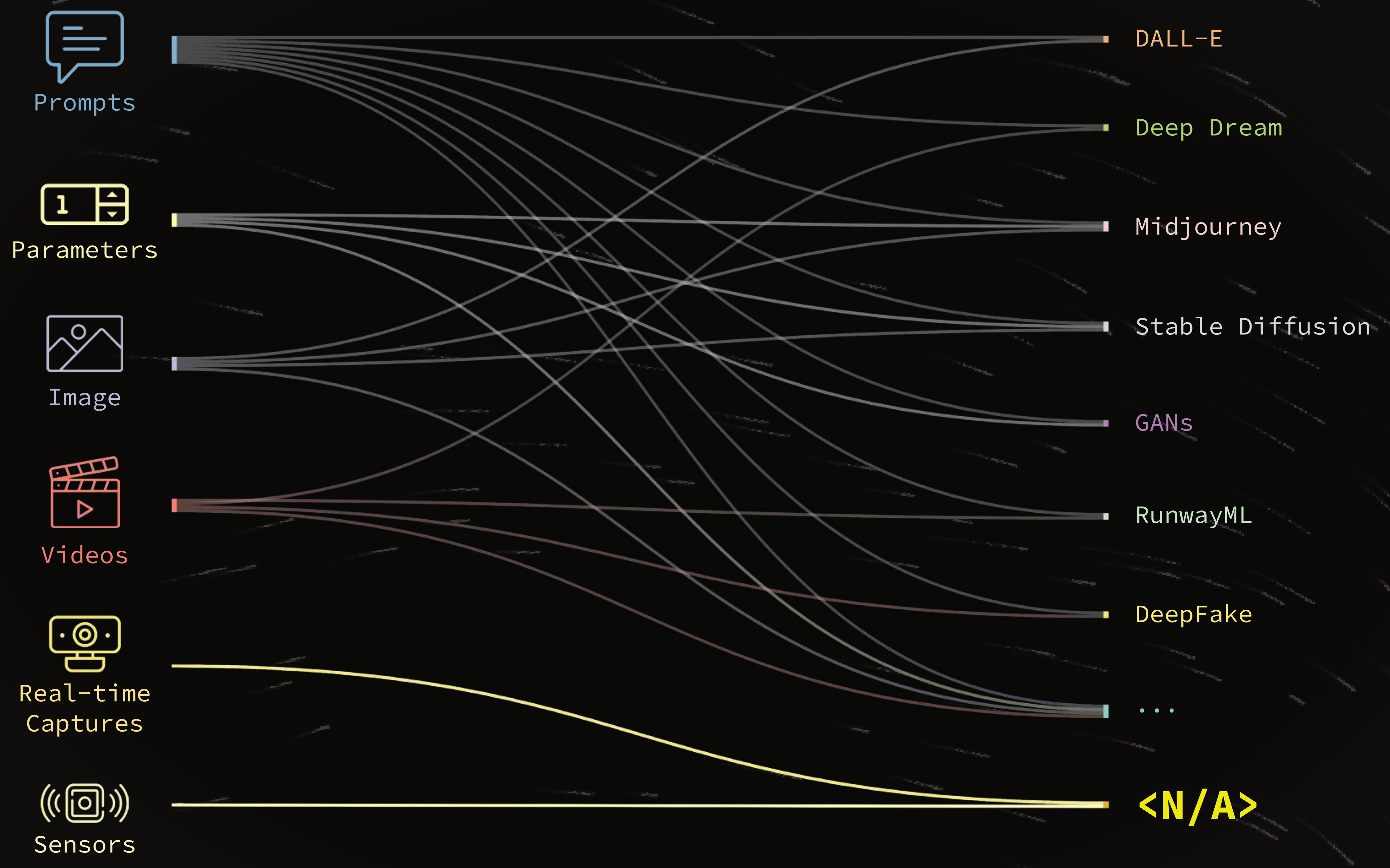
上海市人工智能与深度学习前沿科学研究基地

BACKGROUND

cd Live-Diffusion/Background

./Limited_Interactiveness

> Current AI products are capable of receiving prompts, parameters, images, and videos as input. However, these systems lack the ability to process real-time data from dynamic sources such as webcams or sensors directly. This limitation means that while AI models can work with pre-recorded or static inputs, they cannot yet respond instantly to live environmental changes or user interactions captured through real-time hardware, hindering the development of fully interactive AI experiences.



./Accessibility_Gap

> Although a significant number of people express interest in AI technology, only a few possess the foundational knowledge required to develop generative models effectively and fully harness AI's potential.

91 % Respondents
Interested
in AI Tools

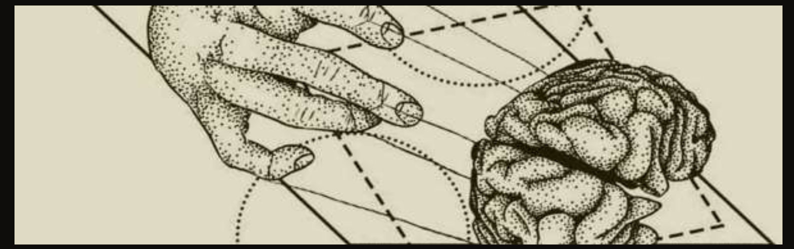
63 % Interviewees
Have Used
AI Tools before

18 % Interviewees
Are Proficient
in AI Tools

Proficiency

Prompting

Developing expertise in crafting effective and precise prompts. Understanding how the AI interprets and responds to different phrasing to achieve the desired outcome.



Parameter Adjustment

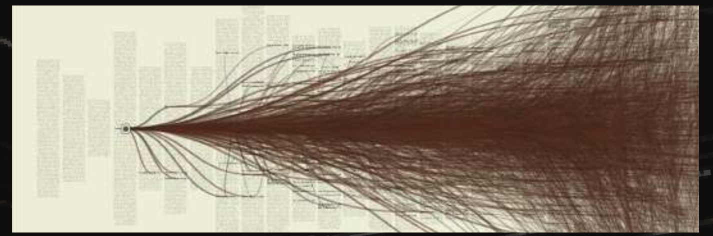
Systematically adjusting and optimizing the parameters of a model or system to enhance its performance.

Environment Configuration

Preparing the system by installing and setting up essential libraries, frameworks, and dependencies for GPU acceleration.

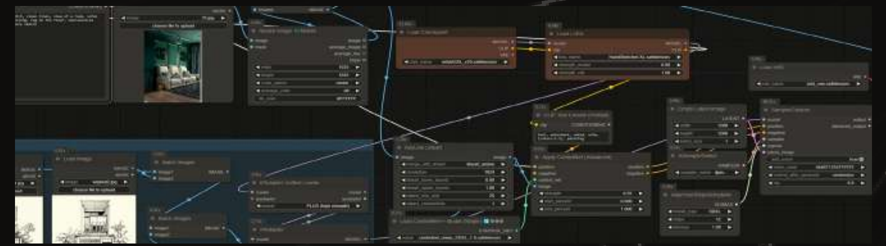
./Steep_Learning_Curve

> Learning AI image generation presents a considerable learning curve, demanding a comprehensive understanding of various technical aspects to achieve results that align with expectations.



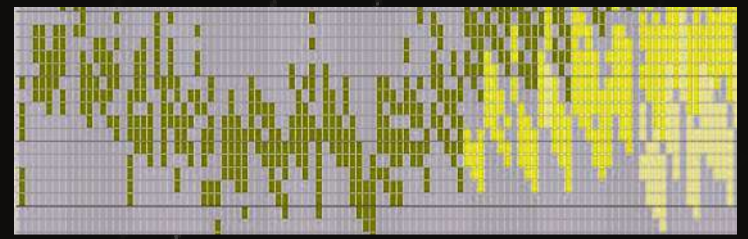
Model Fine Tuning

Adjusting a pre-trained AI model's parameters using a smaller, specific dataset to improve its performance on a particular task.



Complex Pipeline

Enhancing by modules like ControlNet and LoRA, which guide the output using specific inputs such as poses, edges, or depth maps.



Model Benchmarking

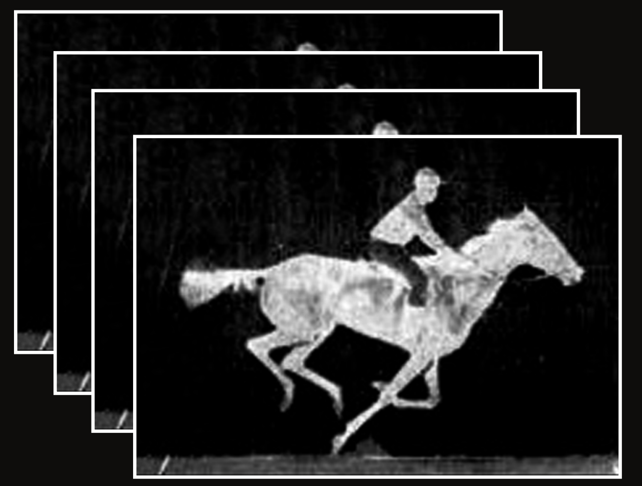
Evaluating and comparing the performance of different AI models to determine which model performs best under specific conditions.

Time

CONCEPT

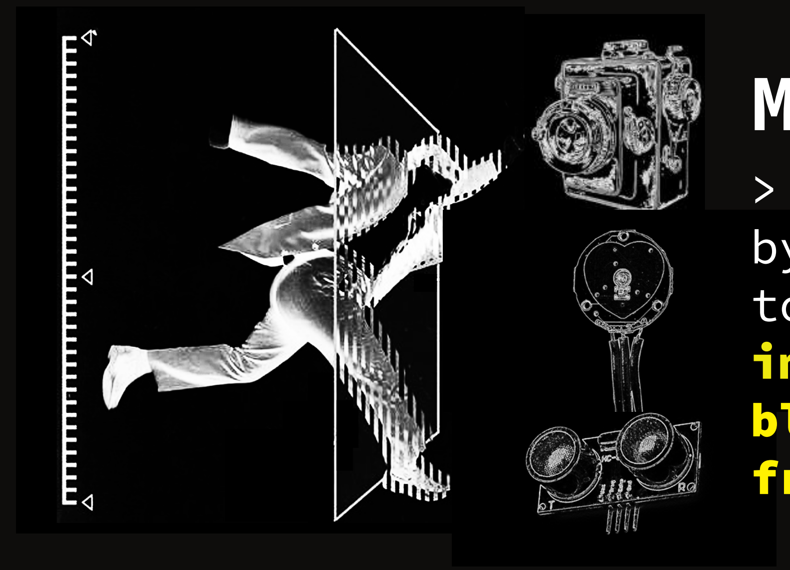
cd Live-Diffusion/Concept

./Objectives



Real-time Interaction

> The system shall **harness various input signals in real-time** to create AI-generated images that adapt dynamically **based on user interactions**, providing an immersive and responsive experience. This will involve continuously monitoring and interpreting input data from hardware or software sources.



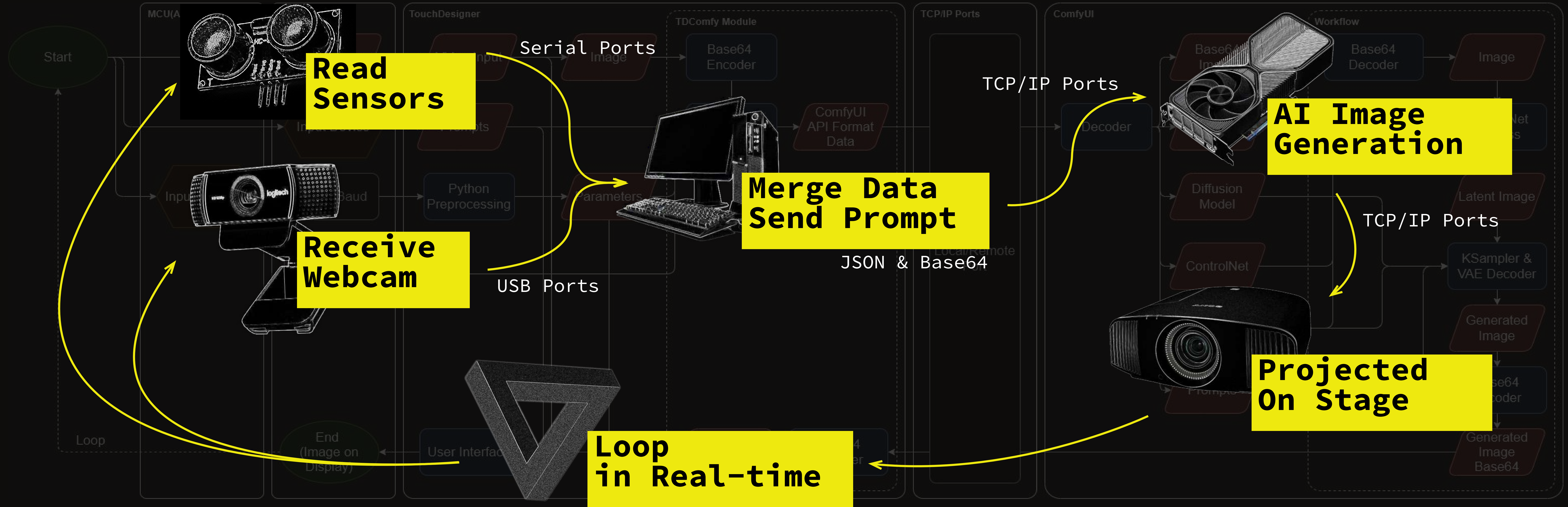
Multimodal Perception

> The system shall **employ multimodal perception** by integrating inputs from a range of sensors to create **dynamically responsive AI-generated images**, enhancing artistic expression through a **blend of** environmental and physiological **data from various sensors**.

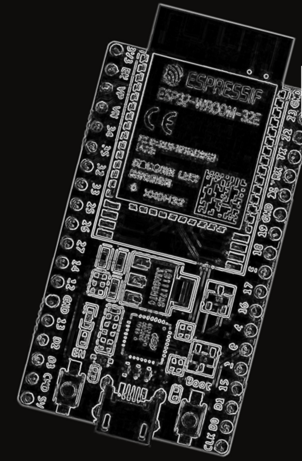
User Accessibility

> The system shall **prioritize user accessibility** by **translating complex AI industry jargon** into clear, comprehensible language and providing a **user-friendly interface** that welcomes users of all technical backgrounds.

./System Design



./Technology Feasibility>



ESP32
Receive Data

> ESP32 is capable for **Receiving Data** from different sensors and send to computer using **Serial Port**.

TouchDesigner
Merge Data

> TouchDesigner can **Get Webcam Images** and **Read Serial Port**. It also has the ability for **Merge These Data** and **Send to AI** backend.

ComfyUI
Process Data

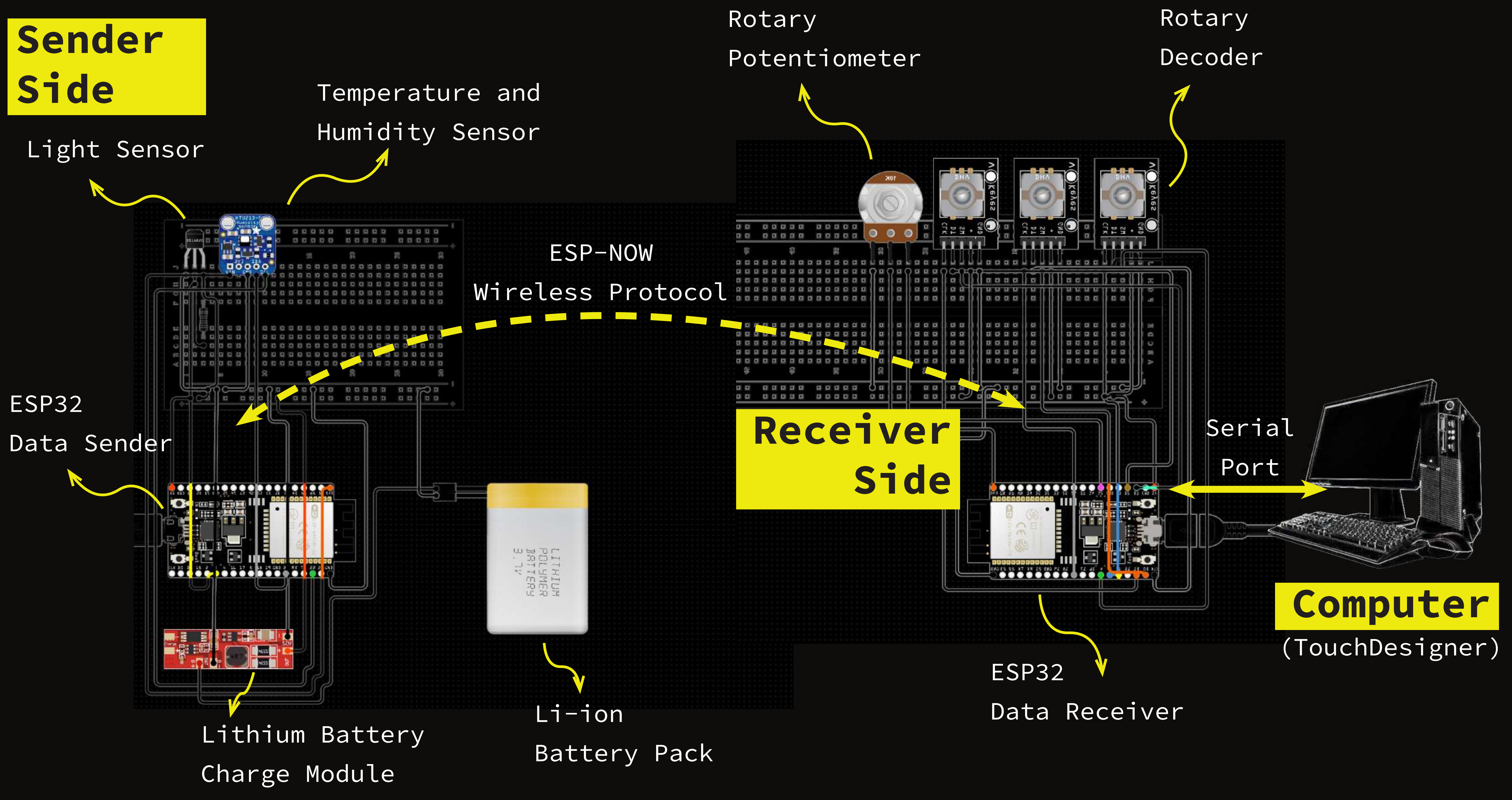
> ComfyUI can **Read and Process Merged Data** send from TouchDesigner and **Load Different Models to Generate Images.**

DEPLOYMENT

cd Live-Diffusion/Deployment

./Sensor_Reading_Collection

> The reader side is responsible for getting sensor readings and sending them to the receiver side using ESP-NOW protocol. The receiver takes care of receiving readings and prints in the serial port with the knobs' readings. They control either prompt or parameters separately.



./Code_Snippets

Arduino

> In the coding process, the codes mainly consist of five functionalities as follows:

sendData

```
//RECEIVER MAC Address
uint8_t broadcastAddress[] = {0x3E, 0xEA, 0x7B, 0x19, 0xA0, 0x58};

// Structure example to send data
// Must match the receiver structure
typedef struct struct_message {
    char a[32];
    int sensorLight;
    int sensorTemp;
    int sensorHumi;
} struct_message;

// Create a struct_message called myData
struct_message myData;

esp_now_peer_info_t peerInfo;

// callback when data is sent
void OnDataSent(const uint8_t *mac_addr, esp_now_send_status_t status) {
  Serial.print("\r\nLast Packet Send Status:\t");
  Serial.println(status == ESP_NOW_SEND_SUCCESS ? "Delivery Success" :
"Delivery Fail");
}

 ...

// Set device as a Wi-Fi Station
WiFi.mode(WIFI_STA);

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

// Once ESPNow is successfully Init, we will register for Send CB to
// get the status of Trasnmitted packet
esp_now_register_send_cb(OnDataSent);

// Register peer
memcpy(peerInfo.peer_addr, broadcastAddress, 6);
peerInfo.channel = 0;
peerInfo.encrypt = false;

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

sendData()

Set up ESP-NOW communication, defining data structure and peer information, then send sensor data with delivery status feedback.

SensorRead

```
#include <DHT.h>

// DHT sensor pin and type
#define DHTPIN 4
#define DHTTYPE DHT22

// light sensor pin
#define LIGHT_SENSOR_PIN 34

// Initialize DHT sensor
DHT dht(DHTPIN, DHTTYPE);

float sensorLight;
float sensorTemp;
float sensorHumi;

void sensorRead() {
  // Read light sensor value (analog)
  SensorLight = analogRead(LIGHT_SENSOR_PIN);

  // Read temperature and humidity from DHT sensor
  SensorTemp = dht.readTemperature(); // Celsius by default
  SensorHumi = dht.readHumidity();

  // Check if any readings failed and exit early (to try again).
  if (isnan(SensorTemp) || isnan(SensorHumi)) {
    Serial.println("Failed to read from DHT sensor");
    return;
  }
  return;
}
```

sensorRead()

Use DHT module and analogRead() to get readings from different sensors.

SerialUpdate

```
float sensorLight;
float SensorTemp;
float SensorHumi;

// callback function that will be executed when data is received
void OnDataRecv(const esp_now_recv_info *info, const uint8_t *incomingData, int
len) {
  memcpy(&myData, incomingData, sizeof(myData));
  //write servo data
  sensorLight = myData.SensorLight;
  sensorTemp = myData.SensorTemp;
  sensorHumi = myData.SensorHumi;
}
...

void setup() {
   ...
  // Set device as a Wi-Fi Station
  WiFi.mode(WIFI_STA);
  // Init ESP-NOW
  if (esp_now_init() != ESP_OK) {
    Serial.println("Error initializing ESP-NOW");
    return;
  }
  // Once ESPNow is successfully Init, we will register for recv CB to get recv
packer info
  esp_err_t result = esp_now_register_recv_cb(OnDataRecv);
  if (result == ESP_OK) {
    Serial.println("Callback registered successfully");
  } else {
    Serial.println("Failed to register callback");
  }
}
```

receiveData()

Receive data using ESP-NOW, and update parameters that assigned to sensor data.

RotaryEncoderHandler

```
// Rotary Encoder 1
#define CLK 27
#define DT 26
#define SW 25

// Encoder 1
volatile int16_t position1 = 2;
volatile int16_t lastCLKState1;
volatile bool positionChanged1 = false;

void setup() {
   ...
  // Encoder 1 pin modes
  pinMode(CLK, INPUT);
  pinMode(DT, INPUT);
  pinMode(SW, INPUT_PULLUP);
  lastCLKState1 = digitalRead(CLK);
  attachInterrupt(digitalPinToInterrupt(CLK), handleEncoder1, CHANGE);
   ...
}

// Rotary decoder 1 handler
void IRAM_ATTR encoderHandler() {
  int16_t currentCLKState1 = digitalRead(CLK);
  if (currentCLKState1 != lastCLKState1 && btn1Status == HIGH) {
    if (digitalRead(DT) != currentCLKState1) {
      position1++;
    } else if(position1 > 2){
      position1--;
    }
    positionChanged1 = true;
  }
  lastCLKState1 = currentCLKState1;
}
```

encoderHandler()

Handle a rotary encoder interrupt by updating position value based on rotation direction.

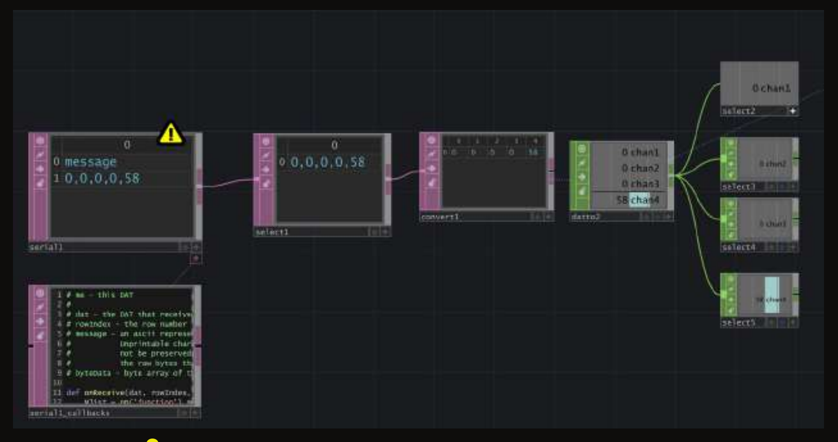
SerialUpdate

```
void serialUpdate(){
  Serial.print(position1);
  Serial.print(",");
  Serial.print(position2);
  Serial.print(",");
  Serial.print(position3);
  Serial.print(",");
  Serial.print(knobValue);
  Serial.print(",");
  Serial.print(sensorLight);
  Serial.print(",");
  Serial.print(sensorTemp);
  Serial.print(",");
  Serial.print(sensorHumi);
  Serial.println(",");
}
```

serialUpdate()

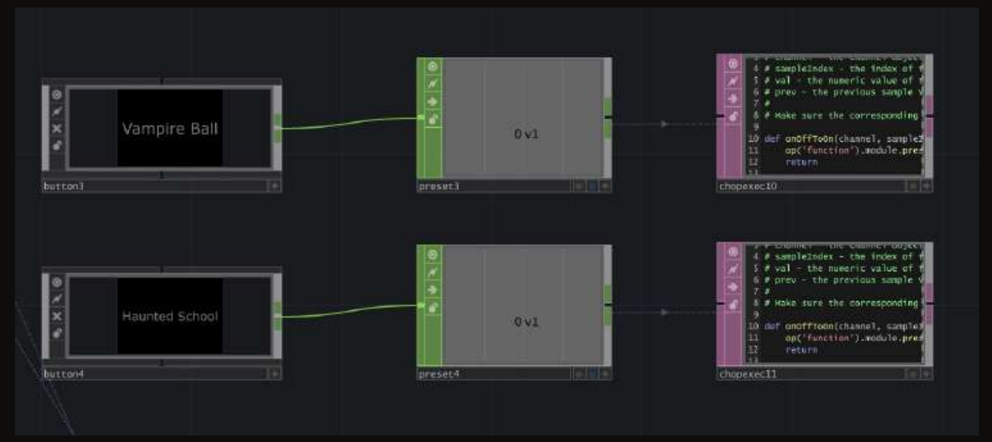
Send data in a predefined structure through serial port.

./Nodes_Modules TouchDesigner



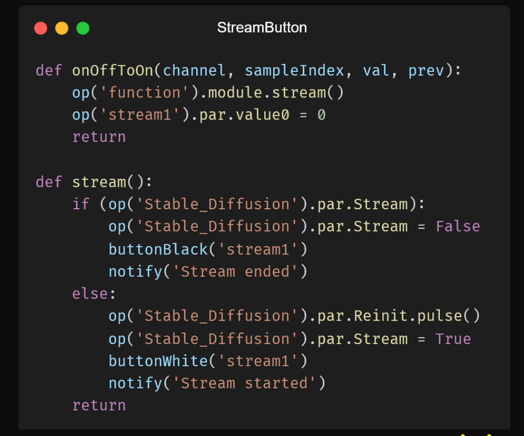
Split Data
Split data received from Serial Port

UI Deployment
Build simple UI using TouchDesigner. Translate Parameter Jargons

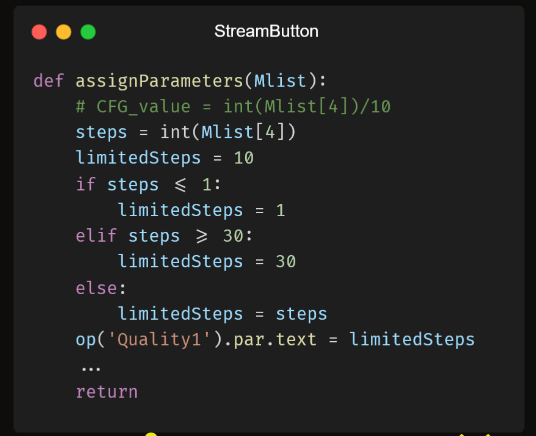


Button
Achieve button function using Python code.

./Code_Snippets Python



buttonPress()
Stream Button Press function code.



assignValue()
Assign received value from serial to TD DAT.

changeValue()
Change parameter value using keyboard in case of emergency.

loadPreset()
Load Preset function can change the prompt and non-sensor parameters in one click.

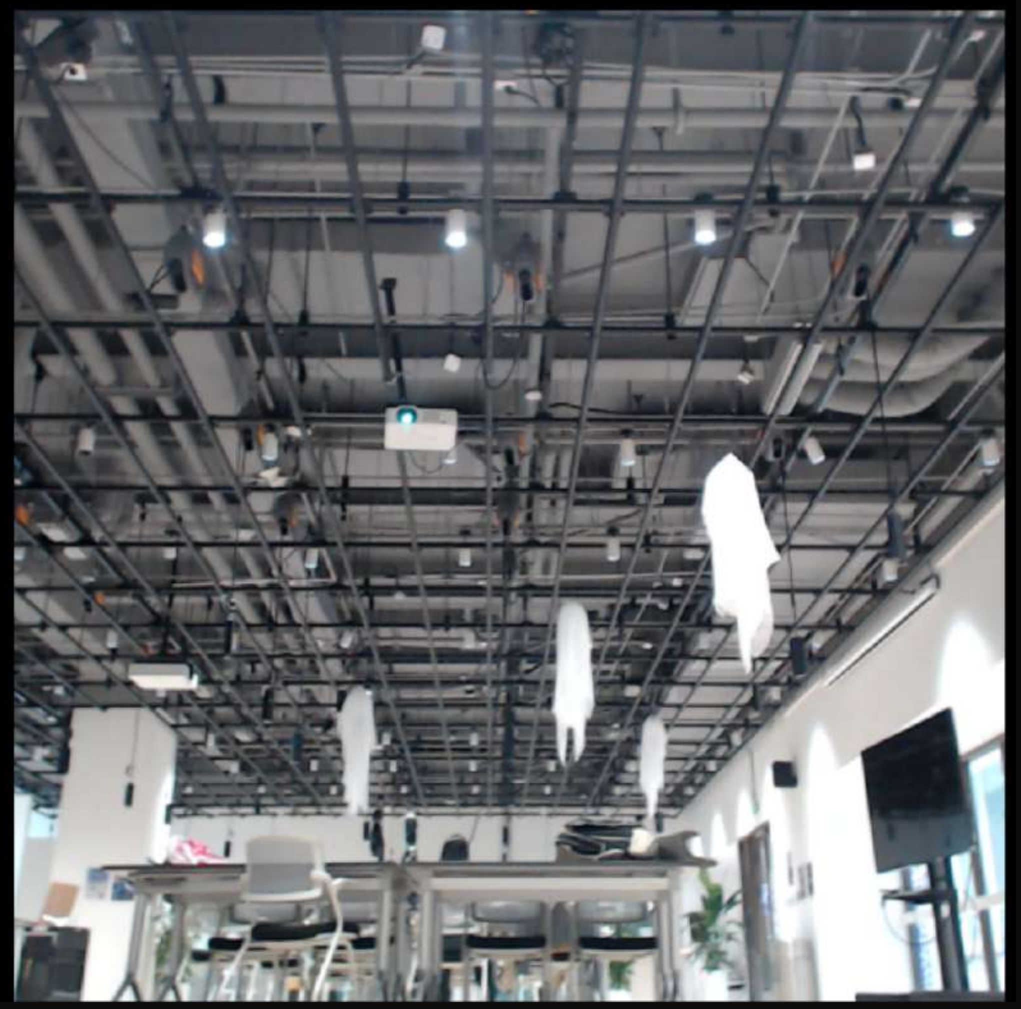
saveImage()
Save favorable generated images into local disk storage with current parameter and time.

OUTCOME

cd Live-Diffusion/Outcome

Generated Images

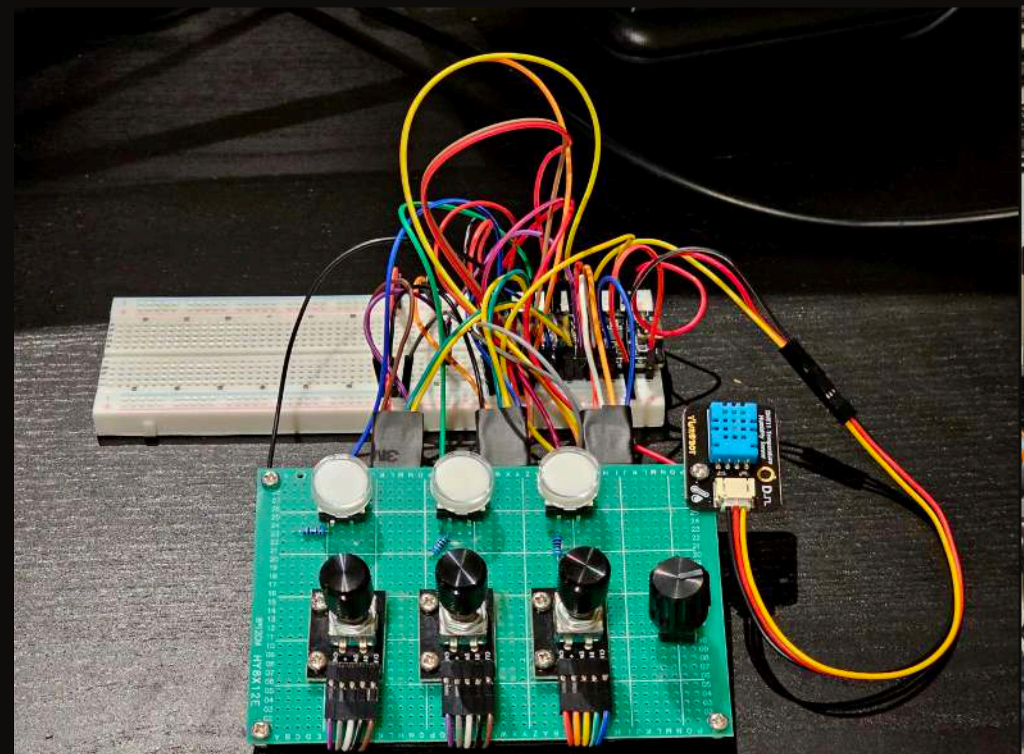
Webcam Images



Sample System User Experience

Presenting @Undergraduate Research Symposium

TouchDesigner



Sensor & Controller

Presenting and Exibiting @IMA Gallery

Exibiting @NYUShanghai Halloween Event

Aegis

Space maintenance drone

In space, EVA maintenance is a very dangerous mission, we propose a space drone based on ION propulsion technology with precise robotic arms, in order to substitute EVA maintenance tasks.

During the project we experimented and optimised ION propulsion technology. When designing the remote control for the robotic arm, we found that the traditional solution was too complicated, and we designed a new set of remote controls for the gimbal.

2024.9.21

Team members:
Hao Shi　Jinran Ye　Sichen Zhen　Zixuan Liu

Background

The original design requirements of space spacecraft are high reliability and easy maintenance.
However, many historical events have shown that aircraft maintenance needs more development.

News

When will Starliner come home? Boeing and NASA still don't know

Stich anticipates resolving the Starliner's helium leak with the mission team this week. Despite challenges, the spacecraft is ready for emergency ISS departure, with 27 of 28 RCS thrusters approved for reentry. The mission's extension is a surprise boon, with Amy Decker, from the chief engineer's office, enthusiastically calling the additional data "AWESOME."

NASA Rejects Jared Isaacman's Plan To Save The Hubble Telescope

NASA considered but rejected a plan to service the Hubble Space Telescope. Mark Clampin, head of NASA's Astrophysics, cited risks in trying to save Hubble and stated they won't enhance it after reviewing commercial options. Clampin appreciated the analysis from the NASA team, SpaceX, and Polaris.

Why is there no good repair plan ?

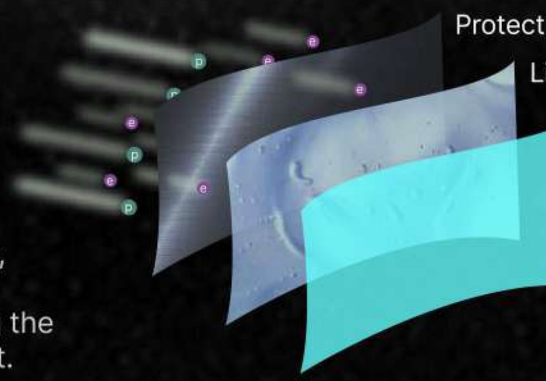
1 Less redundant means of safety protection for astronauts

2 The feasibility of maintenance work for astronauts cannot be accurately assessed

3 The cause of the fault is not clear

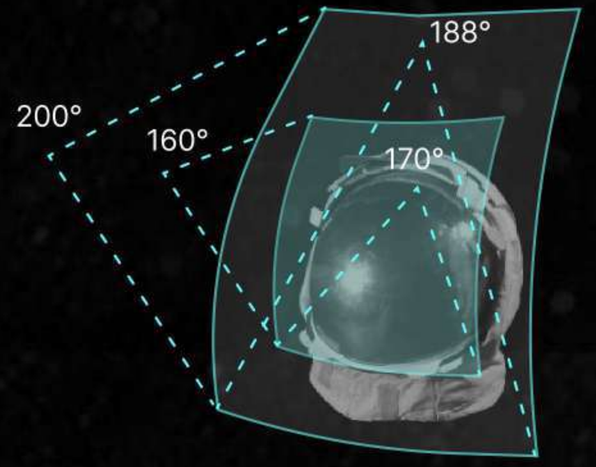
1.1
Intense Radiation

Radiation can cause **embrittlement**, **decomposition**, or other physical changes in materials, compromising the structural integrity of the spacecraft.



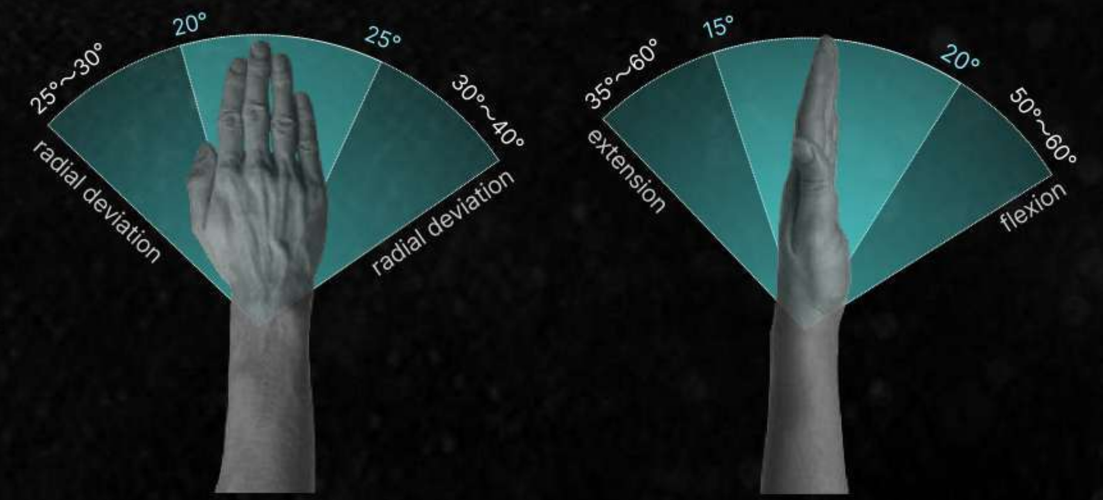
2.1
Limited Vision

Astronauts need helmets to maintain the internal air pressure of the spacesuit, the glass cover inevitably limits the field of view. After wearing the helmet, **the field of vision will be reduced to 60%** of that without the helmet.



2.2
Limited Movement

Gravity forces the blood in our bodies to flow downward, and in space, this process becomes chaotic, **leading to edema**. This can lead to vision changes such as decreased sharpness and structural changes in the eye itself.



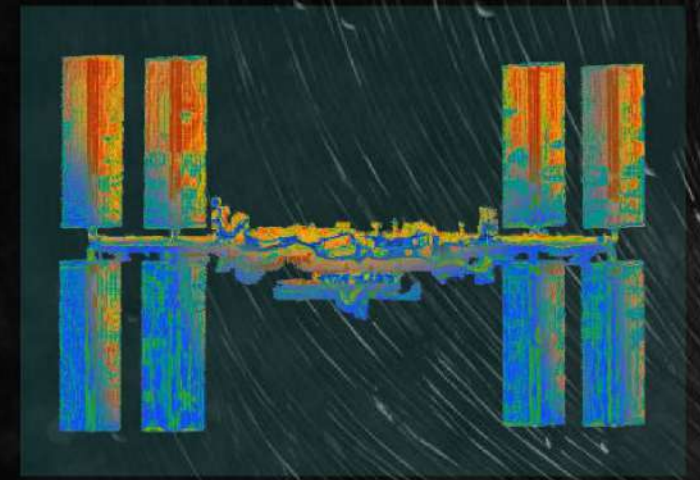
3.1
Life Expires

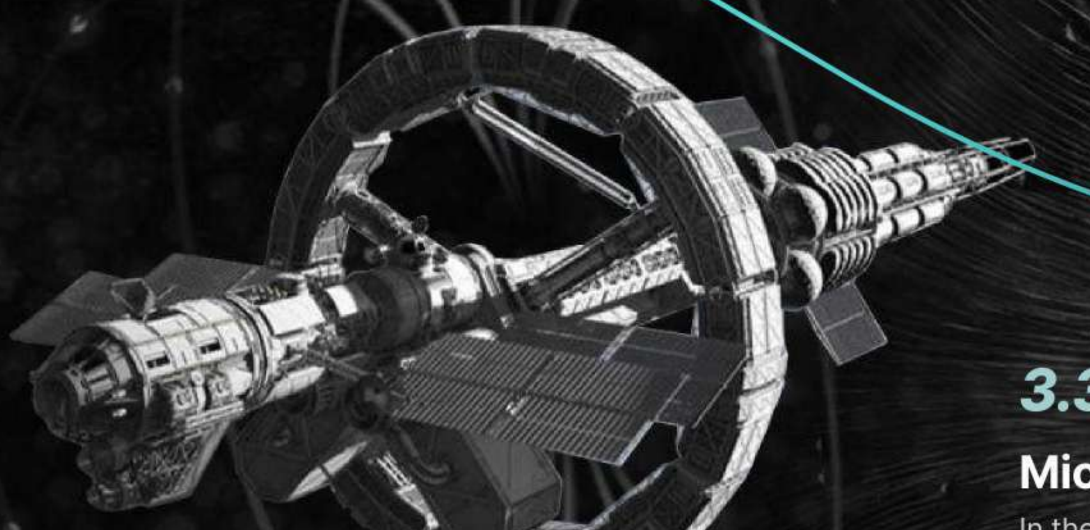
Spacecraft operating in low Earth orbit, the design life is generally **5-10 years**, through maintenance and maintenance, can extend its life to more than **15 years or even longer**.

Spacecraft operating in low Earth orbit, the design life is .

3.2
Ultralow Temperature

At extremely low temperatures, some of the materials used by aircraft may **become weak**, resulting in reduced carrying capacity and vulnerability to damage.





3.3
Microgravity

In the microgravity environment, maintenance equipment and parts are floating around in space, and astronauts **must perform maintenance work** while keeping many tiny items under control

Discovery

Due to technical limitations, there is no safe and reliable maintenance program seems to be a major reason to hinder the development of space work

Reduce the threats humans face during spacewalks

Enhance the data collection capability when faults occur

Data source: BBC News, Pengpai News, The conversation,VOI

Research

What is the maintenance process of serving spacecraft ?

Risk Of Lossing Pressure

The preparation process for leaving the craft is complicated, air leakage may occur, and astronauts may face **explosive loss of pressure** and be **sucked out** of the spacecraft.

4 major preparation process

Equipment Inspection | Tool Preparation | Psychological Counseling | Implement

Why Robotic Arm is Cumbersome ?

Risks And Benefits Coexist

The existing robotic arm is a bulky and complex component that cannot be discarded as part of the spacecraft, even if it malfunctions.

High Technical Complexity

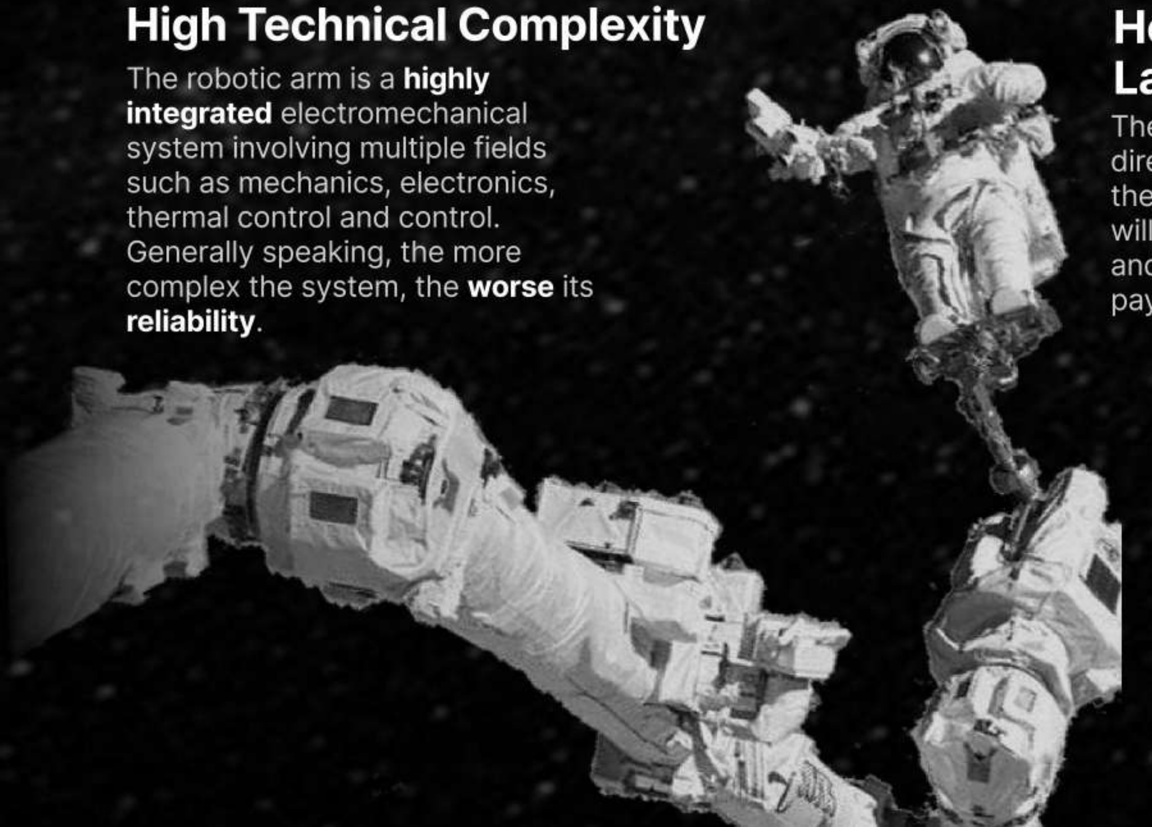
The robotic arm is a **highly integrated** electromechanical system involving multiple fields such as mechanics, electronics, thermal control and control. Generally speaking, the more complex the system, the **worse** its **reliability**.

Heavy Weight And Large Size

The weight and size of the robotic arm directly affect its installation and use on the spacecraft. An overweight robotic arm will **increase the burden** on the spacecraft and **affect** its overall **performance** and payload.

High Operational Complexity

The operation of robotic arms requires precise control and coordination, especially when performing delicate operations and complex tasks. Operators need to undergo rigorous training and **practice to master** the operating skills of the robotic arm.



Sending people to space is very expensive

It is not an efficient way to deploy additional personnel to go into space to perform spacecraft maintenance tasks.

Programmability

Machines can be programmed as needed to adapt to different job requirements, whereas human skill transfer often takes time and training

Fuel Supply

Machines are essentially goods, and there are fewer conditions to consider than sending them to heaven.

High Compatibility

There is no need to think too much about carrying machines or cargo into space, and there is no need to change the overall design of the rocket.

Remote Sensing Control

Remote control operation and deployment through base stations such as ground stations or space stations

High Certainty

With proper planning and operators, machines can continue to work at high intensity and are easier to control than humans.

Long Term Period

Astronauts need to undergo lengthy training
Meet the requirements for space maintenance

Basic Training
300～600h

Professional Training
300～600h

Training an astronaut requires a lot of manpower, material resources and time. It is very irrational for astronauts to go out and face danger.

Crew seating arrangements, life support systems, and astronaut comfort need to be considered

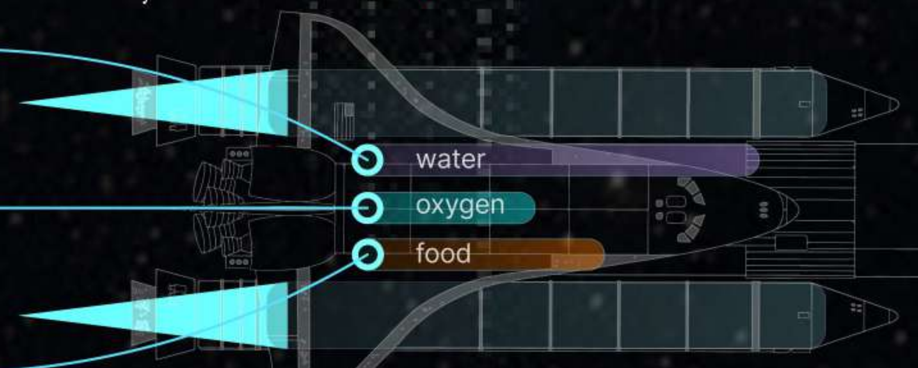
High Cost

The material consumption of each astronaut

2.5kg
drinking water per day

550liter/0.9kg
oxygen consumption per day

0.6kg
The weight of food for one astronaut is 0.6 kilograms per day



Describes the relationship between a rocket's speed and its mass, fuel consumption rate, and exhaust velocity

$$\triangle V = Ve\ ln\,(\frac{m_i}{m_f})$$

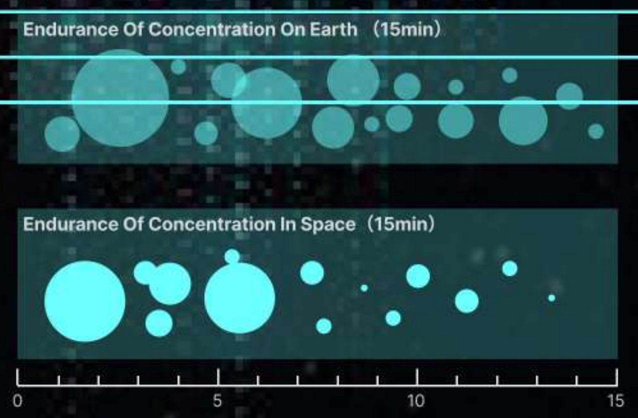
The more astronauts we put into space, the longer the missions, the heavier the payloads will be, and the rockets will be **incredibly expensive**.

Control Capture

The spacecraft is controlled manually or automatically to approach the target, but the risk of collision is always there and the astronauts may be in danger

Limited Working Hours

The concentration time is only about **10 min**, if you have to force yourself to concentrate, then **15 min** is already the limit.
Not to mention we are in space

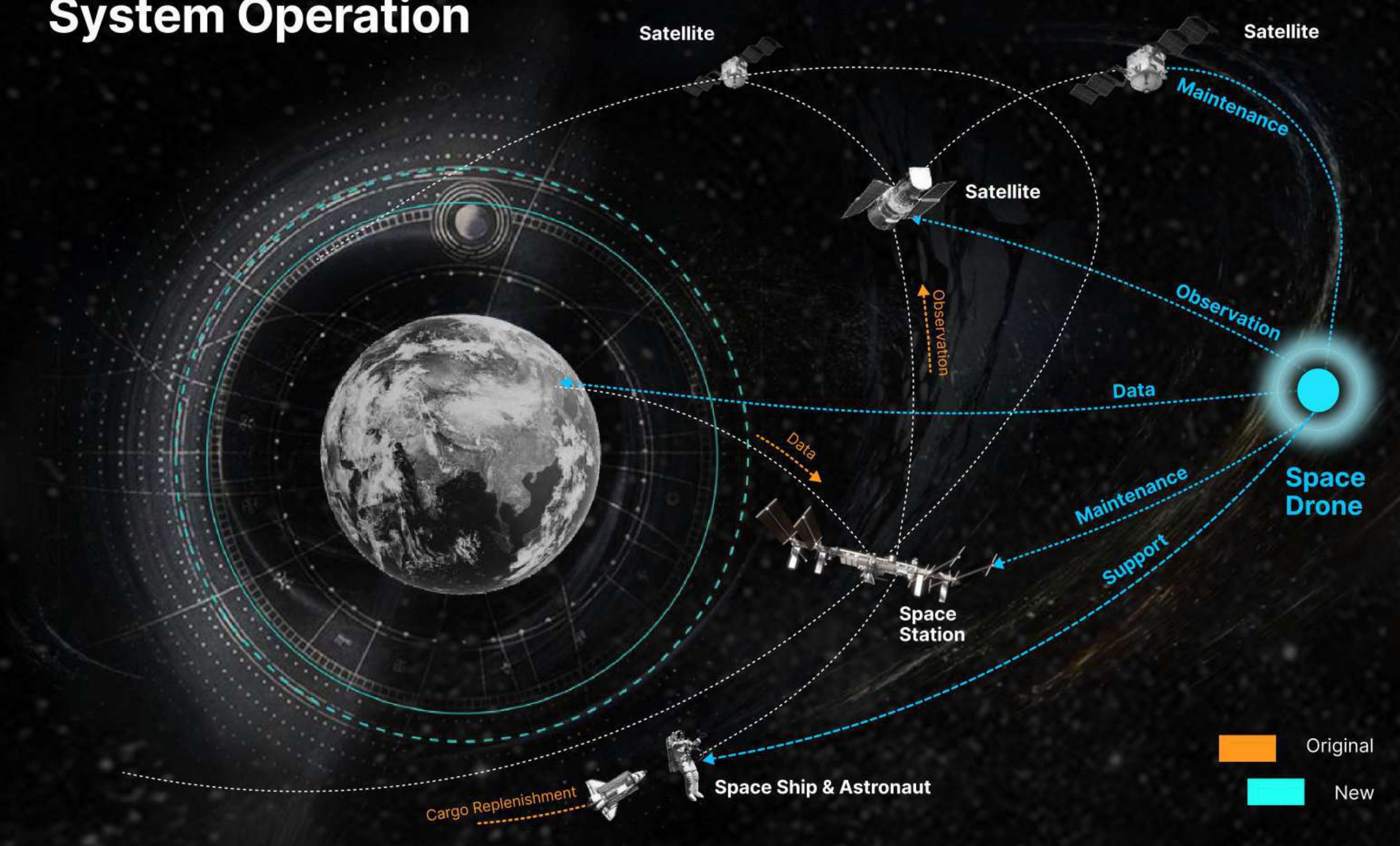


HOW might we

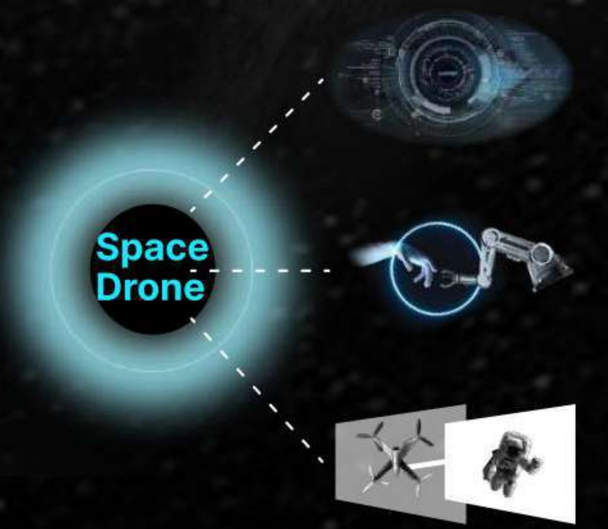
A drones with robotic arms can be used to perform repairs instead of humans

Concept

System Operation



Ideation



Enhanced Observation
Have more information collection capabilities, free angles, and multiple technical means to perceive and observe failures of artificial satellites

Precise Arms
Using a drone equipped with a robotic arm that can interact in real time ,remotely operated in the space ship or even on the ground.

Enhanced Safety
Efficient and flexible maneuverability, when astronauts encounter danger or need assistance during extravehicular walking,Space drones could provide support and bring back rescues

Designated

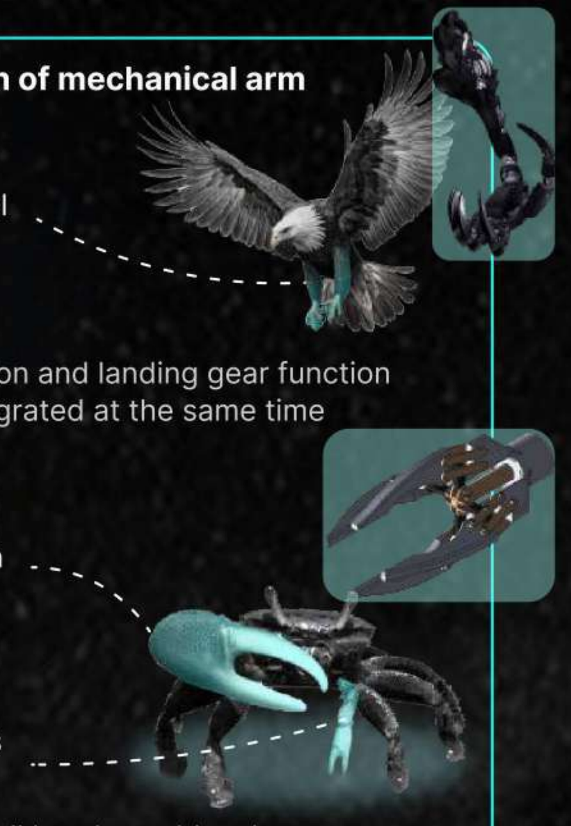
1 Provide More Observation Methods

2 The Robotic Arm Needs To Be Easier To Operate

3 Provide One More Mean Of Protection

Sketch

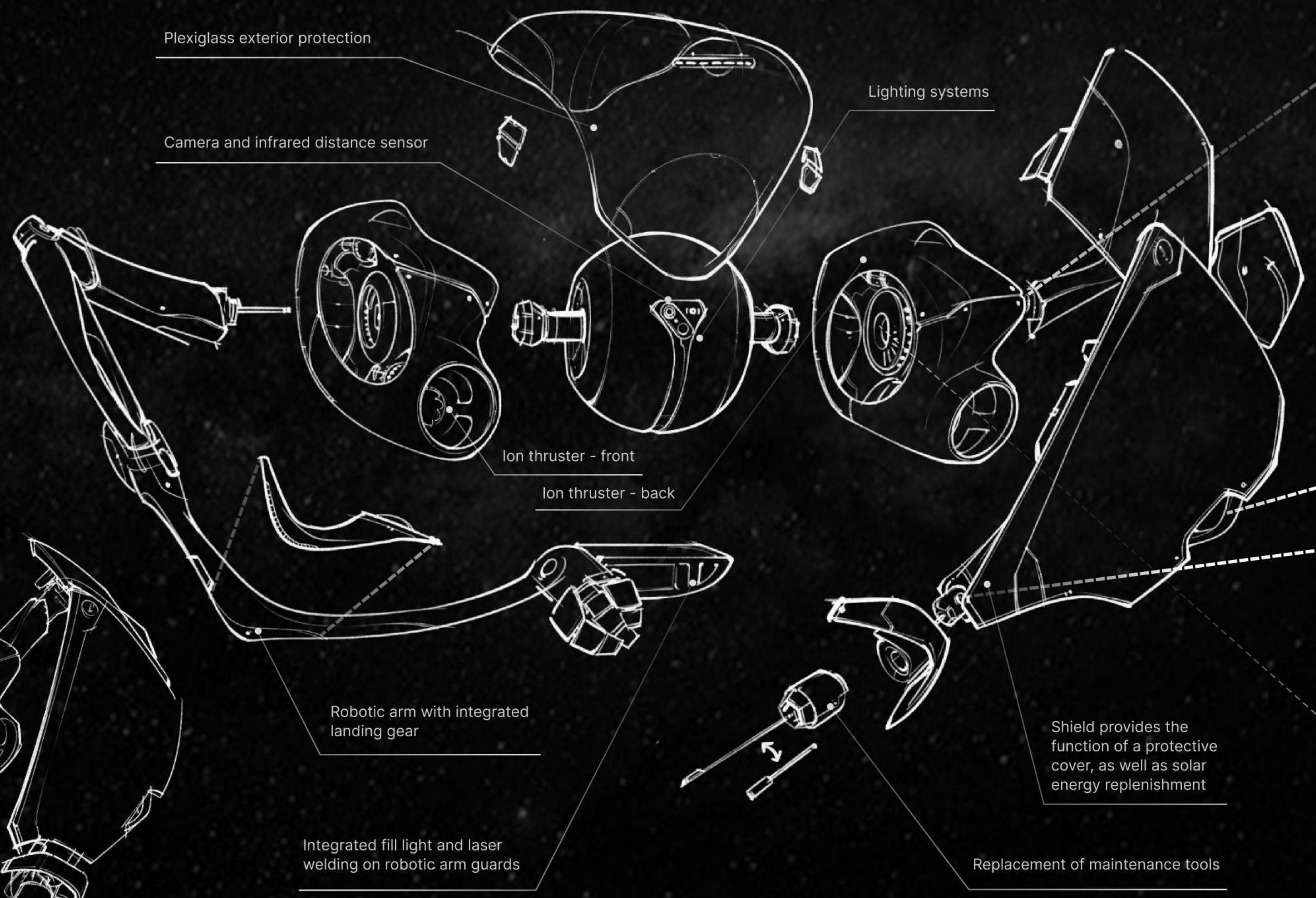
Inspiration of mechanical arm



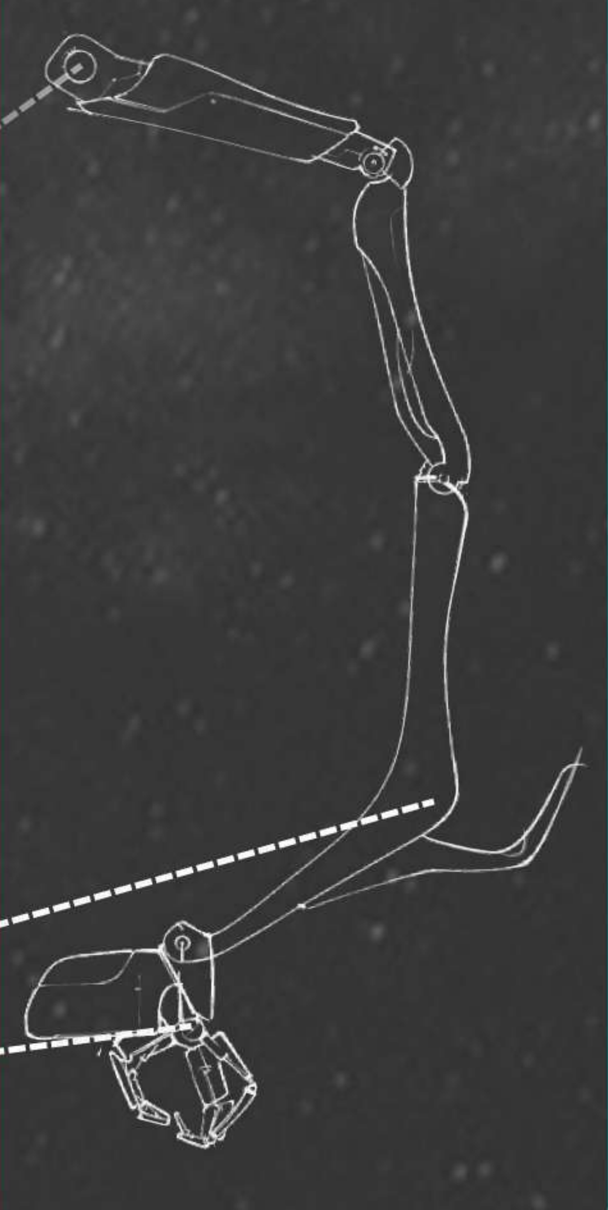
Big and small hands could make space repair missions more flexible

Complete Machine

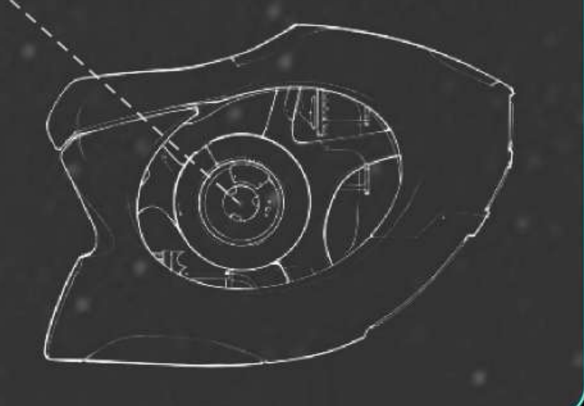
Exploded Diagram



Mechanical arm (without shield)

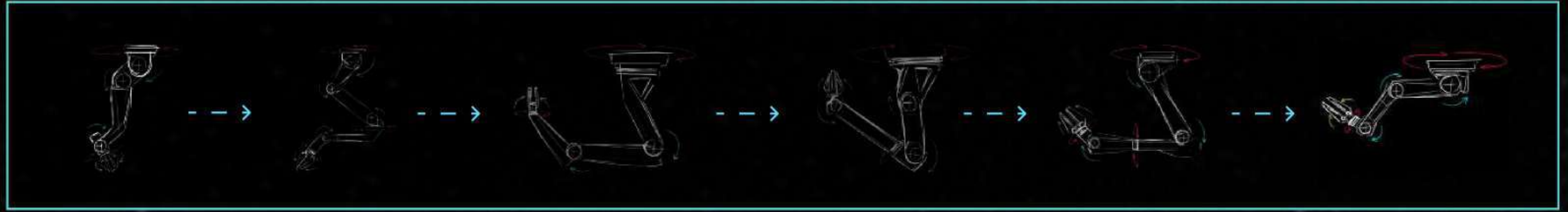


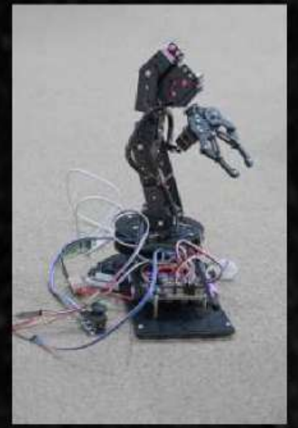
ION thruster power unit



Testing And Modeling

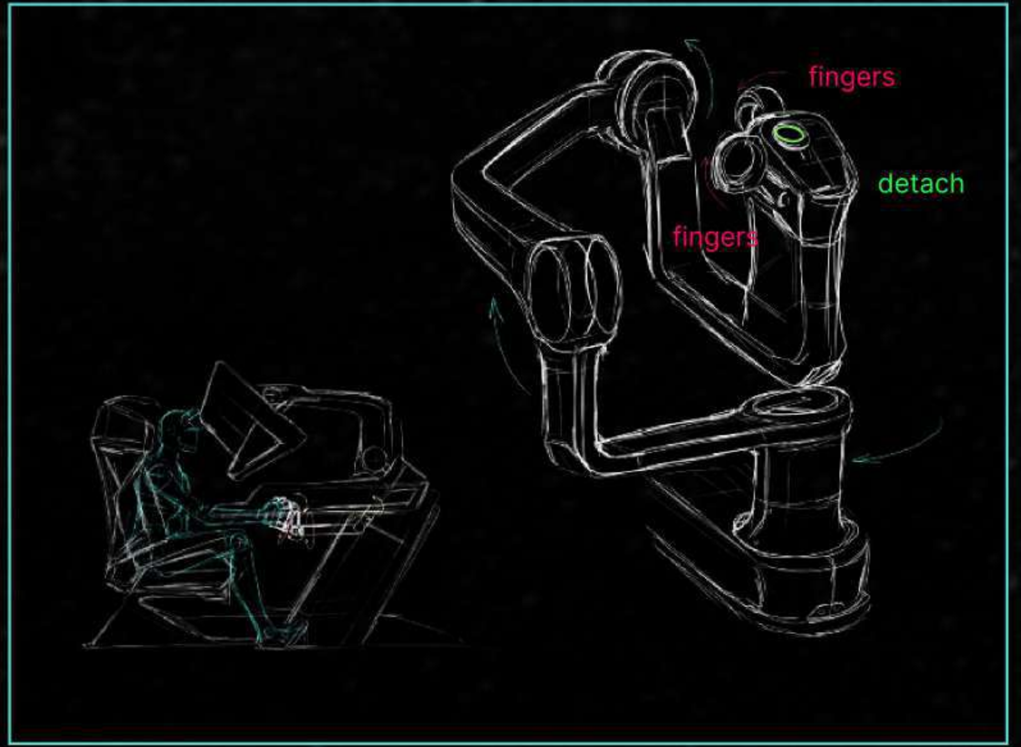
Exploration Of Robotic Arm Forms

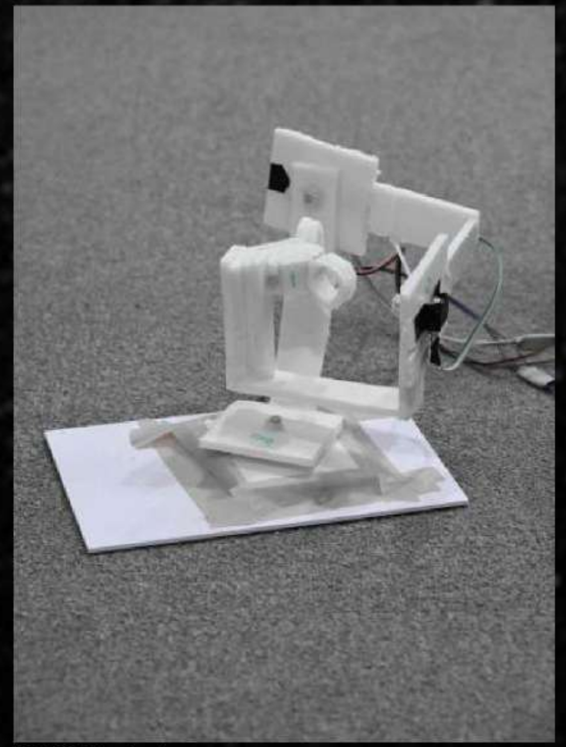




Different arm span lengths, different shaft placement positions, different gripping methods, and different storage and folding methods

Exploration Of Robotic Arm Operation Methods

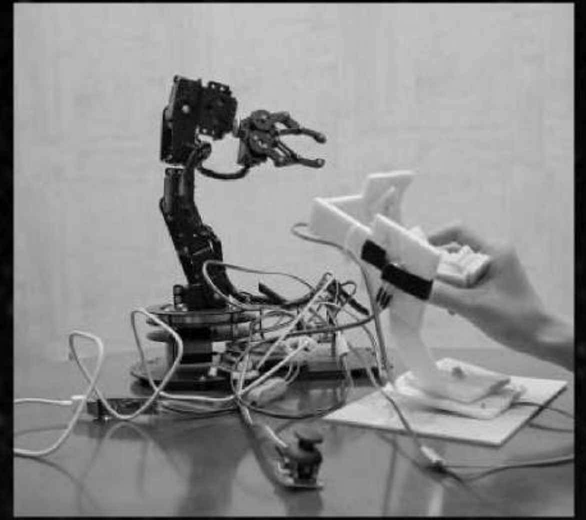




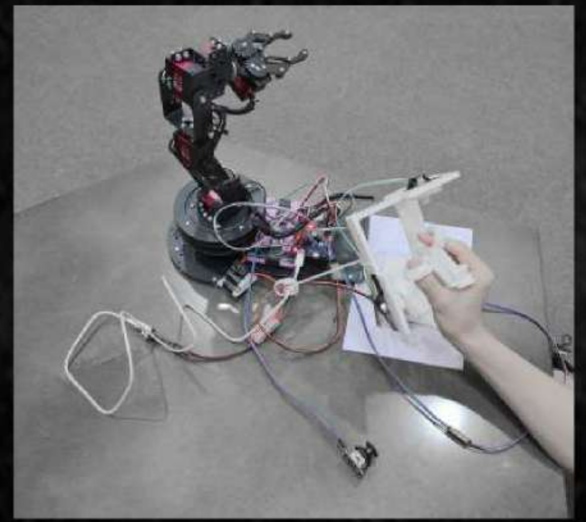
PVC Prototype

The workings of a professional camera gimbal provided the inspiration, and with a total of four angle sensors, the gripping function on the robotic arm has been fully realised. Operator training time should be cut down somewhat compared to the joystick style of remote control currently used on the Space Shuttle.

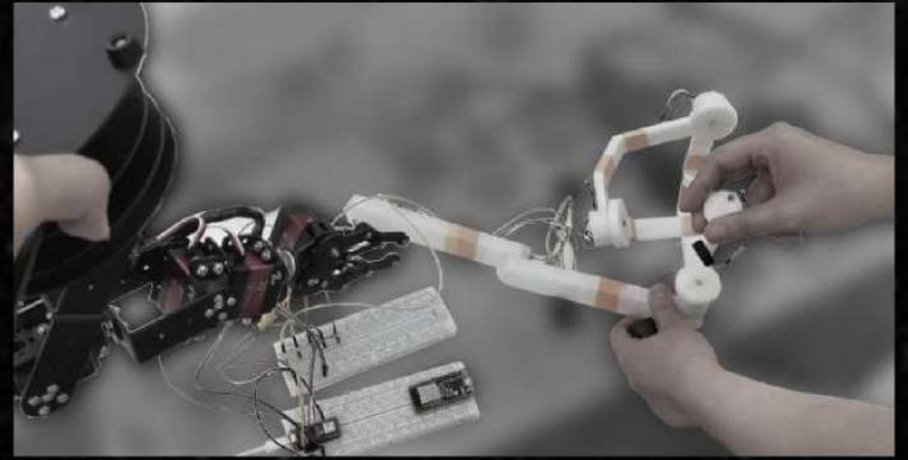
Use In Combination



When wired, the input angle of the gimbal can be transmitted to the robotic arm in real time. Considering that we are testing on the ground and there is a gravity factor, when actually used in space, the servo will respond more quickly



With the wireless module connected, off-site operation is already possible.



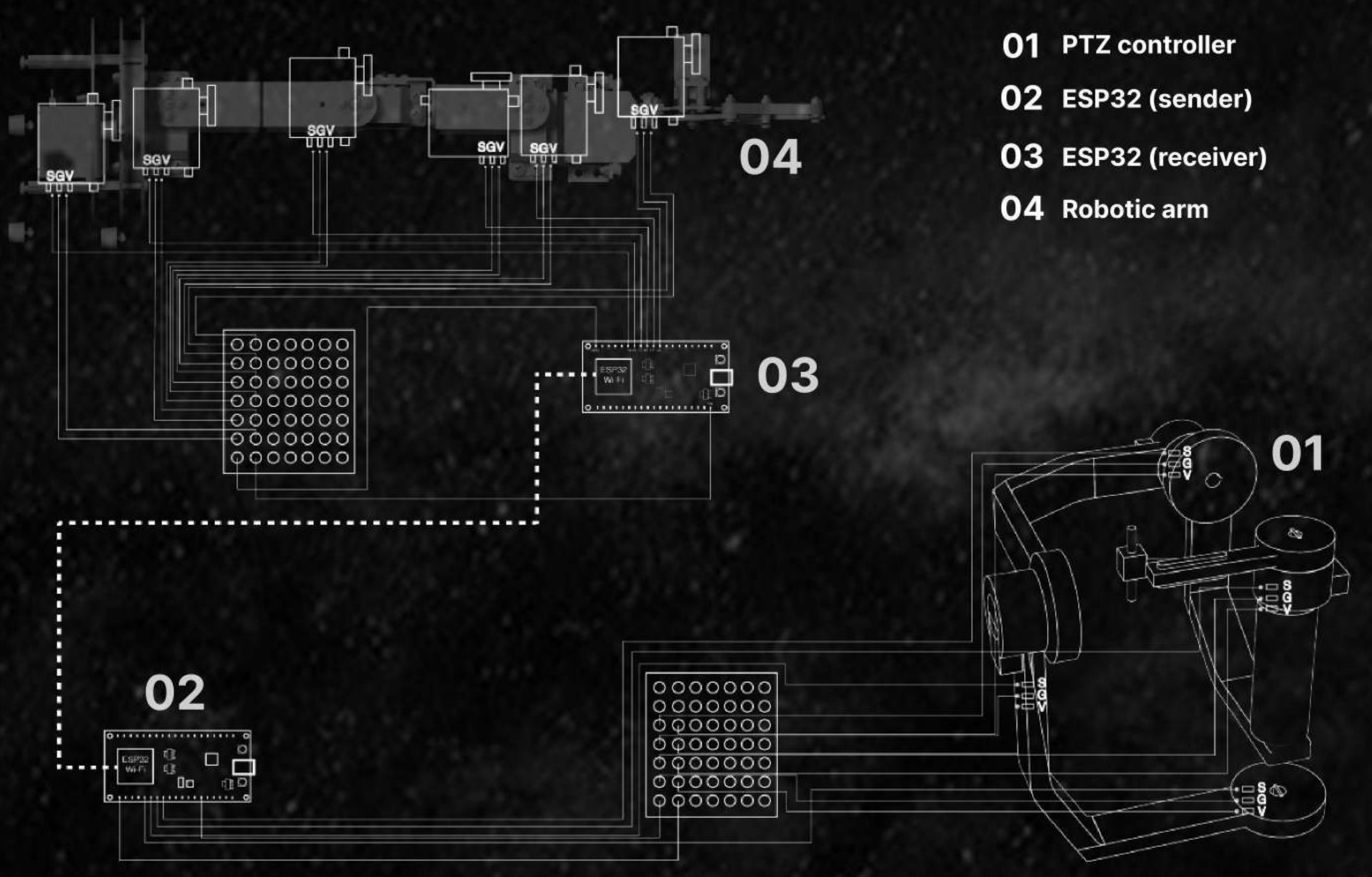
Precise Operation

Due to the use of angle sensors and the ergonomic position of each sensor's pivot, it is less prone to misuse than a joystick.

Intuitive Operation

Because of the camera gimbal-like shape, it's easy to understand how it works at a glance, with the pinching action of the thumb and index finger performed by two pivot arms and an angle sensor.

Coding



01 PTZ controller
02 ESP32 (sender)
03 ESP32 (receiver)
04 Robotic arm

1. Sensor Angle Mapping

```
void setup() {
 pinMode(ServoSensor6R,INPUT);
 pinMode(ServoSensor3R,INPUT);
 pinMode(ServoSensor2R,INPUT);

 ...
 }

void loop() {
  int ServoSensor2R_RawData = analogRead(ServoSensor2R);
  int ServoSensor3R_RawData = analogRead(ServoSensor3R);
  int ServoSensor6R_RawData = analogRead(ServoSensor6R);
  int ServoSensor2R_Fixed = map(ServoSensor2R_RawData, 0, 4095, 0, 270);
  int ServoSensor3R_Fixed = map(ServoSensor3R_RawData, 0, 4095, 0, 540);
  int ServoSensor6R_Fixed = map(ServoSensor6R_RawData, 0, 4095, 0, 270);
  int ServoSensor2R_Maped = map(ServoSensor2R_Fixed, 0, 270, 270, -90);
  int ServoSensor3R_Maped = map(ServoSensor3R_Fixed, 0, 270, 0, 270);
  int ServoSensor6R_Maped = map(ServoSensor6R_Fixed, 0, 270, 270, 45);

  ...
  }
```

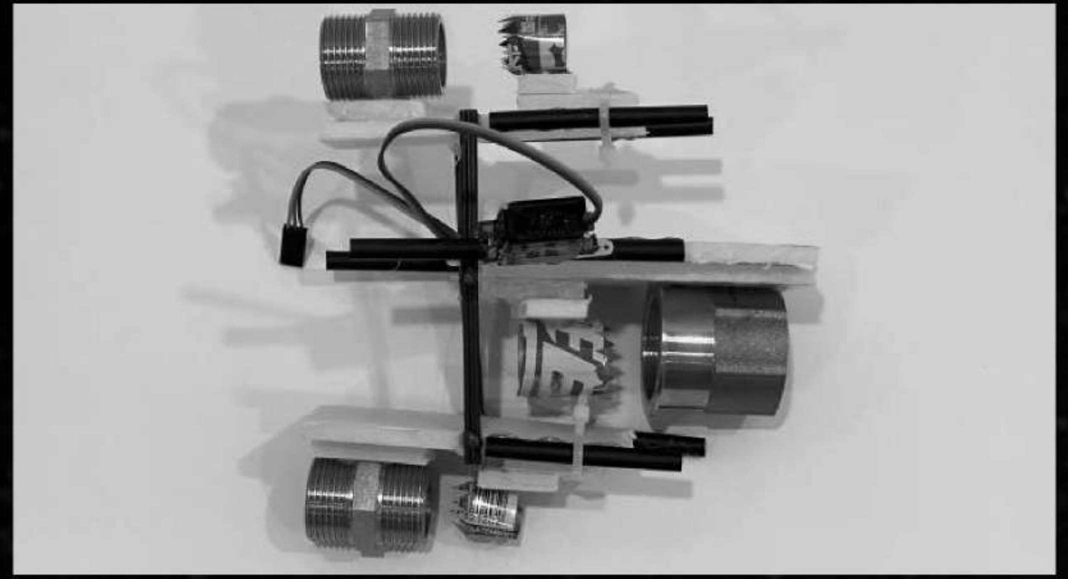
2. Servo Control

```
//Servos Define
//19 s6r ; 18 s3r ; 5 s2r ; 21 s4r ; 15 s5r ; 17 s1r ; 16 YI ; 4
ZI ;
int s1r = 17;
int s2r = 5;
int s3r = 18;
int s4r = 21;
int s5r = 15;
int s6r = 19;

Servo Servo6R;
Servo Servo5R;
Servo Servo4R;
Servo Servo3R;
Servo Servo2R;
Servo Servo1R;
```

3. Communication Between Microcontroller

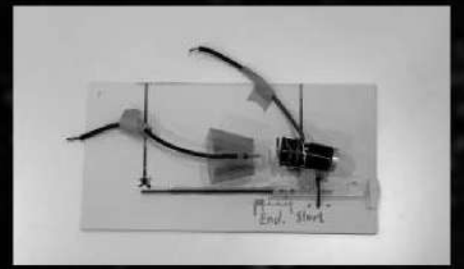
```
//RECEIVER MAC Address
uint8_t broadcastAddress[] = {0×78, 0xEE, 0×4C, 0×00, 0xA8, 0×28};

// Structure example to send data
// Must match the receiver structure
typedef struct struct_message {
   char a[32];
   int Sensor2R;
   int Sensor3R;
   int Sensor6R;
} struct_message;

// Create a struct_message called myData
struct_message myData;

esp_now_peer_info_t peerInfo;

// callback when data is sent
void OnDataSent(const uint8_t *mac_addr, esp_now_send_status_t status) {
  Serial.print("\r\nLast Packet Send Status:\t");
  Serial.println(status == ESP_NOW_SEND_SUCCESS ? "Delivery Success" :
"Delivery Fail");
}
...

// Set device as a Wi-Fi Station
WiFi.mode(WIFI_STA);

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

// Once ESPNow is successfully Init, we will register for Send CB to
// get the status of Trasnmitted packet
esp_now_register_send_cb(OnDataSent);

// Register peer
memcpy(peerInfo.peer_addr, broadcastAddress, 6);
peerInfo.channel = 0;
peerInfo.encrypt = false;

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

ION Propulsion Power Unit Experiment



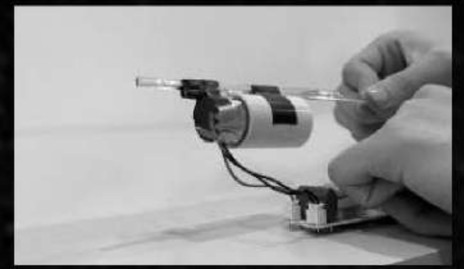
Final Power Unit

Testing Of Ion Thruster



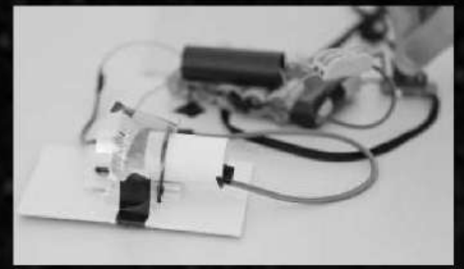
First Try
Use needle-shaped negative electrode to excite electrons and tested the distance between the positive and negative electrodes

Wind Speed 1.2m/s
Stability



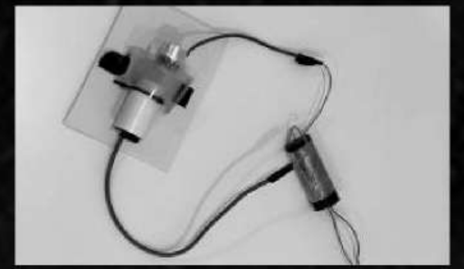
Second Try
Experiment with zigzag electrodes to study the impact of electrode shape on ion excitation efficiency

Wind Speed 1.7m/s
Stability



Third Try
Testing the impact of fairing shape on ion excitation efficiency

Wind Speed 2.1m/s
Stability



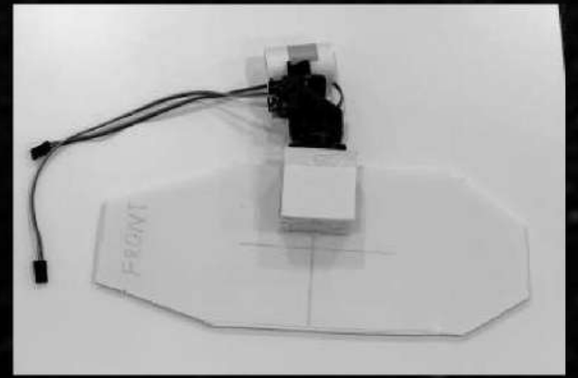
Fourth Try
Tested larger voltages, impact on efficiency and stability

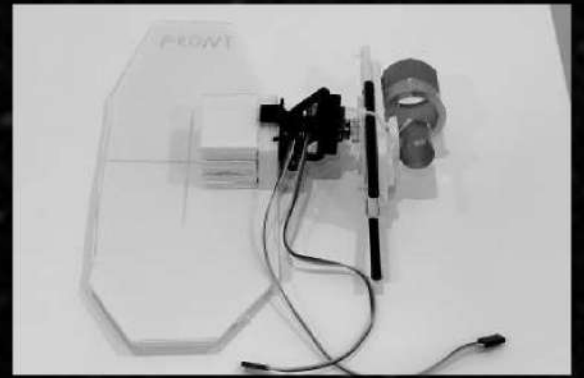
Wind Speed 2.1m/s
Stability

Final
The combination of sawtooth and venturi electrodes can produce ideal thrust

Wind Speed 3.4m/s
Stability

Servo Design





In terms of power design bilateral total of 6 ion thrusters are used, 4 for forward propulsion and 2 for reverse, so only one 180 degree servo is needed on a single side to achieve - yaw angle, roll angle, pitch angle change.

User Interface

Menu - Tool Settings

The carousel-style interaction allows for quick access to the drone's functions.

The left dial is responsible for adjusting the drone's settings, the dial on the right is responsible for switching the tools on the robot arm.

Rescuing Astronaut From Losing Control

In rescue mode, the flight guidance HUD switches, with the locked astronaut highlighted in red, the rescue target's vitals and communication status on the right, and radar and flight parameters on the left.

Flight Control

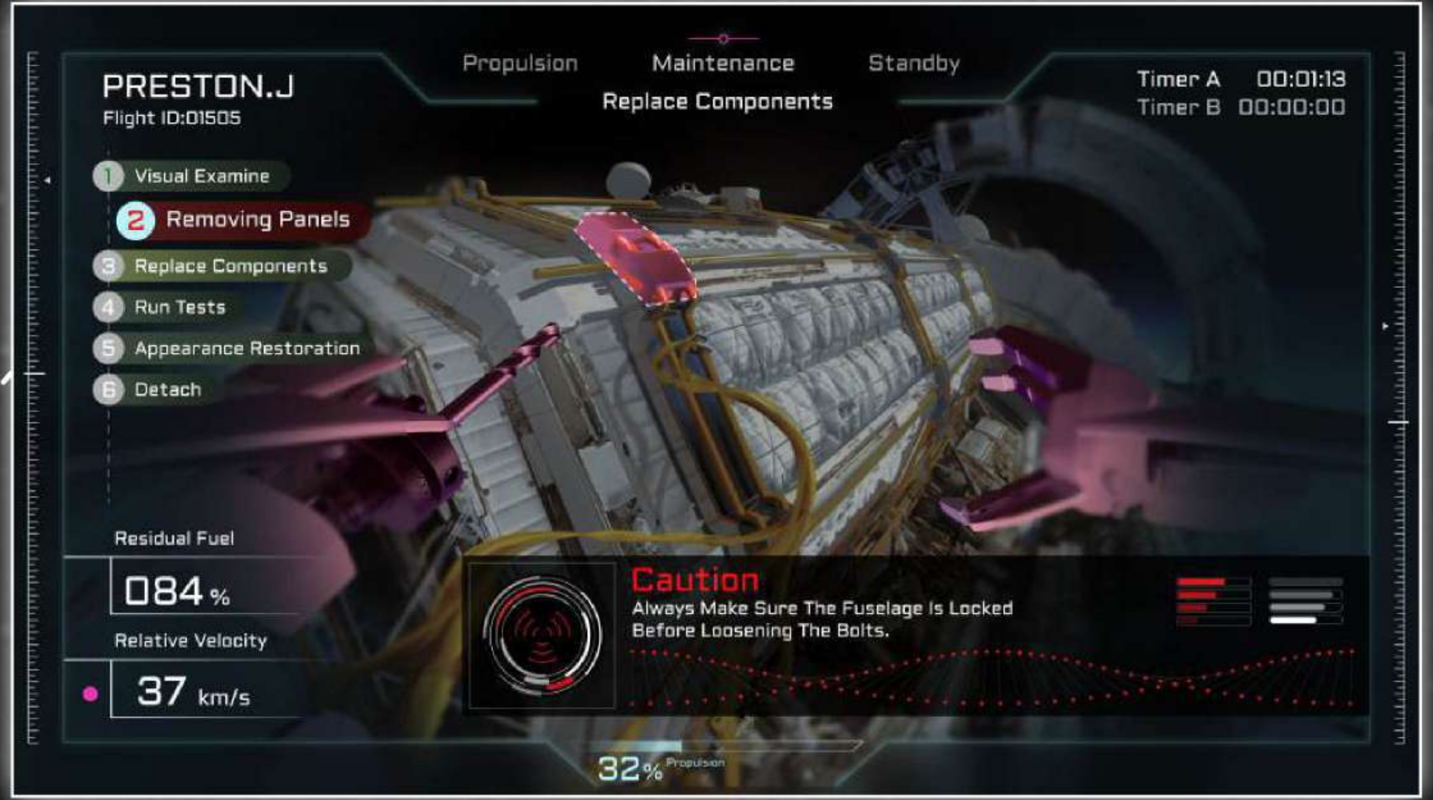
While flying, the pilot can precisely control the direction of the drone's movement by aligning the blue guidance box and the ring pointer.

The left side of the interface will show the remaining fuel, relative speed to the target. The right side will show the operating status of the six thrusters.

Maintenance Operating

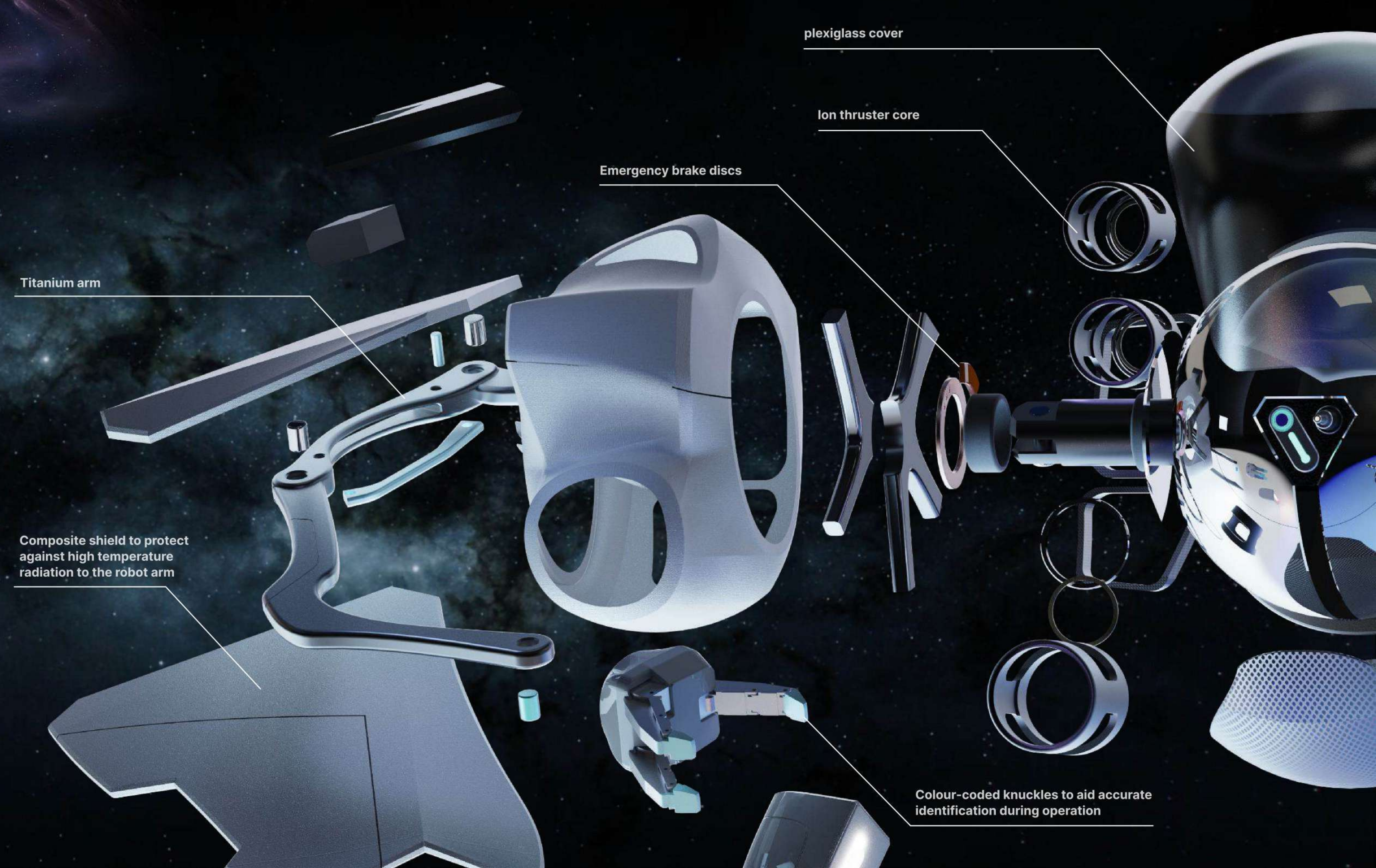
When performing a repair mission, the target to be repaired will be highlighted in red, and the body of the drone is also displayed in red to help the pilot distinguish the boundaries and prevent collisions.

The left side of the interface will show the flow of the mission, and the bottom side will display mission-related information.



Final Outcome

Exploded Diagram



Gaudi - Vision

Inspiration

Wuhan Architecture



Style of Gaudi's Architecture



AI Image Generation Model

OpenAI
DALL-E

Stable Diffusion
Model

Google
DeepDream

Background

Gaudí's Biographical Overview

Antoni Gaudí was born on June 25, 1852, in Reus, Catalonia, Spain, into a family of coppersmiths. He moved to Barcelona for his studies in architecture at the Provincial School of Architecture, graduating in 1878. Gaudí's career is inextricably linked with Barcelona, where his most notable works are located. His unique approach to the Modernisme movement, which incorporated a variety of styles and techniques, along with his devotion to nature, religion, and Catalan culture, distinguished him early on. Gaudí's architecture evolved significantly over his lifetime, from a Victorianism style to more natural and organic forms that defined his later works. Despite facing criticism for his avant-garde style during his lifetime, Gaudí's legacy has grown substantially over time, and he is now celebrated as a visionary in modern architecture. His contribution to the Modernisme movement and his innovative use of materials and structural solutions have cemented his status as one of the most influential architects of the 20th century.

Key Features of Gaudí's Style

Gaudí's architectural style is distinguished by its integration of natural forms, vibrant colors, textured surfaces, and organic shapes. He was inspired by his deep appreciation of nature, which is evident in the fluidity and organic quality of his designs. Gaudí often employed the use of trencadís, a mosaic made from broken tile shards, to add vibrant textures and colors to his buildings. This technique, along with his innovative use of materials like ironwork for ornamental purposes, became hallmarks of his work. Gaudí's architecture is also known for its complex geometric forms, which were often inspired by natural structures, contributing to the unique and unmistakable style that defines his contribution to the Art Nouveau movement.

Philosophical and Inspirational Underpinnings

Gaudí's work was deeply influenced by his religiosity, a profound fascination with nature, and the integration of Catalan cultural symbols. His devout Catholic faith inspired the spiritual symbolism that permeates his work, particularly evident in the Sagrada Família. Gaudí's observation of nature influenced his architectural forms and structures, leading him to mimic natural shapes and utilize them in innovative structural solutions. Additionally, Gaudí's designs often include elements of Catalan nationalism, reflecting his pride in his heritage. These influences combined to create a body of work that is both deeply personal and universally appealing, marking Gaudí as a pioneer in integrating philosophical and cultural dimensions into architectural design.

Key Features of Gaudi's Style

Catenary Arches and Parabolic Structures

Gaudí utilized the catenary arch, which is the curve that a chain or rope forms when supported at its ends and acted upon by gravity. This principle was used to create structures that are both aesthetically pleasing and architecturally sound, evident in many of his works.

Organic and Natural Forms

Gaudí often drew inspiration from the natural world, mimicking the shapes and structures found in nature. His work is characterized by curves, undulating lines, and forms that reject rigid geometric shapes in favor of those that reflect the irregularity and elegance of nature.

Structural Innovation

Gaudí was not only an artist but also a pioneer in structural engineering. He experimented with new construction techniques, such as using tilted columns and hyperbolic paraboloid structures, to achieve both strength and aesthetic uniqueness.

Material and Color Harmony

Gaudí also had a keen eye for selecting materials that naturally possess vibrant colors, such as the use of different types of stone, ceramics, and glass. He combined these materials in ways that their natural colors complemented the overall palette of his designs, as seen in the Casa Vicens, where the use of brightly colored tiles contrasts with the natural tones of the brick and stone.

Trencadís Mosaics

Gaudí extensively used trencadís, a technique involving broken pieces of ceramic tiles, glass, or stone, to create vibrant mosaics. This technique allowed him to play with color in an almost painterly fashion, creating vivid, textured surfaces that catch the light and bring his structures to life.

Symbolism

Gaudí's buildings are rich in Christian symbolism and personal reflections. Incorporating symbolic elements can add layers of meaning to a structure, making it not just a building but a narrative in stone and mortar.

AI Generative Image

Overview of Artificial Intelligence in Art

- 1956 — Apperence of the term *"Artificial Intelligence"*
- 1960s — Early Algorithmic Art
- 1970s — Expansion of AI in Creativity
- 1980s — Integration with Digital Tools
- 1990s — The Internet and Neural Networks
- 2000s — The Age of Machine Learning
- 2010s — The Rise of Generative Models
- 2020s — AI Becomes a Medium
- Today

Relevant AI Techniques

For a project aiming to emulate Antoni Gaudí's architectural style using AI, specific technologies such as neural networks, deep learning, and style transfer techniques are pivotal. Neural networks can analyze Gaudí's designs to understand the underlying patterns and characteristics unique to his style. Deep learning allows the AI to process these complex datasets, improving its ability to generate accurate representations over time. Style transfer, a technique used to apply the stylistic elements of one image to another, could be directly applied to architectural designs, enabling the AI to reimpose Gaudí's distinctive aesthetic onto modern architectural forms. These technologies collectively facilitate the AI's ability to interpret and replicate Gaudí's complex artistic style in architecture, offering a new lens through which his work can be appreciated and extended.

Ethical and Aesthetic Considerations

Using AI to recreate or innovate upon human artistic styles raises several ethical and aesthetic considerations. Questions of authorship and authenticity emerge, particularly concerning the originality of AI-generated works and their fidelity to the human artists' intentions. The preservation of artistic integrity is also a concern, as the use of AI challenges traditional notions of creativity and the artist's unique touch. Projects like this navigate these issues by focusing on the collaborative aspect of AI in the creative process, viewing AI as a tool that extends the human capacity for innovation rather than replacing it. Ethical guidelines and transparent methodologies can help maintain the balance between honoring the original artist's legacy and exploring new creative frontiers.

Project Concept

From Gaudi Style to AI Generation and Interactivity

Develope AI Model
- Data preprocessing
- Model training with Gaudi-style images
- Identification of key stylistic elements
- Integration of artistic vision

User feedback to improve model

User Input
- Customization of designs
- Interactive refinement of generated images

AI-Generated Gaudi-Style Images
- High-detail images
- Consistency with Gaudi's style

Objective
- Capture the spirit of Gaudi's architecture
- Recreate Gaudi's style in new designs

Applications and Impact

Creative exploration in architecture

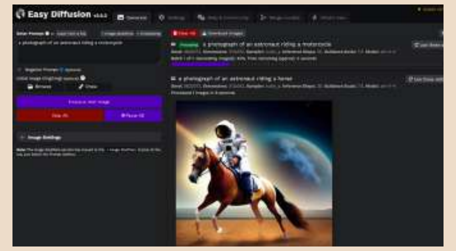
Accessible design capabilities

Keeping Gaudi's legacy alive

Modeling Process

1. Choose Diffusion Backend

To make the AI re-drawing function work, I first experiment with several ways that can make it work. And Choose the one with the best performance.



ComfyUI	Easy Diffusion	Automatic1111
Pros:	**Pros:**	**Pros:**
Powerful & Customize	Intuitive UI	Most Stable
•Instinct node Interface •Powerful Node •Support API	• Simple Interface	•Powerful Pre-set Functionalities
Cons:	**Cons:**	**Cons:**
Learning Curve	Simpliciy	Customizability
•Node interface is hard to operate for beginners	•Limited Functionality •Hard to Modify	• Hard to Modify

2. Choose Diffusion Model

Since it's impossible for using a weak GPU to train a well performed Diffusion Model, I decided to use a well-trained Diffusion Model with a Lora Model to guide its style to make it as close as Gaudi

After Comparing the most popular and well-performed model for realistic image generation, we choose the Realistic-Vision V6.0 as our base model

Stable Diffusion 1.5 base model

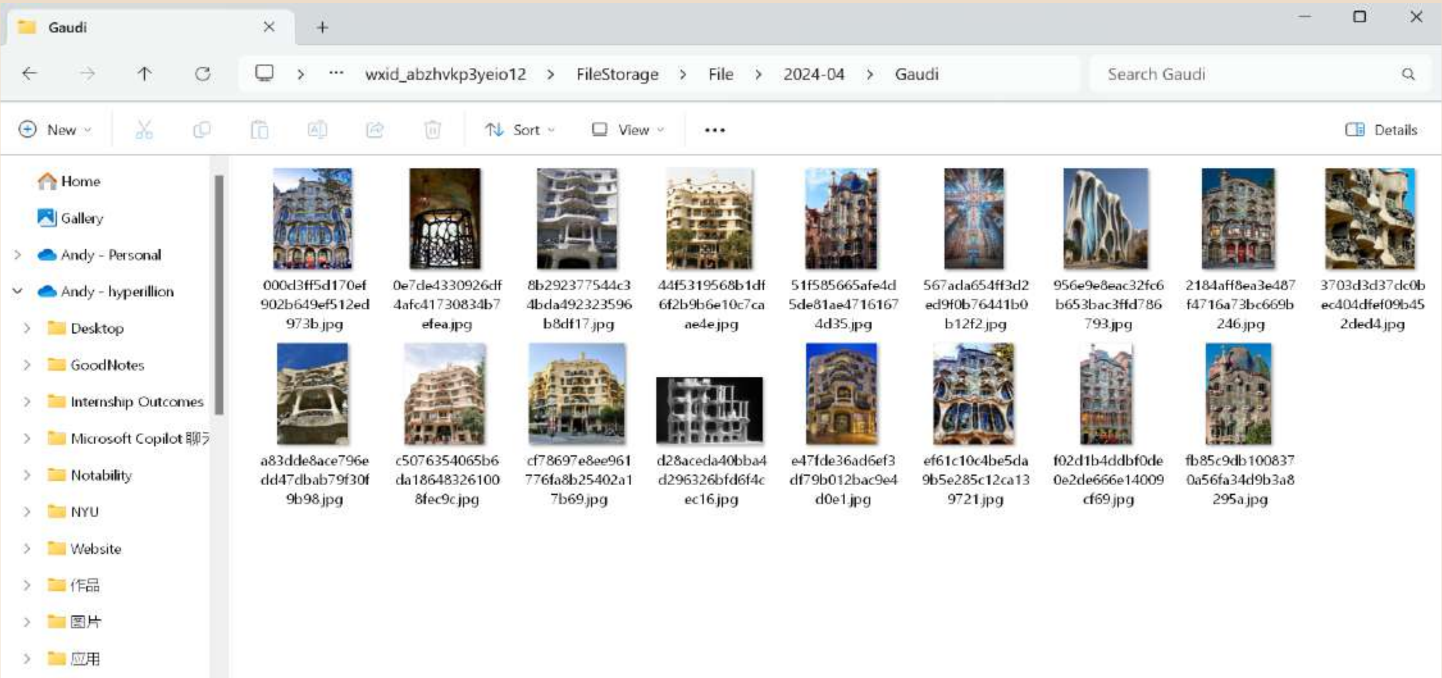
Realistic Vision V60B1_ V51HyperVAE

Architecture Real Mix v1.1

Realistic Vision V60B1_ V60B1VAE

3. Self-train Lora Model

Using several Gaudi Architecture Photography works to train a Lora Model



4. Set Control Net

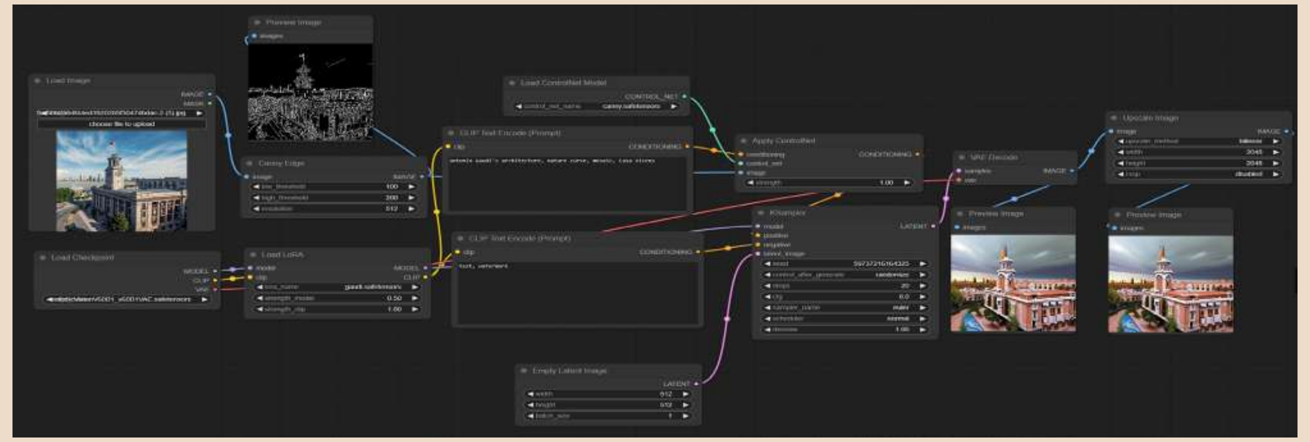
Problem found:
- Depth produces a significant difference from the original image but it is closest to Gaudi's style
- Canny is the most loyal to the original image but it will lose Gaudi's nature curve on the edge of the architecture

Solution:
After many attemptions, I found a way to merge these two features together.
- Use **Canny** to guide the first half of the image generation
- Use **Depth** the guide the last half of the image generation

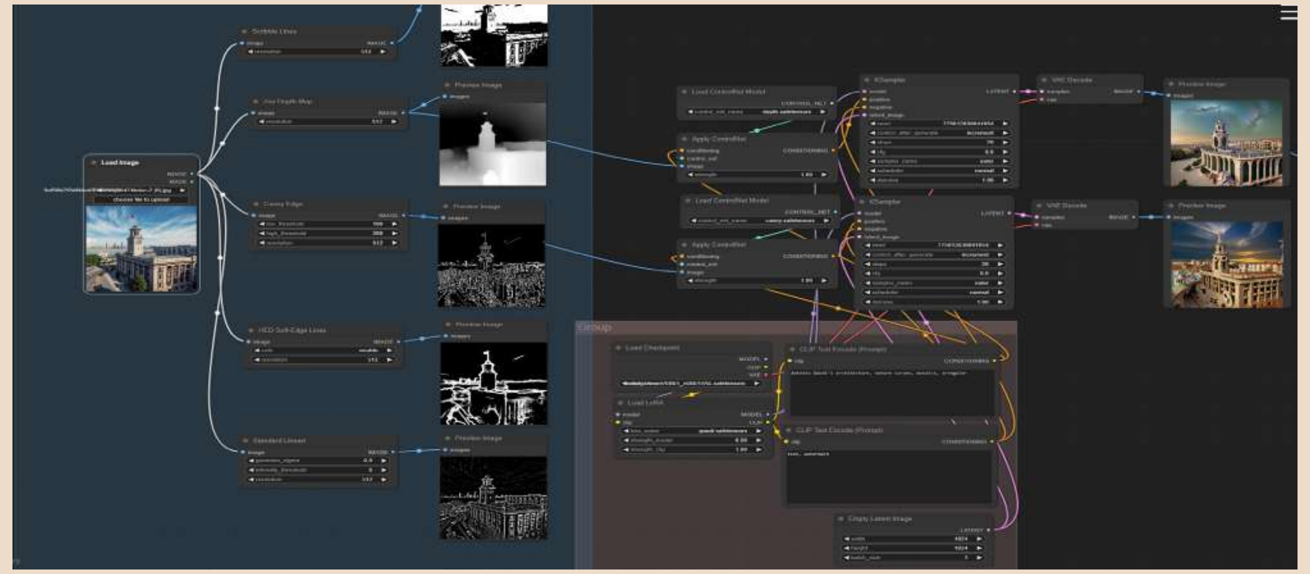
At the beginning, we use the image to follow the original image to have a proper "base". After the base is established, we can use depth controlnet to add more gaudi elements and features to it.

5. ComfyUI workflow parameter and combination adjustment

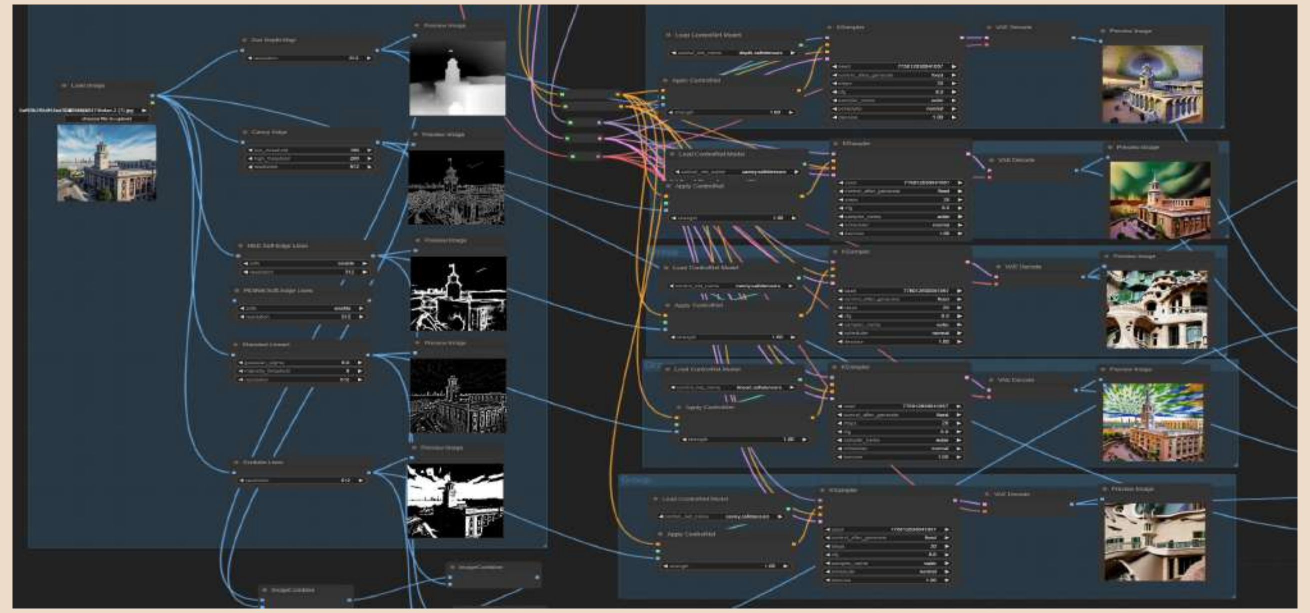
V1



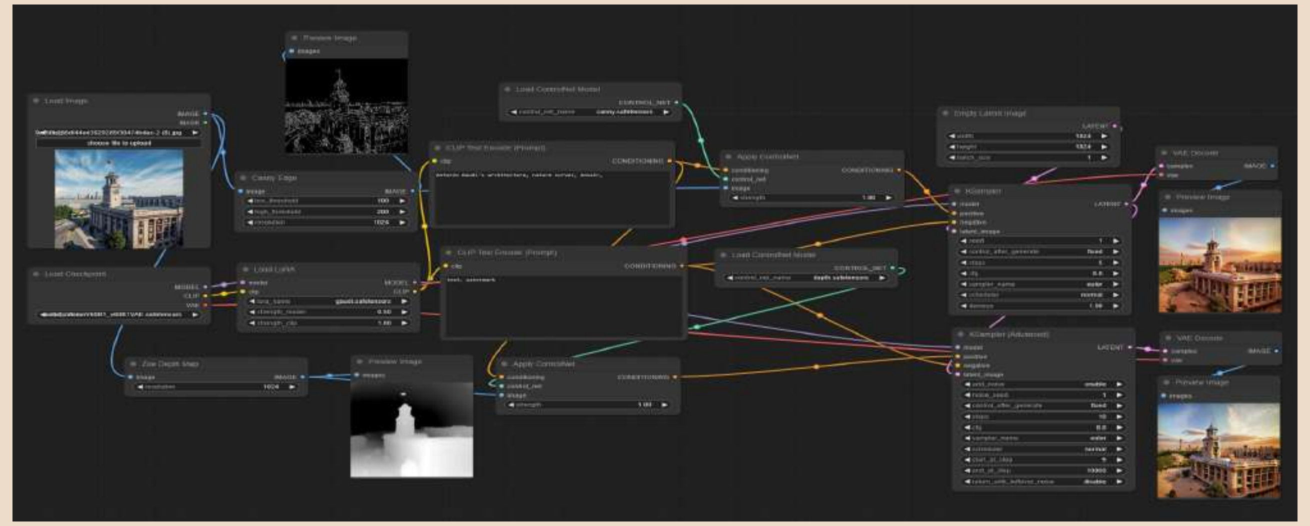
V2



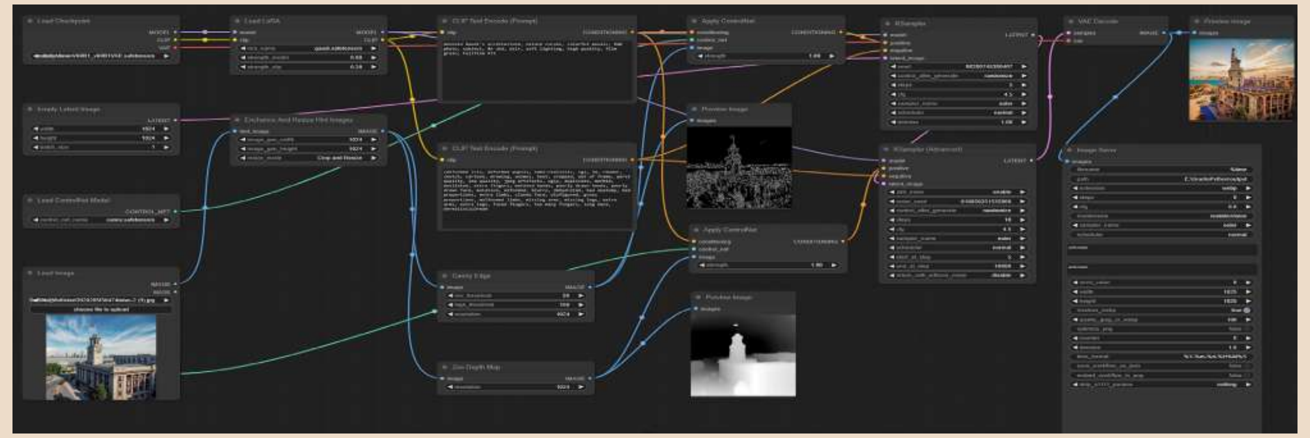
V3



V4



V5



v1: Test the feasibility of the system / Technical validation

v2: Explore the system further / Test more ControlNet models, Find the model that has the best performance

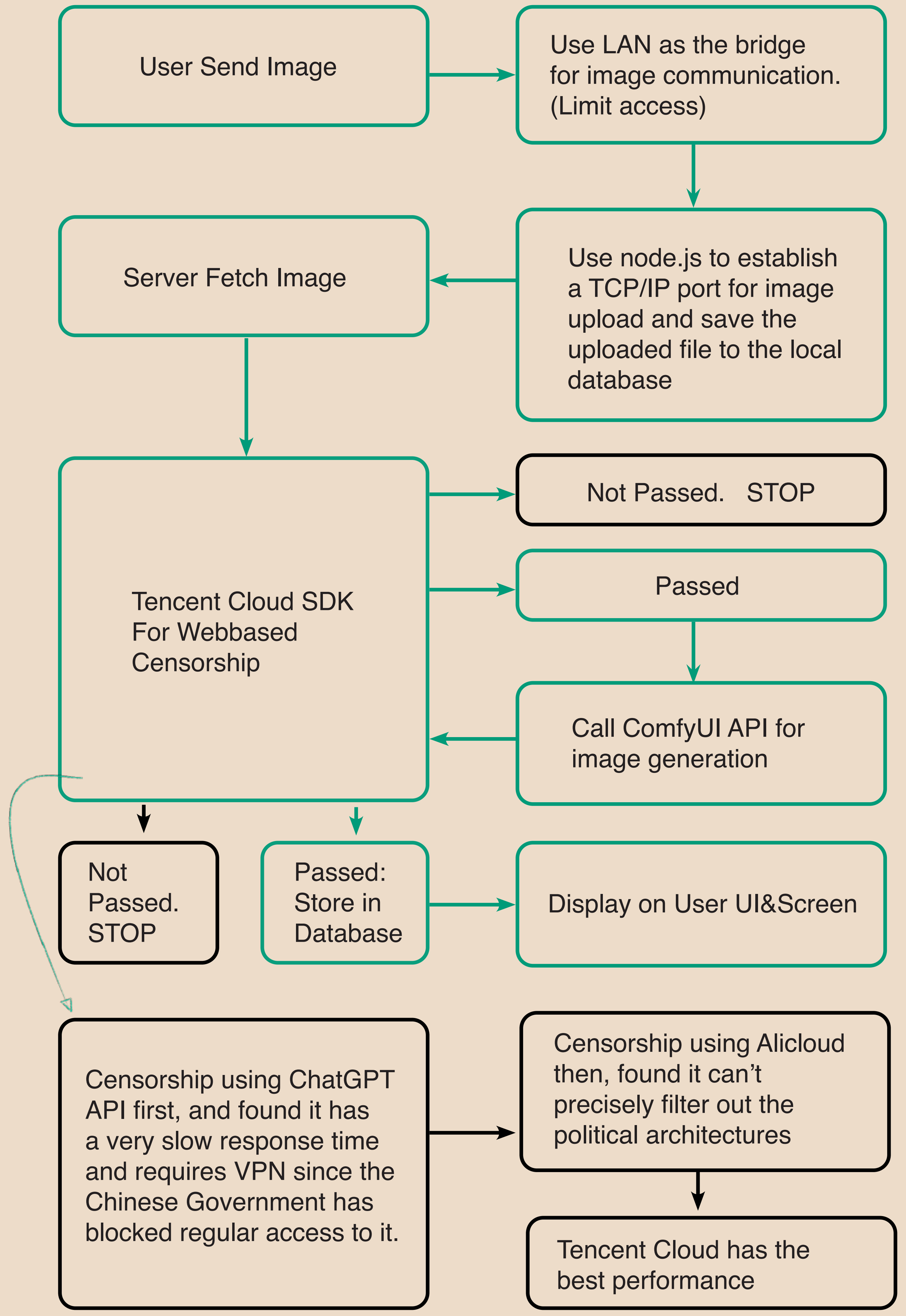
v3: make slight changes to the parameters / explore more ControlNet models, and make an image grid for better comparison

v4: Finalize two ControlNet models / Get the best performance

v5: Merge two ControlNet models / Utilize the best part of each ControlNet Model

After V5: adjust the parameters and the prompts to find the best result

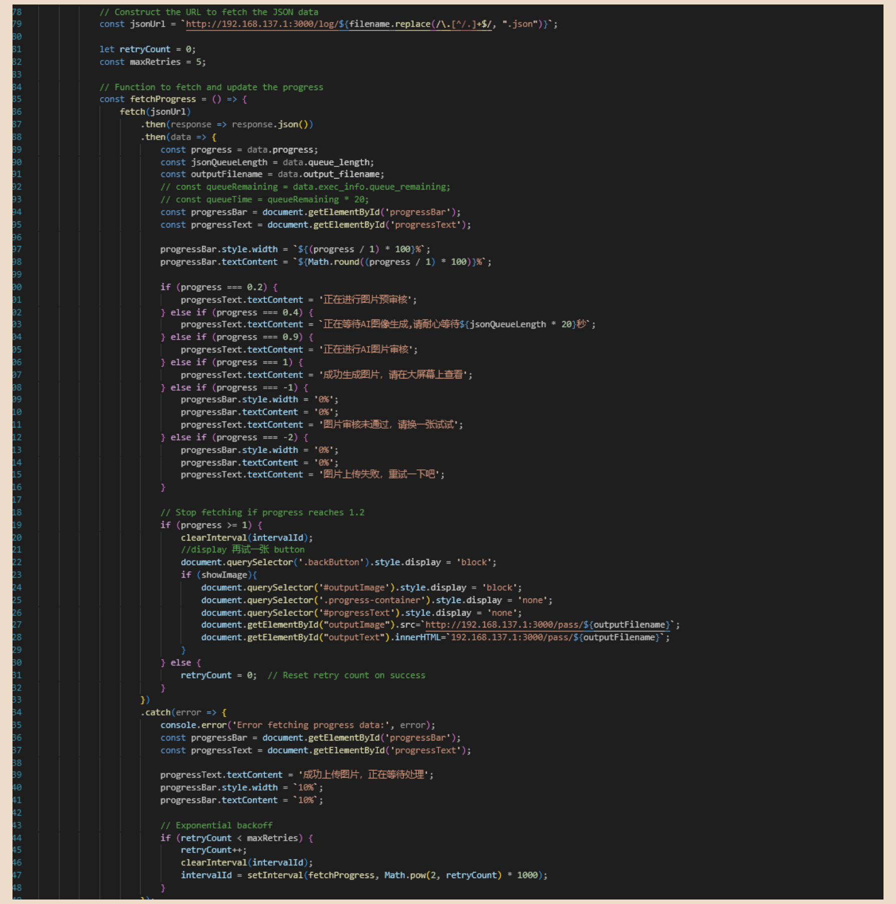
Deployment flow & Censorship



Coding

Nodejs Server

Web-based Mobil UI



You can find the full code at the following link: https://github.com/Hyperillion/Gaudi-Vision/

Image Cloud Check

Send Image

Display Image

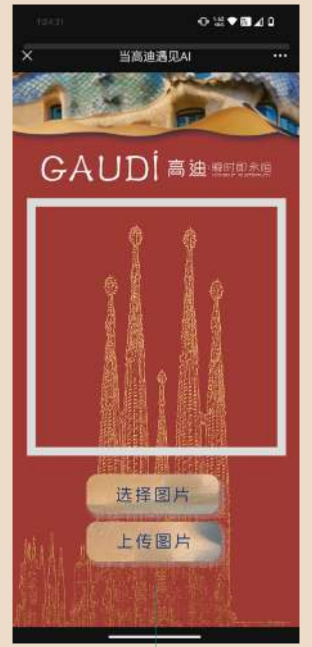
User interaction process

This project is deployed in China Architecture Science and Technology Museum. After confirming the work flow and site information with them, I designed a more detailed user interaction that display the generated images both on the big screen and user mobile phone.

Step 1

Scan QR code to access UI
(UI background is Gaudi Sagrada Familia)

Step 2



Select image
Upload Image

UI provides a button to upload images for image review (architecture only)

Includes user terms and disclaimers: images are for this test only, not for commercial use, generated images do not represent the position of the Museum of Science and Technology, uploading represents a shared image that the Museum of Science and Technology has the right to use, and so on.

The user clicks on the upload image button and enters the system image selection interface.

Image is being reviewed

Image generated successfully

Then the user waits for the picture to be generated and a progress bar appears on the mobile phone to inform the user of the current processing progress.

Step 3

After the generation is finished, the image will appear on the big screen (duration of image appearance: 15s). At the same time, the UI on the mobile phone displays the generated image, and the user can save it with a long press.

Final outcome

Gaudi Architecture AI Workshop

Feedback From Audiences

This project is very interesting, and the generated images look quite similar to Gaudi's architecture. Children love playing and want to upload every picture to try.

It feels quite innovative, reproducing Gaudi's style in an AI way. I just feel that the degree of restoration can be a little higher.

I really like this project. The use of AI at the end of the entire exhibition hall continues Gaudi's aesthetics, symbolizing Gaudi's eternal artistic value. It happens to be located behind this eternal Gaudi section, which has a strong sense of inheritance.

BEYOND INK-WASH

MAY 2023

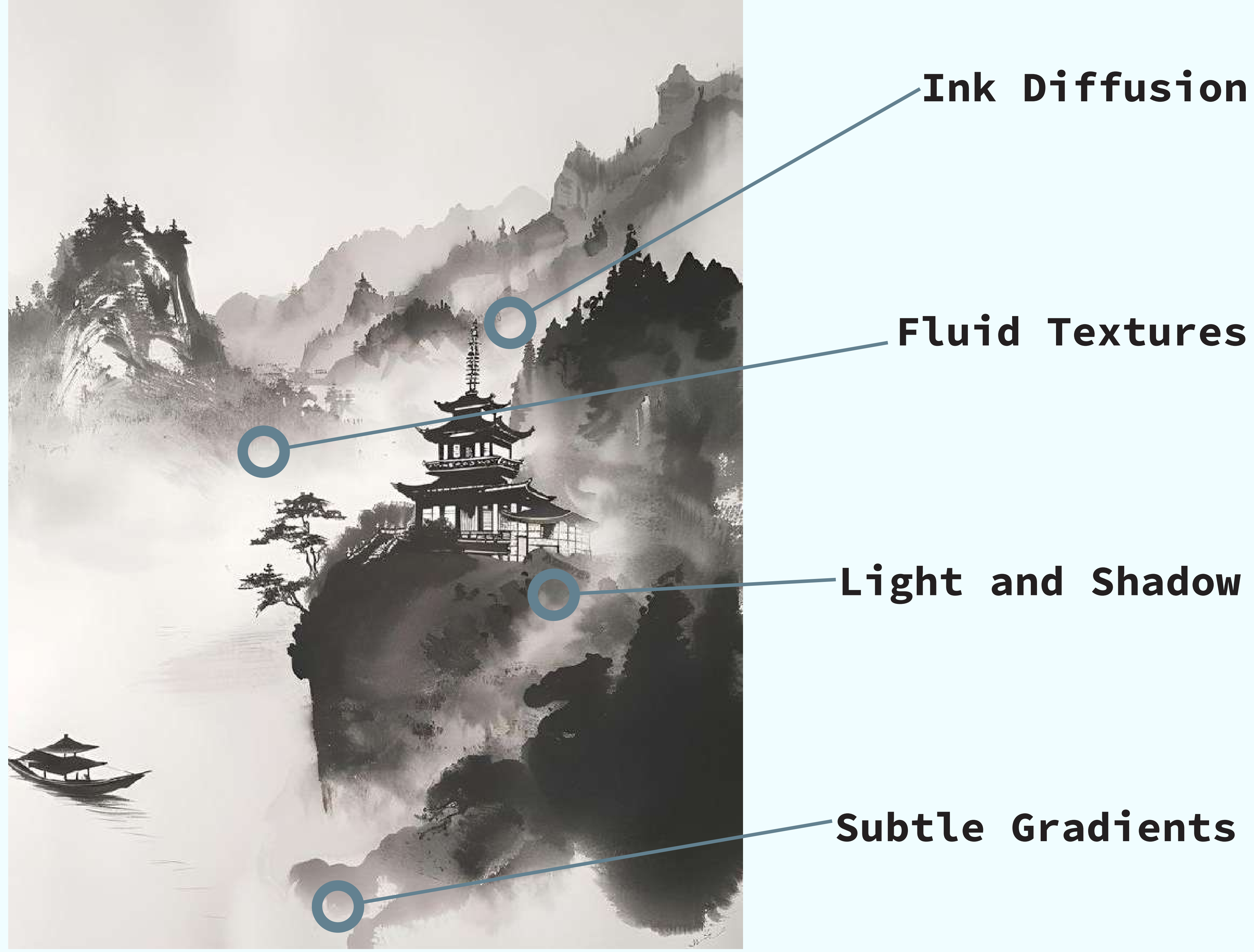
Interactive & Generative Ink-wash Painting

Beyond the Ink-wash is an interactive digital system that recreates the elegance of traditional Chinese ink-wash paintings through modern programming technologies. The project empowers users to draw a personalized ink-wash artworks though body interaction, offering an interactive experience with the traditional ink-wash paintings.

INSPIRATION

Ink-Wash Aesthetics

My inspiration starts from the visual style of traditional Chinese ink-wash paintings which is known for the minimalistic and expressive representation of nature and landscapes. In my project, I hope I can create a virtual ink-wash world that beyond just paintings.



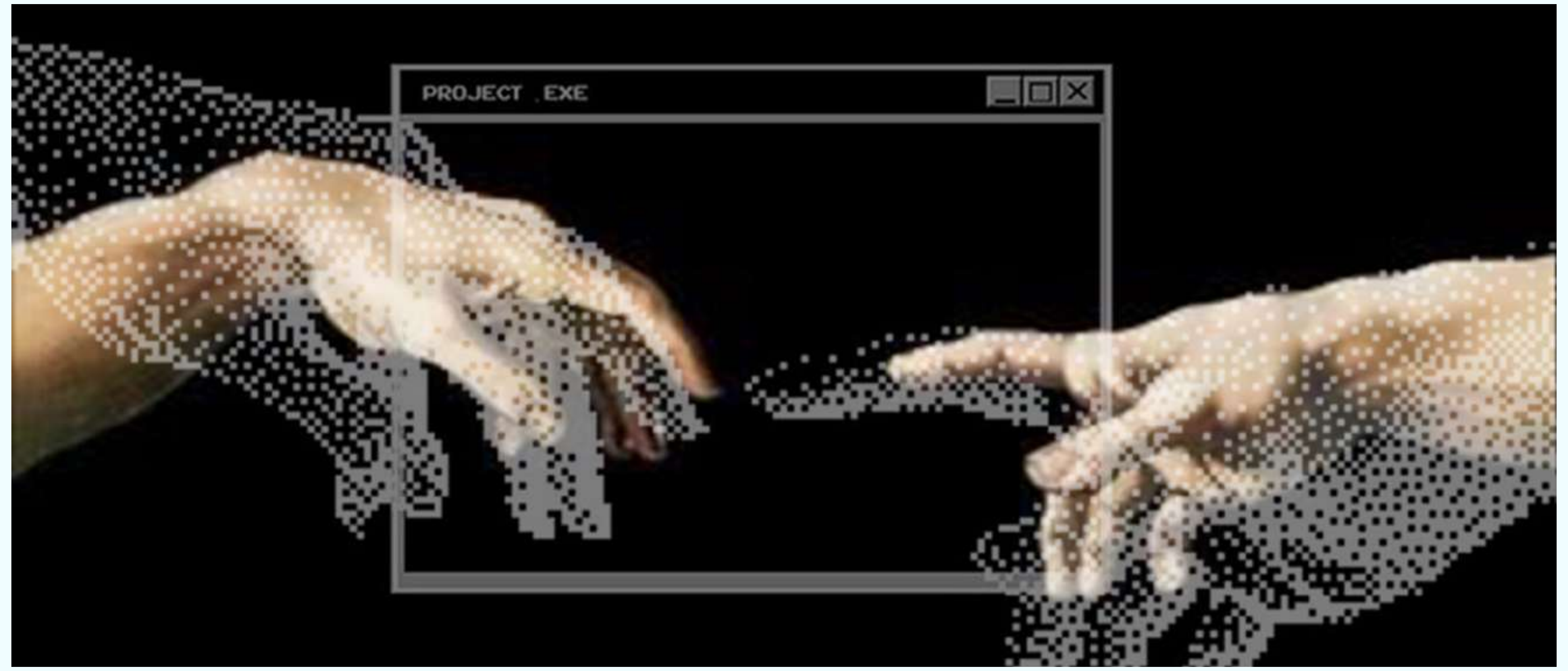
Collision of Modern and Tradition

As for the Ink-wash paintings, it already has thousands of years of history. However, the coding can be treated as the product of contemporary invention. This project can demonstrate how technology can serve as a bridge between traditional art forms and modern interactive experiences.

Ink-wash Painting	**Programming**
Tang dynasty	England
618AD	1843

Digitalize Ink-Wash Art Creation

I hope I can preserve the cultural heritage of ink-wash art while modernizing it through digital mediums. Through this process, the in-wash painting can be transformed from the exclusive mastery into an accessible and interactive experience.

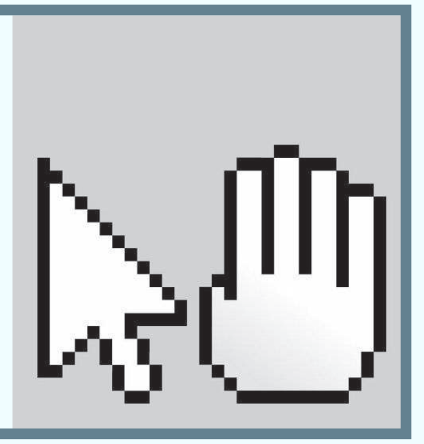


Broader Accessibility

The project wants to invite audiences of all ages, cultural backgrounds, and artistic abilities can engage with the rich tradition of ink-wash painting. By simplifying the creative process through an interactive and intuitive platform, it opens the door for more people to explore and appreciate this art form without the need for prior training or expertise.

Draw in Traditional Brush

Draw in Mouse & Body



DEPLOYMENT

Visual Reference

To be honest, I'm not that good at painting. To make the project embed the most intuitive ink-wash painting aesthetics, I chose a human-made ink-wash painting as my visual reference.

Mountain in the Background

The mountains are covered by the light fog, giving the audience a sense of soft silence. It also has a significant brushwork on the mountain's edge, which becomes the most challenging part of reproduction.

Lake/River

When the water is still, it becomes almost transparent which is quite hard to make the audience realize its existence. But when the weather is rainy, the raindrops can easily interact with the water and we can use ripples to visualize the water flow.

Willow Leaves

The willow leaves are another challenge that I've encountered in this project. I decided to use a spring and ball structure to code the willow due to its hanging features.

Boat in the Lake

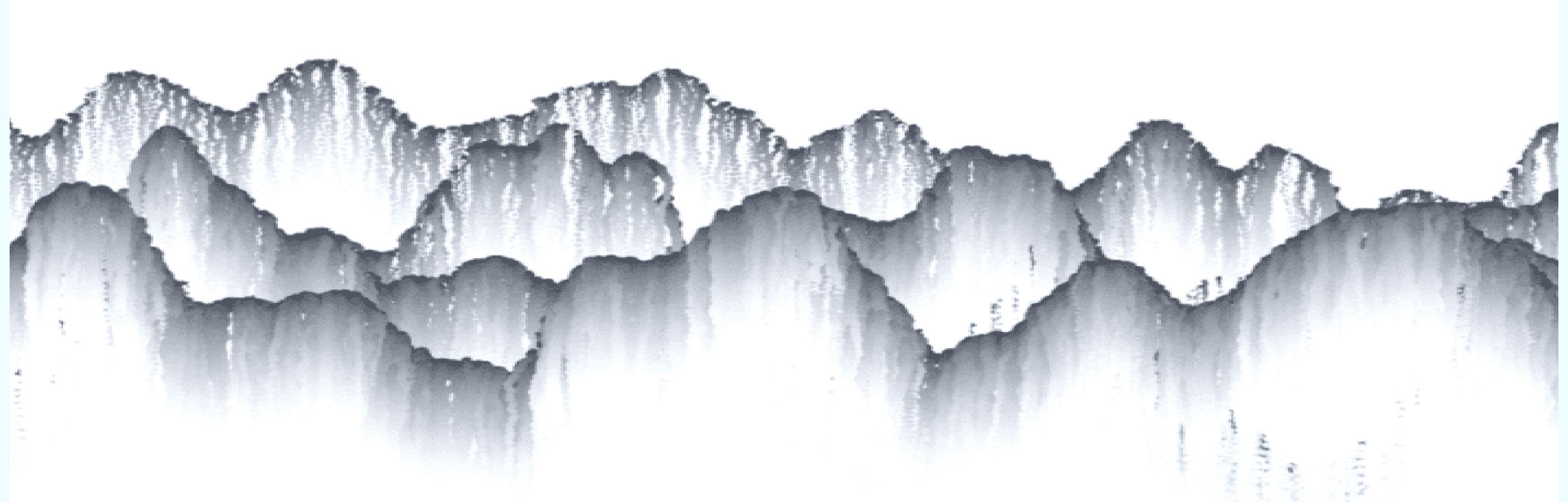
The boat can be treated as one of the element that makes the project vivid. The boat can bring an active and life-like element to the whole frame.

Mountains and hills

V1: Initially, the project employed lines according to **Perlin Noise** to generate mountain shapes, but this approach lacked the soft, organic diffusion that characterizes traditional ink-wash painting.

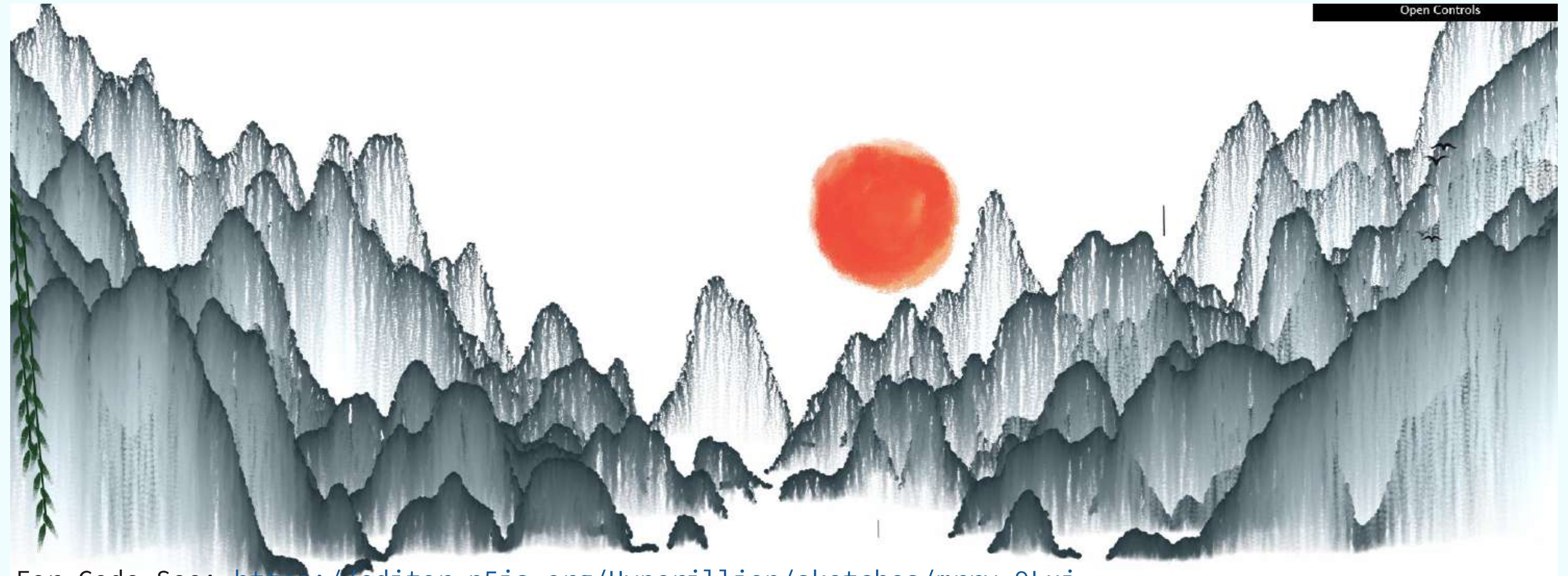
For Code See: https://editor.p5js.org/Hyperillion/sketches/GTJrPpcya

V2: After observing the limitations of using lines to draw mountains, it was suggested to explore a **particle system** to better replicate the ink diffusion style. A particle system allows for dynamic simulation of ink flow, mimicking how ink naturally spreads on absorbent paper with variations in density and gradients.



For Code See: https://editor.p5js.org/Hyperillion/sketches/rqnMZKT9E

V3: To make the hills appear more realistic and harmonize seamlessly with the river in the center, I implemented a system where the **hills' height dynamically responds to the x-position** of the canvas. This approach creates a natural flow and alignment with the river's path. Additionally, by varying the hill heights with each iteration of drawings, the system introduces **subtle variations** that enhance the sense of depth and perspective, making the composition feel more organic and visually engaging.



For Code See: https://editor.p5js.org/Hyperillion/sketches/mrrv_9Lxj

Water Reflections

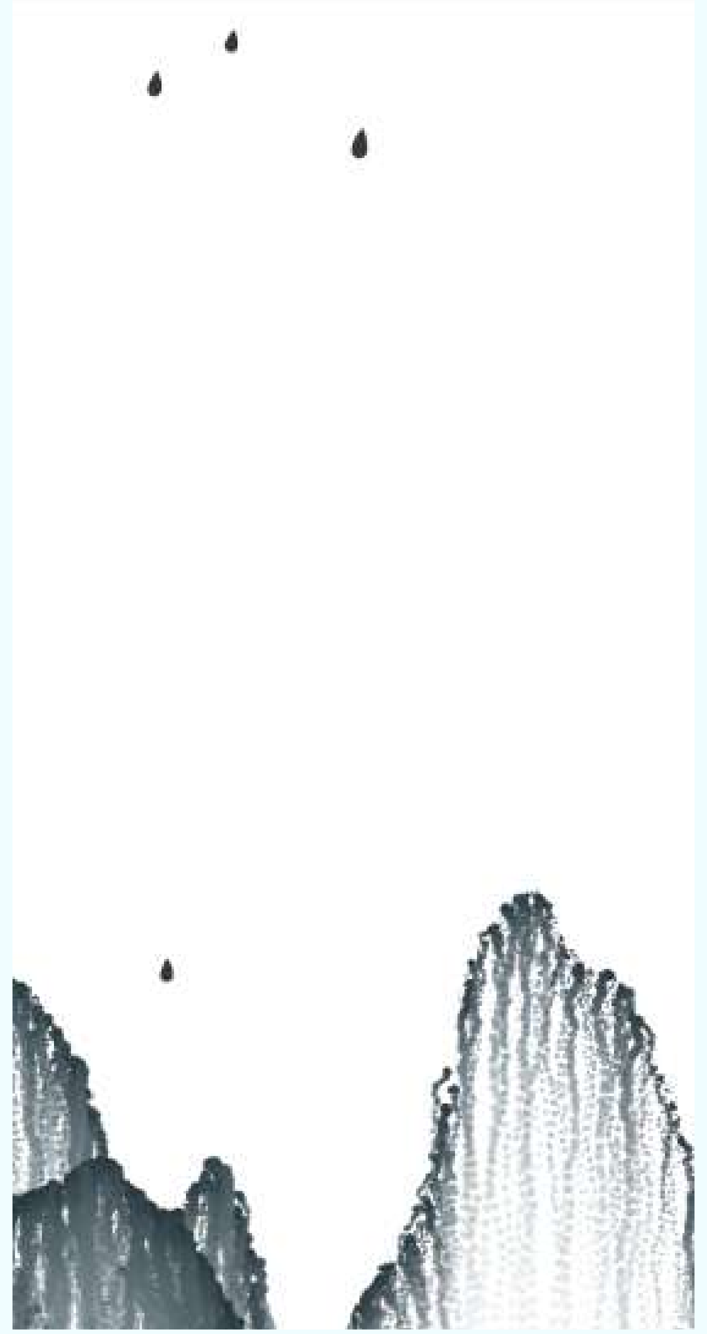
When the particles are drawing the hills, I generate a **mirrored particles** to draw the water reflection to make the more realilstic. I added **sin Value** on it to simulate the water ripple effect.

For Code See: https://editor.p5js.org/Hyperillion/sketches/mrrv_9Lxj

Gravity and Force System

In order to create a realistic environment, implementing a gravity system is essential for simulating natural interactions between objects and other dynamic components behave realistically as they would in the physical world.

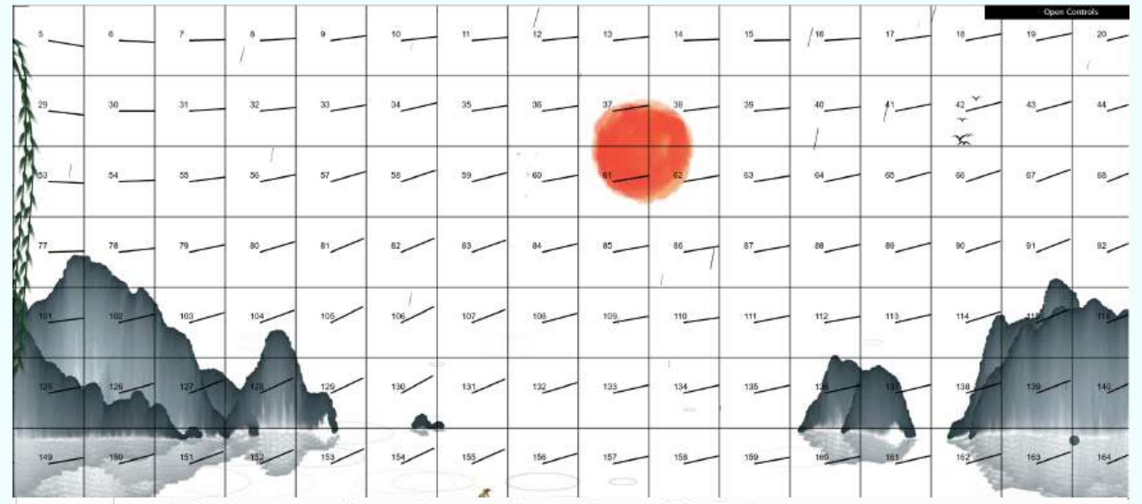
```
class Ball {
  constructor(x, y, r) {
    this.pos = createVector(x, y);
    this.vel = createVector();
    this.acc = createVector();
    //
    this.rad = r;
    this.mass = this.rad / 10;
    //
    this.damping = 0.97; // -0.03%
    this.gravity = createVector(0, 0.3);
    this.angle = 0;
  }

  firm(x = 100, y = 100) {
    this.pos = createVector(x, y);
  }

  applyGravity() {
    this.applyForce(this.gravity);
  }

  applyForce(f) {
    if (this.mass <= 0) {
      console.log("Wrong mass!");
      return;
    }
    let force = p5.Vector.div(f, this.mass);
    this.acc.add(force); // force accumulation
  }
```



For every object in the system including raindrops, forces acting upon it are calculated in real-time, and its velocity is dynamically updated based on its mass and the cumulative forces.

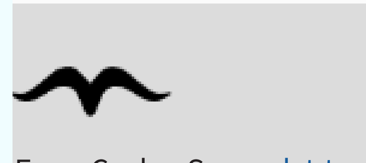
Bird Flocking System

The bird flocking system is built using a dynamic **flow field** generated by the provided code, which calculates angles for movement based on **Perlin noise** values.



```
  // draw and update the flow field;
  for (let r = 0; r < rows; r++) {
    for (let c = 0; c < cols; c++) {
      let x = c * RESOLUTION - 0.25 * width;
      let y = r * RESOLUTION;

      // angle
      let xFrq = x * FREQ_POS + frameCount * FREQ_TIME;
      let yFrq = y * FREQ_POS + frameCount * FREQ_TIME;

      let noiseValue = noise(xFrq, yFrq); // 0 to 1
      let angle;
      angle = map(noiseValue, 0, 1, -PI / 4, PI / 4); //
      if (r >= 8) {
        if (angle >= 0) {
          angle = -angle;
        }
      }
      angles.push(angle);
```

Preview

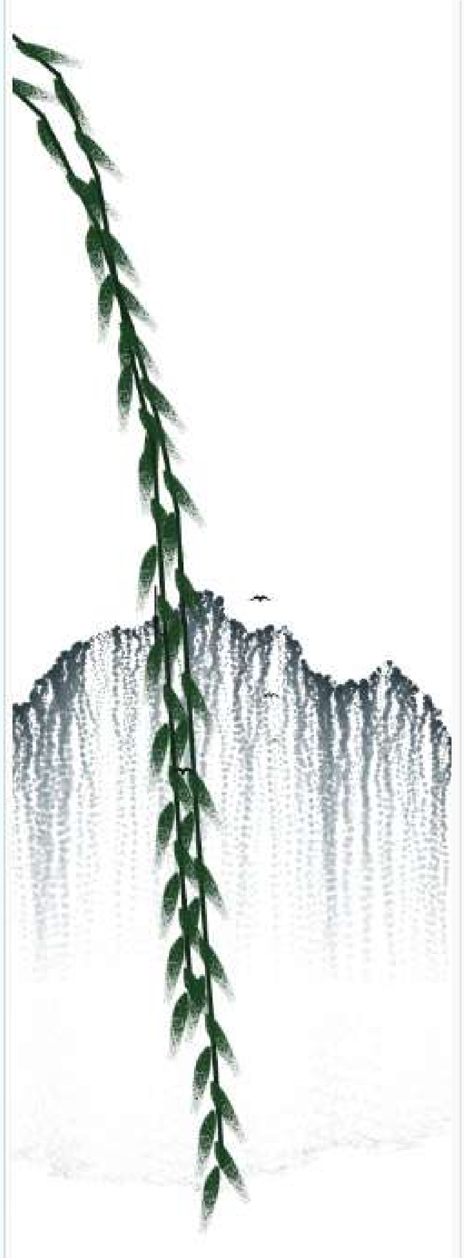


Animated Bird movement using vertex shape

For Code See: https://editor.p5js.org/Hyperillion/sketches/svewtRYw2

Willow Leaves

The willow leaves are designed using a spring system, allowing them to respond dynamically to wind and other forces in a lifelike manner.



```
function willow() {
  // springs
  for (let i = 0; i < springs0.length; i++) {
    springs0[i].update();
    springs0[i].display();
  }
  for (let i = 0; i < springs1.length; i++) {
    springs1[i].update();
    springs1[i].display();
  }

  balls1[0].firm(-15, 30);

  balls1[1].applyForce(createVector(1, -1));
  balls1[2].applyForce(createVector(0.5, 0));
  balls1[5].applyForce(createVector(0.2, -1));

  balls0[0].firm(-25, 40);

  balls0[1].applyForce(createVector(1, -0.7));
  balls0[2].applyForce(createVector(0.5, 0));
  balls0[3].applyForce(createVector(0.2, 0));
  balls0[4].applyForce(createVector(0.2, 0));
  balls0[5].applyForce(createVector(0.2, -1));

  for (let i = 1; i < balls0.length; i++) {
    if (addWind) {
      let force = p5.Vector.mult(mouseVel, 0.004);
      balls0[i].applyForce(force);
    }
    balls0[i].applyGravity();
    balls0[i].updatePosition();
  }
  for (let i = 1; i < balls1.length; i++) {
    if (addWind) {
      let force = p5.Vector.mult(mouseVel, 0.004);
      balls1[i].applyForce(force);
    }
    balls1[i].applyGravity();
    balls1[i].updatePosition();
  }
  // image(leaves, 10, 10);
}
```

Preview

Draw Willow leaves using vertex shape and erase()

For Code See: https://editor.p5js.org/Hyperillion/sketches/68yiMsrfj

Boat & Ripples

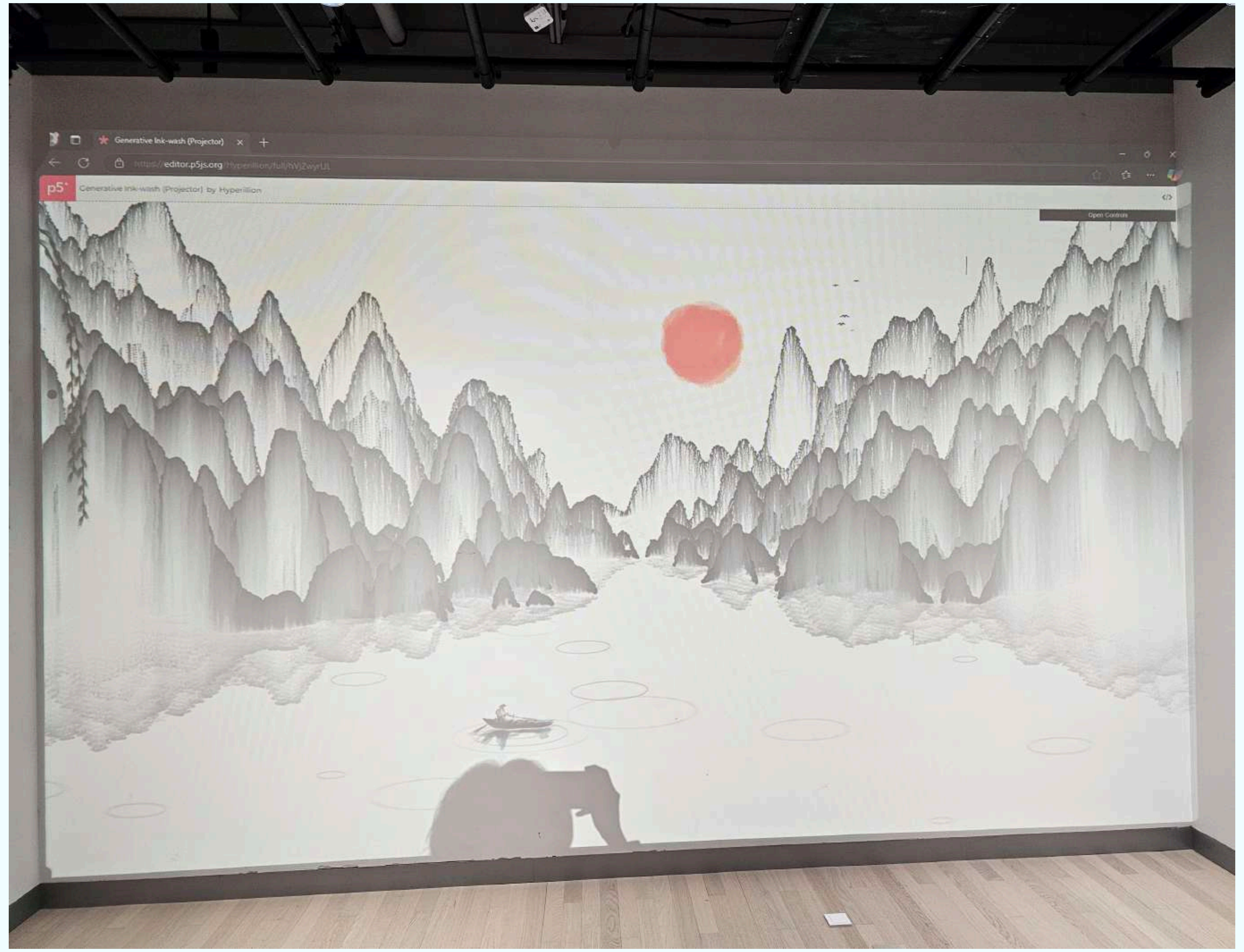
Incorporating boat with ripple effects adds a crucial layer of realism to the water, capturing the subtle dynamics of its surface.

```
  display() {
    if (this.isDone) {
      //Ripple
      rippleLayer.push();
      rippleLayer.noFill();
      rippleLayer.stroke(200, this.pos.y - height / 3 - this.rippleY / 1.8);
      rippleLayer.translate(this.pos.x, this.pos.y);
      rippleLayer.scale(this.scale / 2);
      rippleLayer.ellipse(0, 0, this.rippleY * 0.5, this.rippleY * 0.12);
      rippleLayer.pop();
    } else {
      //raindrops
      push();
      noStroke();
      fill(0, 0, 0, 200);
      translate(this.pos.x, this.pos.y);
      rotate(this.angle - 90);
      scale(this.scale - 0.6);
      rainDrop();
      pop();
```

Ink-wash style boat with cos()+Perlin Noise to simulate the floating effect on the water.

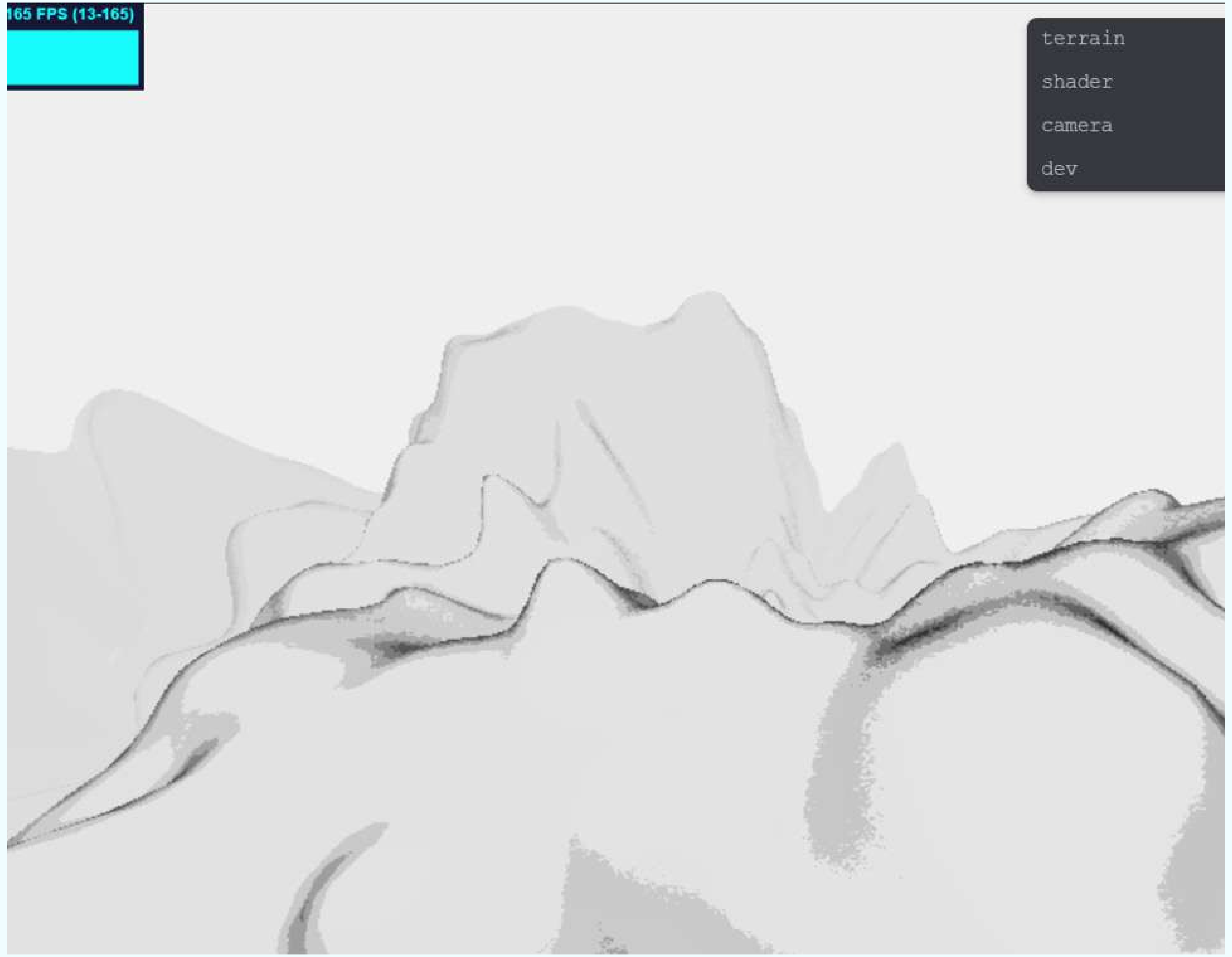
OUTCOME

Presented on IMA end-of-semestershow



FUTURE DEVELOPMENT

Currently I'm working further on digitalizing ink-wash aesthetics into 3D world. Here is a customize shader I worte in threejs that reproduce the ink-wash style.



FURTHER INFORMATION

For more projects information, please visit my portfolio website:

https://andyyejr.gitlab.io/portfolio-en