



# GAMER+

IMA Capstone II

Mingxuan Xie

Supervised by Andy Garcia

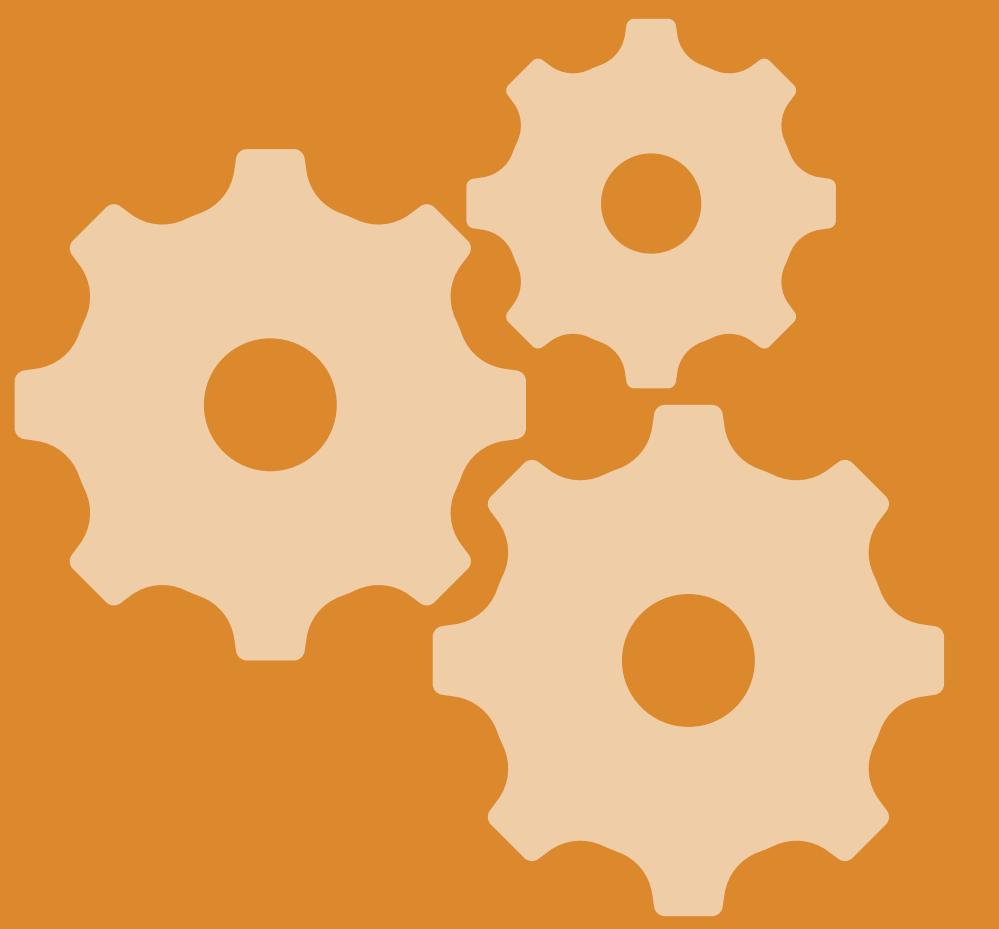
Adaptive GameController +

Rehabilitation +

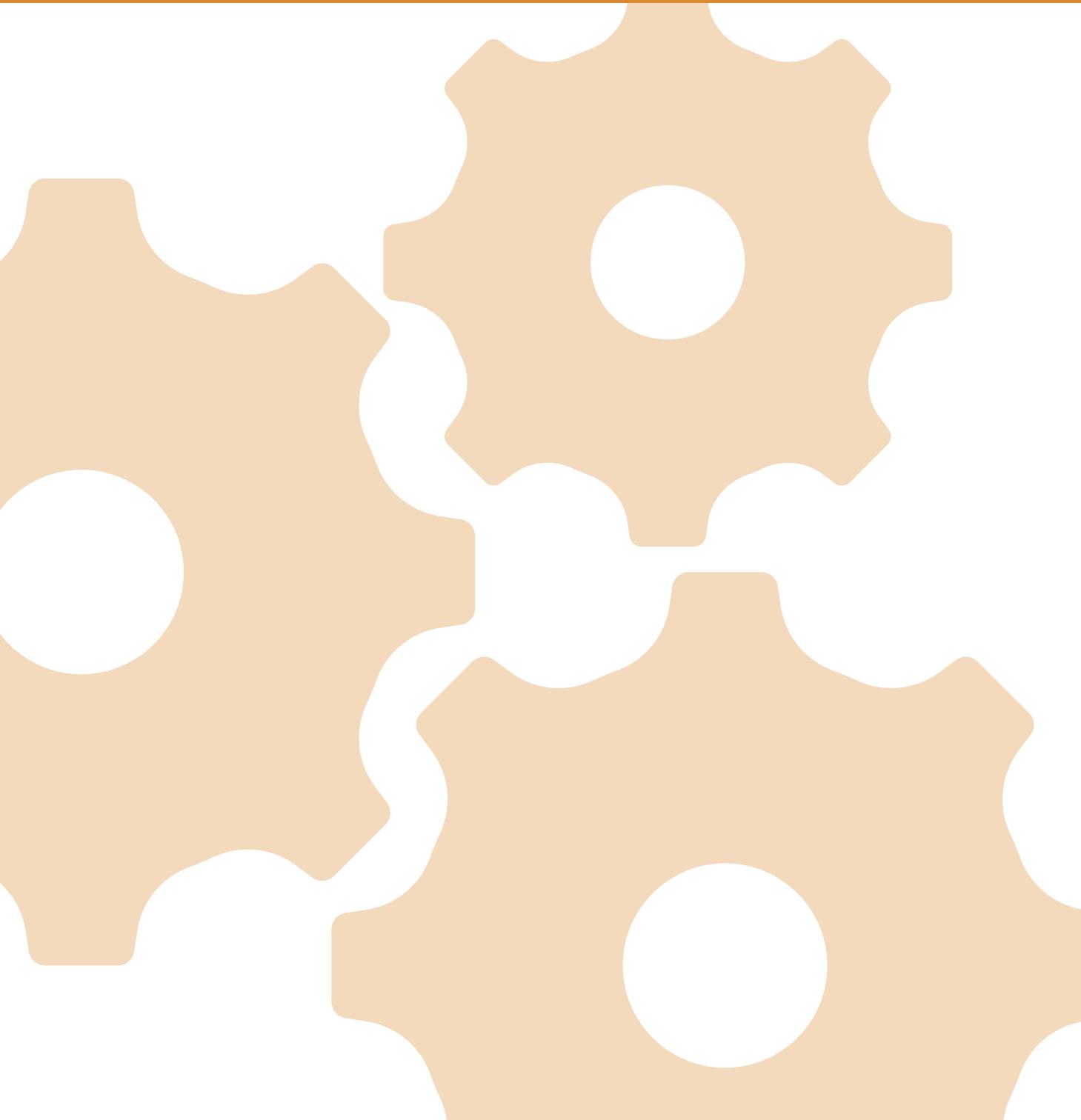
lovely codesigner with Cerebral Palsy

[Logbook live view, with all media ready to play](#)

# BACKGROUND

- 
- Individuals with congenital neurological impairments often face significant challenges in developing effective muscle movement strategies. During self-directed exercises, the intense focus required for limb control can lead to excessive muscle and nerve tension, resulting in suboptimal training outcomes. Moreover, the necessity for long-term, consistent maintenance exercises can be monotonous, with progress appearing gradual and lacking immediate positive feedback. This often leads to reliance on parental assistance during home-based sessions.

# CO-DESIGNER

- 
- born with cerebral palsy, possesses unique physical attributes:
  - **Balance:** Challenges with single-leg standing
  - **Hand Functionality:** Left hand capable of independent grasping; right hand primarily limited to index finger movement with noticeable tremors
  - Despite these challenges, Siyi has a vivid imagination and a unique perceptual perspective. She enjoys novels, comics, animations, and dramas, and has skills in drawing, writing, editing, photo manipulation, and Excel. Supported by her loving parents, Siyi's involvement as a co-designer ensures the project's relevance and effectiveness.

# PROBLEMS

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- Lack of Personalized Training Methods: Due to congenital neurological damage, individuals find it difficult to discover or be taught muscle movement techniques that are tailored to their specific needs.
- Ineffective Self-Directed Training: When exercising independently, the concentration on controlling limbs causes excessive tension in muscles and nerves, diminishing the effectiveness of the training.
- Monotonous and Lengthy Rehabilitation Process: Sustained maintenance exercises are essential but often tedious, with slow progress and minimal positive reinforcement, leading to dependence on parental support during home sessions.

# OBJECTIVES

This project aims to develop an integrated hardware and software solution utilizing physical computing principles. By designing a game controller that incorporates rehabilitation exercises, the system will address the unique physical characteristics of individuals with disabilities. The goal is to transform traditional rehabilitation into an engaging and interactive experience, fostering independence and enhancing motivation.



# WEEK 1

## RESEARCH + METOR MEETING

Learn more about the area

Collect more aspects and ideas about it

# METOR MEETINGS

- Meet with Andy
  - we talked about the Project plan and the progress during the winter break. Also started to explore some existing products
- Meet with Minki
  - Borrowed some circuit materials--Arduino Uno R4 wifi, cables, Microsoft adaptive series, magnets.



Customize your Surface Pen



Microsoft Adaptive Mouse



Microsoft Adaptive Mouse Tail and Thumb



Microsoft Adaptive Hub  
Microsoft Adaptive Hub connects to



# METOR MEETINGS

- Meet with Ian
  - got some insight about gaming, the room to explore under a game design's point of view. Possibilities to corporate with Mihoyo
- Meet with Rudi
  - Get some criticism on the project design--technoloty/engineering solution might not really touch the essential pain points of someone like Siyi, usually they worried more about how to make a living and create social connection.  
Gain some resources and material suggestions.

Rodolfo Cossovich 晚上 11:01  
<https://nyu.zoom.us/my/cossovich>

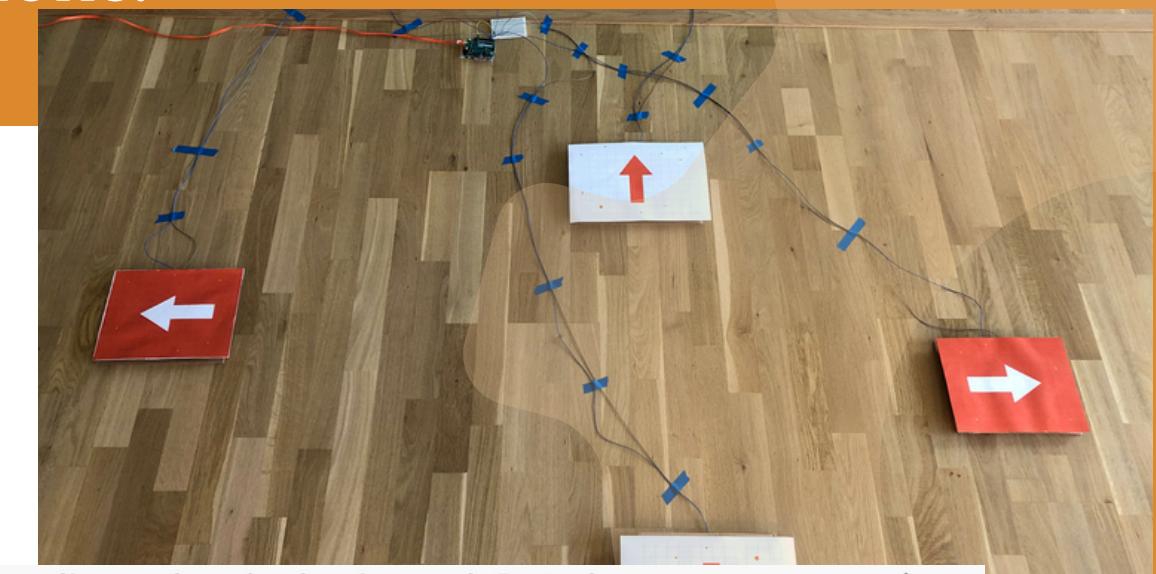
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Aflatoony and Shenai - 2021 - Unp... PDF

Aflatoony and Jin (Susan) Lee - 202... PDF

codea-a-framework-for-co-designi... PDF

I suggest you put in the materials list an Arduino nano 33 IoT, two sheets of acrylic, and a plank of wood. Put also some sensors (you can check the list interaction lab provides)

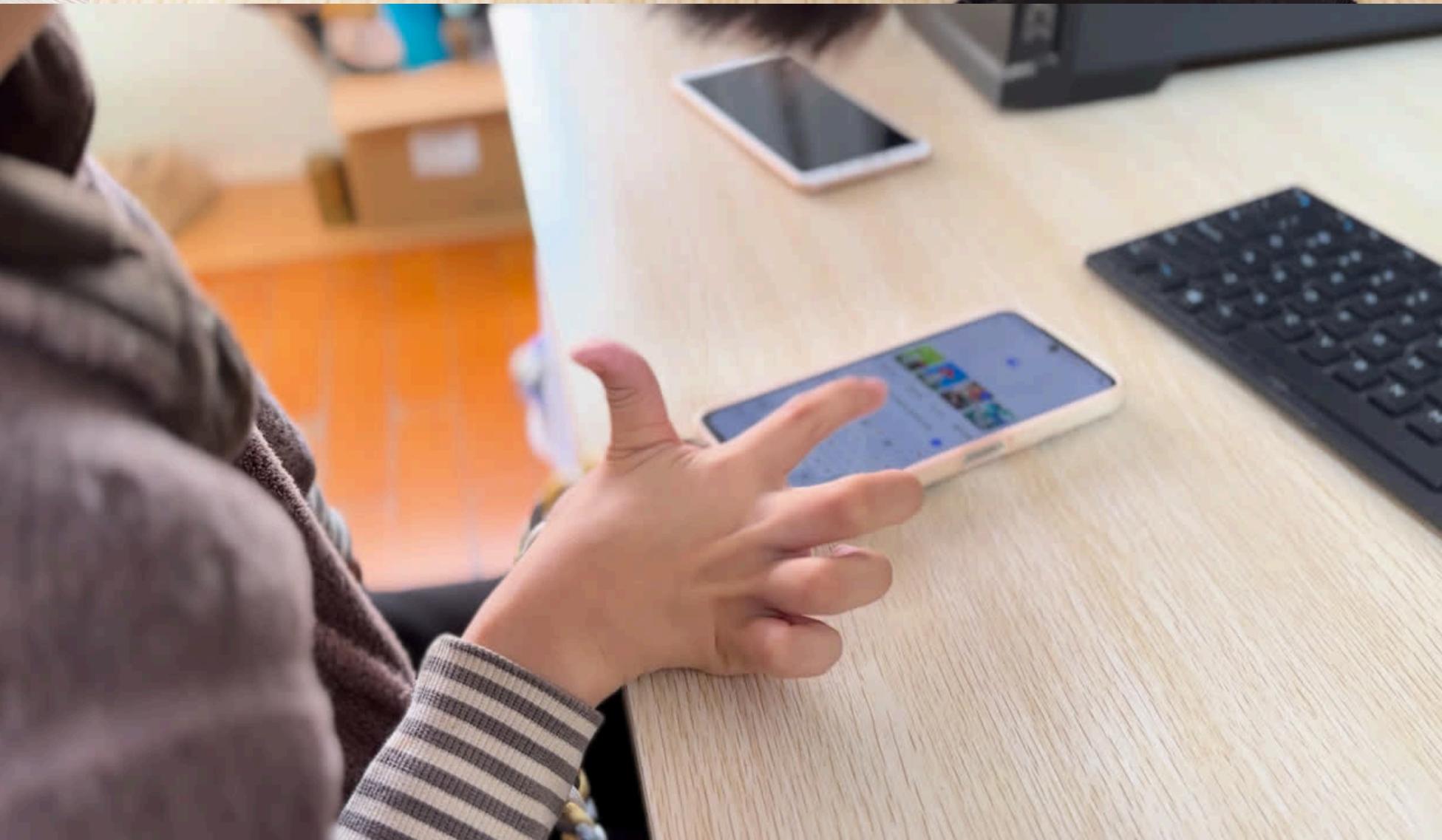


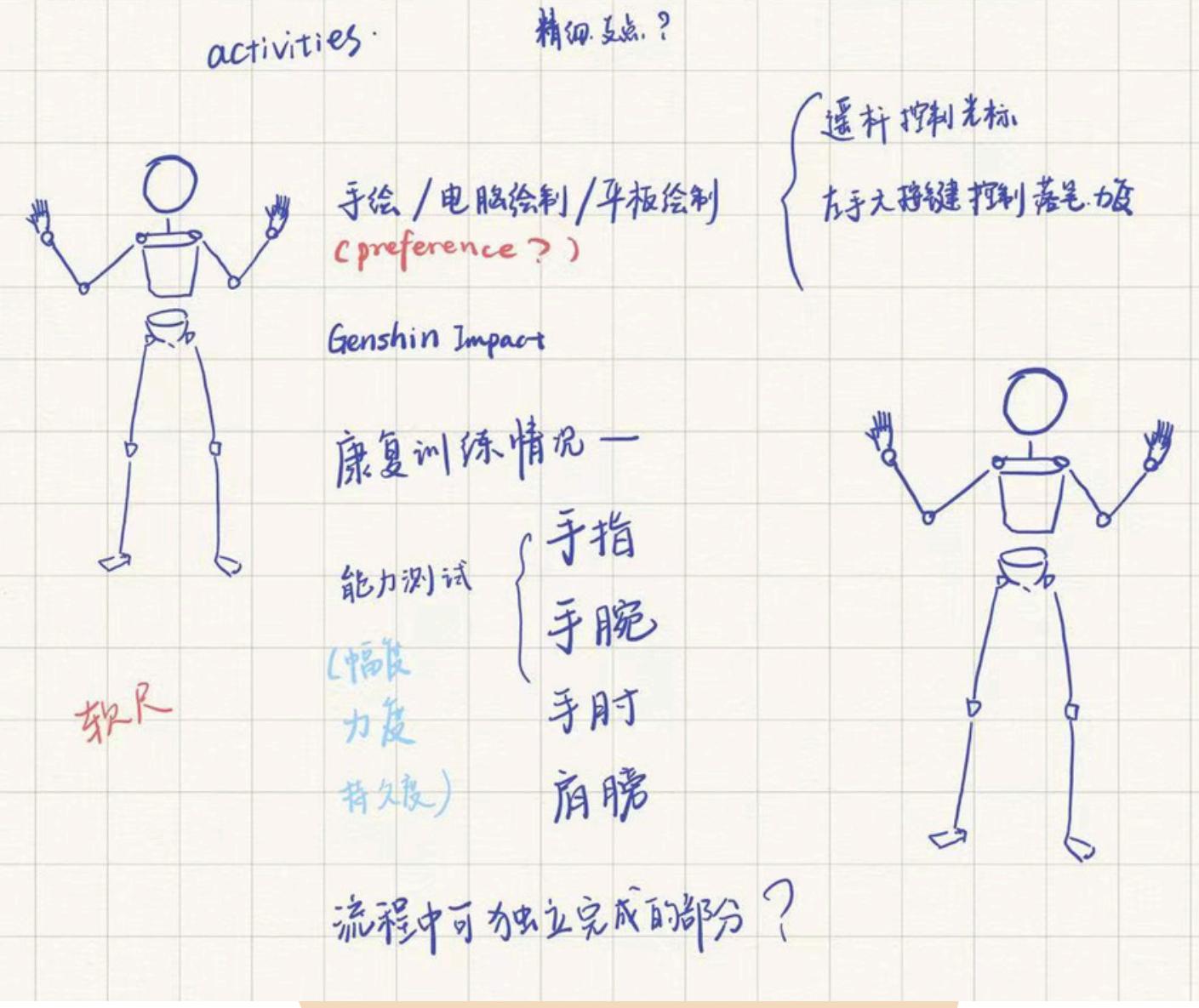
# **WEEK 2**

## **In-person Interview**

**Prepare materials+mini prototype tp learn her abilities**

**Design Half-structure Interview**





## • Physical Abilities & Challenges

- Right Hand: Only index finger is flexible; other fingers have limited mobility and are prone to tremors.
- Balance: Difficulty maintaining body stability, such as standing on one foot.
- Left Hand: Limited ability to grasp objects independently.

## • Motor Challenges & Observations

- Fine Motor Control: Needs a firm grip on objects, leading to fatigue.
- Hand Tremors: Causes difficulty in precise control, especially with small movements.
- Upper Limb Tension: Uses upper arm muscles for control, leading to muscle strain.

## • Daily Life & Interaction with Technology

- Prefers finger-based interaction (e.g., smartphone touchscreens) over traditional input methods.
- Finds computer mouse clicks difficult, affecting control.
- Prefers matte screen protectors for better tactile feedback.

## • Key Rehabilitation Needs

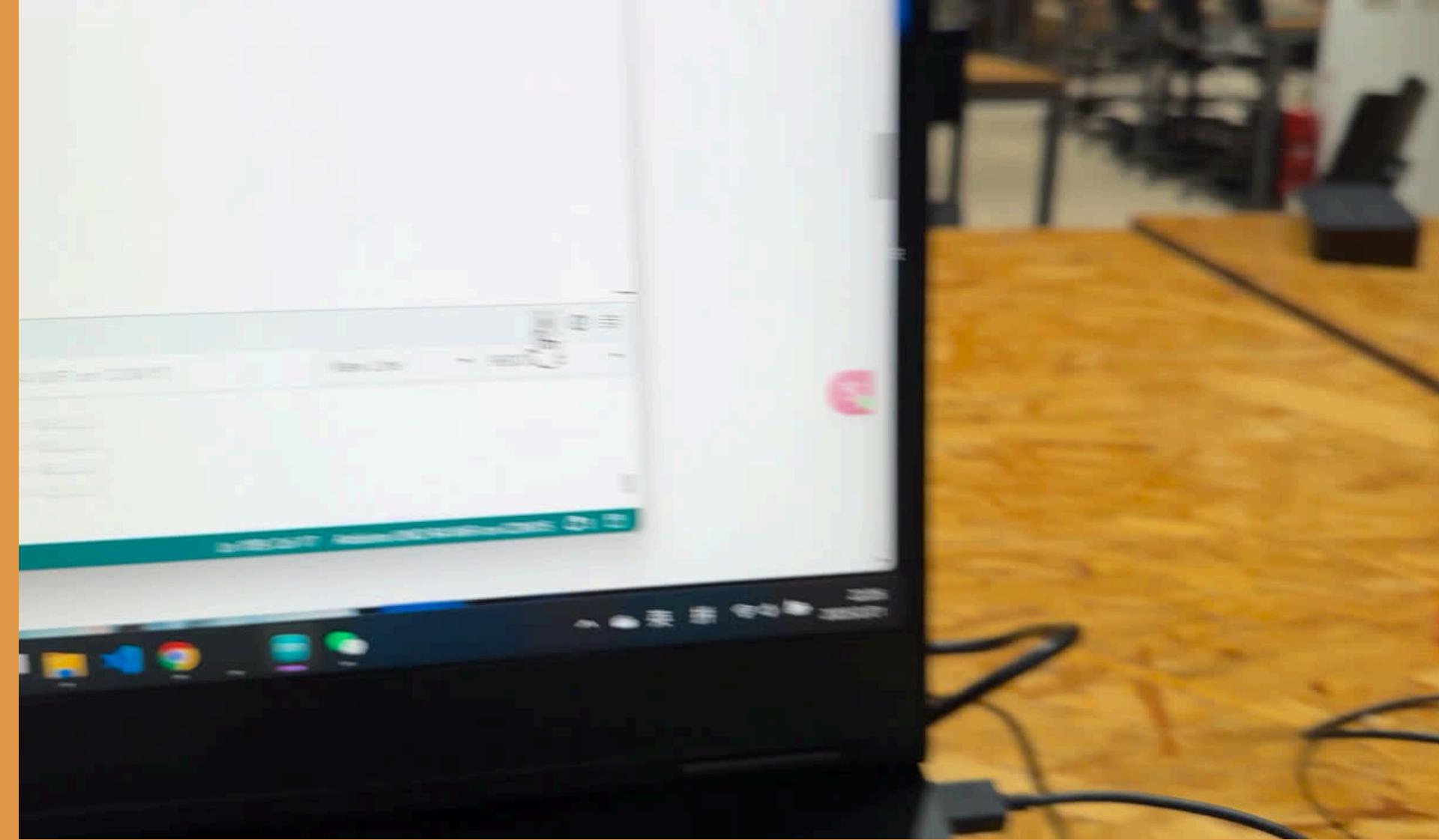
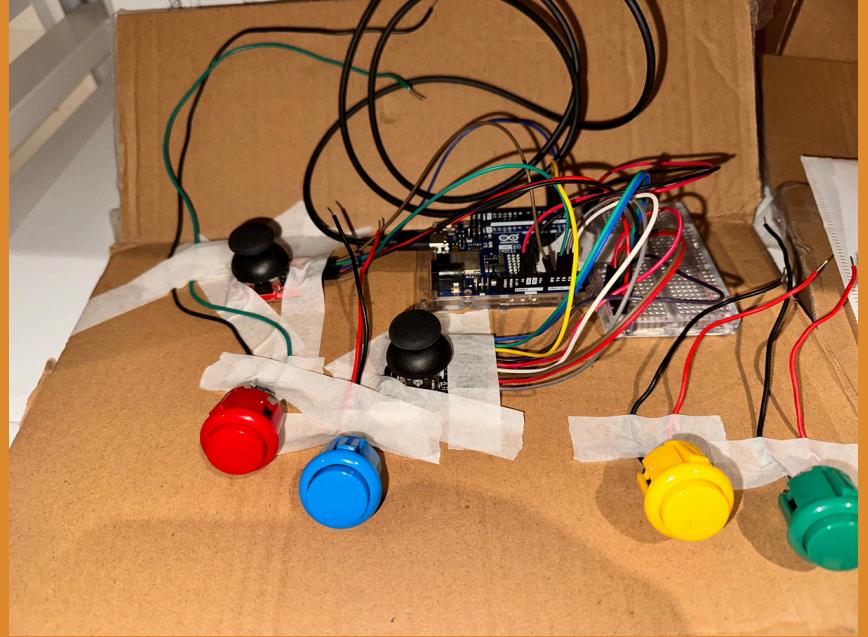
- Hand Function Training: Strengthening grip, improving finger coordination.
- Upper Limb Mobility: Reducing muscle strain, enhancing controlled movement.
- Balance & Coordination: Increasing stability in daily tasks.

# WEEK 3

## Prototype + Materials

Connecting circuits with laptop

# ARDUINO UNO R4 WIFI



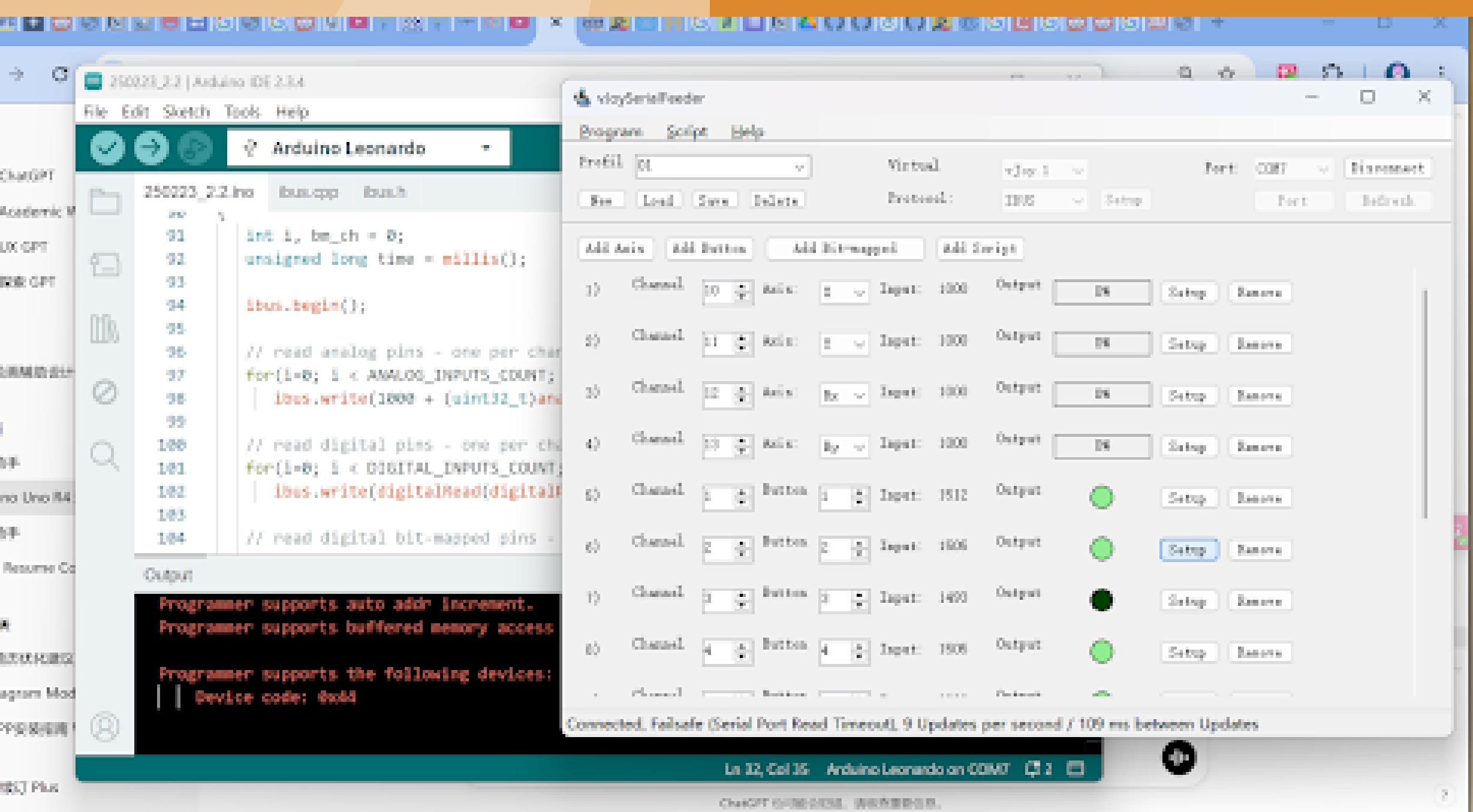
- Basically, prepared 2 joysticks and 8 buttons (the first version was 4, later add to 8) that are enough to map input into a potential gamePad. Successfully read all the data from Arduino. However, the part of mapping input from Arduino to PC input failed.

# WEEK 4

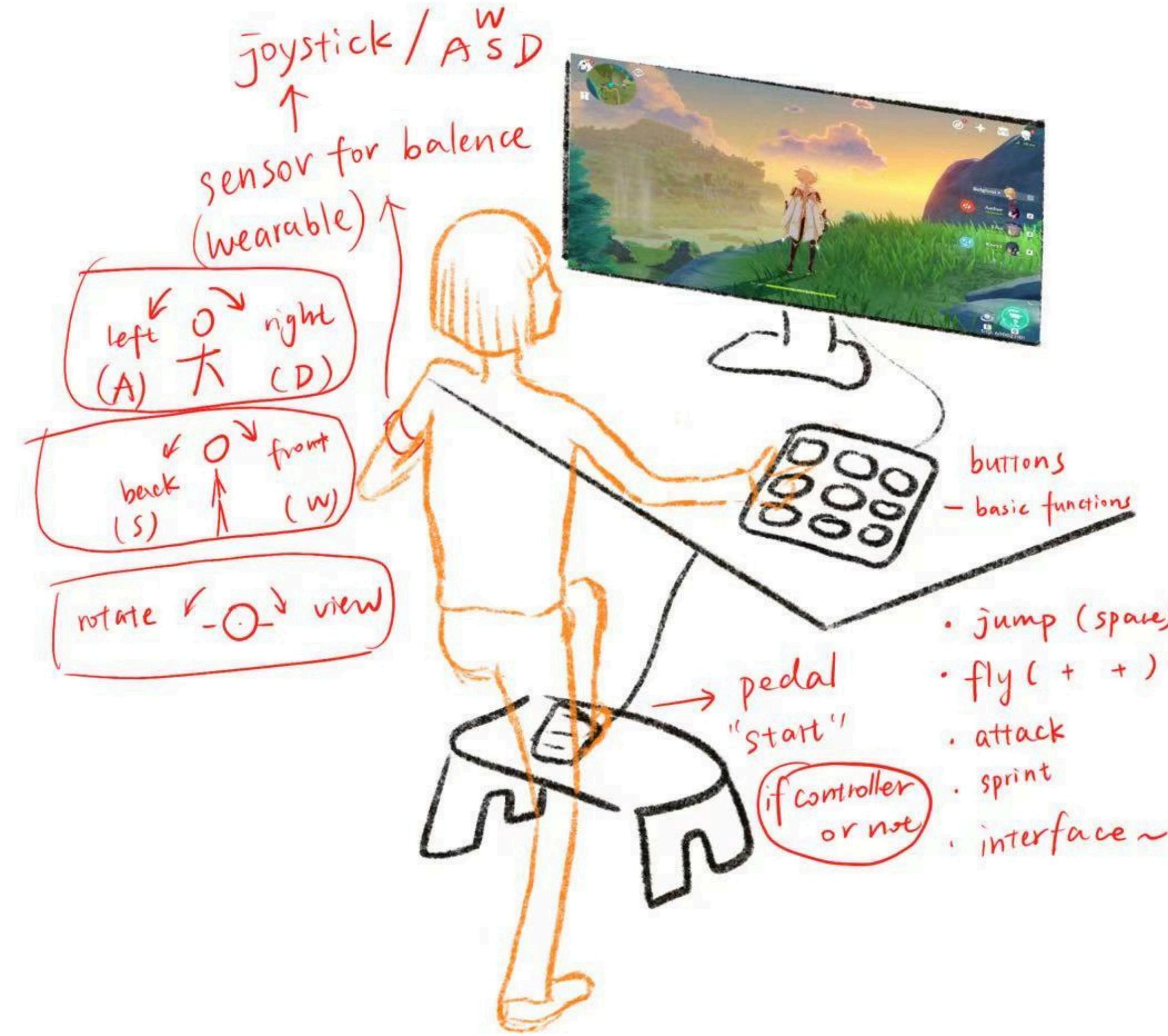
## Prototype

Replace with Arduino Leonardo  
Test different kinds of sensor

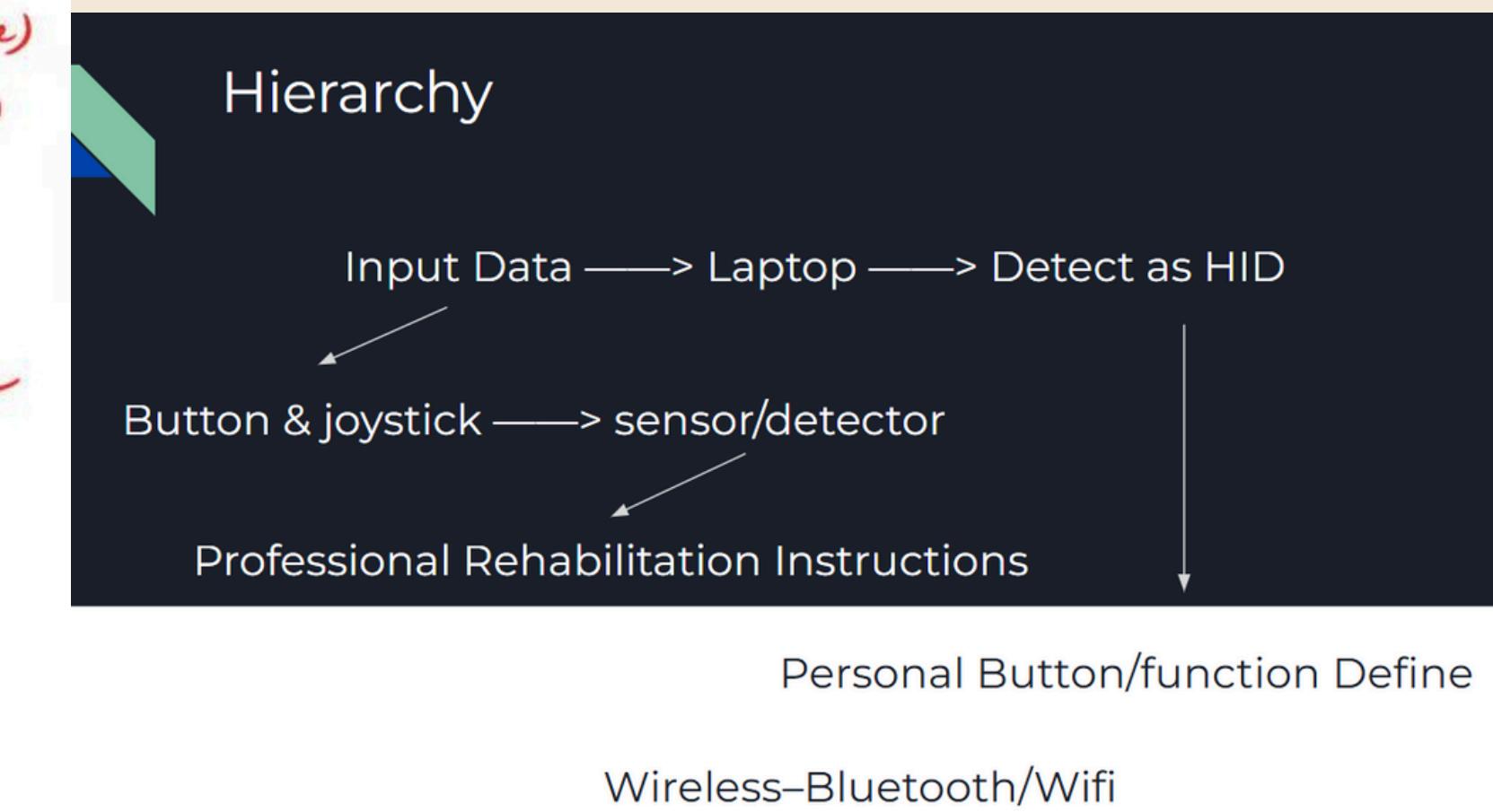
# ARDUINO LEONARDO + VJOY+VJOYSERIALFEEDER



- Ordered an Arduino Leonardo online and it arrived. Replaced Uno with Leonardo and tried to send a message to Vjoy through ibus. It showed reflections! but somehow the communication was always a timeout
- Keep on testing and taking a look at adaptive Wii Fit under the guidance of Andy.



- Visualize the expected final performance of the project.
- Refine the Hierarchy of the whole project development



# WEEK 5

## PROTOTYPE + USER STUDY

Xinput Works!

# dmadison/ ArduinoXInput



Xinput library for USB capable Arduino boards

3 Contributors    6 Issues    382 Stars    63 Forks

## dmadison/ArduinoXInput: Xinput library for USB capable Arduino boards

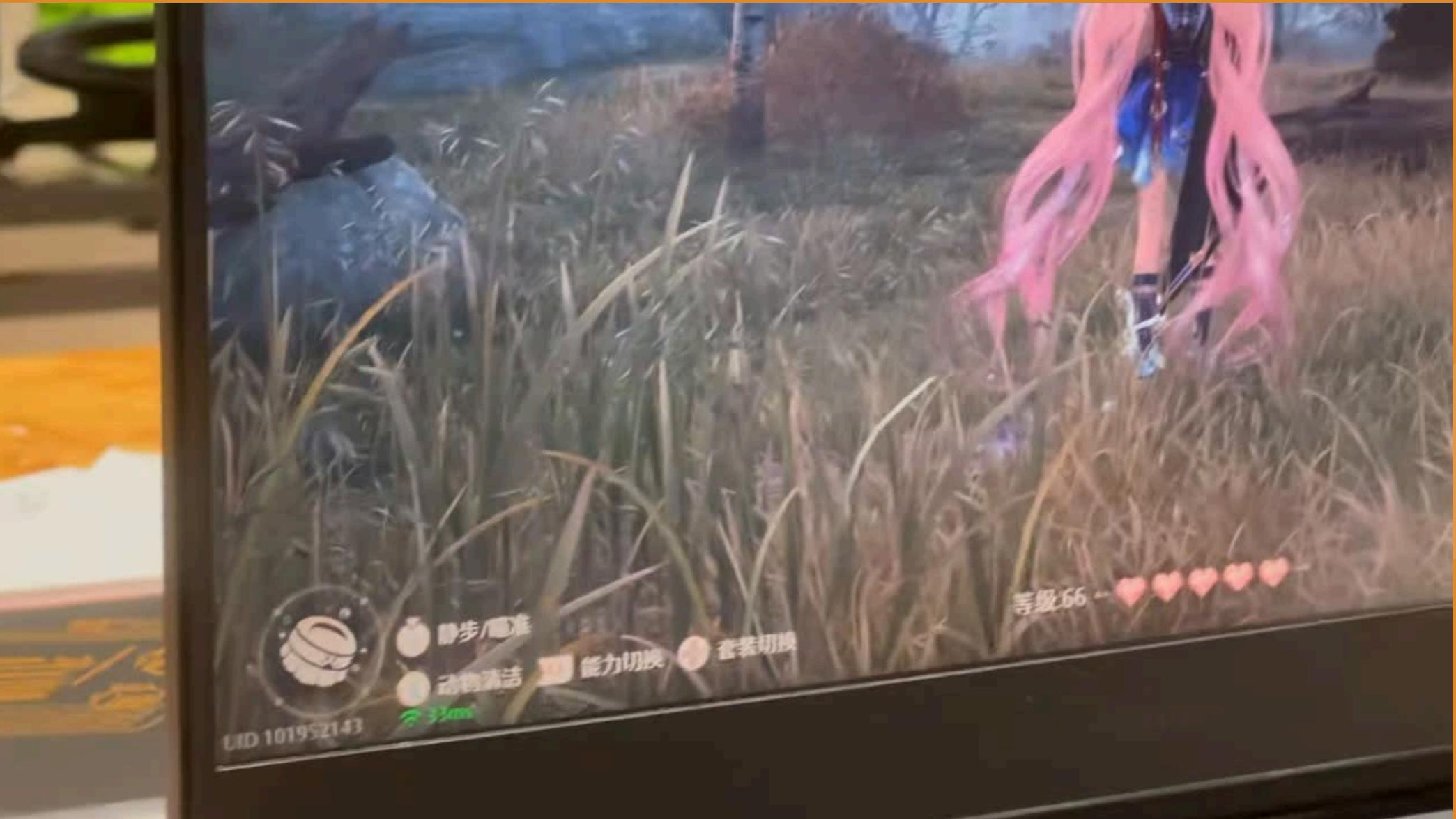
Xinput library for USB capable Arduino boards. Contribute to dmadison/ArduinoXInput development by creating an account on GitHub.

[GitHub](#)

After trying dozens of arduino libraries or packages, I finally found Xinput, which allows the computer to recognize Leonardo as an Xbox game controller. After a series of debugging and circuit adjustments, the conventional controller input controls connected to Leonardo can easily play the game.

This method will involve replacing the core files of the Arduino IDE software, so there are some problems in program burning and updating - Leonardo can only be recognized as a board by the IDE occasionally and briefly. [solved]

# PROTOTYPE



# PROTOTYPE



After realizing the connection between arduino and computer system software and hardware, the project has entered the next stage - replacing conventional joysticks/buttons as gamepad input, combining sensors and specific rehabilitation training content

Since spring has not yet arrived and the weather is still cold, my codesigner has not yet started the rehabilitation session in the hospital. So based on her and her mother's descriptions and demonstrations, I decided to start with simple exercises:

1. Stand on one leg. Put one foot on a small bench, put your weight on the other foot, and maintain your body balance independently for a few minutes;
2. Hand gripping exercises. Using a gourd bottle that is close to the thickness of a fist, try to find a way for your left hand to independently complete "positioning" and "grabbing"

Taking Wii Fit Balance as reference, and suggested by Prof. Andy, I decided to build up a balance board for the standing exercise that Siyi daily does. Then I started to sketch and order force sensors online

# GALLERY SKETCH PREVIEW



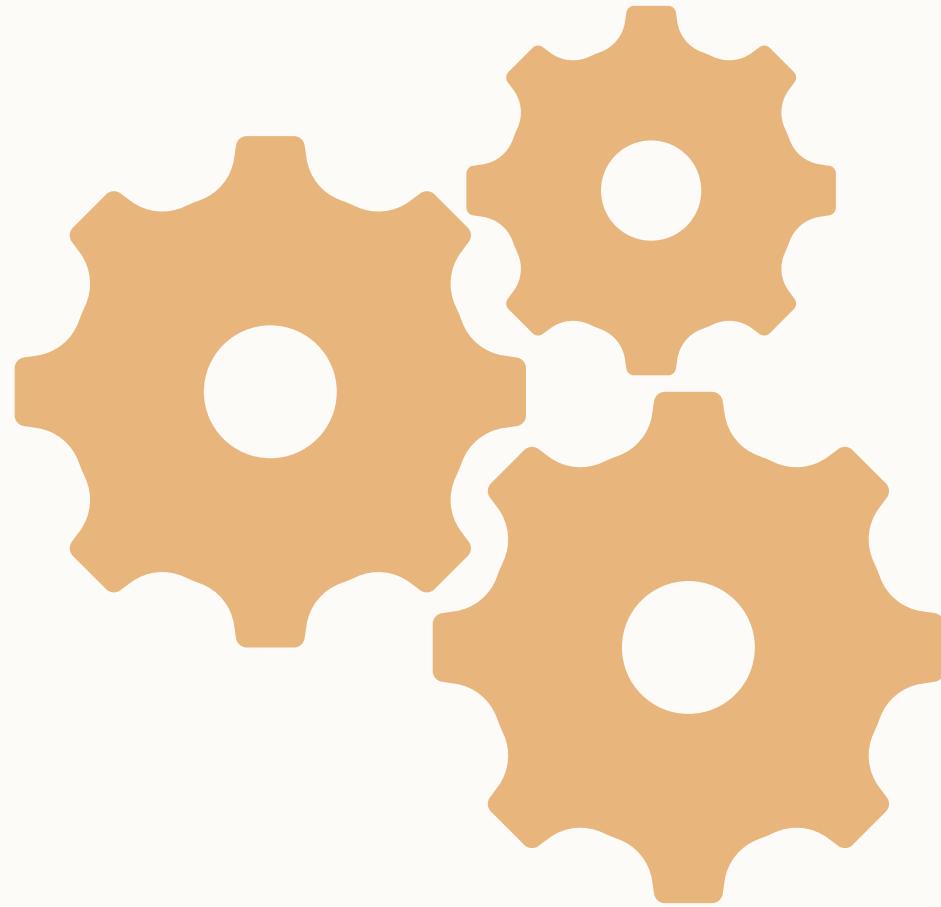
Ideally, produce and set up 1-2 or even more sets of interactive devices that "control the Genshin Impact game by detecting rehabilitation training content" + a poster, curtain or screen to display the project concept and story video in the process [like a documentary, better with professional interviews with Siyi, her family, Minki, Rudi...also Doctors from hospital]

# WEEK 6

First Rehab Visit  
+ Balance Board Development

# FIRST REHAB SESSION(PUTUO HOSPITAL)

Some Exercises  
Supervised by the doctor



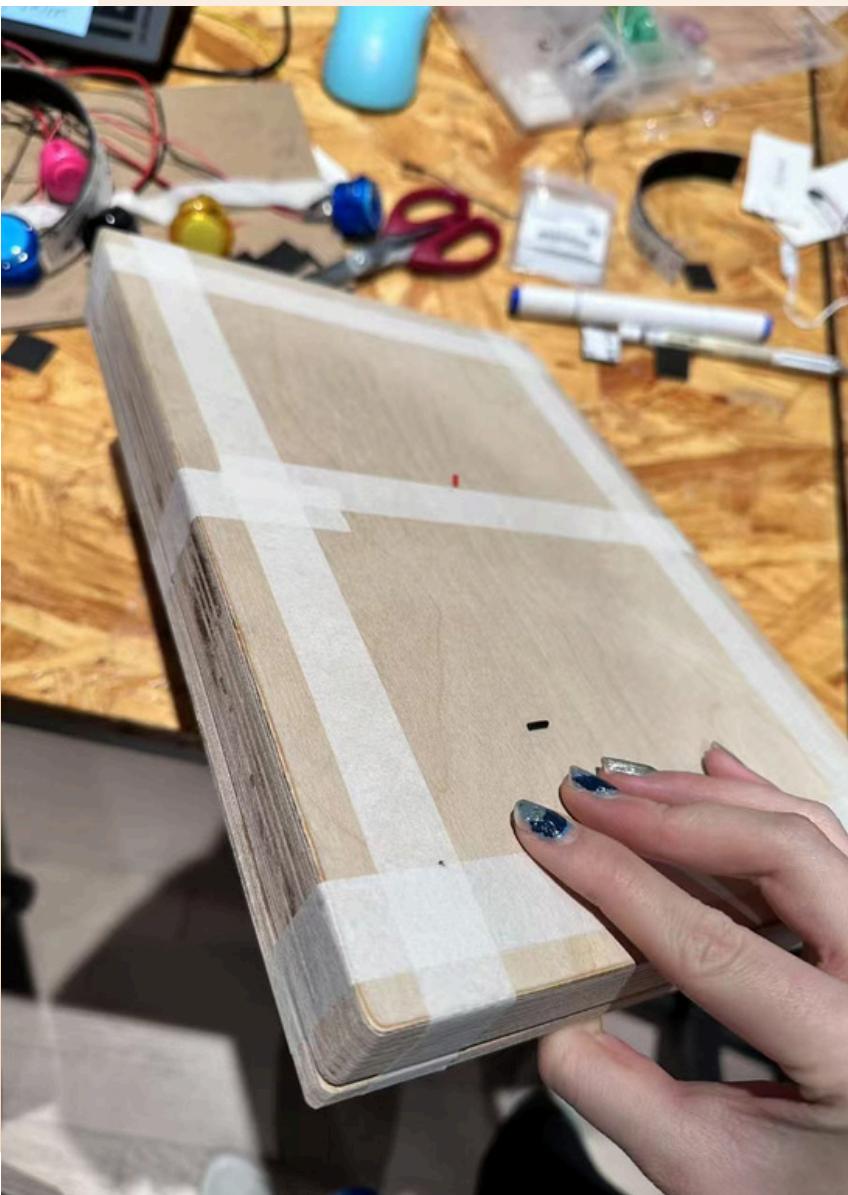
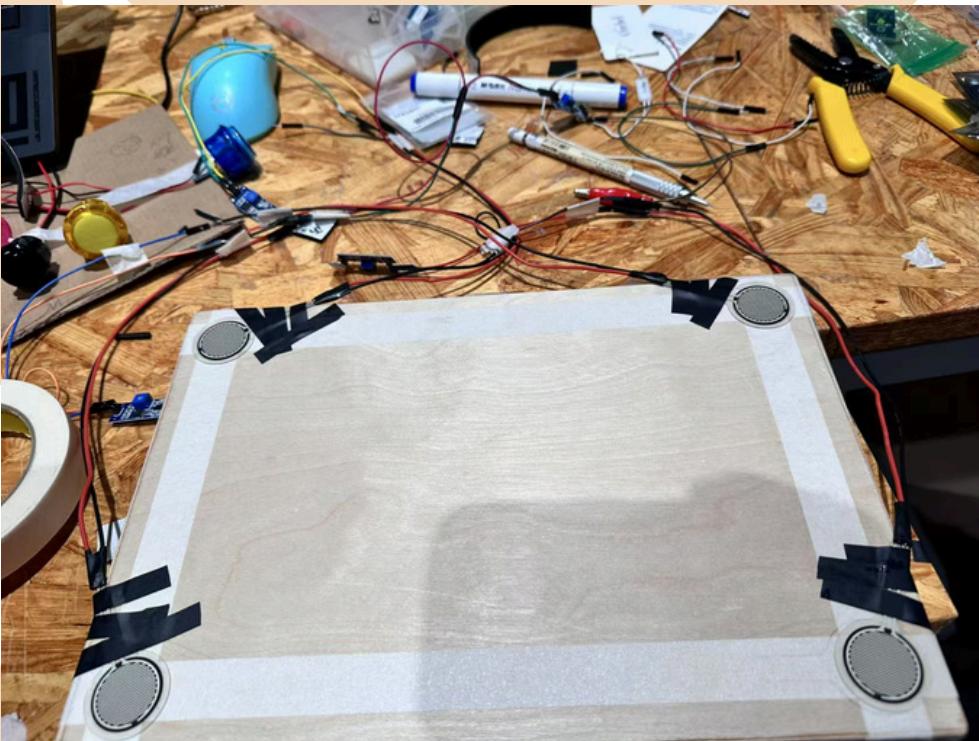
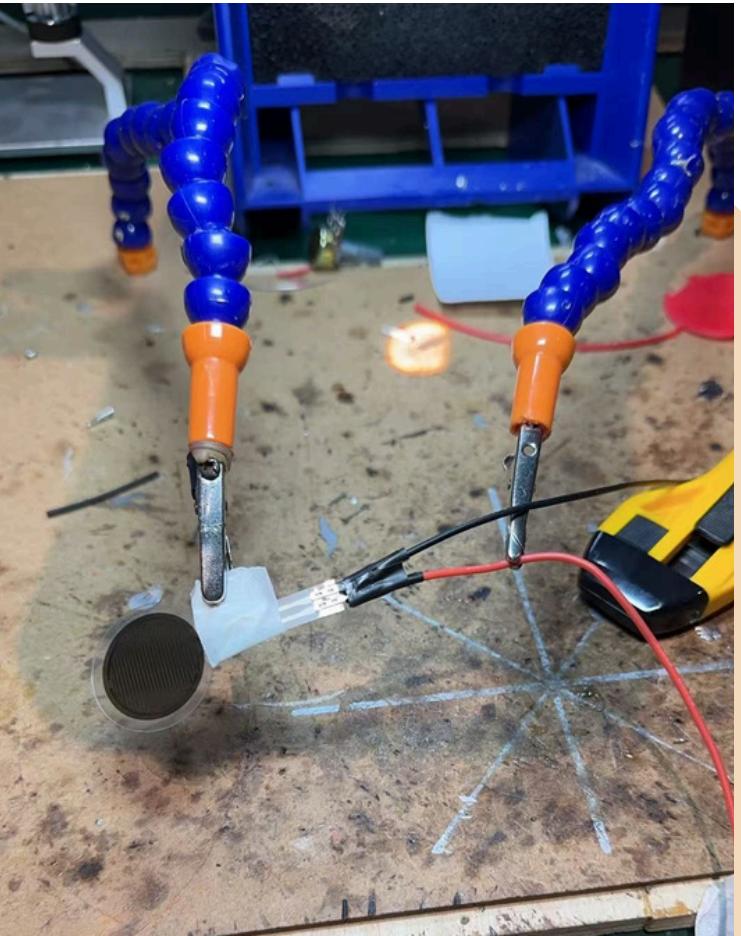


## FIRST REHAB VISIT

The doctor helped Siyi massage and stretch muscles in various parts of the body, helped Siyi relax and then provided training guidance by combining systemic and local targeted exercises.

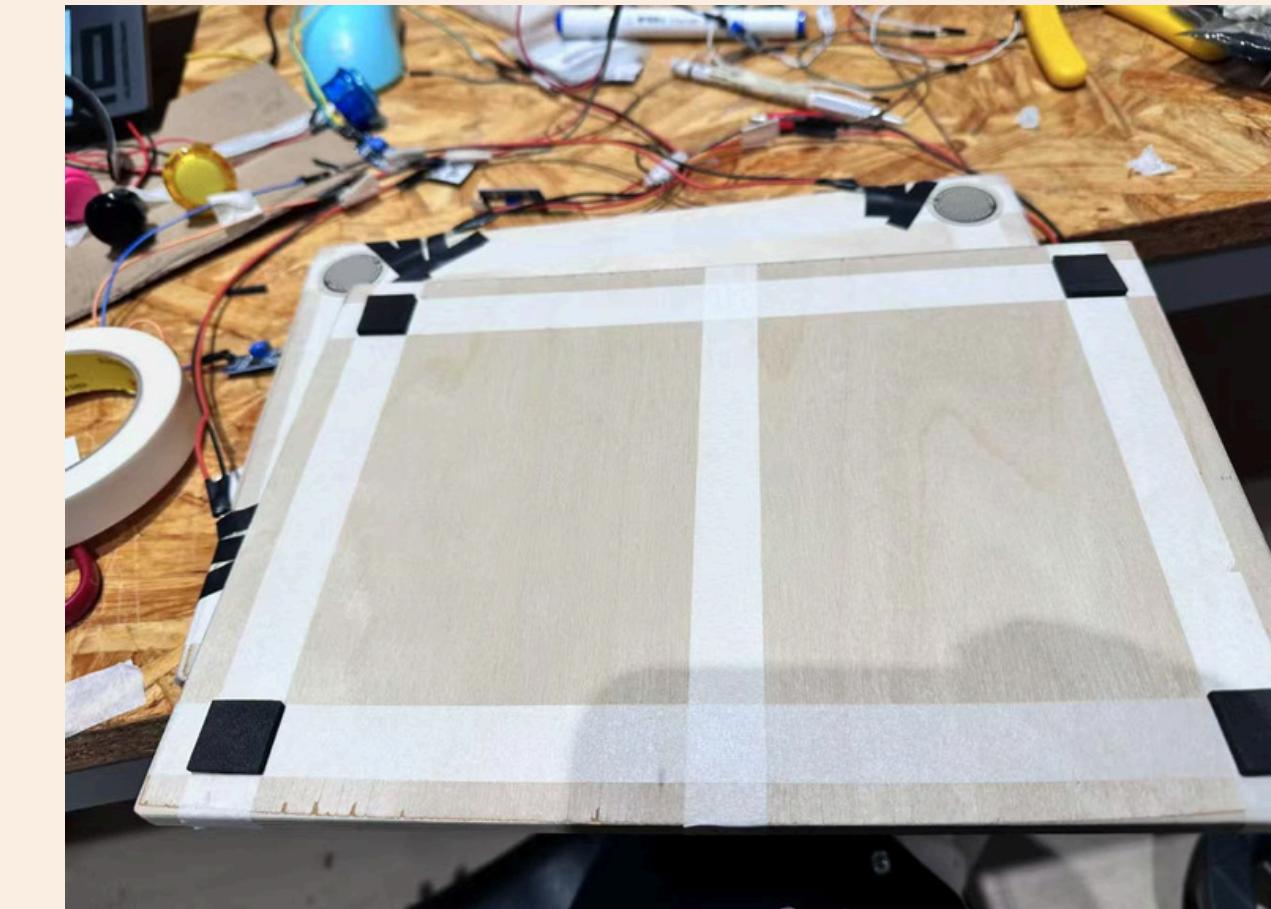
Compared with the single-leg standing (balance exercise) that Siyi did at home before, the exercises under the guidance of doctors are larger in scope and have a more direct activation effect on the body. This made me have self-doubt about "capturing Siyi's balance posture in a standing state through a balance board to help her exercise active control." In addition, Siyi's mother told me that they will go to another more authoritative hospital to try a new round of rehabilitation training next week, and suggested that I compare the doctor's methods and judgment to adjust the direction of the project.

# PROTOTYPE



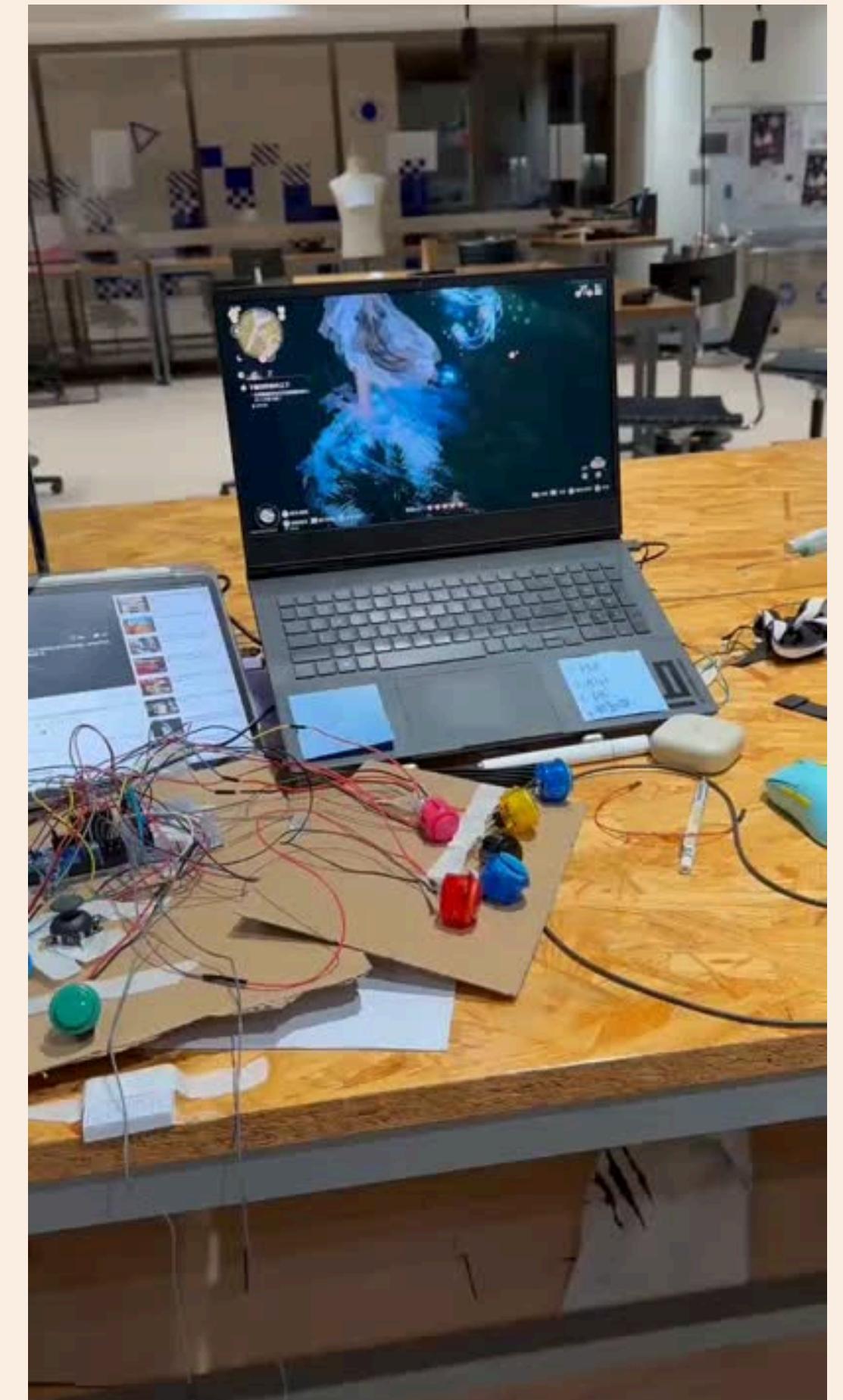
- So, I decided to continue trying to implement the controller of the balance board, and try to bring the project or demo to the new hospital during my visit in the next few weeks to seek the doctor's advice.

- cut wood with the help of Da Lin
- Soldiered Forcesensors and build up basic circuit
- Serial-print output and basically optimal the code/parametter



# PROTOTYPE

- When I was debugging parameters for the finished balance board (read and programmed through uno), and trying to convert the pressure values at the four corners into x-y "balanced" data and input it into Leonardo's A0A1 (the original y, x input pins of the leftjoystick). The good news is that the game character appears to respond; but what is not ideal is that the game character keeps twitching and spinning in place. I think this at least proves that the balanced board is feasible as an input, but the signal transmission and preprocessing require further debugging and optimization.
- In addition, I invited several friends who also play Genshin Impact (the game Siyi is playing) to test the existing basic game keys and help me evaluate and sort the frequency and method of use of each function key, so as to design and research other possible input control replacements in the future. In addition, for Genshin Impact, Dpad (up, down, left, and right buttons) means character switching, which is an essential control in the game experience, which I omitted because Leonardo does not have enough pins. This means that either the D0, D1, and D13 pins are used directly according to the Xinput example code, or the number of pins is expanded through an external chip.



# WEEK 7

Rehab visit  
+ Doctor words  
+Project Development

Connecting circuits with laptop

# SECOND REHAB SESSION VISIT(NEW DOCTOR)



I accompanied Siyi to her first session of the new rehab training program at Huashan Hospital and took some notes from the doctor:

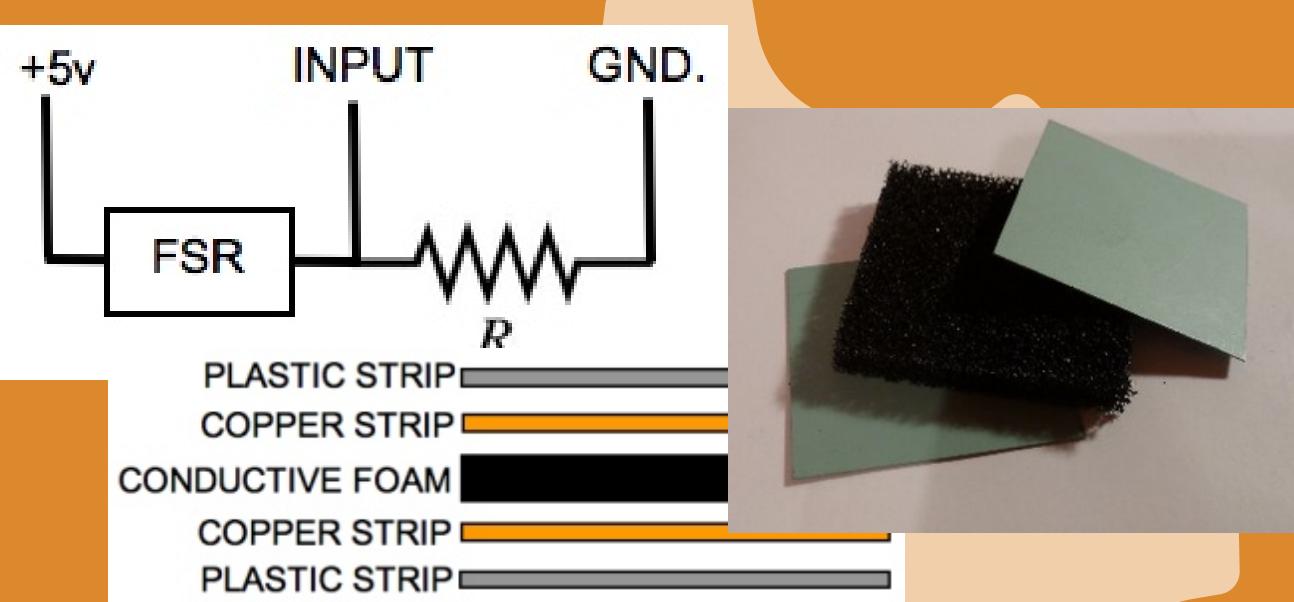
1. High muscle tone → Requires long-term passive stretching to improve flexibility.
  - a. Passive activation is the main focus.
  - b. Effective active exercises are relatively limited.
2. Good limb strength, but poor localized control
  - a. She tends to use her whole body to complete movements rather than engaging her core (hips/lower back).
  - b. Performs well in a relaxed state but tenses up easily, leading to spasms (uncontrolled movements).
3. Daily active exercise recommendations:
  - a. Fix the core (lower back) and use limbs to complete targeted movements.
  - b. Balance training: The yoga ball + walker combination is commonly used in rehab settings.

# INSIGHTS & CONCERN

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- The current force sensor setup on the balance board provides limited feedback. I previously considered adapting it into a cushioned platform, which is safer and allows stable practice on the floor/bed.
- However, the doctor emphasized that the yoga ball + walker method is widely used in rehab due to its strong physical feedback and effectiveness. I'm torn between the two approaches.
- Adding hand/arm motion detection to the balance board could enhance interaction, but I'm unsure if we can fully integrate this within our project timeline while aligning with Siyi's rehab progress.

# CONCLUSION/POTENTIAL SOLUTION



foam force sensor DIY:

<http://iainmccurdy.org/diy/forcesensorfoam/forcesensorfoam.html>



1. Let users to play with the balance board in a sitting or supine position instead of the initial standing balance training
2. Continue with the current design with wood and conduct a round of user test first.
3. research and consider--combine with half yoga ball[suggested by Prof. Andy], or foam force sensors[Introduced by Prof. Eric]

# PROJECT DEVELOPMENT--BALANCE BOARD

After a lot of hard work and attempts, and two weeks, I finally succeeded in getting the balance data read by the balance board to smoothly control the movement of the game character.



# PROJECT DEVELOPMENT--BALANCE BOARD

# 1. Mathematical Modeling & Serial Data Analysis

## 2. Movement

# Mapping(mapping character walking and running modes as well)

# 3. Signal Communication: from UNO PWM to Leonardo AnalogRead-- resistor-capacitor low-pass filter

# 4. Smoothing & Stability

## Functions

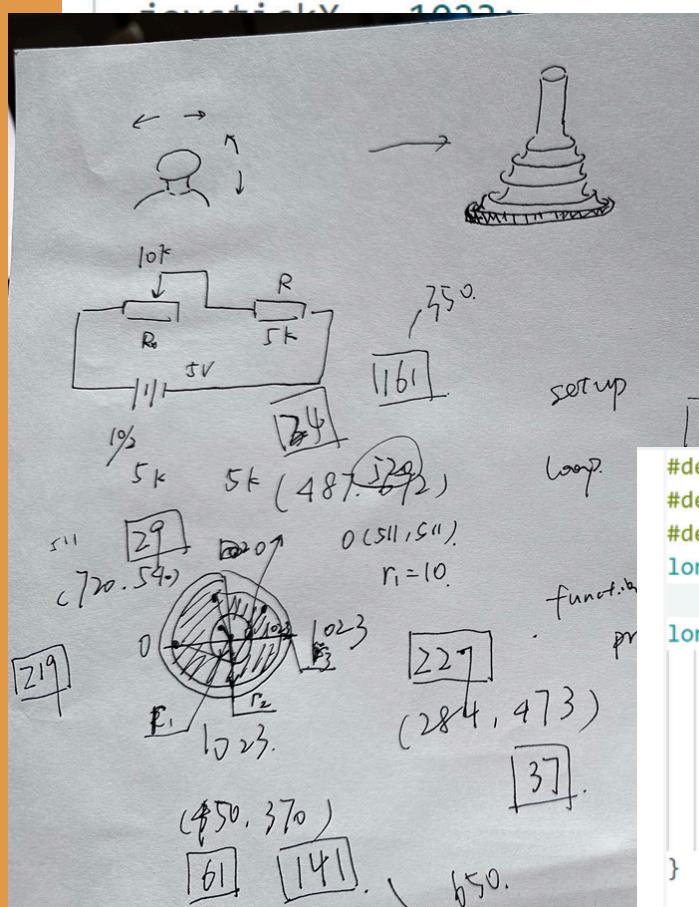
```
if (joystickX < x1) {
    joystickX = 0;

} else if (joystickX >= x1 && joystickX <= x2)
    joystickX = map(joystickX, x1, x2, 0, 512);

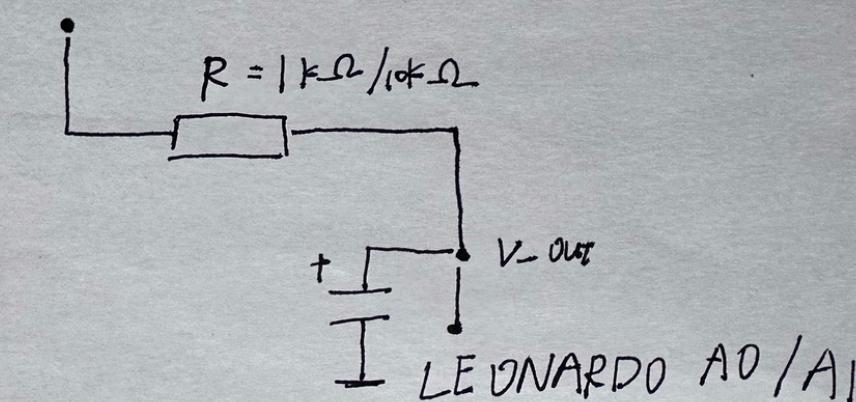
} else if (joystickX > x2 && joystickX < x3)
    joystickX = 512;

} else if (joystickX >= x3 && joystickX <= x4)
    joystickX = map(joystickX, x3, x4, 512, 1023);

} else {
    joystickX = 1023;
```

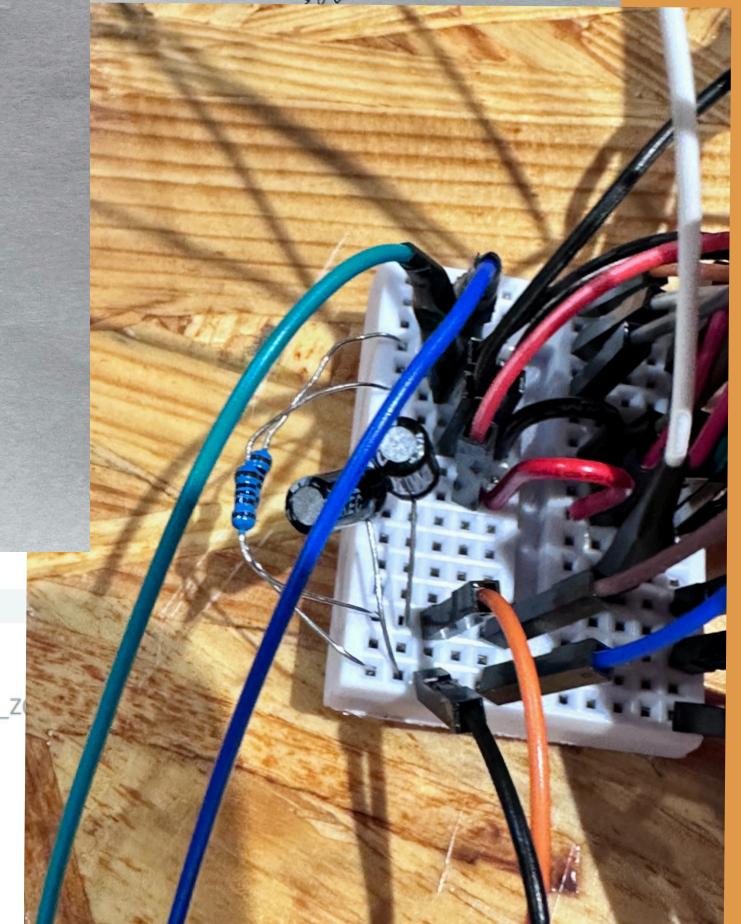
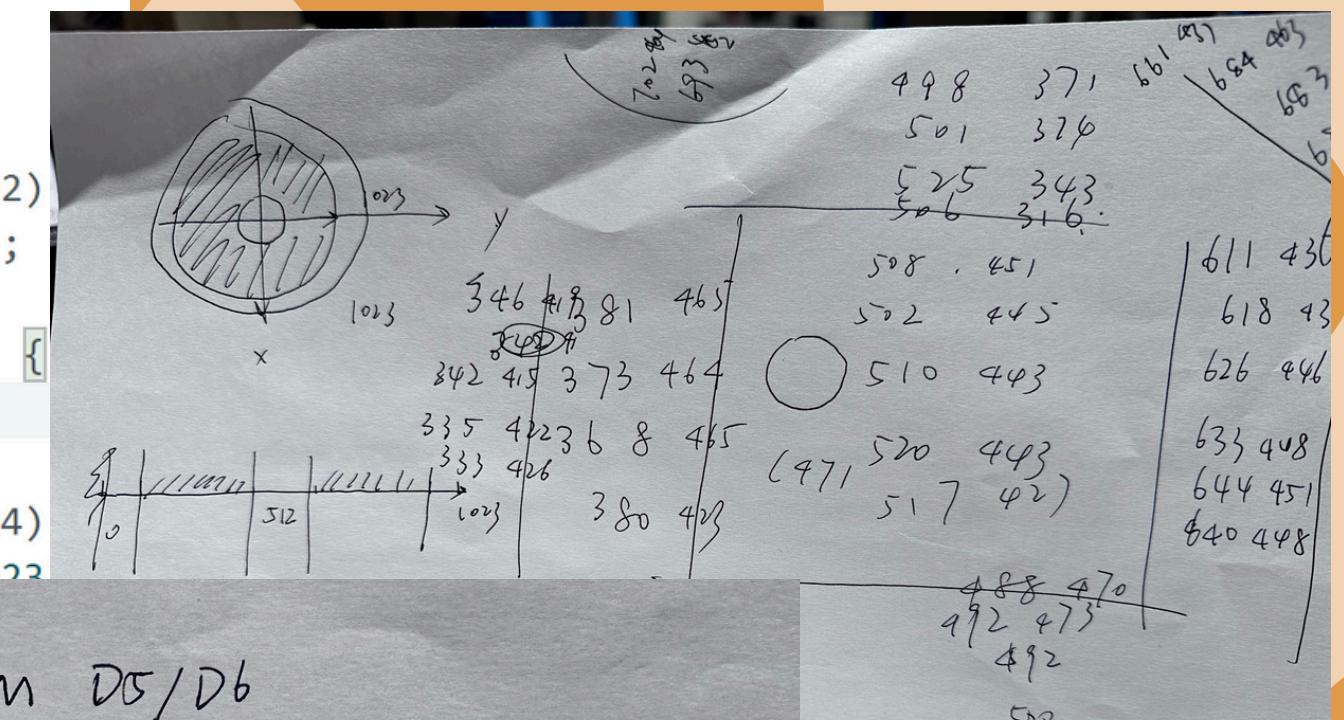


UNO PWM DS/DT



```
#define
#define
#define
long smoothedF1 = 0, smoothedF2 = 0, smoothedF3 = 0, smoothedF4 = 0;

long smoothData(long newValue, long oldValue) {
    if (abs(newValue - oldValue) < DEAD_ZONE) {
        // if (newValue - oldValue) < DEAD_ZONE || abs(newValue - oldValue) > LIMIT_Z
        return oldValue;
        // newValue = oldValue;
    }
    return (SMOOTH_FACTOR * newValue) + ((1 - SMOOTH_FACTOR) * oldValue);
}
```



Logbook live view, with all media ready to play.