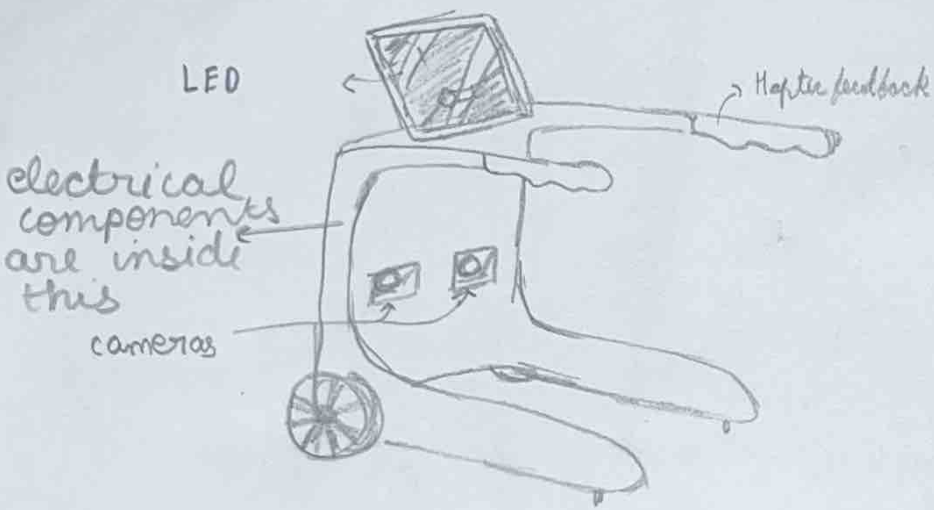
Group code: Tue-20 Student names: Rishabh, Sahil, Sanat, Bhuvansh, Saarthak EDL 2025

Project title: Smart Walker for Clinical Rehabilitation. Date: 21.01.25

Use your notebooks for discussions and rough work. Fill out this sheet after working individually and discussing within your team.

1. **In simple words, describe what you are going to build in your project, what its purpose is, and how it will function.** Be as detailed as possible, covering all the major aspects of your project.
   a. What is the main goal of your project?
   b. What problem does it solve, and how?
   c. Who will use your project, and in what context?

   Draw a pencil sketch of what your project will look like at the end of the course, for final demo.

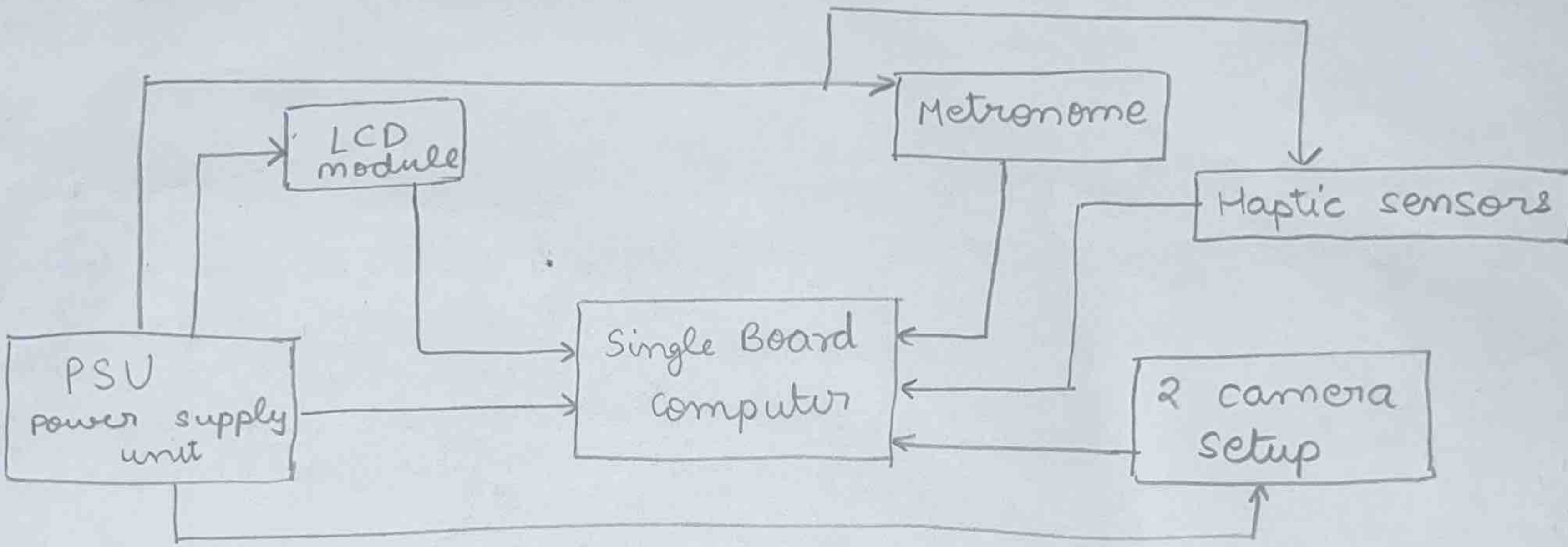


a) The goal of this project is to make a smart walker device which can be used to Measure/ Capture gait patterns/ walking patterns and derive relevant information from it for ~~This will~~ better and efficient Rehabilitation.

b) We can capture the data using camera and provide feedback to patient in real-time and also have recording of the session which can be shared to doctor for supervision.

c) Patients recovering from accidents, strokes, Suffering from conditions to compromise their mobility and need assistive aid ~~and~~ for faster recovery

2. **Draw a block diagram of your project.** Create a visual representation showing the key components or subsystems of your project. For each block in the diagram, briefly explain its main function and how it fits into the overall system.
   a. What are the main subsystems or modules of your project?
   b. How do they interact with each other?



Group no. – TUE-20.

3. **Write down details for these blocks:** What are the key performance metrics for each block (e.g., power, size, speed)? What trade-offs are you considering in your design choices? Are there any constraints or limitations for each block?

Block	Key specifications of this block	Design choices for this block
PSU	According to some sources on the internet we need 5V 2A supply for powering a Pi 5	we could use lipo cells in parallel with a battery protection circuit or an already available PSU with similar specs
Single source computer	~~we~~ Currently we dont expect using heavy AI models we are planning to use 2 camera stereo setup so a Pi 5 should be sufficient	we could use a Pi compute module and design a custom PCB that has only the peripherals we require instead of a Pi 5 block
Camera	We require 1080p video for ~~ste~~ depth detection.	We would use Pi Camera module.
LCD	For User Interface	A Large Touch Display (13' inch)

4. **What are the unknowns or uncertainties in this project?** Identify aspects of your project that you are uncertain about or that require further research. This may include areas where you know what you need to do but are unsure how to approach it.
    a. What technical challenges or questions are you facing?
    b. Are there any assumptions you must make in order to move forward?

- Use of stereo camera for accurate detection of feet
- Role of A.I.. (using deep learning models.)
- Power Supply Unit design.
- How would we make the frame of the walker

Other things to consider from now until Milestone 1 deadline:

5. **Roles and Responsibilities: How will the work be divided among team members?** Assign specific tasks and responsibilities to each team member. Be clear about who is responsible for each part of the project.
    a. Who will work on which blocks or subsystems?
    b. What are the deadlines for each task?
    c. How will the team communicate and coordinate to ensure everyone is on track?

6. **Next Steps: What is your plan for the next phase of the project?** Outline what needs to be done in the short-term to move forward.
    a. What are the immediate next tasks or priorities?
    b. Are there any dependencies between tasks? How will you handle these interdependencies?
    c. What resources or materials do you need to proceed?

7. **Feedback and Collaboration: How will you gather feedback and collaborate during the project?** Describe how your team plans to share progress, give and receive feedback, and collaborate throughout the course of the project.
    a. How often will you check in with your team members?
    b. Will you conduct regular brainstorming or review sessions?

Smart walker for clinical rehabilitation

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01

Problem Statement

What is the problem?

Patients undergoing rehabilitation often use walkers incorrectly, leading to:

- **Improper foot placement.**
- **Uneven weight distribution.**

These issue causes :

- **Increased risk of injuries.**
- **Slower recovery times.**

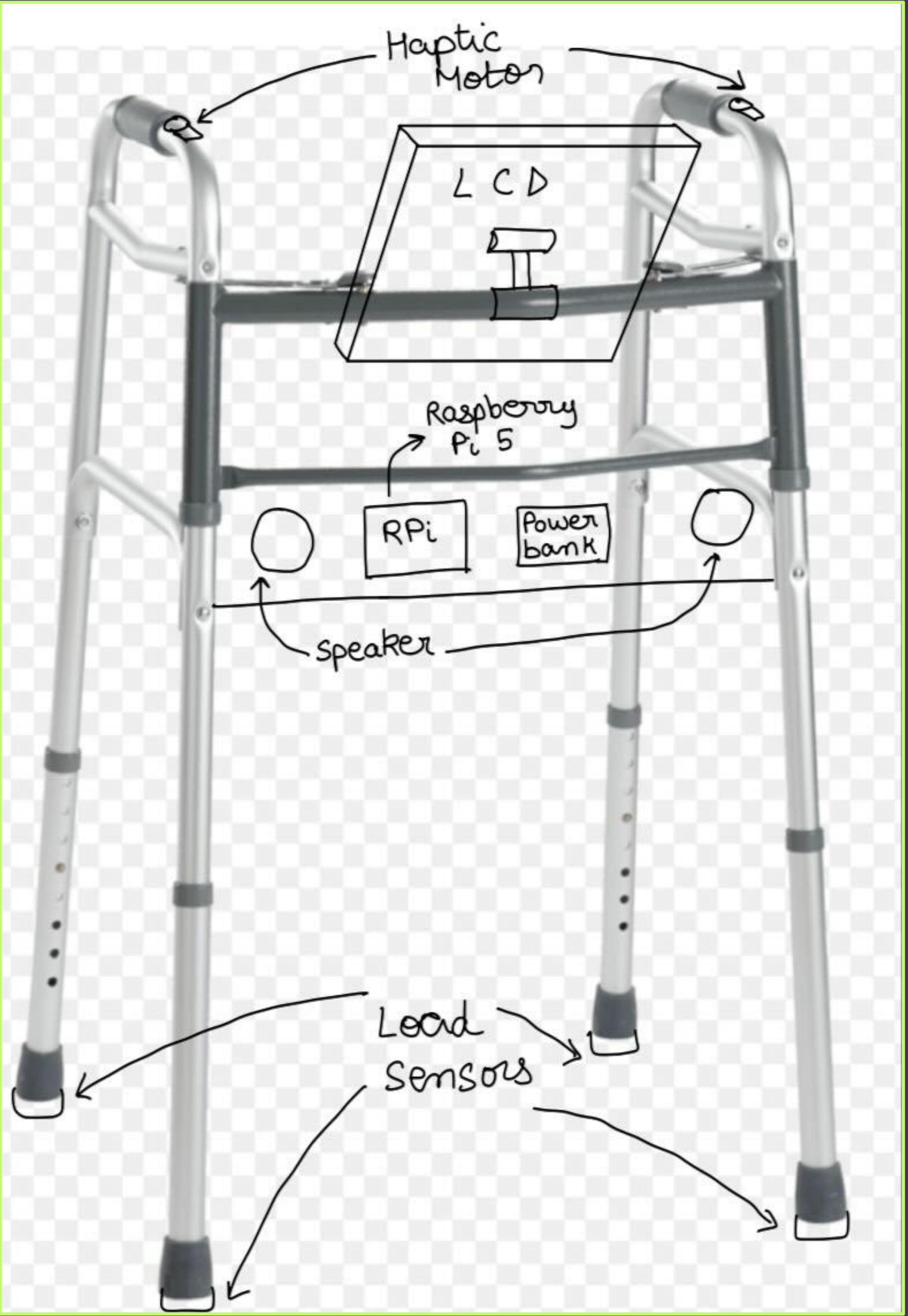
Why is this Important ?

- Improper walker usage can lead to long-term mobility issues.
- There is a need for a smart, assistive device to improve rehabilitation outcomes

Current solutions lack real-time feedback to guide patients effectively !

02

Proposed Solution



Our Solution

A Smart Walker that provides real-time feedback to users during rehabilitation.

Key features:

- **Correct foot placement guidance** using a stereo camera.
- **Weight distribution monitoring** using load cells on each leg.
- **Real-time feedback** via haptic sensors, LCD display, and voice feedback.

Value Proposition:

- Reduces risk of injuries during rehabilitation.
- Accelerates recovery by ensuring proper walker usage.
- Provides clinicians with data to monitor patient progress.

03

How Will We Achieve the Specifications?

Methodology and Component Selection:

- **Research & Literature Review:** Identified gaps in existing walker technologies.
- **Professor Meet:** Discussions with Prof. Neeta (BSBE Dept) to identify problems to analyse.
- **Cost Optimization:** Selected affordable components considering accuracy factor.

04

Technical Details

Sr. No	Usage (Name of the "Circuit block/Functional block" in which components is used)	Part description (OpAMP,ADC,DAC etc)	Manufacturing Part Number	Package type/Footprint	Availiable in WEL?	Vendor	Required Qty + Spare	Cost per each item	Total Cost
1	Weight Sensing Block	Load Sensor	613 N	load cell sensor	No	Robu	4+2	108	648
2	Weight Sensing Block	ADC	HX711	Breakout Board	No	Robu	4+2	40	240
4	Compute Block	Raspberry Pi 5	Raspberry Pi 5 Model 8GB	Development Board	No	Robu	1+0	8209	8209
5	Display Module	HDMI Capactive Touch	N/A	N/A	Yes		1+0		
6	Stereo Camera Module	Stereo Camera Module	IMX219-83	Camera Module	No	Robu	1+0	4799	4799
7	Haptic Feedback	DC Vibration Motor Module	N/A	Vibration Module	No	Robu	2+2	54	216
8	Audio System	Digital Amplifier Board	PAM8403	Digital Amplifier Board	No	Robu	1+1	65	130
9	Audio System	Speaker	N/A	8OHM Trumpet	No	Robu	2+2	42	168
10	Power Source	Power Bank	APB-15	Power Bank	No	Amazon	1+0	1899	1899
11	LED Feedback	LED	CJMCU-123 WS2812	LED Module	No	Robu	4+2	15	90
12	Data Logging	SD Card	Raspberry Pi Micro SD	Memory Card microSD	No	Robu	1+0	399	399
13	Walker	Walker			No	Amazon	1+0	853	853
								TOTAL	17651

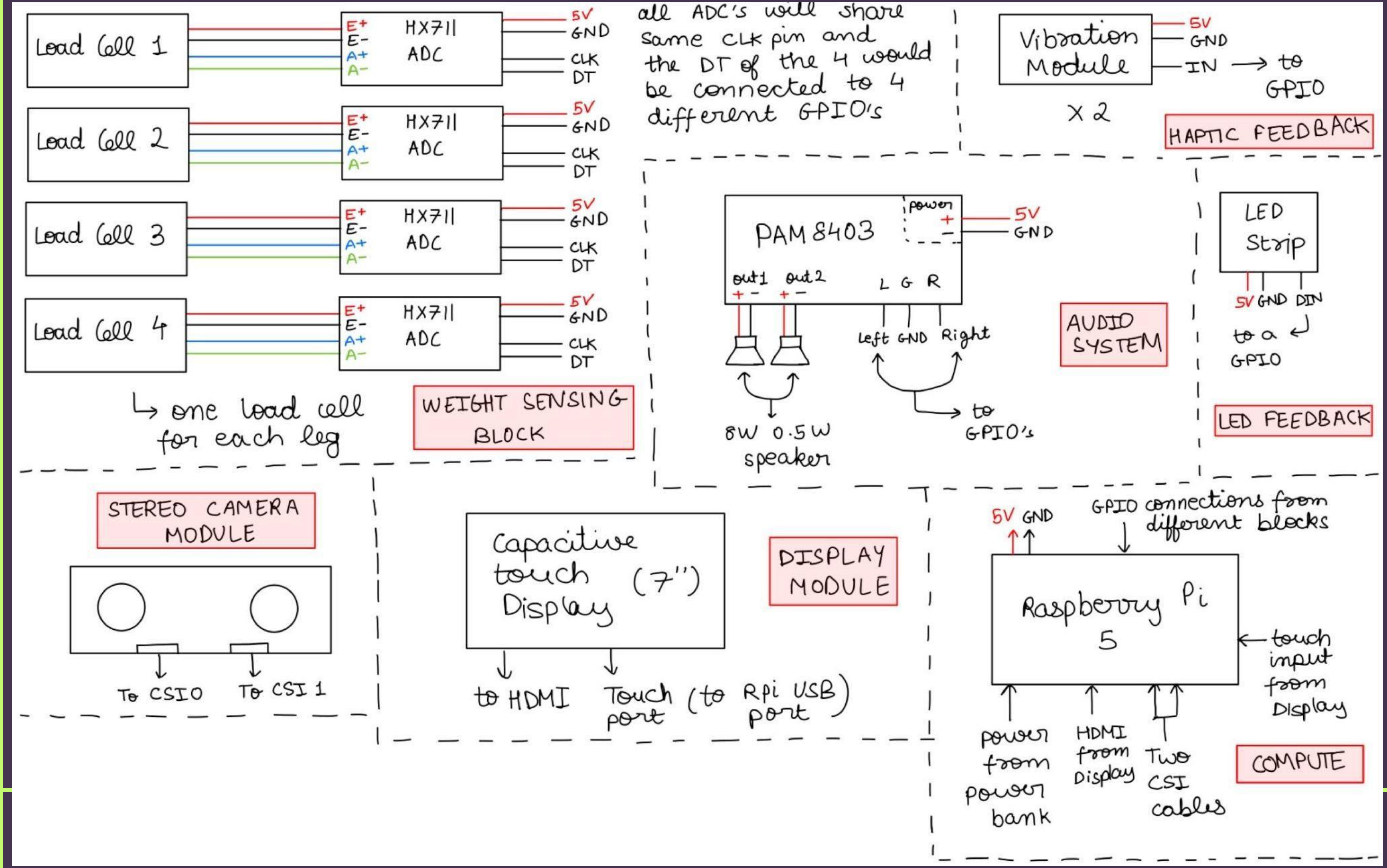
Justification of Component Choices:

- **Load Sensor (613 N)**: Chosen for high accuracy and durability in measuring weight distribution on the walker legs.
- **ADC (HX711):** Selected for its compatibility with load cells and ability to provide precise digital output for weight measurement.
- **Raspberry Pi 5 (8GB)**: It should provide sufficient processing power for real-time data processing and integration of multiple sensors.
- **HDMI Capacitive Touch Display:** Offers an intuitive user interface for real-time feedback and guidance.
- **Stereo Camera Module (IMX219-83)**: Chosen for accurate depth perception and cost-effectiveness compared to depth cameras.

Justification of Component Choices:

- **DC Vibration Motor Module:** Provides tactile feedback to users, enhancing the real-time guidance system.
- **Digital Amplifier Board (PAM8403):** Ensures clear audio feedback with low power consumption.
- **Speaker (8OHM Trumpet):** Delivers loud and clear voice feedback for user guidance.
- **Power Bank (APB-15):** Provides portable and enough power for the entire system.
- **LED Module (WS2812):** Used for visual feedback (e.g., color-coded alerts) to guide users.
- **SD Card (Raspberry Pi Micro SD):** Enables data logging for monitoring user progress over time.
- **Walker:** Acts as the physical base for integrating all components.

Block and Circuit Diagrams



05

GANTT CHART

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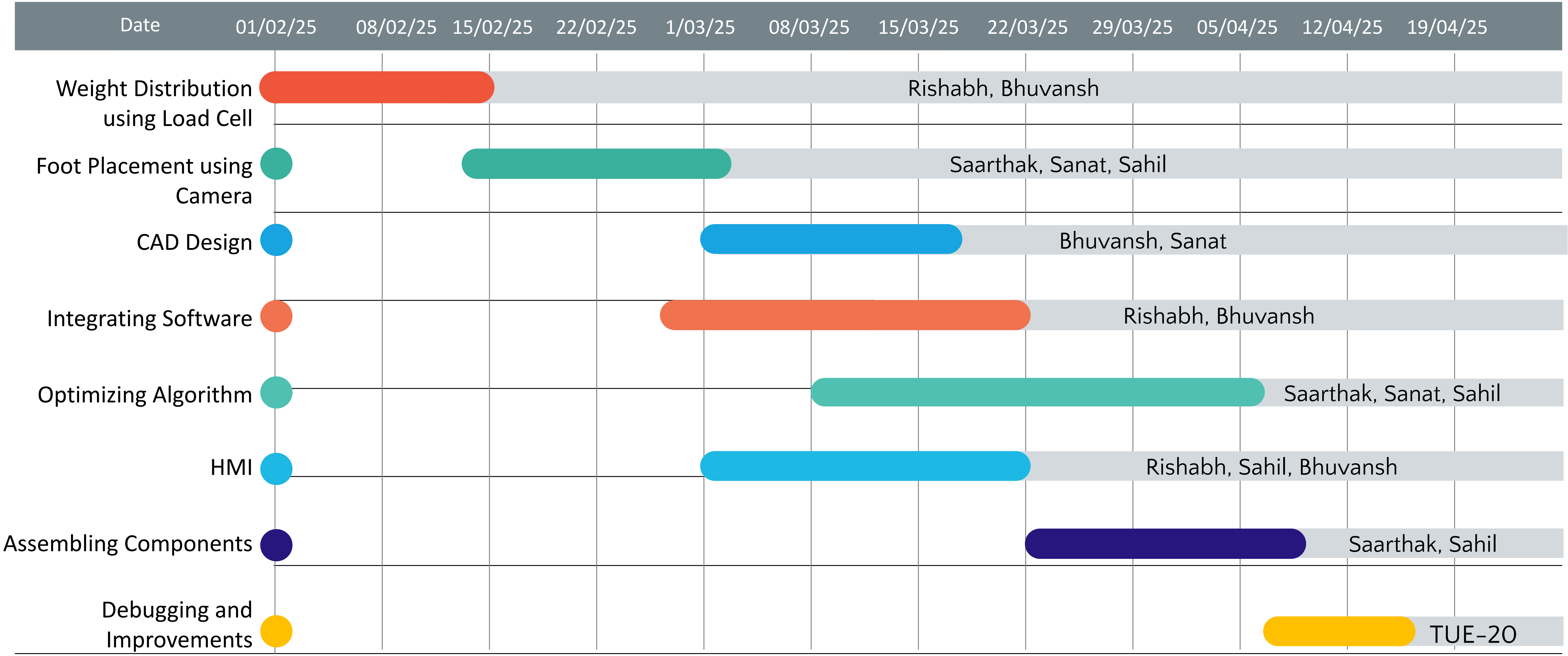
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29/03/25
05/04/25
12/04/25
19/04/25
Weight Distribution using Load Cell
Rishabh, Bhuvansh
Foot Placement using Camera
Saarthak, Sanat, Sahil
CAD Design
Bhuvansh, Sanat
Integrating Software
Rishabh, Bhuvansh
Optimizing Algorithm
Saarthak, Sanat, Sahil
HMI
Rishabh, Sahil, Bhuvansh
Assembling Components
Saarthak, Sahil
Debugging and Improvements
TUE-20

06

Key Risks and Mitigation Strategies

Risks:

- Load cells may provide noisy data.
- Integration challenges between hardware and software.
- Stereo Camera calibration error.
- Delay in Feedback.
- R-pi processing limitations.

Mitigations:

- Regularly calibrate load cells to maintain accuracy.
- Test each block individually before integration.
- Perform regular calibration to ensure accurate depth measurements.
- Optimize code for efficiency.

07

Deliverables

Expected Outcomes:

- A functional smart walker prototype.
- Real-time feedback system for foot placement and weight distribution.
- Data logging for clinician analysis.
- Documentation (technical report, user manual).

Impact:

- Improved rehabilitation outcomes for patients.
- Potential for commercialization in the healthcare industry.

Smart walker for clinical rehabilitation

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01

Milestone 1 Feedback

Addressing Feedbacks

Feedback

- Focus on Human Machine Interaction

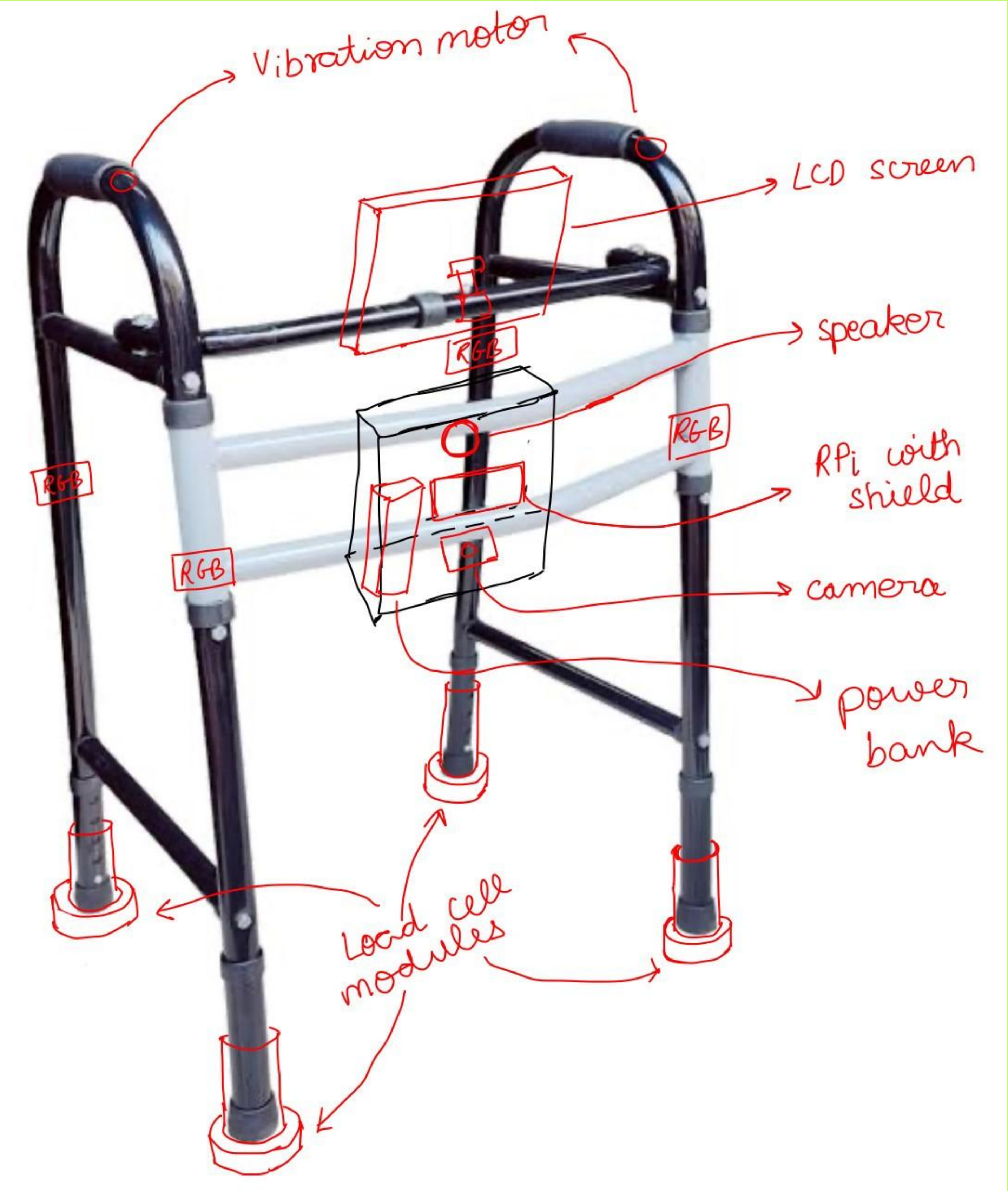
These issue causes :

- Incorporated haptic sensing for when to look at the screens

02

Overview

Overview:



Key Components:

- **Microcontroller** – Raspberry Pi 5 for processing and control.
- **Sensors** – Load cell with HX710A ADC for weight measurement.
- **Stereo camera** - for pose detection.
- **Communication Protocols** – SPI for LED control, PWM for vibration motor, bit-banging for ADC communication.
- **Display & Audio** – Screen with HDMI interface; speaker for audio output.
- **Software & Algorithms** – YOLO-based pose detection, real-time data processing, and calibration techniques.

03

Deviations and Progress

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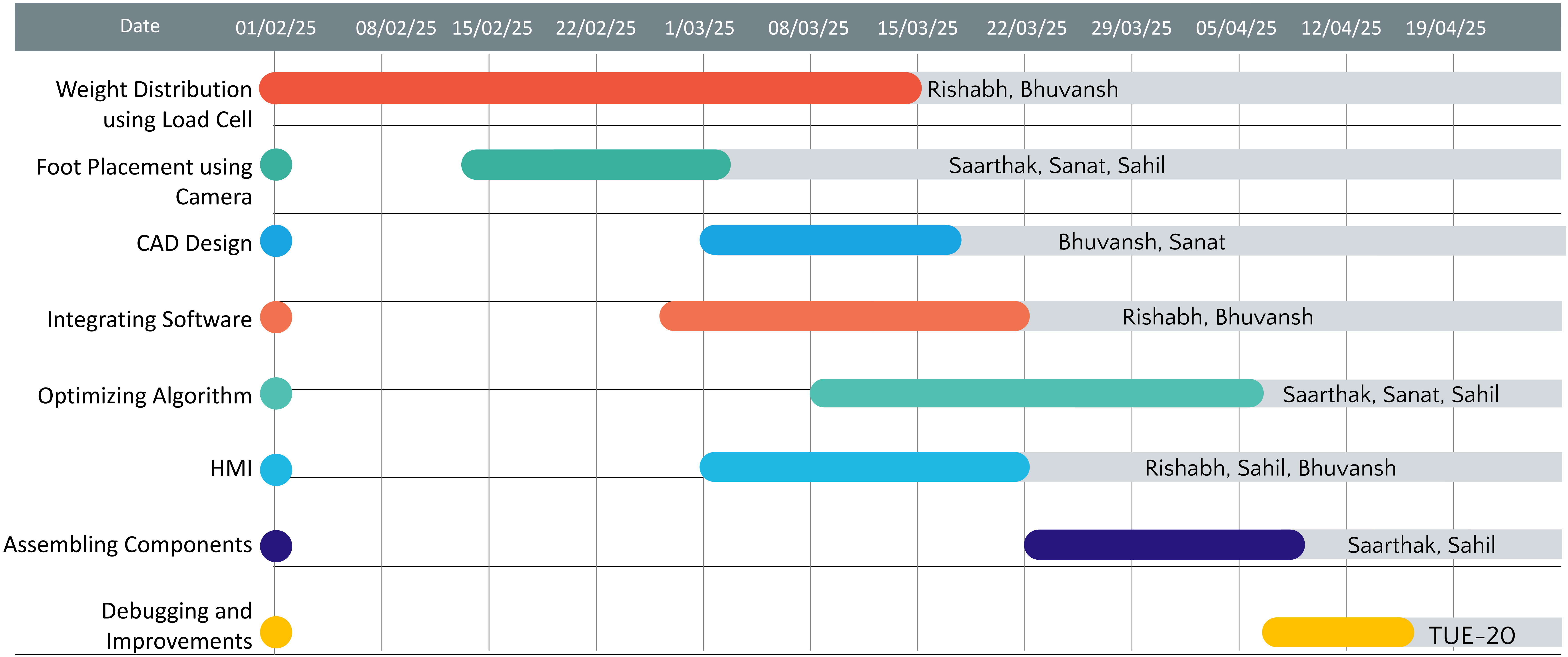
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15/03/25
22/03/25
29/03/25
05/04/25
12/04/25
19/04/25
Weight Distribution using Load Cell
Rishabh, Bhuvansh
Foot Placement using Camera
Saarthak, Sanat, Sahil
CAD Design
Bhuvansh, Sanat
Integrating Software
Rishabh, Bhuvansh
Optimizing Algorithm
Saarthak, Sanat, Sahil
HMI
Rishabh, Sahil, Bhuvansh
Assembling Components
Saarthak, Sahil
Debugging and Improvements
TUE-20

Deviations:

- **Load Cell Delay:** The load cell hasn't arrived yet, so we've focused on testing other subsystems like pose detection and camera integration.
- **Stereo Module Compatibility:** The stereo module isn't compatible with Raspberry Pi 5, so for testing purpose we have used the camera module 2 noIR.

04

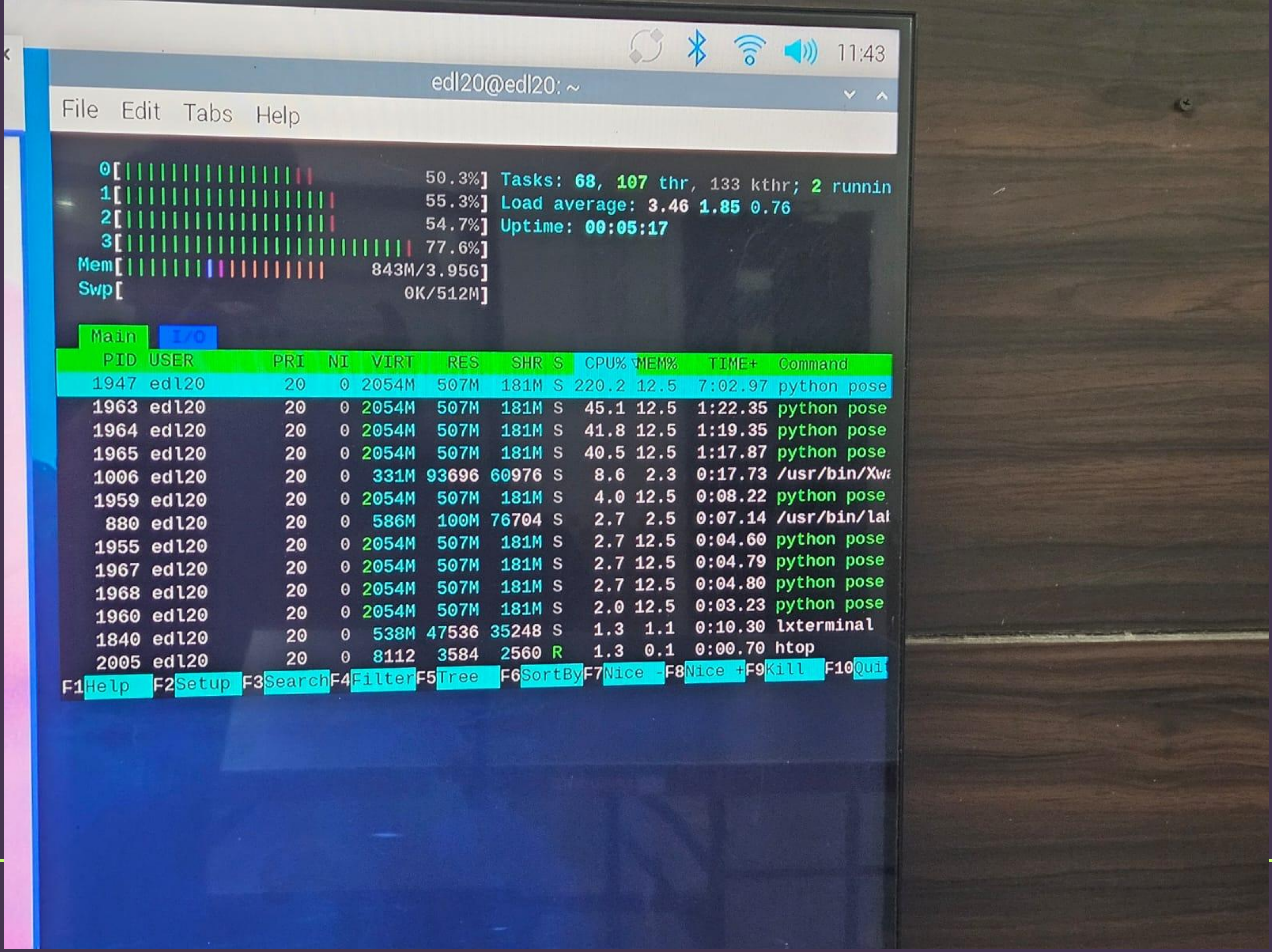
Technical Updates & Subsystem Design

Load Cell & ADC Selection:

- The HX711 and HX710a ADC modules were evaluated for load cell data acquisition.
- The load cell's expected voltage output is ±4.95 mV (max), while the ADC input range is approximately 12 mV for both HX711 and HX710a.
- Sampling Rate Considerations:
  - HX711: 10 SPS / 80 SPS
  - HX710A: 10 SPS / 40 SPS
  - Real-time applications need a minimum of 24 SPS, leaving us with two viable options: 40 SPS and 80 SPS. At higher sampling rates, noise and offset are lower for HX710A.
- Final Selection: While both will be used for prototyping, the HX710A has an integrated temperature sensor, aiding in calibration, making it the preferred choice for the final design. Also HX711 has extra channel which we are not using.

Pose Detection & Processing Load:

- The YOLO model was successfully tested for pose detection.
- CPU utilization was 60-70%, and GPU (HDMI output driving 1080p TV) was 70%.
- Since our final screen will have a lower resolution than 1080p, we expect even better performance.
- The model currently runs at 40-50 FPS, ensuring real-time pose tracking.


11:43
edl20@edl20: ~
File Edit Tabs Help
0[50.3%]
1[55.3%]
2[54.7%]
3[77.6%]
Mem[843M/3.95G]
Swp[0K/512M]
Tasks: 68, 107 thr, 133 kthr; 2 runnin
Load average: 3.46 1.85 0.76
Uptime: 00:05:17
Main I/O
PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
1947 edl20 20 0 2054M 507M 181M S 220.2 12.5 7:02.97 python pose
1963 edl20 20 0 2054M 507M 181M S 45.1 12.5 1:22.35 python pose
1964 edl20 20 0 2054M 507M 181M S 41.8 12.5 1:19.35 python pose
1965 edl20 20 0 2054M 507M 181M S 40.5 12.5 1:17.87 python pose
1006 edl20 20 0 331M 93696 60976 S 8.6 2.3 0:17.73 /usr/bin/Xwa
1959 edl20 20 0 2054M 507M 181M S 4.0 12.5 0:08.22 python pose
880 edl20 20 0 586M 100M 76704 S 2.7 2.5 0:07.14 /usr/bin/lab
1955 edl20 20 0 2054M 507M 181M S 2.7 12.5 0:04.60 python pose
1967 edl20 20 0 2054M 507M 181M S 2.7 12.5 0:04.79 python pose
1968 edl20 20 0 2054M 507M 181M S 2.7 12.5 0:04.80 python pose
1960 edl20 20 0 2054M 507M 181M S 2.0 12.5 0:03.23 python pose
1840 edl20 20 0 538M 47536 35248 S 1.3 1.1 0:10.30 lxterminal
2005 edl20 20 0 8112 3584 2560 R 1.3 0.1 0:00.70 htop
F1Help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice - F8Nice + F9Kill F10Quit

Communication & Bit-Banging Implementation

- The HX711 and HX710a ADC modules were evaluated for load cell data acquisition.
- On an oscilloscope, the generated pulse period was 8-10 µs, well within the required range (min: 0.2 µs, max: 50 µs).
- CPU usage was minimal (1-2%).

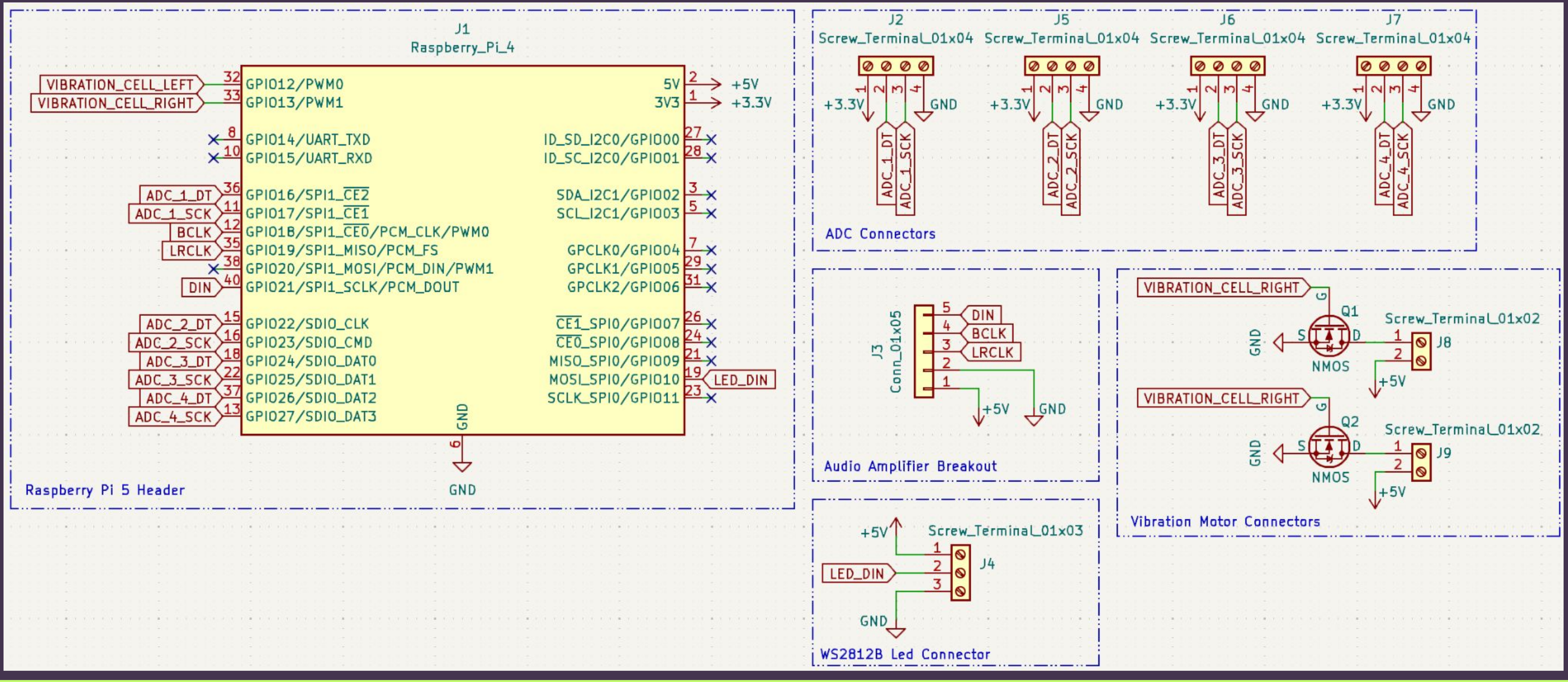
Peripheral Testing & Challenges

- Vibration Motor: Yet to be tested, but will use Raspberry Pi's hardware PWM (no CPU overhead).
- LED Control: SPI-based control, yet to be tested.
- Camera Testing:
  - Noir camera works but has a pinkish tint.
  - The normal camera is not functioning—we suspect hardware issues.
  - Plan: Test the normal camera on a Raspberry Pi 4 in the next lab session.
- Audio Output Issues:
  - PWM audio lacks a proper driver.
  - Alternative 1: MAX98357 I^2S audio chip (dedicated breakout board slot in the design).
  - Alternative 2: A screen with built-in audio output.

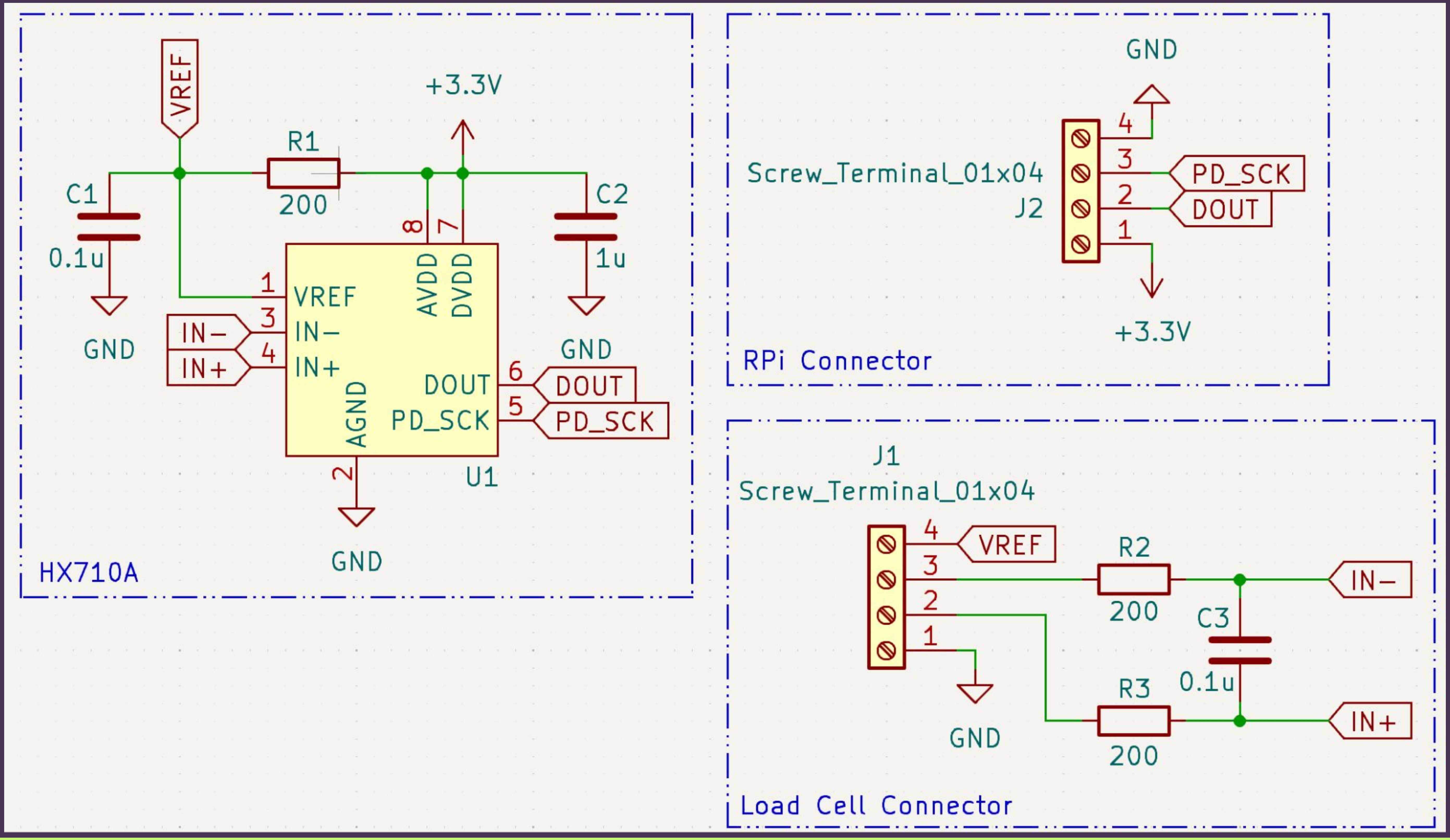
05

Circuit Diagrams

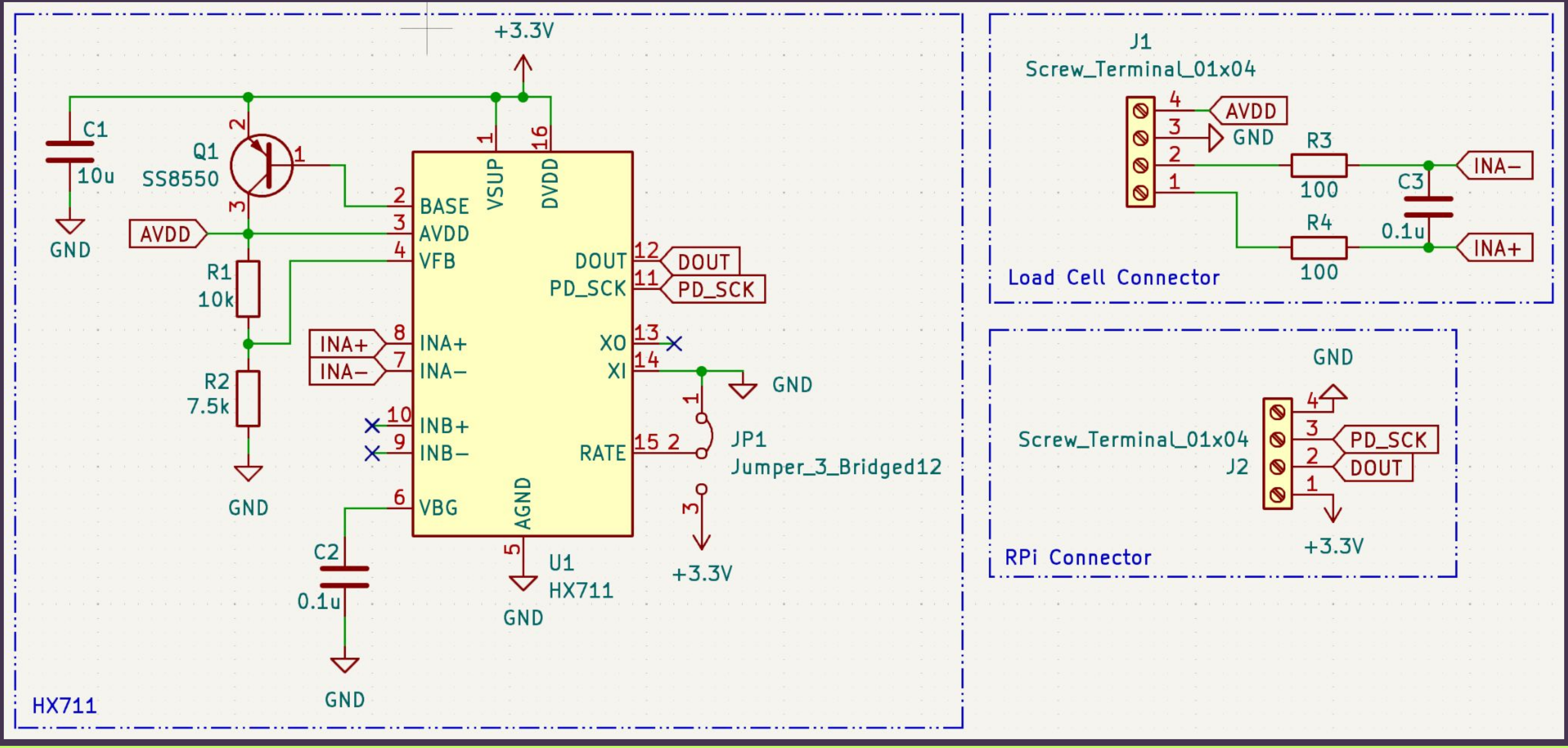
Shield


J1
Raspberry_Pi_4
VIBRATION_CELL_LEFT
VIBRATION_CELL_RIGHT
GPIO12/PWM0
GPIO13/PWM1
GPIO14/UART_TXD
GPIO15/UART_RXD
ADC_1_DT
ADC_1_SCK
BCLK
LRCLK
DIN
GPIO16/SPI1_CE2
GPIO17/SPI1_CE1
GPIO18/SPI1_CE0/PCM_CLK/PWM0
GPIO19/SPI1_MISO/PCM_FS
GPIO20/SPI1_MOSI/PCM_DIN/PWM1
GPIO21/SPI1_SCLK/PCM_DOUT
ADC_2_DT
ADC_2_SCK
ADC_3_DT
ADC_3_SCK
ADC_4_DT
ADC_4_SCK
GPIO22/SDIO_CLK
GPIO23/SDIO_CMD
GPIO24/SDIO_DAT0
GPIO25/SDIO_DAT1
GPIO26/SDIO_DAT2
GPIO27/SDIO_DAT3
5V
3V3
+5V
+3.3V
ID_SD_I2C0/GPIO00
ID_SC_I2C0/GPIO01
SDA_I2C1/GPIO02
SCL_I2C1/GPIO03
GPCLK0/GPIO04
GPCLK1/GPIO05
GPCLK2/GPIO06
CE1_SPI0/GPIO07
CE0_SPI0/GPIO08
MISO_SPI0/GPIO09
MOSI_SPI0/GPIO10
SCLK_SPI0/GPIO11
LED_DIN
GND
Raspberry Pi 5 Header
J2
J5
J6
J7
Screw_Terminal_01x04
ADC_1_DT
ADC_1_SCK
ADC_2_DT
ADC_2_SCK
ADC_3_DT
ADC_3_SCK
ADC_4_DT
ADC_4_SCK
ADC Connectors
J3
Conn_01x05
DIN
BCLK
LRCLK
Audio Amplifier Breakout
VIBRATION_CELL_RIGHT
Q1
Q2
NMOS
Screw_Terminal_01x02
J8
J9
Vibration Motor Connectors
Screw_Terminal_01x03
J4
LED_DIN
WS2812B Led Connector

HX710A Load Sensor



HX711 Load Sensor



06

Test Plan & Results

Preliminary Testing

- Pose detection validated with real-time performance.
- Bit-banging for ADC communication tested successfully.
- Pending tests: vibration motor, LED, load cell integration, normal camera verification.

Intermediate Testing (Upcoming)

- Load cell integration once the component arrives.
- Further ADC performance validation.
- Camera compatibility testing on Raspberry Pi 4.
- LED and vibration motor tests.

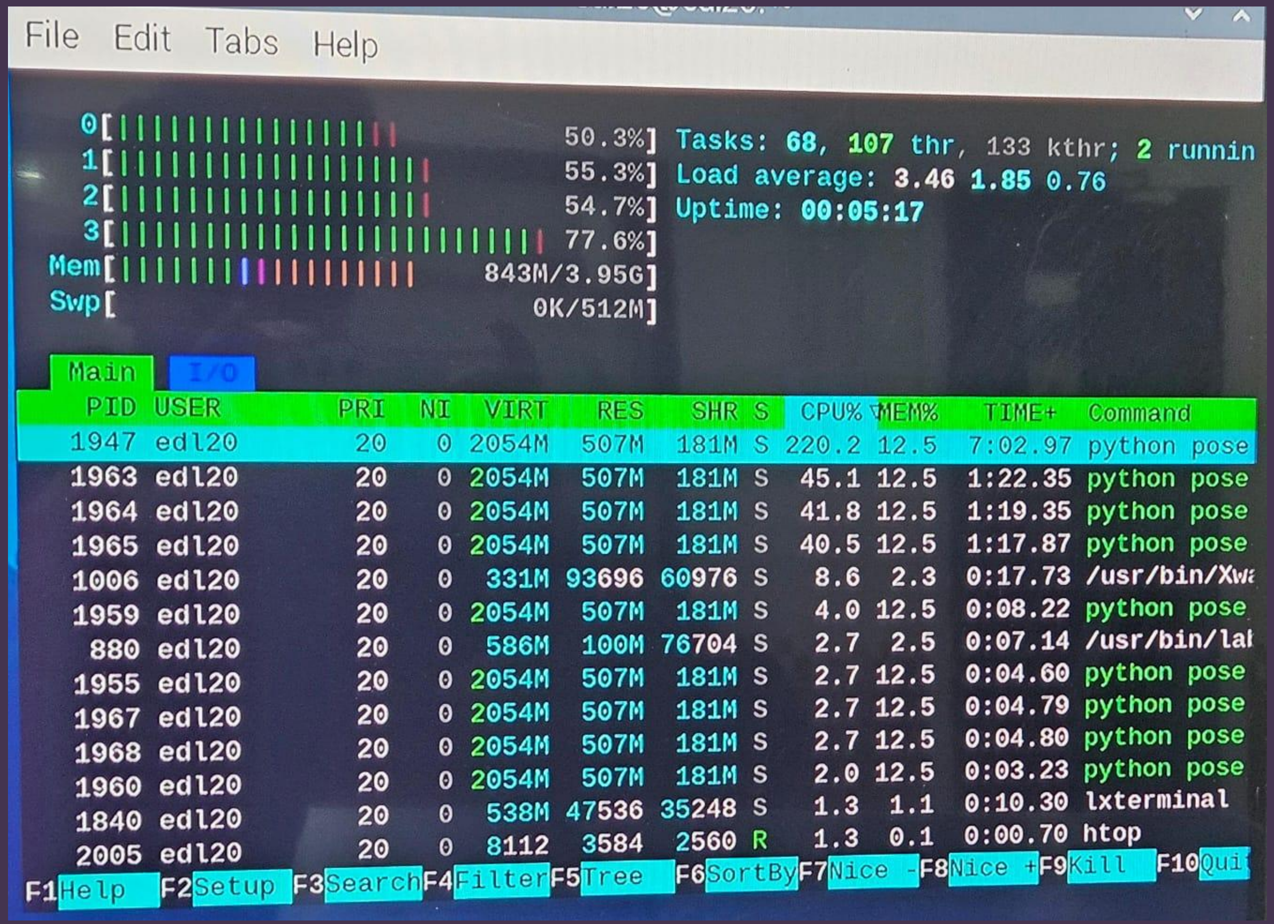
Final Testing & Prototyping Considerations

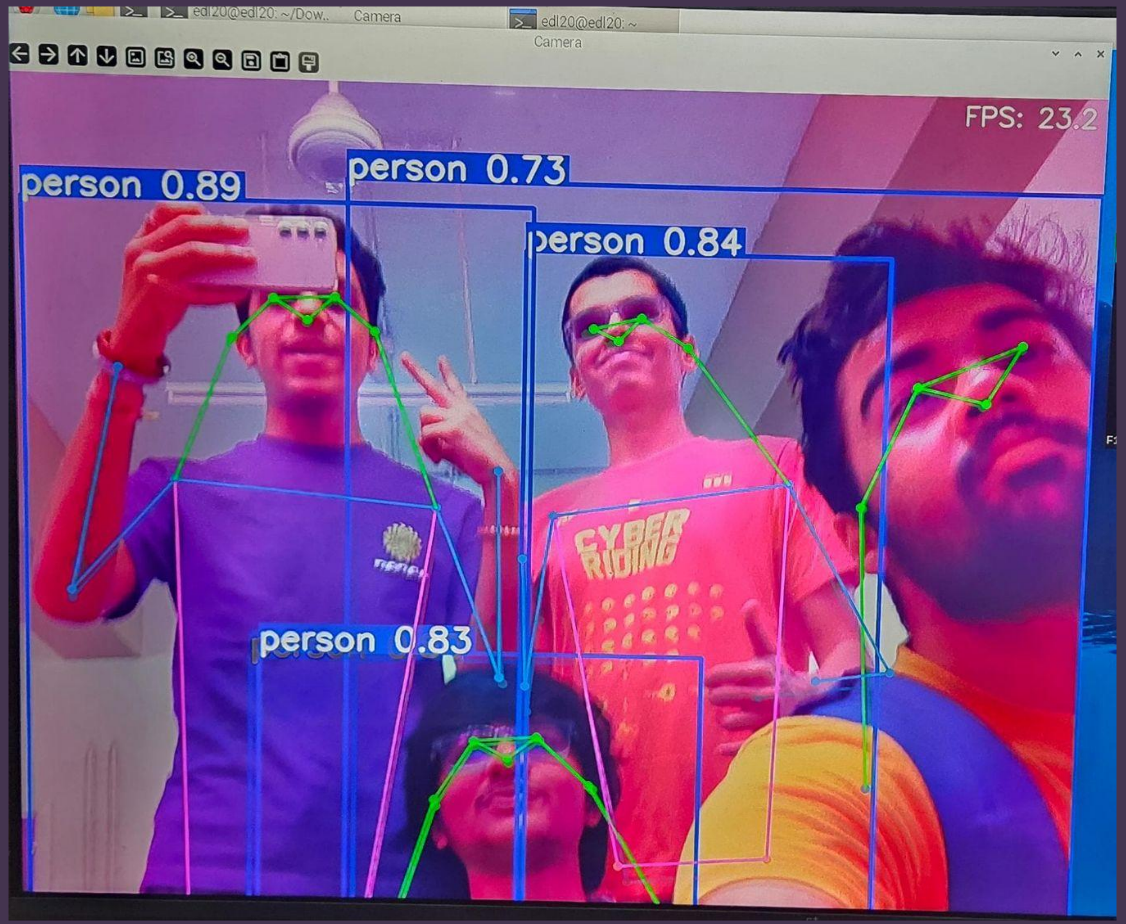
- Assembling the complete system with optimized ADC selection.
- Ensuring real-time data acquisition and minimal CPU load.
- Implementing I^2S audio if PWM remains problematic.

07

Preliminary testing results

- Achieved 20-22 FPS for pose detection at the default clock speed of 2.4 GHz
- uses 50 percent of 3 cores on CPU.
- Boosted performance to 40-45 FPS by overclocking to 2.7GHZ






Camera
person 0.87
FPS: 29.3

08

Thinking Ahead of Milestone

- Initiated CAD Designing, starting with Camera case for stable visual output
- Explored depth estimation using a single camera as an alternative to traditional stereo vision, aiming for a more efficient and cost-effective solution

Smart walker for clinical rehabilitation

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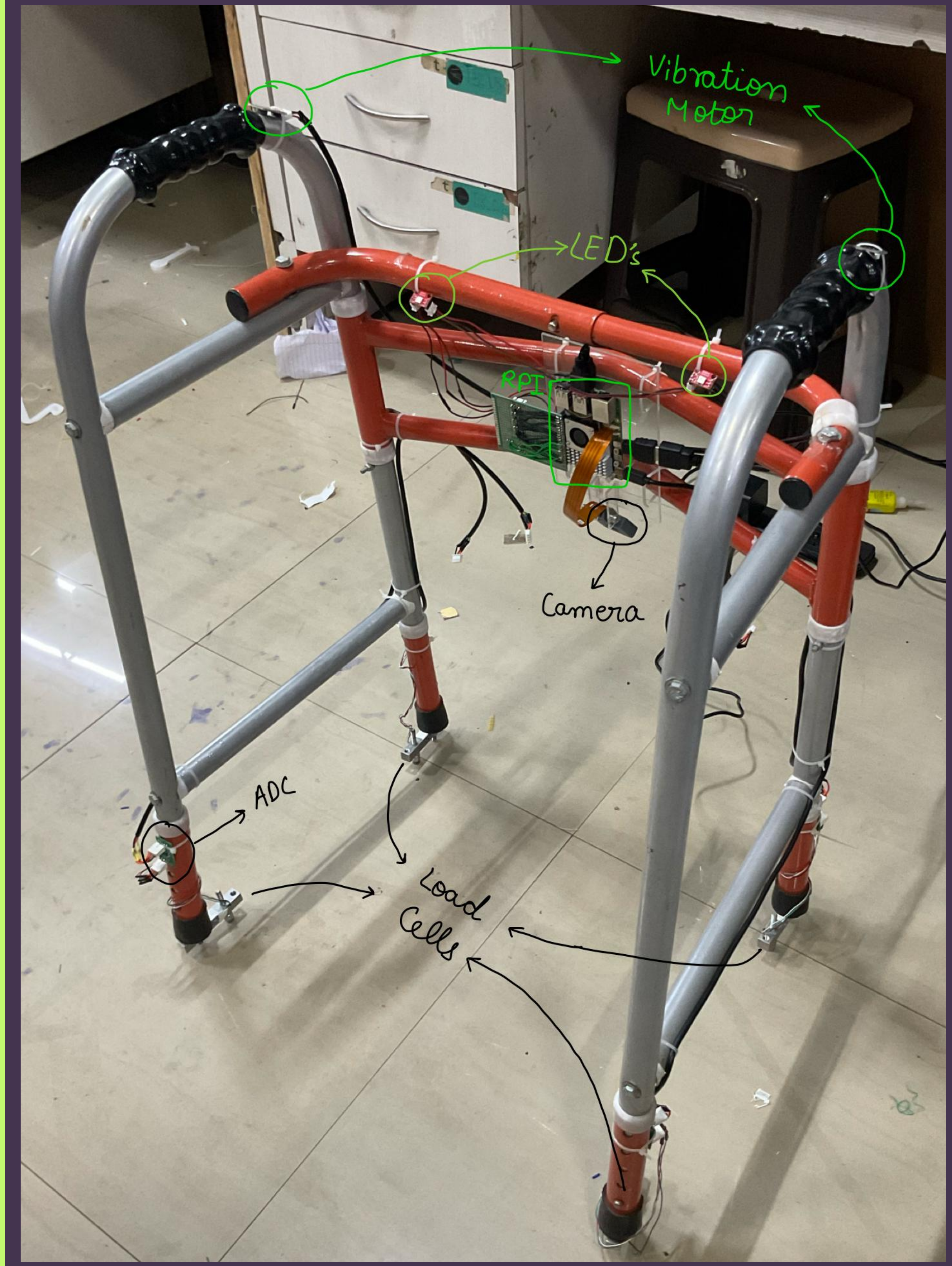
01

Milestone 2 Feedback

Feedbacks	Solutions
• To use connector wires for easy replacement for different components.	• For ADC, leds, vibration motors, we have used JST connector wires.
• To use bluetooth for showing the camera feed and audio.	• We have not reached that stage.

02

Overview



Overview:

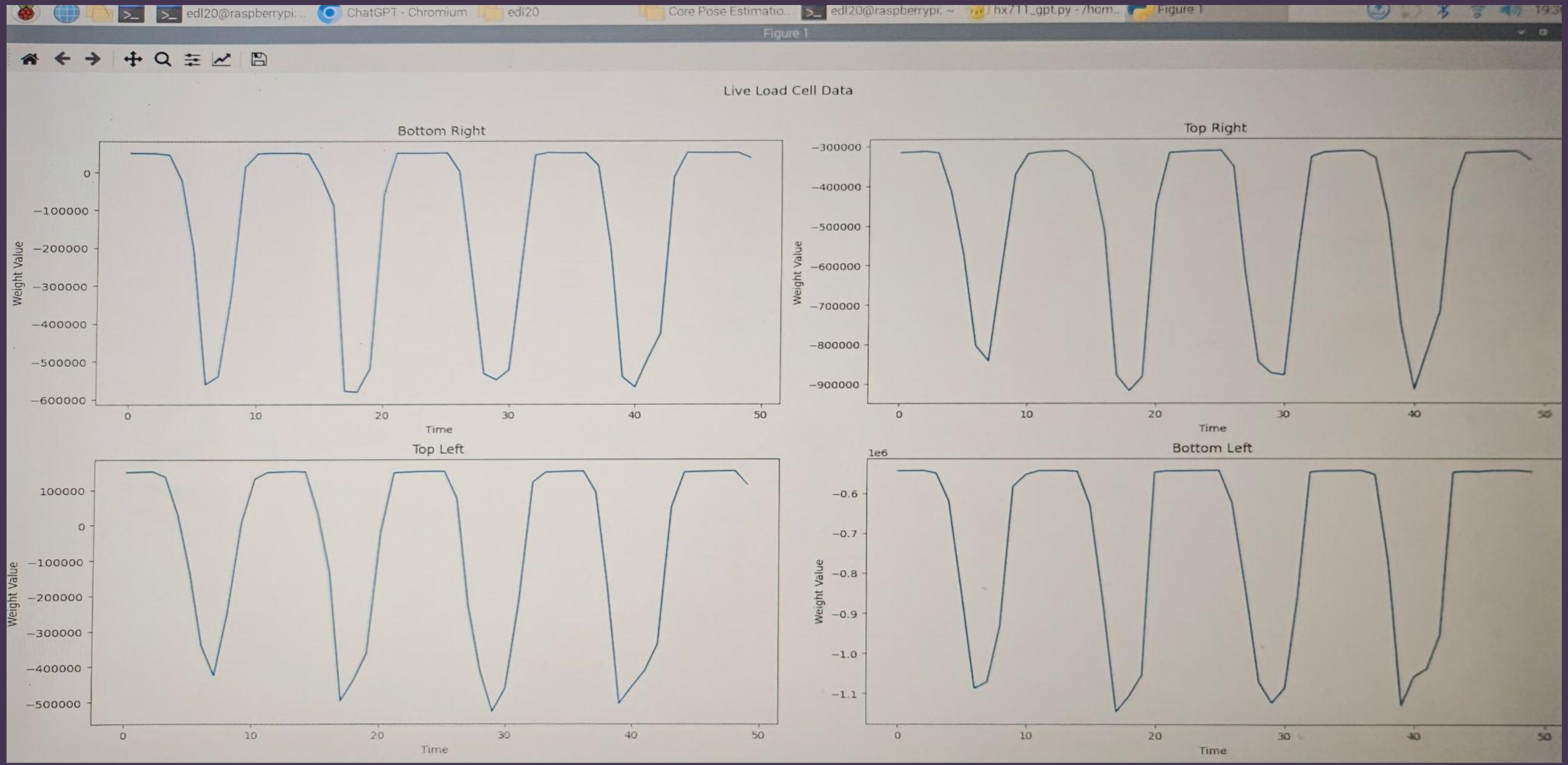
- **Component Assembly:** All components have been assembled except for the LCD screen for the user interface.
- **Temporary Display Setup:** Currently using a monitor to display the camera feed and audio. A standalone display will be used later for mounting on the walker.
- **Integration Status:** All individual components are functioning, but full system integration is still pending.
- **Pending Tasks:** Finalizing the PCB shield and completing the CAD design for the enclosure.

03

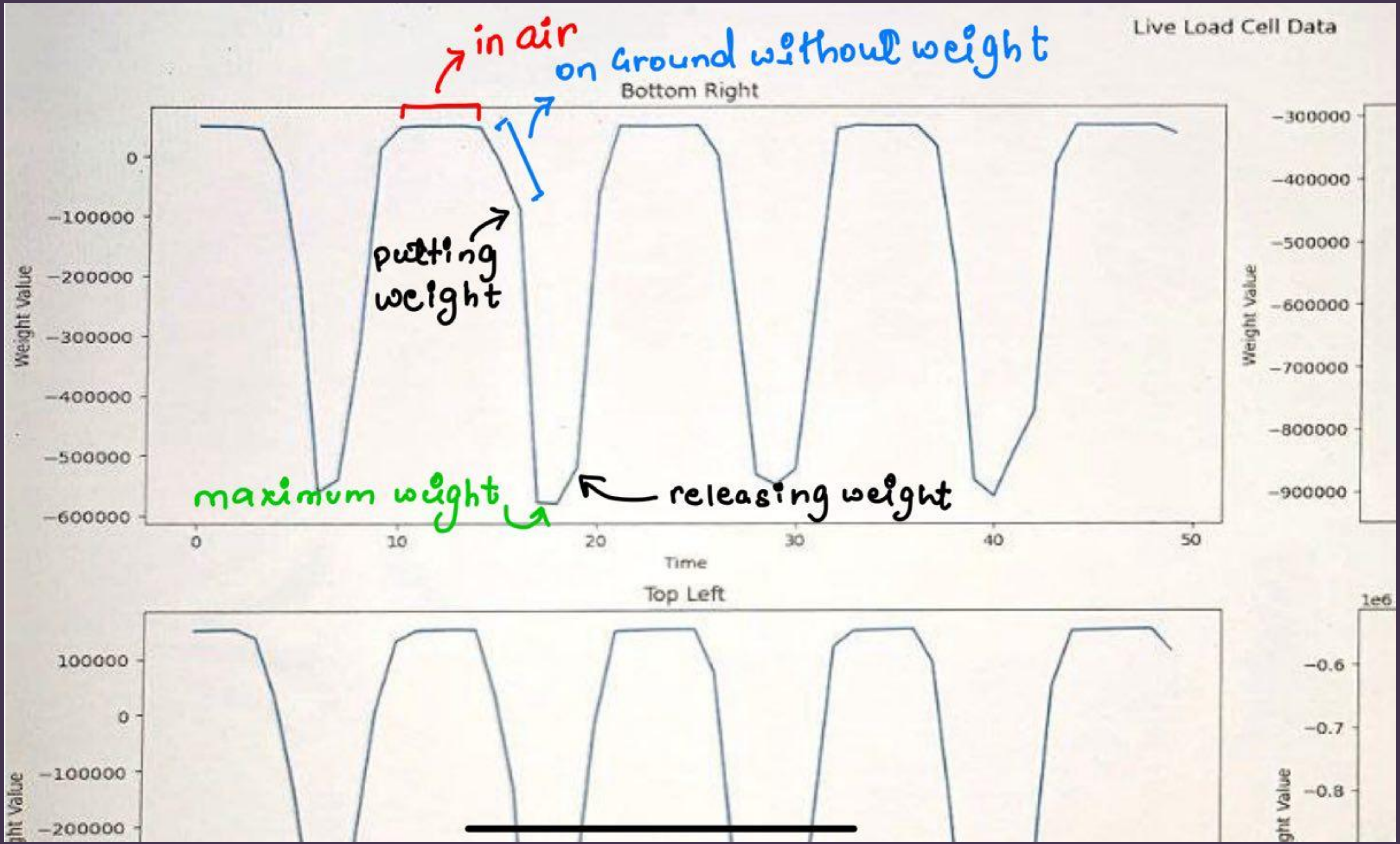
Proof of Concept

Load Sensor Working

- Load cell video

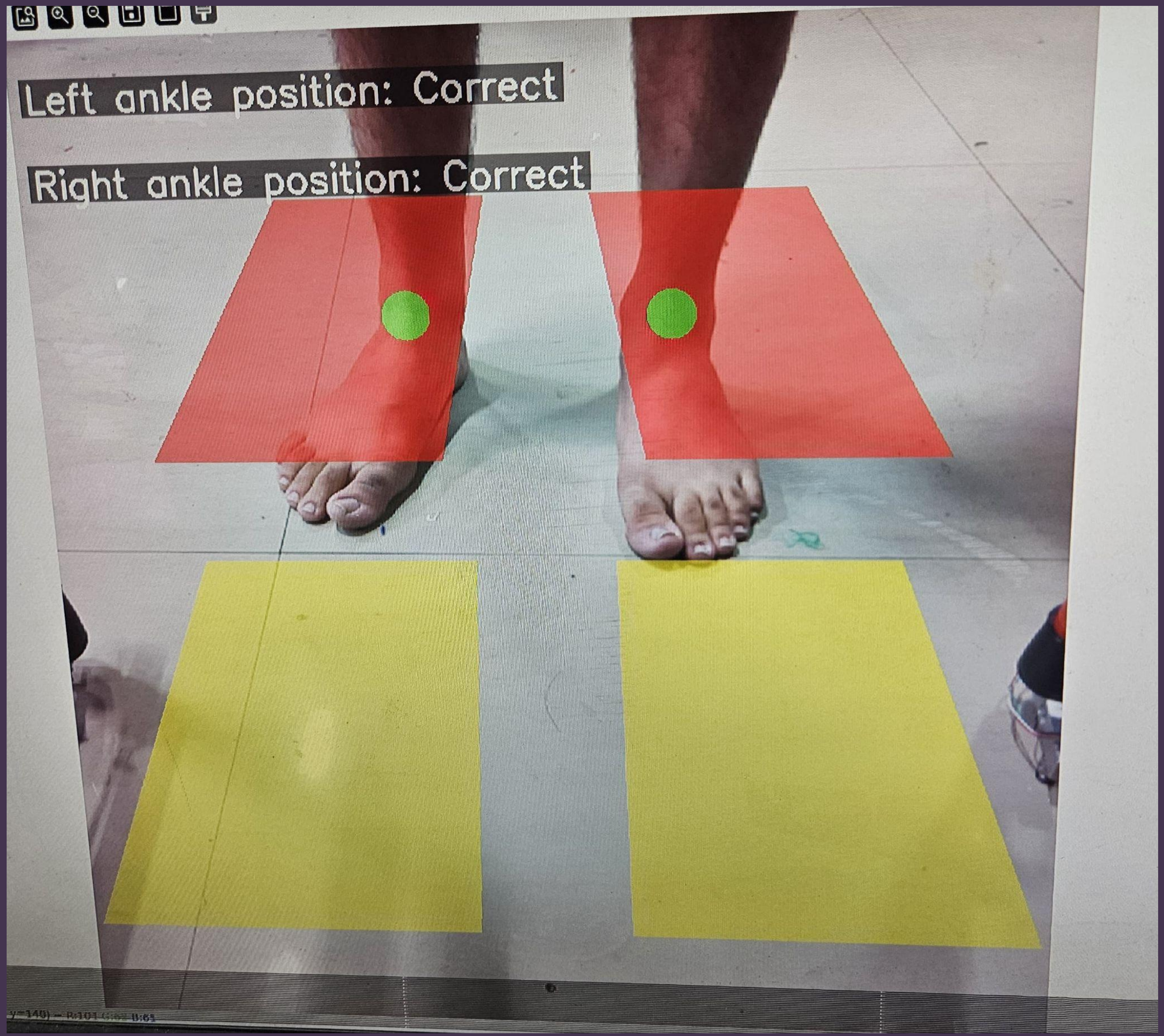


Walking Pattern

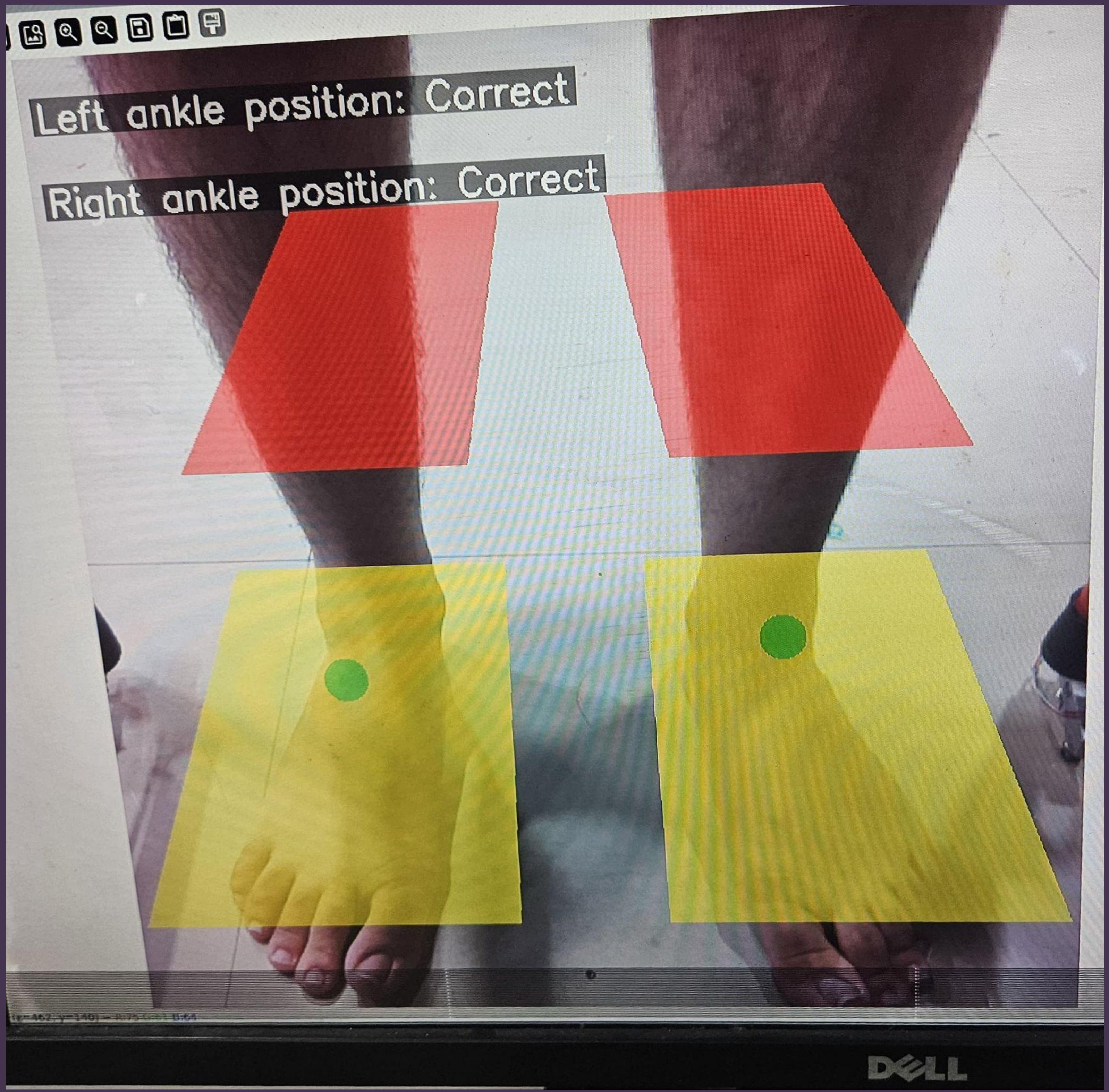


Feet Placement Feedback

- Working Video



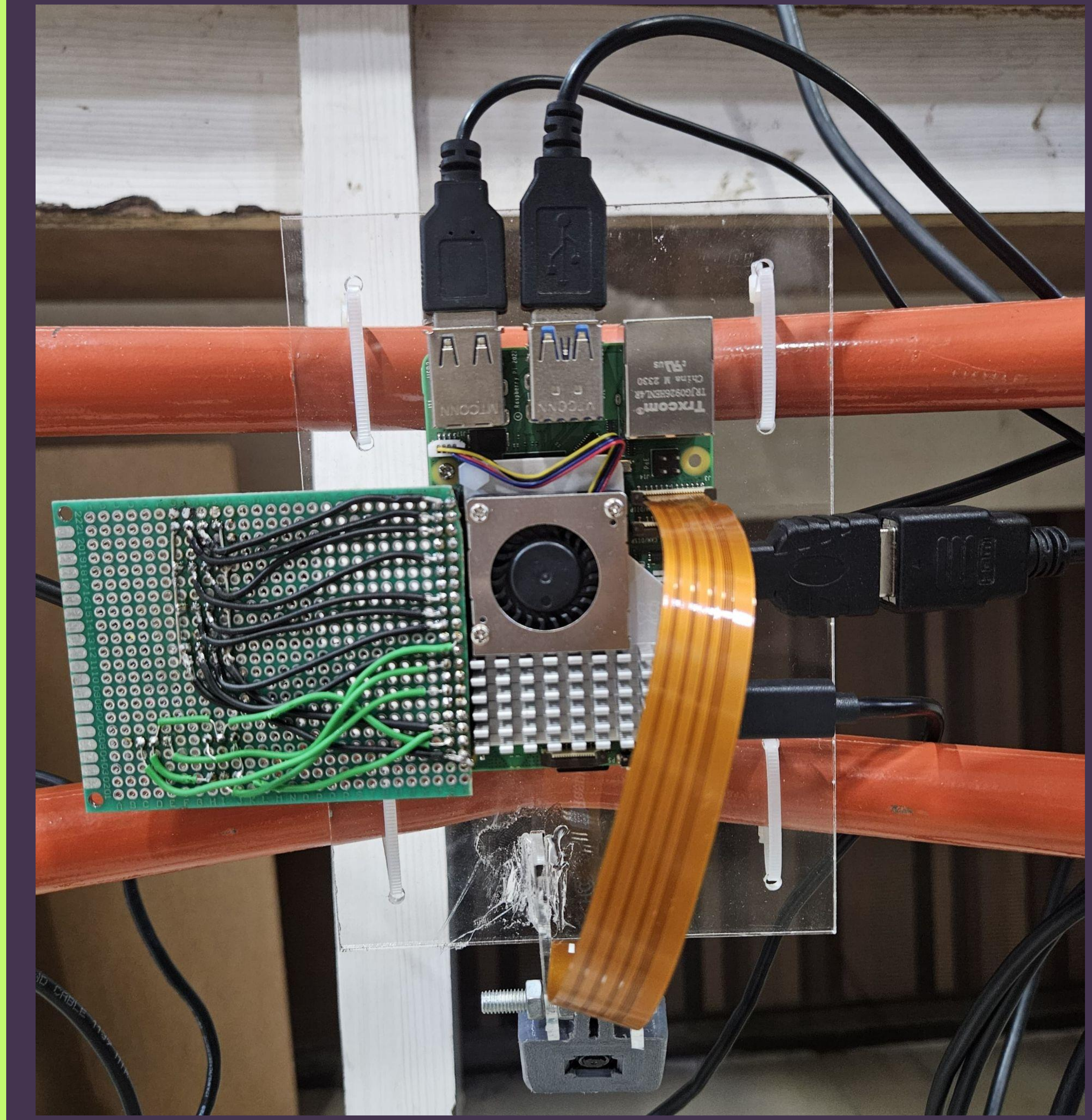
Feet Placement Feedback



Walker-Mounted Testing Assembly

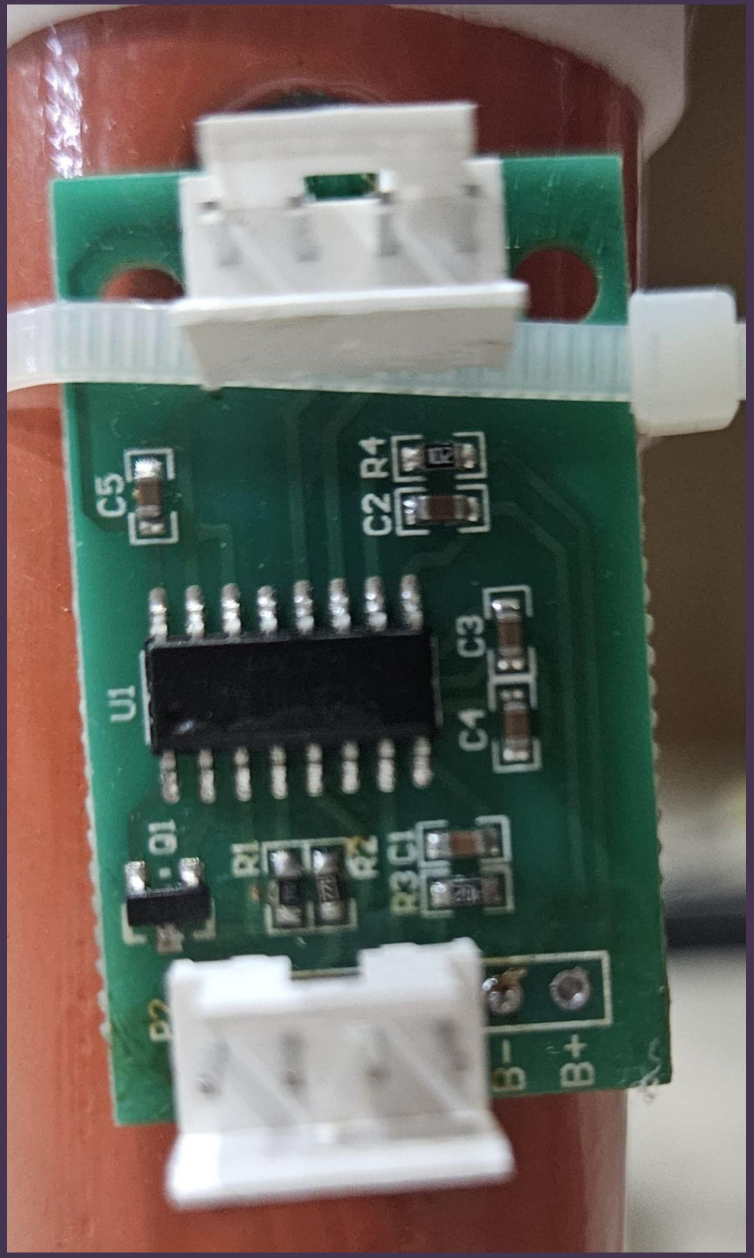
- Used an acrylic sheet to mount the microcontroller, camera module, and other components.
- Used zip ties for attaching it to walker for POC testing.
- Connected all components to the microcontroller using a perforated board, which will later be replaced by a PCB shield.

Walker-Mounted Testing Assembly



ADC - PCB

- **Current Setup:** Using a modified HX711 on a breakout board circuit.
- **Testing & PCB Design:** Evaluated the HX710A on a breadboard with load cells and designed a custom PCB for integration.
- **PCB Layout:** Designed the HX710A PCB layout based on specifications from the datasheet.



ADC Selection:

- The HX711 and HX710a ADC modules were evaluated for load cell data acquisition.
- Sampling Rate Considerations:
  - HX711: 10 SPS / 80 SPS
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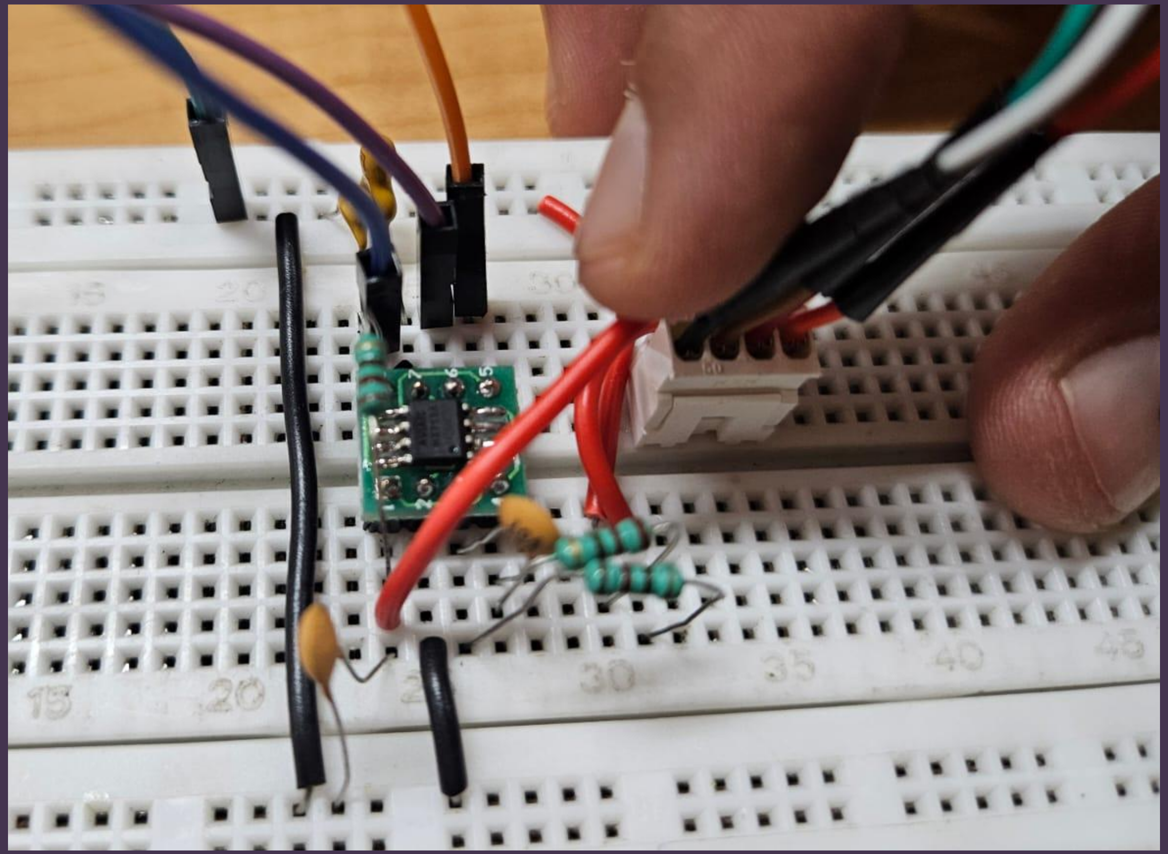
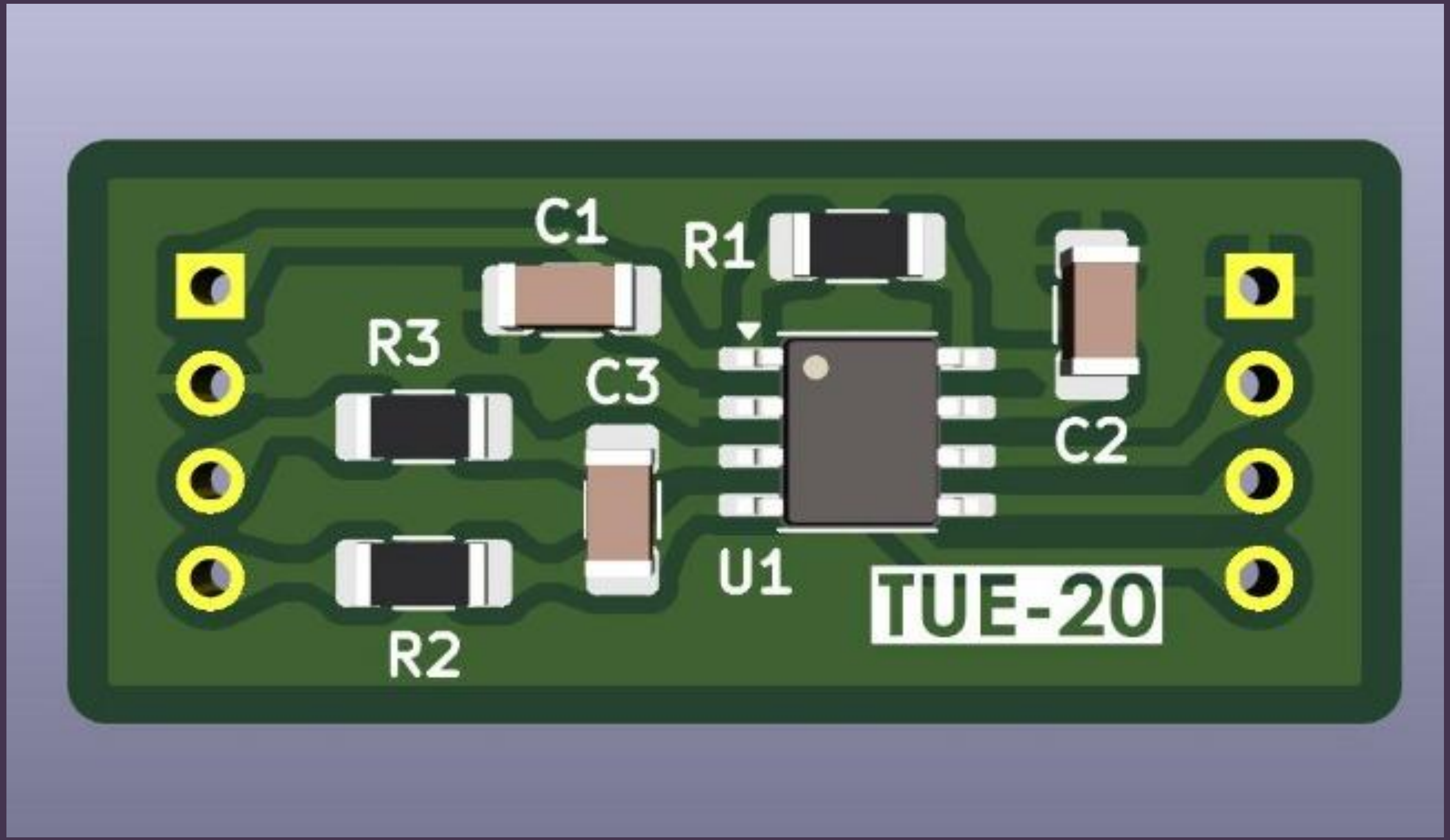
- Final Selection: While both will be used for prototyping, the HX710A has an integrated temperature sensor, aiding in calibration, making it the preferred choice for the final design. Also HX711 has extra channel which we are not using.

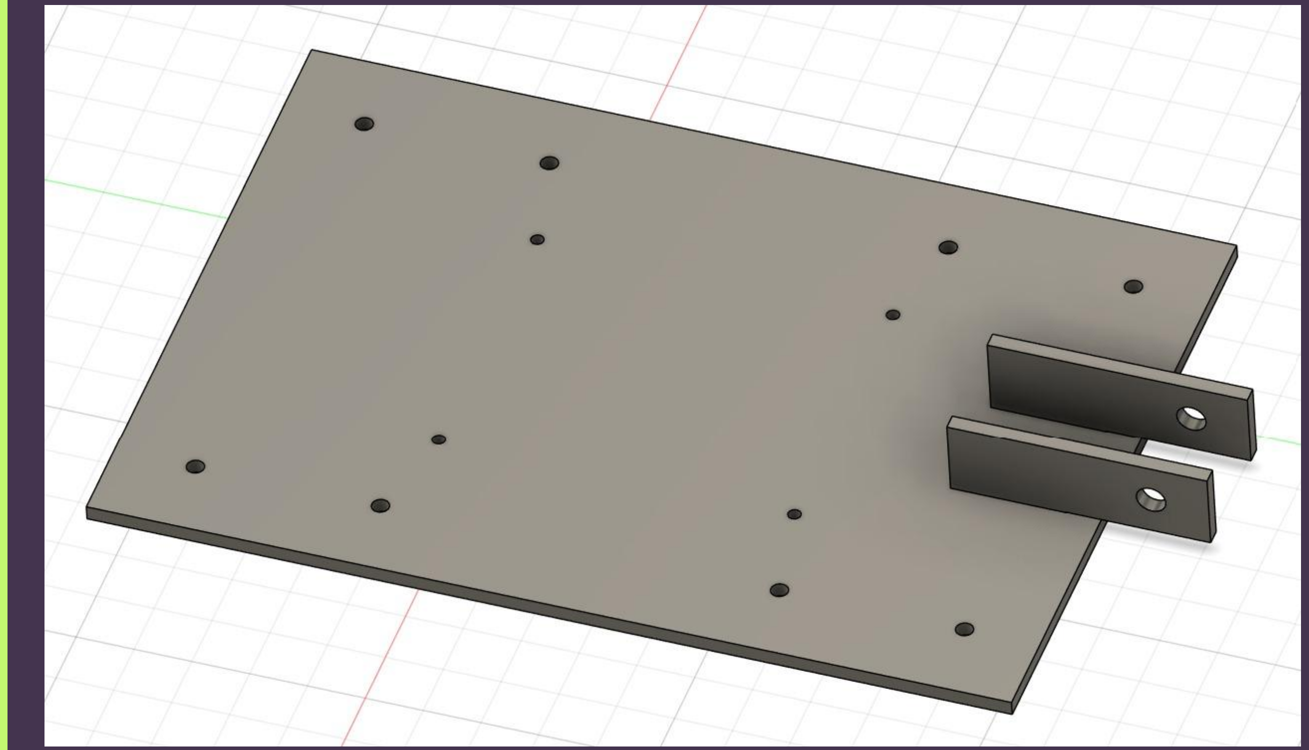
ADC - PCB

- [HX710a working video]

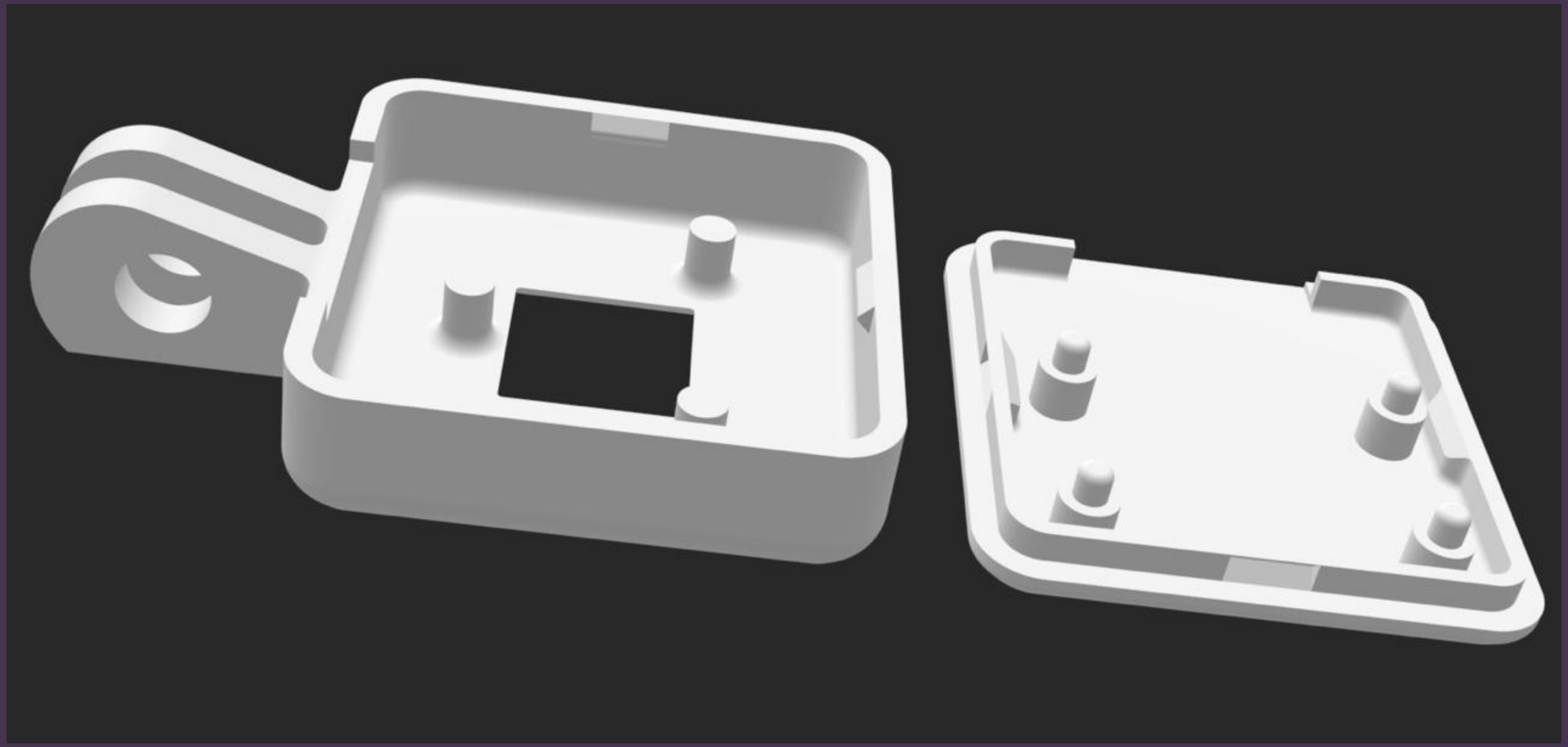




CAD model



Mount(for testing)

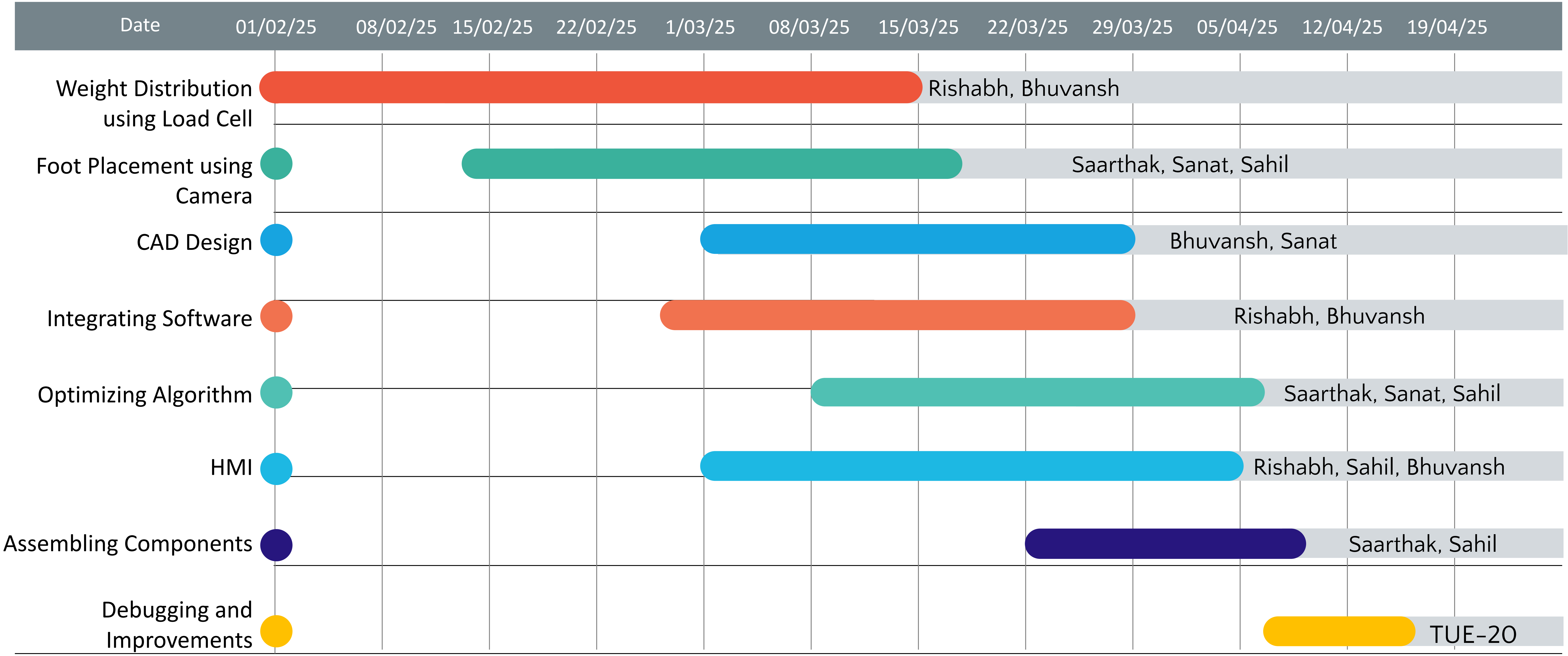


Camera Case

04

Progress and Deviations

GANTT CHART


Date
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29/03/25
05/04/25
12/04/25
19/04/25
Weight Distribution using Load Cell
Rishabh, Bhuvansh
Foot Placement using Camera
Saarthak, Sanat, Sahil
CAD Design
Bhuvansh, Sanat
Integrating Software
Rishabh, Bhuvansh
Optimizing Algorithm
Saarthak, Sanat, Sahil
HMI
Rishabh, Sahil, Bhuvansh
Assembling Components
Saarthak, Sahil
Debugging and Improvements
TUE-20

Deviations:

- **Foot Placement detection using camera :** Experimented with the stereo module and Raspberry Pi Camera 2.0, testing various YOLO pose detection models. Integrated a perspective view adjustment based on the camera angle relative to the foot.
- **CAD Design delay:** The CAD for the camera module is complete, but the enclosure design is delayed since it depends on preliminary testing to finalize the shield dimensions.
- **HMI :** The software for operating the walker is delayed due to extended component testing.

05

Plan for final Demo

Pending Tasks till final demo :

- **System Integration:** Developing code to synchronize the load cells, vibration module, and camera module for seamless operation.
- **HMI Software:** Implementing software for user interaction with the walker, including start functionality and post-use reporting.
- **Model Enhancement:** Improving foot placement accuracy by incorporating more advanced models or depth imaging or ARUCO markers.
- **Final Enclosure:** Designing a protective enclosure to securely house all assembled components.
- **Data Logging:** To send the recorded data to Doctors for further investigation.

WalkWise

Smarter steps to healing

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Saarthak Krishan (22b3959)
Sahil Desai (22b3903)

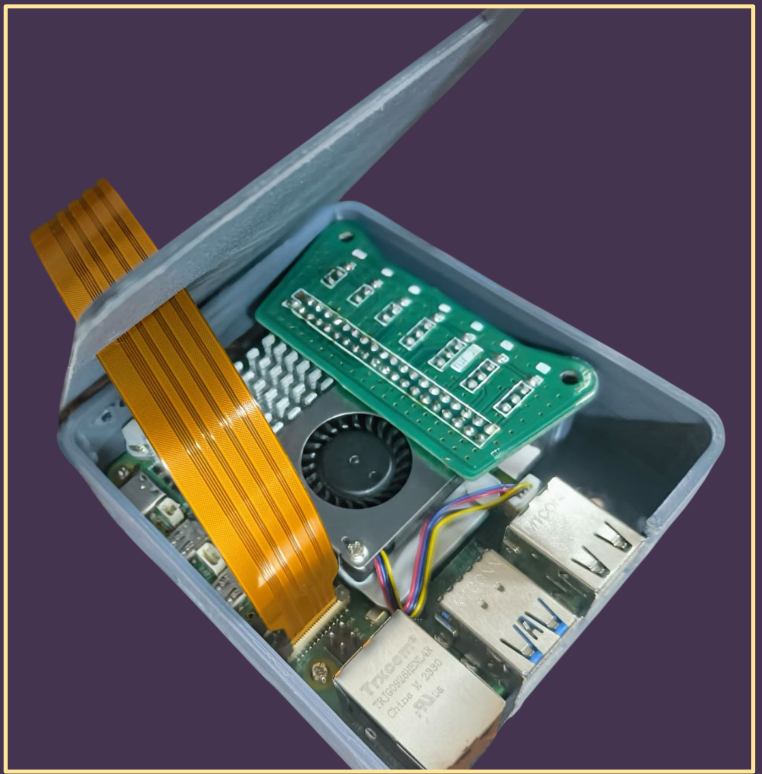
Summary :

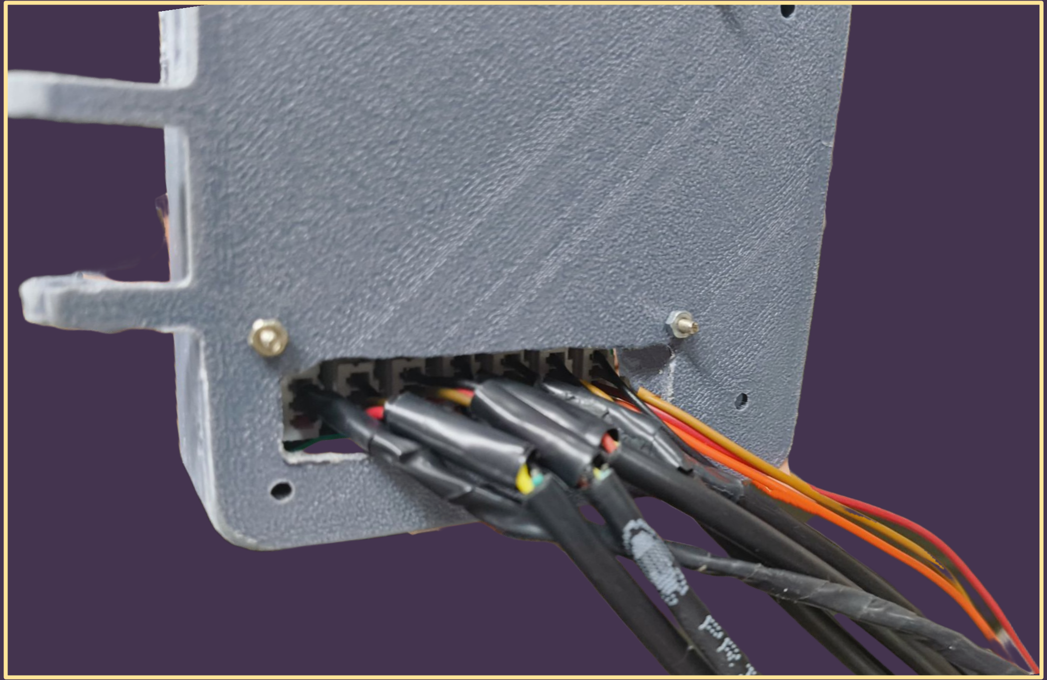
A smart walker that helps elderly and rehabilitating patients walk correctly by guiding foot placement, monitoring weight distribution, and providing real-time feedback to reduce injury risk and speed up recovery.

Status of Project

Key specifications and requirements proposed at beginning of semester	Status at end of semester	Remarks
Detect correct foot placement using camera.	Complete	
Monitor weight distribution with load cells on each leg of the walker.	Complete	
Provide real-time feedback via haptic sensors and LCD display.	Complete	We have kept the LCD feedback headless removed due to concerns it might cause users to focus on the screen, increasing the chance of falls
Log walking pattern data (steps, errors, weight balance) for clinical review.	Complete	
Provide voice feedback to guide users.	Incomplete	Dropped as existing feedback methods were found to be sufficient.

Final Prototype





Final Prototype