2 Project Plan

2.1 TASK DECOMPOSITION

Two teams were created, software and hardware, allowing for specialized task decomposition. Team members were assigned a team based on strengths and task requirements.

1. **Software** - Focus on data filtering and depth algorithms.
   (a) Create a python file that takes in stereo camera input and transforms it into depth data.
   (b) Research and select a framework that suits our software requirements.
   (c) Convert depth input into a 4x4 grid.
      i. Use openCV to partition the depth data.
      ii. Take each partition's largest value.
      iii. Take the previous value of the partition to avoid any false values.
   (d) Create code that sends a signal to haptic feedback motors.
      i. Convert Depth Data from (0.5m-7m) to a intensity value between (0-255).
      ii. Identify GPIO port location to transmit for software PWM.
      iii. Take the take the intensity value and transmit that value to the GPIO port.
   (e) Create user agreement.
2. **Hardware** - Focus on haptic motor array and housing of devices.
   (a) Research and select a framework that suits our software requirements.
   (b) Construct and test haptic motor array.
      i. The haptic motor array will be a 4 x 4 matrix of haptic motors embedded into both a forearm sleeve and back brace.
   (c) Construct and test stereoscopic camera housing.
      i. The stereoscopic camera will get depth information from wherever the wearer is looking. This device may be either handheld or placed on the wearers head and secured with headgear.
   (d) Construct and test control unit.
      i. A central unit will take the depth information and vibrate each motor at the necessary intensity. This will be done using a Raspberry Pi.
   (e) Battery
      i. Selecting a battery that will be able to:
         A. Run for 2 hours plus.
         B. Able to handle the power draw from 16 vibration motors, onboard processor, and stereo camera.
         C. Small and wearable form factor.
         D. Safe and reliable.

(f) Assemble device, connecting motor array, camera, and control unit.

i. All three components will be connected in order to construct the final device. Information from the camera will go to the control unit and then finally to the haptic motor array.

(g) Construct test environment.

i. Create an obstacle course where the person needs to navigate using the System in detecting different obstacles. Both inside and outside courses.

(h) Run field testing.

i. We will conduct extensive and thorough testing in several scenarios.

(i) 3D Printing

i. Creating a housing for the stereo Camera such that the user will be able to to use it.

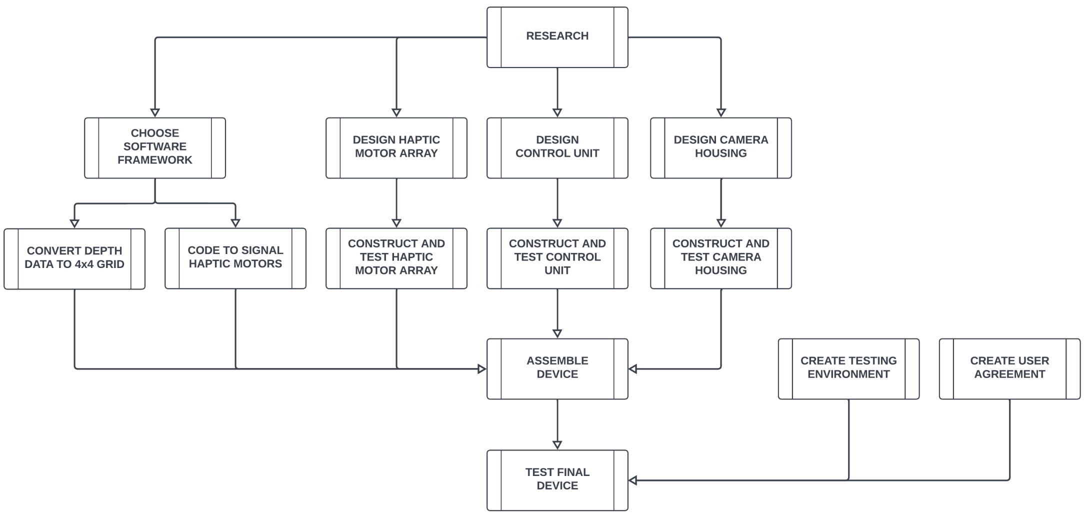

Figure 1: Task Dependence Graph.

2.2 PROJECT MANAGEMENT/TRACKING PROCEDURES

We will use Agile Development methodology with 2-week sprints. The key advantages of agile for this project are:

1. **Iterative development** - Requirements and solutions can be refined incrementally through build-test-feedback loops. This allows incorporating user testing insights as they emerge rather than fully defining everything upfront.

2. **Adaptability** - Agile is better suited for handling uncertainty and changes that often arise with novel hardware/software projects like this. Plans can be adjusted as needed.

3. **Early value** - Agile prioritizes working software over documentation, allowing demoable prototypes early on rather than waiting for everything to be built. This enables validation.

4. **Collaboration** - With its emphasis on close teamwork and user feedback, agile promotes the cross-functional collaboration needed in this multi-disciplinary project.
5. **Focus** - Breaking work into 2-week sprints maintains focus on the current priorities rather than getting overloaded by the full scope.

The group will use Git for software management, two weekly meetings for progress reports (alt. online at Webex or Discord), Discord for link transfer and voice communication, Snapchat for quick text communication, and Google Drive for file transfer and collaboration.

2.3 PROJECT PROPOSED MILESTONES, METRICS, AND EVALUATION CRITERIA

Several key milestones have been identified for our project to ensure proper and timely progression towards our project objective.

1. Haptic Feedback Motors
   (a) Connecting LED light with the raspberry pi and being able to run a script that lights the LED on/off.
   (b) Connecting Haptic feedback motor to the raspberry pi and being able to turn vibrations on/off.
   (c) Controlling haptic feedback motor intensity using python script.
   (d) Controlling 16 haptic feedback motors using python script.
   (e) Connecting the haptic feedback motors to a wearable device.
2. Stereo Camera
   (a) Connecting the Kinect to get depth data.
   (b) Partitioning that data into 16 values with the highest value in each partition.
   (c) Getting that information to run at 16hz in a python script and relaying that information to the vibration motors.
   (d) Getting a proof of concept functional and ordering a d435i depth sensing camera.
   (e) Transforming the existing system to take depth information from d435i depth sensing camera instead.
   (f) Housing the camera in a 3d printed goggle and a flashlight.
3. Speaker (Low priority)
   (a) Purchasing a speaker and successfully getting it to play sounds controlled from our board.
   (b) Setting up a button and a button listener in a python script that is able to play a sound when button is pressed.
   (c) Creating a text to speech converter that reads out words.
   (d) Getting d435i RGB information and using an existing api to list all objects detected.
   (e) Getting the speaker to list all of the objects seen in the camera.

2.4 PROJECT TIMELINE/SCHEDULE

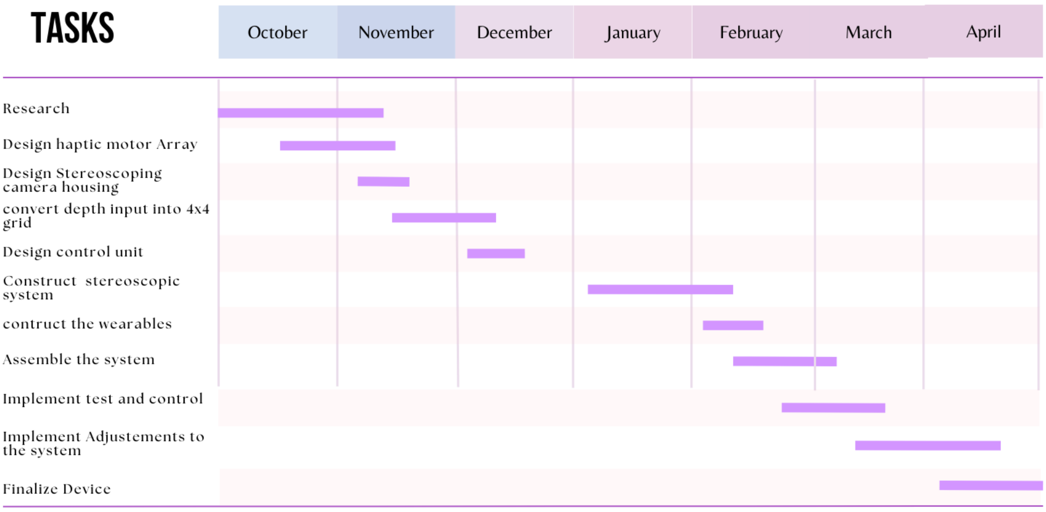

Figure 2: Gantt Chart.

2.5 RISKS AND RISK MANAGEMENT/MITIGATION

Agile project can associate risks and risk mitigation with each sprint.

1. Vibrations via haptic motors are a non-functional method of communicating depth information (0.5).
    (a) In the event that haptic motors are non-viable for our project needs, whether that be because the motors interfere with each other or it is simply not interpretable by the wearer, we will instead pivot to a pressure based communication system. Research has shown this to be an effective method to communicate environmental information.
2. Stereoscopic depth sensing is not able to communicate depth information to the wearer at an acceptable framerate or accuracy (0.4).
    (a) In this event, we will instead use a LIDAR based system.
3. The Raspberry Pi is incompatible with our project specifications (0.7).
    (a) In the event that the Raspberry pi is not able to compute the data coming in from the stereo camera we will purchase an equivalent device that uses faster processing.
4. The device cannot be miniaturized to be wearable (0.3).
5. The device degrades after donning and doffing (0.6).

(a) It will be important to ensure the haptic motors are secure and stay in one position on the wearer's body. If this is an issue we will create a plastic cover for the motors that can be sewn into the fabric to keep the motors in place.

2.6 PERSONNEL EFFORT REQUIREMENTS

Requirement	Hours Required	Explanation
Research and select a framework.	10	We will need to ensure that we select a sufficient framework for our needs.
Design haptic motor array.	15	We need to make sure that the vibrations are given as intended.
Design stereoscopic camera housing.	15	Needs to fit securely.
Convert depth input into a 4x4 grid.	30	Use openCV to partition the depth data.
Design control unit.	30	Must connect the camera and haptic motors without error.
Construct haptic motor array.	30	Building multiple prototypes.
Test haptic motor array.	20	Ensure it works optimally.
Construct stereoscopic camera housing.	15	Needs to fit well and be lightweight.
Create code that sends signals to haptic motors.	30	Connect the software to the motors.
Construct control unit.	30	Needs to be built to our requirements.
Implement and test control unit.	20	Must send and receive data without discrepancies.
Assemble device.	40	Bringing all of the pieces together.
Test device.	40	Testing with multiple challenges and people.
Create user agreement.	3	Writing an official user agreement for liability.

2.7 OTHER RESOURCE REQUIREMENTS

1. Tatoko 10 mm x 3 mm Haptic Motors
2. Intel D435i Stereoscopic Camera
3. Raspberry Pi
4. Breadboards, 16 Gauge Wire, heat shrink

5. Forearm sleeve (Unit to hold the haptic motor array)
6. 3D Printer
7. Battery Bank