Group No: 40

Progress Review II Report

ME4202

Design and Development of a Multi-functional Robotic Walker

By

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1 FEEDBACK FOR PROGRESS REVIEW I

1. **Adding names of Supervisors & Group members.**
2. **Properly indicating the connections between subsystems.**
3. **Time crunch – Not elaborating on all the content included in some slides.**

The above points were made regarding the Presentation and not the Progress of the Project. We agree with these points and will ensure such mistakes will not happen in any upcoming presentations**.**

4. **Numerical Analysis would aid comparison between different walkers built in previous research studies.**

We acknowledge this valid concern. Nevertheless, most papers we researched on did not include enough data to make sufficient numerical conjecture. Individual sub-systems- for example, in the navigation stack the use of A* vs Djikstra Algorithms could be thus analysed. Nevertheless, such parameters were heavily dependent on other factors such as terrain and computational capabilities and is thus redundant.

5. **Cost effectiveness seemed to have predetermined the research direction.**

We acknowledge this valid concern brought up by the panel. Our reasoning in this instance is two-fold.

a. **Making the Walker accessible to a wider stakeholder range.**

The costlier the walker and its components get, the narrower its end users become. We wanted to develop a solution theoretically accessible to most users in need**.**

b. **Area for Novelty**

We have been able to innovate and propose novelties instead of picking existing products off the shelf. The best example- out of many- for this is the development of our own Stereo Vision Camera System made using two webcams instead of buying an costlier depth camera.

We have also tried, in line with the comments received, when and where possible to ensure that our research and project direction to be minimally affected by the cost factor.

2 INTRODUCTION

2.1 ABSTRACT

Our project presents an autonomous walker designed for individuals with mobility limitations. It utilizes a navigation stack built on Robot Operating System (ROS) for self-directed movement guided by user-specified goals through a multimodal interface combining LiDAR, sound source localization and computer vision. Additionally, the walker offers a mechanism for sit-to-stand mobility assistance and provides active user guidance through an array of force-sensing resistors. We successfully implemented and configured the ROS stack, fabricated a functional prototype, and conducted structural analysis. Future work focuses on fine-tuned navigation, user studies, and clinical trials to evaluate the system's potential for real-world application, promoting independence and mobility for users.

2.2 OBJECTIVES

1. Study the existing problems associated with mobility and identify key focus areas, research gaps.
2. Design and development of an appropriate mechanical structure for the platform of walker.
3. Development of the autonomous navigation system, walking guidance system, and standing assistance system of the walker.
4. Testing and validation of the developed robotic walker.

3 PROGRESS OF THE PROJECT

This passage summarises the completed activities and ongoing work for the Design and Development of a Multifunctional Robotic Walker.

3.1 PROGRESS IN-LINE WITH THE PROJECT OBJECTIVES

Objective 1: *Study the existing problems associated with mobility and identify key focus areas, research gaps.*

Completion of Objective 1 was achieved during Progress Review 1.

Objective 2: *Design and development of an appropriate mechanical structure for the platform of walker.*

Through the completion of the following tasks:

Design Calculations, Motor Kinematics, 3D Design, 3D Model Simulation, Final Platform Fabrication.

We have successfully completed our 2nd objective.

Objective 3*: Development of the autonomous navigation system, walking guidance system, and standing assistance system of the walker.*

The completion of the following tasks was achieved:

Testing Platform Fabrication, Motor Control and Odometry, SLAM, Autonomous Navigation Stack, Sound Source Localization, Stereo Vision, Depth Estimation, Gesture Recognition, User Height Estimation, Sitting-to-standing Actuation.

Once the tuning of the navigation stack is perfected along with the functionality of human following, we will have achieved completion of all aspects of the autonomous navigation system. Then the implementation of the walking guidance system will complete Objective 3.

Objective 4: *Testing and validation of the developed robotic walker.*

Objective 4 entails testing and validation of our design and hence would not reach completion till all systems are well integrated. At present, we are designing and conducting unit tests to assess the capabilities of individual systems.

3.2 COMPLETED ACTIVITIES:

1. Testing Platform Fabrication: A functional testing platform has been built to conduct experiments and validate the developed algorithms. *(obj. 3)*
2. Design Calculations: All necessary design calculations related to mechanical, electrical and electronic components have been completed. *(obj. 2)*
3. Motor Kinematics: Kinematic modelling of the motors and wheels has been established to understand the relationship between motor output and robotic walker movement. *(obj. 2)*
4. Motor Control and Odometry: Motor control algorithms have been implemented for precise movement and robust odometry estimation for tracking the walker's position. *(obj. 3)*
5. SLAM (Simultaneous Localization and Mapping): A SLAM algorithm has been integrated to enable the walker to build a map of its surroundings and localize itself within it. *(obj. 3)*
6. Sound Source Localisation: Techniques to identify and locate sound sources have been developed, enabling the walker to react to audio cues and set goals on the navigation stack. *(obj. 3)*
7. Autonomous Navigation Stack: A core navigational stack, including path planning and obstacle avoidance, has been implemented to guide the walker autonomously. *(obj. 3)*
8. 3D Design: A detailed 3D model of the final walker design has been created using computer-aided design software. *(obj. 2)*
9. 3D Model Simulation: Structural analysis of the 3D model has been conducted using a Finite Element Analysis (FEA) software. *(obj. 2)*
10. Final Platform Fabrication: The final platform has been fully fabricated. All wiring has been completed. *(obj. 2)*
11. Stereo Vision: Using two webcams, a low-cost stereo setup has been implemented in the walker enabling depth perception. *(obj. 3)*
12. Gesture Recognition: For the walker to be able to recognize the user in a crowded environment an algorithm to distinguish a unique gesture or a combination of gestures has been developed. *(obj. 3)*
13. Depth Estimation: Upon detection of the key gestures the walker to be able to discern where the user is and set a goal to that point. *(obj. 3)*

14. User Height Estimation: Height needs to be estimated for the walker to be to adjust its height to suit the arm resting position. *(obj. 3)*
15. Stand-to-Sit Actuation: In the final platform, we have integrated a linear actuator that would aid the user in getting up from a sitting position and vice versa. *(obj. 3)*

3.3 WORK IN PROGRESS:

A. Force-sensitive Resistor (FSR) Mapping for Motor Control: To facilitate active walking guidance FSR Array is being calibrated and mapped to control motor velocity. *(obj. 3)*

B. Integration of the three main subsystems of the walker: Autonomous Navigation, Sitting-to-Standing Assistance and Walking Guidance systems. *(obj. 3)*

C. Tuning of Autonomous Navigation: The autonomous navigation algorithms are being refined and tuned to optimize performance and ensure safe and reliable navigation in different environments. *(obj. 3)*

D. Human Following Feature: Development is ongoing for human following functionality, allowing the walker to autonomously track a designated person. *(obj. 3)*

E. Designing and conducting tests: Unit tests to test the individual systems and functional tests in controlled environments are to be conducted. *(obj. 4)*

3.4 INDIVIDUAL CONTRIBUTION

Table 3.4.1 Individual Contribution

Nidula Senarathne (190582R)	**Ranul Vithanage (190655U)**	**Pesala Welangalle (190678R)**
Testing Platform Fabrication	3D Design	Autonomous Navigation Stack
Design Calculations	Final Platform Fabrication	Sound Source Localisation
Motor Kinematics	Sit-to-stand Actuation	Simultaneous Localisation and Mapping (SLAM)
Motor Control and Odometry	Stereo Vision	
Structural Simulations	Gesture Recognition	
	Depth Estimation	
	User Height Estimation	

3.5 KEY FINDINGS

1. We have developed a functional prototype that we currently use successfully to test the navigation stack and other movement functionalities of the robot.
2. Our design calculations and motor kinematic analysis has showcased the suitability of the final platform to be useful in our intended manner.
3. We have successfully built a map of the prototype's environment and after been given navigation goals it was successful in navigating in such environments. The prototype also showed dynamic obstacle avoidance capability.
4. We have calibrated the Microphone array that we are using to collect the 'Direction of Arrival' of sound sources.
5. We have built a 3D design and fabricated the final platform from it. The platform is sturdy and capable of bearing the payloads as required.
6. We have set up a mechanism for sit-to-stand assistance utilizing a linear actuator in our final design that is functional and can handle the payload that's required.
7. We have been successful in developing a computer vision algorithm to measure the distance to a user from the camera setup.

4 FUTURE WORKS

The main objectives of the project have almost been achieved. Namely the first two objectives; the Literature Review and the Fabrication of the mechanical structure has been duly completed. Of the next objective what is left is the integration of all systems to work together. That can be time-consuming, so we have allocated time accordingly in our plan. Once those tasks are completed, we will be able to focus on the testing and validation of the individual systems one by one and the whole integration of systems as a whole. Given in Figure 4.1 is a detailed walkthrough of the plan in the form of a Gantt Chart.

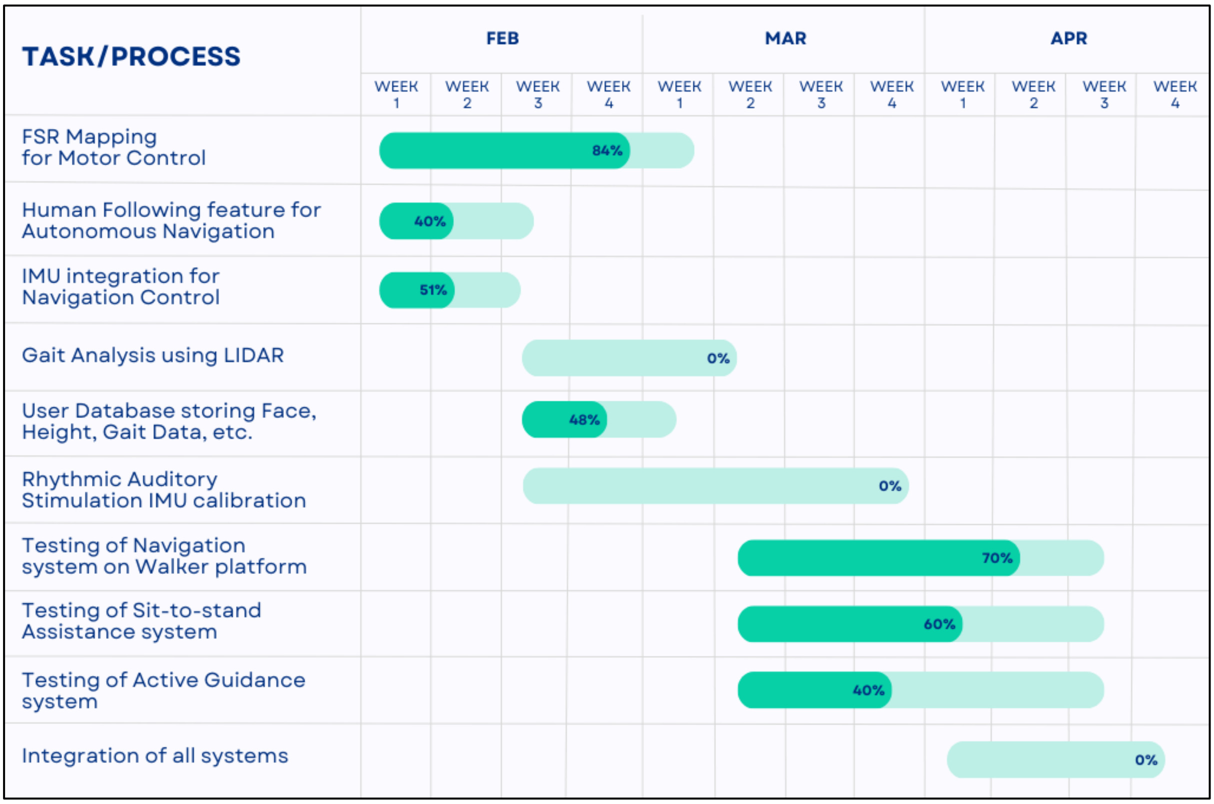

Figure 4-1 Future Work Plan