Group No: 40

Project Proposal

ME4202

Design and Development of a Multi-functional Robotic Walker

By

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1 Introduction

In an era marked by an increasing prevalence of mobility-related challenges across various demographics, innovative solutions are essential to enhance the quality of life and independence of individuals facing diverse mobility needs. One such solution is the development of advanced robotic walkers that can address a range of conditions requiring mobility support and assistance.

Robotic walkers have the potential to provide physical support for walking and aid in daily activities for not only the elderly but also individuals with neurological conditions such as Parkinson's disease or multiple sclerosis. They can offer a sense of security and autonomy to people recovering from injuries or surgeries, and those with temporary mobility impairments due to accidents or medical treatments. Moreover, individuals with chronic pain conditions like arthritis or joint disorders can benefit from the assistance provided by these walkers.

This research project focuses on the design and development of a multi-functional robotic walker, aiming to utilize advanced robotic assistive technology in enhancing mobility aids.

2 Context

In the global demographic landscape, there has been a swift global rise in the number of elderly people, projected to surpass 2 billion by 2050 according to the World Health Organization's report in 2018. It has been revealed that 24% of people aged over 65 use some sort of mobility device [1] which is a 50% increase [2] from values from studies before 2015. Moreover, neurological disorders, including Parkinson's disease and multiple sclerosis, affect millions worldwide, causing a range of mobility challenges that can hinder daily activities and diminish the overall quality of life [3][4].

The use of mobility devices has been seen increasingly in temporary lower body immobility treatment and is considered one of the 1st steps in the rehabilitation process for such injuries, working on partial weight bearing of the lower body. Of people with any sort of physical disability, 6.7% use walkers [5]. Overall, when considering the entire global population, the use of walkers has increased by 2% since 2004 [5]. All these contribute and point to the fact that the use of mobility devices is on the rise. Of all such mobility devices, walkers are the best-suited and safest for people with poor balance, mobility, or lower extremity impairment.

Recent developments in the field of robotic walkers have showcased remarkable advancements as they are no longer limited to providing basic mobility assistance; they now incorporate sophisticated features such as obstacle detection and avoidance, adaptive terrain navigation, and fall prevention mechanisms [6]. Furthermore, advancements in sensor technology and real-time data processing have enabled these walkers to offer personalized assistance based on individual user needs and preferences [7]. This recent progress underscores the potential of robotic walkers to significantly enhance the quality of life for individuals with mobility challenges, particularly the elderly and those with mobility impairments, by granting them greater independence, safety, and autonomy in their daily activities.

3 Research gap

Our research project seeks to design and develop a robotic walker capable of assisting people with mobility challenges in shared environments like hospitals, nursing homes, healthcare facilities, rehabilitation centres, assisted living communities, etc. It addresses the limitations of existing research in the domain of the utilisation of robotic walkers in a shared environment, where personalized operating parameters are essential for each user.

Our research recognizes the dynamic nature of such environments, where user-dependent operating parameters such as operating height and assistance levels may vary widely. Consequently, there is a pressing need for an approach that accounts for these variations and provides a personalized, adaptable experience for each user.

By equipping walkers with a summoning capability users are able to conveniently call the walker to any location, providing them with heightened autonomy and ease of use. Moreover, by integrating sit-to-tand assistance capabilities into the robotic walker we aim to address the challenges associated with transitions between sitting and standing positions. This integration not only assists users in moving from one location to another but also supports them in performing essential daily activities with greater autonomy.

Addressing these aspects, our project aims to optimize the user experience, making the robotic walker an indispensable tool for enhancing mobility and quality of life.

4 Aim and objectives

4.1 Aim

To improve the daily lives of individuals with mobility challenges, using assistive robotic technology.

4.2 Objectives

1. Study the existing problems associated with mobility and identify key focus areas and research gaps.
2. Design and development of an appropriate mechanical structure for the platform of the 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.

4.3 Scope of project

In our project, we aim to design and develop a multifunctional robotic walker for the care of individuals with mobility issues.

While the target group is not limited to these scenarios, our system is particularly suited for those encountering one or more of the following difficulties:

1. Risk of Falls: A significant segment of our target group faces an increased likelihood of falling when walking or maintaining an upright posture without external aid. Our solution offers support to mitigate this risk, enhancing stability and promoting safe mobility.

2. Navigation Impairments: For individuals who struggle to navigate within indoor environments or make appropriate judgments in various situations, our system acts as a guiding companion, assisting in manoeuvring through complex spaces effectively.

3. Cognitive Load Management: Multitasking can be particularly challenging for some individuals, especially when it involves activities like avoiding obstacles while walking. Our solution alleviates this burden by providing obstacle detection and avoidance, allowing users to focus on their movements.

The functionalities of the proposed multi-functional robotic walker are as follows.

1. Summoning Capability (Autonomous Navigation): The walker can autonomously navigate to a user's location upon receiving a summoning command. This feature eliminates the need for the user to manually retrieve the walker and ensures it's readily available when needed.
2. Active Walking Guidance and Support: The walker provides real-time guidance and support while the user walks. It adapts its movement to the user's pace, assisting in maintaining stability and preventing falls.
3. Standing Assistance: The walker aids users in transitioning between sitting and standing positions, as well as vice versa. This assistance promotes greater independence and confidence during these common movements.
4. Multiuser Operating Height Adaptation: The walker can adjust its operating height to accommodate different users. This ensures optimal ergonomic positioning for users of varying heights and needs, enhancing comfort and usability.

5 Methodology

1. Study the existing devices associated with mobility and identify key functionalities and research gaps.

- Literature Review: Conduct thorough research on the existing technology used in walkers and identify research gaps and areas that require improvement or innovation.
- Survey and Data Collection: Conduct surveys or interviews with mobility device users, healthcare professionals, and experts in the field. Gather data on user preferences, limitations of current devices, and specific requirements for the new walker platform.
- Comparative Analysis: Create a comparative matrix to assess the strengths and weaknesses of existing devices.

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

- Conceptualization: Brainstorm and generate multiple design concepts for the mechanical structure of the walker platform considering factors like stability, weight distribution, adjustability, and integration of support features.
- Detailed Design: Select the most optimum design and create detailed engineering drawings and specifications for the chosen design.

- Prototyping: Build a physical prototype of the mechanical structure using appropriate materials and manufacturing techniques.

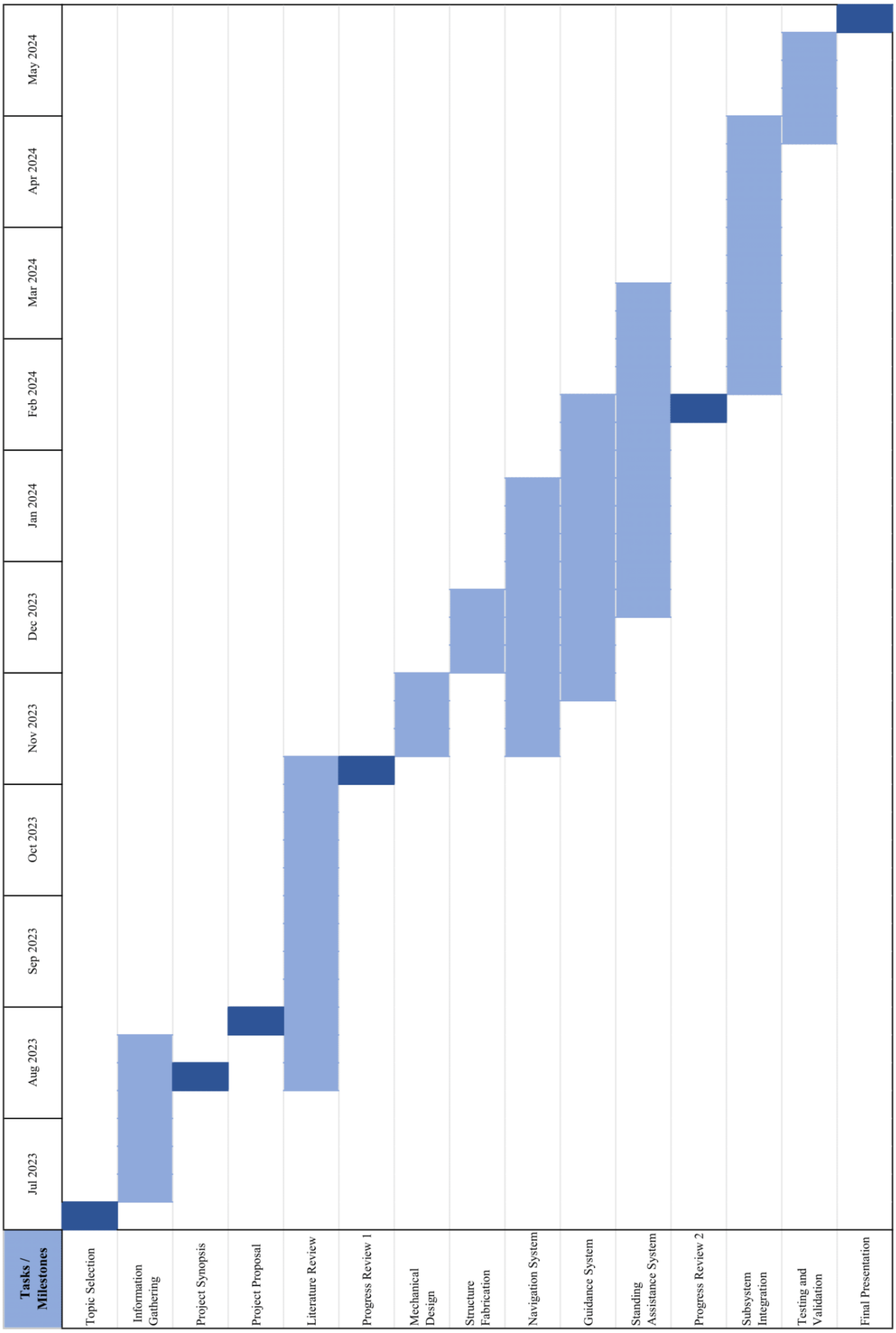
3. **Development of the autonomous navigation system, walking guidance system, and standing assistance system for the walker.**

- Requirement Identification: Define the functional requirements of each system.
- Selection of Components: Choose appropriate sensors, actuators, and electronics for each system.
- System Development: Develop the control software to integrate sensor inputs, process data, and control the actuators for each system.

4. **Testing and validation of the developed system.**

- System Testing: Testing of Mechanical Structure, Autonomous navigation system, Walking guidance system, and Standing assistance system
- Controlled Environment Testing: Assess the walker's functionalities in controlled environments, conducting tests to validate the performance of each subsystem and as a whole.
- Iterative Improvement: Continuously iterate and optimize the system based on testing outcomes, user input, and the challenges encountered in real-world scenarios.

6 Work plan


Tasks / Milestones
Topic Selection
Information Gathering
Project Synopsis
Project Proposal
Literature Review
Progress Review 1
Mechanical Design
Structure Fabrication
Navigation System
Guidance System
Standing Assistance System
Progress Review 2
Subsystem Integration
Testing and Validation
Final Presentation
Jul 2023
Aug 2023
Sep 2023
Oct 2023
Nov 2023
Dec 2023
Jan 2024
Feb 2024
Mar 2024
Apr 2024
May 2024

7 Budget

System	Component	Description	Price
Mechanical Structure	Aluminum Box Bars, Extrusion Bars & Fasteners	(Rough estimate. Depends on final design)	Rs. 25,000.00
	Wheels	6-inch Wheels	Rs. 1,400.00
	Caster Wheels	4-inch Caster Wheels	Rs. 850.00
Autonomous Navigation System	2D LIDAR Sensor	Slamtec RPLIDAR A1	Rs. 31,462.00
	Web Camera	Logitech C270 Web Camera	Rs. 8,500.00
	Microphone Array	ReSpeaker Mic Array - Far-field w/ 7 PDM Microphones	Rs. 26,000.00
Walking Guidance System	Force Sensing Resistors (6 Nos.)	Pololu Force Sensing Resistor, 1.5 Inch Square	Rs. 27,150.00
Standing Assistance System	Linear Actuator	YNT-09 Linear Actuator with stroke 400mm; 45W / 24VDC / 2000N	Rs. 12,000.00
Common to Systems	Controller Board	Raspberry Pi 4 Model B 4 GB RAM	Rs. 21,083.00
	Encoder Motors (2 Nos.)	ChiHai Motor CHP-42GP-775ABHL	Rs. 22,500.00
	Motor Controller	BTS 7960 DC Motor driver	Rs. 1,450.00
	Power Supply	24V 2A SMPS Power Supply	Rs. 1,400.00
Total			**Rs. 178,795.00**

8 References

[1] N. Gell, R. Wallace, A. LaCroix, T. Mroz, K. Patel, Mobility Device Use Among Older Adults and Incidence of Falls and Worry About Falling: Findings From the 2011–2012 National Health and Aging Trends Study, HHS Public Access, May 2016.

[2] S. Passary, “Use of walking aids going up for Elder Americans,” Tech Times, https://www.techtimes.com/articles/51335/20150507/use-of-walking-aids-going-up-for-elder-americans.htm

[3] Parkinson's Foundation. (2021). Statistics. https://www.parkinson.org/Understanding-Parkinsons/Statistics

[4] Multiple Sclerosis International Federation. (2020). Atlas of MS 2020, https://www.msif.org/about-us/who-we-are-and-what-we-do/advocacy/atlas/

[5] “Walkers,” *Physiopedia*. https://www.physio-pedia.com/Walkers

[6] Smith, A. B., Jones, C. D., & Martinez, E. F. (2022). Advanced Robotic Walkers with Enhanced Obstacle Detection and Fall Prevention. Journal of Robotics and Assistive Technologies, 8(1), 45-58.

[7] Johnson, R. M., Williams, K. L., & Lee, S. H. (2021). Personalized Assistance in Robotic Walkers through Sensor Integration and AI Decision-Making. Assistive Robotics Journal, 15(3), 178-192.