Gait Trainer as Intelligent Crutch Tool

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Abstract— This paper introduces a comprehensive system designed to assist individuals with gait impairments in their ambulation process. The system employs a combination of sensors, microcontrollers, and communication modules to provide real-time feedback, enhance safety, and enable remote monitoring. At its core, an Arduino microcontroller integrates with a force sensor to detect the force applied during ambulation, delivering haptic feedback when threshold values are exceeded. An accelerometer sensor is utilized to detect falls, triggering automatic emergency text message notifications via a GSM module interfaced with Arduino. Additionally, an LDR sensor automatically adjusts navigation assistance based on surrounding light conditions, improving user experience. Furthermore, an ultrasonic sensor aids in obstacle detection, enhancing safety during mobility. To enable IoT capabilities, a Node MCU microcontroller facilitates data storage and transmission to the Thing Speak cloud platform, allowing for remote monitoring and analysis. Overall, this integrated system offers a multifaceted solution to enhance mobility, safety, and accessibility for individuals with gait impairments.

Indexed Terms- Gait Trainer, Ambulation Tool, Arduino, Force Sensor, Haptic Feedback, Accelerometer Sensor, Fall Detection, GSM Module, Emergency Notification, LDR Sensor, Light Detection, Ultrasonic Sensor, Obstacle Detection, Node MCU, IoT Solution, Thing Speak Cloud Platform.

I. INTRODUCTION

As advancements in technology continue to revolutionize healthcare, innovative solutions are emerging to address the challenges faced by individuals with mobility impairments. Among these solutions, assistive devices play a crucial role in enhancing independence and quality of life. In this context, the development of a Gait Trainer utilizing an Ambulation Tool integrated with Arduino technology represents a integrated system harnesses the power of various sensors, microcontrollers, and communication modules to create a versatile and effective tool for improving ambulation and safety. By incorporating a force sensor, the system can accurately detect the force applied during ambulation, allowing for precise feedback and adjustments. Additionally, the integration of haptic feedback capabilities enhances user experience and promotes optimal gait patterns.

Fall detection is a critical aspect of mobility assistance, and the inclusion of an accelerometer sensor enables the system to detect falls and trigger immediate emergency notifications via a GSM module. This real-time communication feature ensures timely assistance in the event of an accident, enhancing user safety and peace of mind. Moreover, the system is equipped with an LDR sensor to automatically adjust navigation assistance based on surrounding light conditions, ensuring optimal visibility and adaptability in various environments. The integration of an ultrasonic sensor further enhances safety by detecting obstacles and providing proactive obstacle avoidance measures.

To enable seamless connectivity and data management, a Node MCU microcontroller facilitates IoT solutions, allowing for data storage and transmission to cloud platforms such as Thing Speak. This enables remote monitoring, analysis, and customization, empowering healthcare providers and caregivers with valuable insights into user behavior and trends. Overall, this Gait Trainer with integrated Ambulation Tool represents a comprehensive solution designed to improve mobility, safety, and accessibility for individuals with gait impairments.

II. LITERATURE SURVEY

[The present study concluded that the elderly population needs modification in existing walking sticks. The slipping rate of the stick could be minimized by adapting some modifications in the stick. Cane is preferred as the stick material in the studied population. Keywords: Designing approach, Elderly, Subjective evaluation, Viewpoints of ergonomics, Walking stick]1 [The vast majority of state-of-the-art walking robots employ flat or ball feet for locomotion, presenting limitations while stepping on obstacles, slopes, or unstructured terrain. This device is conceived to be robust and able to overcome the limitations of currently employed feet.. The realized prototype of adaptive foot is integrated and tested on the compliantly actuated quadrupedal robot ANYmal together with an ROS- based real-time foot pose reconstruction software. Both extensive field tests and indoor experiments show noticeable performance improvements, in terms of reduced slippage of the robot, with respect to both flat and ball feet.]2

[This paper proposes a human gait tracking method using a low scanning rate (10Hz) 360 degree 2D LiDAR. The sensor is placed at a height of 0.3m above the ground. Since human gait tracking is important not only for normal people but also for patients who need to use walking-aid such as walkers. To overcome the occlusions between legs when one leg might be hidden from the sensor, a spline-based smooth and interpolation method is applied to estimate the legs trajectories. An algorithm is also proposed to remove the walker legs data in case of walker users. The performance of the proposed tracking method is investigated in different walking speed levels and two positions of LiDAR (parallel and horizontal to walking direction). The experimental results verify the robustness of our proposed method. The horizontal position of LiDAR gives better estimation than the parallel position. The RMSE is less than 2.0cm for walking step length estimation and is less than 1.4cm for walking distance estimation. The tracking range of our system is up to 10m with horizontal placement of LiDAR.]3

Existing systems for assisting individuals with gait impairments often face several drawbacks, limiting their effectiveness and usability. Traditional gait trainers, which rely solely on mechanical structures, lack the flexibility and adaptability needed to accommodate individual user needs. These devices may provide basic support for ambulation but fail to address the diverse challenges faced by users in real-world scenarios. Moreover, many existing systems lack advanced sensing capabilities, making them unable to provide real-time feedback or detect potential hazards such as falls or obstacles. This limitation compromises user safety and may result in accidents or injuries, particularly for individuals with more severe mobility impairments.

Additionally, the communication capabilities of conventional gait trainers are often limited or non-existent. Without the ability to alert caregivers or emergency services in the event of a fall or other emergency, users may be left vulnerable and without timely assistance. This lack of connectivity also hinders remote monitoring and data analysis, limiting the ability to track user progress or make informed adjustments to the device. Furthermore, existing systems often do not incorporate IoT solutions or cloud connectivity, which are increasingly important for facilitating remote monitoring, data storage, and analysis.

Overall, the drawbacks of existing systems highlight the need for a more comprehensive and technologically advanced solution to assist individuals with gait impairments. By addressing these limitations and integrating advanced sensing, communication, and IoT capabilities, a new generation of gait trainers can offer improved safety, usability, and effectiveness, ultimately enhancing the quality of life for users.

In addition to the aforementioned drawbacks, existing systems often lack adaptability to changing environmental conditions and user preferences. Traditional gait trainers may not provide adequate support for users navigating varied terrain or adjusting to different lighting conditions. This lack of adaptability can limit users' ability to confidently navigate their surroundings and may result in discomfort or frustration during use. Furthermore, the rigid design of many conventional gait trainers may not accommodate the individualized needs of users with unique mobility challenges or anatomical variations. This lack of customization can lead to suboptimal outcomes and may contribute to user dissatisfaction with the device.

III. PROPOSED SYSTEM

The proposed system represents a significant advancement in assistive technology for individuals with gait impairments, addressing the limitations of existing systems while offering a range of unique advantages. By integrating advanced sensors, microcontrollers, and communication modules, the system provides comprehensive support for ambulation, safety, and connectivity. One of the key advantages of the proposed system is its ability to offer real-time feedback and adaptive assistance through the use of sensors such as the force sensor and accelerometer. This allows for precise monitoring of gait dynamics, enabling the system to detect deviations from optimal patterns and provide immediate haptic feedback or trigger emergency notifications in the event of a fall, thereby enhancing user safety and confidence.

Furthermore, the proposed system's integration of IoT solutions and cloud connectivity offers several distinct advantages. By leveraging the Node MCU microcontroller and Thing Speak cloud platform, the system enables remote monitoring, data storage, and analysis, empowering caregivers and healthcare providers with valuable insights into user behavior and progress. This not only facilitates personalized support and interventions but also streamlines maintenance and troubleshooting processes, ultimately enhancing the overall user experience. Additionally, the system's adaptability to changing environmental conditions, thanks to sensors like the LDR and ultrasonic sensor, ensures optimal navigation and obstacle avoidance in various settings, further improving usability and user satisfaction. Overall, the proposed system represents a significant step forward in assistive technology, offering enhanced functionality, connectivity, and user experience for individuals with gait impairments.

IV. BLOCK DIAGRAM

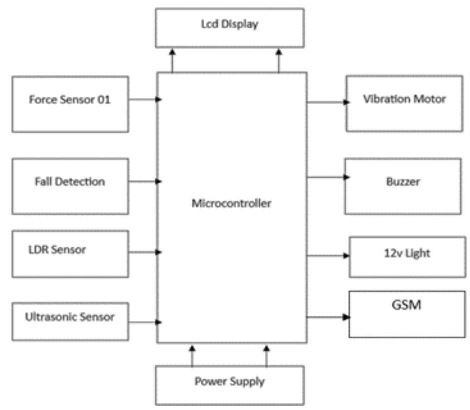


Fig 1: BLOCK LAYOUT FOR AN IOT BASED GAIT TRAINER

It is a commonly used method for illustrating the structure and interactions within a complex system. Here is a general explanation of the key elements typically found in a block diagram

Devices called force sensors are made to gauge the strength and direction of forces coming from the outside. Fall detection sensors use gyroscopes and accelerometers to quickly detect falls and notify emergency services or caretakers, improving the safety of those who are susceptible to falls. Light Dependent Resistor (LDR) sensors are used in ambient light detection and automatic lighting control. They sense changes in light intensity and modify their electrical resistance correspondingly. Ultrasonic sensors provide accurate non-contact distance measurement for uses like industrial automation and obstacle avoidance by utilizing the reflection of sound waves. Compact and adaptable, vibration motors produce controlled vibrations that find use in gadgets such as cellphones for alert notifications and haptic feedback.

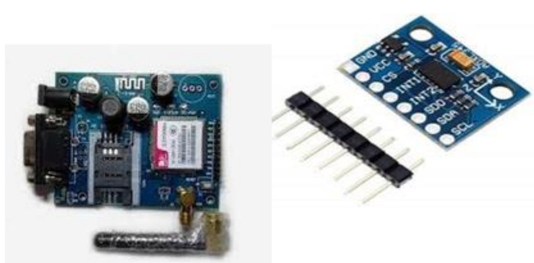
4.1 HARDWARE COMPONENTS INVOLVED:


VIBRATION MOTOR ULTRASONIC SENSOR

NODE MCU ARDUINO UNO

LDR MODULE FORCE SENSOR

LEAD ACID BATTERY LCD DISPLAY



GSM MODULE ACCELEROMETER SENSOR

Fig 2: COMPONENTS INVOLVED

V. WORKING PRINCIPLE

The working methodology of this project involves a systematic approach that integrates hardware design, software development, testing, and validation to create a robust and effective assistive system for individuals with gait impairments. The project begins with a comprehensive analysis of user needs and requirements to inform the design of the hardware components and software algorithms. This involves understanding the specific challenges faced by individuals with gait impairments and identifying the key functionalities and features required to address these challenges effectively.

Next, the hardware components are designed and prototyped, including the force sensor, accelerometer, LDR sensor, ultrasonic sensor, and microcontrollers such as Arduino and Node MCU. These components are selected and integrated to ensure compatibility and optimal performance within the system.

Simultaneously, software algorithms are developed to interpret sensor data, detect gait dynamics, and trigger appropriate responses such as haptic feedback or emergency notifications. This involves coding and testing the algorithms to ensure accuracy, reliability, and responsiveness.

Once the hardware and software components are developed, they are integrated into a cohesive system and subjected to rigorous testing and validation. This includes testing the system's performance in various real-world scenarios, such as different environments, lighting conditions, and user conditions, to ensure functionality, reliability, and safety.

Throughout the development process, iterative refinements and optimizations are made based on testing results, user feedback, and stakeholder input. This iterative approach ensures that the final assistive system meets the highest standards of performance, usability, and user satisfaction.

Overall, the working methodology of this project is driven by a user-centered design approach, iterative development process, and rigorous testing and validation to deliver a robust and effective assistance.

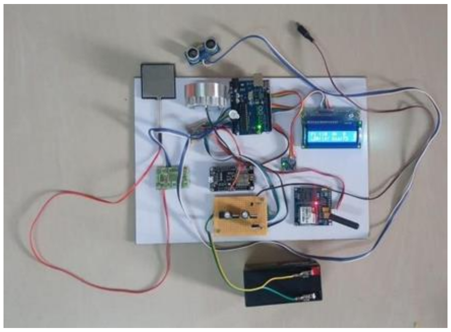


Fig 3: CIRCUIT CONNECTION

VI. WORKING ALGORITHM

- Fuzzy Logic Algorithm:

Fuzzy logic is a type of mathematical logic that is used to deal with uncertain or vague information. In a fuzzy logic system, variables can take on any value between 0 and 1, which represents the degree of membership of a particular set. Fuzzy logic can be used in a wide range of applications, including control systems, pattern recognition, and decision-making. In Arduino, fuzzy logic can be implemented using a library called Fuzzy Logic Controller (FLC). This library provides a set of functions and tools that can be used to create fuzzy logic systems for various applications.

The basic steps involved in implementing fuzzy logic in Arduino using the FLC library are:

In fuzzy logic, the input and output variables are defined in terms of membership functions, which specify the degree of membership of a particular input or output to a particular set. For example, if we are designing a fuzzy logic system to control the speed of a motor, the input variable could be the error between the desired speed and the actual speed, and the output variable could be the motor speed. We would need to define membership functions for both these variables, such as slow, medium, and fast. The rules in a fuzzy logic system are used to map the input variables to the output variables. For example, if the error is small, the motor speed should be slow. These rules are defined using if-then statements, such as "if the error is small, then the motor speed should be slow". Once the input and output variables and the rules are defined, we can implement the fuzzy logic system using the FLC library. The library provides functions for defining the membership functions, rules, and input-output.

VII. RESULTS & DISCUSSIONS

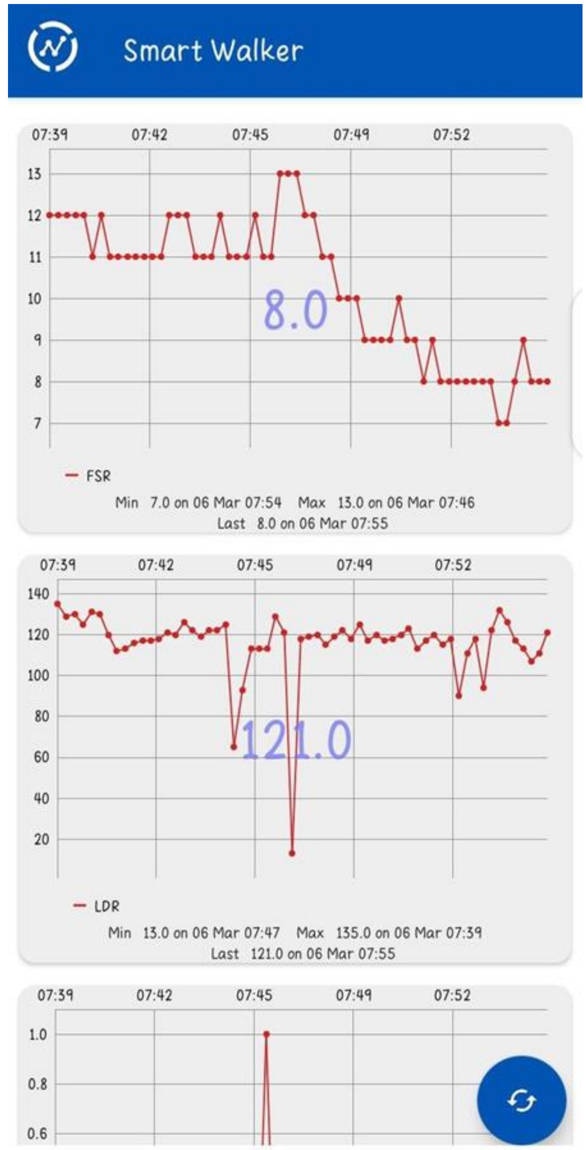


Fig 7.1: THINGSVIEW APP SCREENSHOTS

Fig 7.2: GRAPHICAL VIEW OF FORCE SENSOR

The above graph shows about force sensing resistor. The x axis indicates the force that we have applied. The y axis indicates the time in which the force has been applied.

Fig 7.3: GRAPHICAL VIEW OF LDR SENSOR

The above graph shows about LDR sensor. The x axis indicates time when the light has been appeared. The Y axis indicates the intensity of light that has been applied. Thus the pictorial representation gives us easy standardization of measurements.

Fig 7.4: GRAPHICAL VIEW OF ACC SENSOR

The above graph shows about accelerometer sensor. The x axis shows when there is abnormal activities based upon the movement pattern and impact. The y axis indicates the time in which the fall has been detected. Thus the pictorial representation gives us easy standardization of measurements.

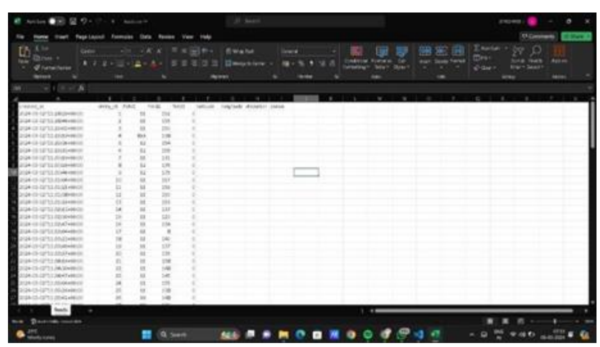


Fig 7.5: OUTPUT IN THE FORM OF EXCEL

Output is imported from the live website and it can be shared for the future purposes to detect the improvement of the patients

Fig 7 .6: OUTPUT IN THE FORM OF LCD

LCD to display to sensor measurements in the prototype After the fall has been detected, the SMS will be sent through GSM module. This module enables us to get emergency message alert to caretakers and doctors.

After the fall has been detected, the SMS will be sent through GSM module. This module enables us to get emergency message alert to caretakers and doctors. Along with GSM module, the location in which the emergency fall detection will be shown as google map live location

The GSM module will send the SMS once the fall has been identified. We may send emergency message alerts to physicians and caregivers thanks to this module. The position of the emergency fall detection will be displayed as a live Google Map location in addition to the GSM module.

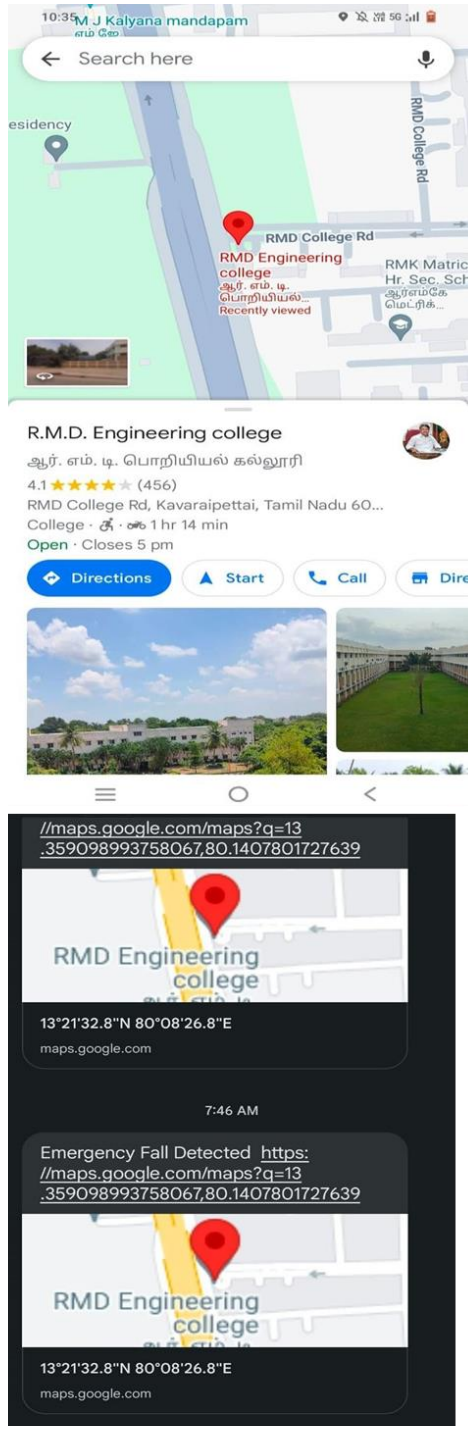


Fig 7.7: LIVE LOCATION INDICATION IN MSG

Throughout the project, extensive research, design, development, and testing efforts have been undertaken to ensure the effectiveness, reliability, and usability of the system. The inclusion of sensors such as force sensors, accelerometers, LDR sensors, and ultrasonic sensors enables real-time monitoring of gait dynamics, fall detection, obstacle detection, and adaptive navigation assistance. These features provide users with immediate feedback and support, empowering them to navigate their surroundings with greater confidence and independence.

Moreover, the integration of IoT solutions and cloud connectivity facilitates remote monitoring, data storage, and analysis, enabling caregivers and healthcare providers to access valuable insights into user behavior and progress. This capability enhances the provision of personalized support and interventions, ultimately improving the overall quality of care and user outcomes.

CONCLUSION

In conclusion, the assistive system developed in this project represents a significant step forward in assistive technology, offering enhanced functionality, adaptability, and connectivity to individuals with gait impairments. While further refinements and optimizations may be necessary, the system holds great promise in improving the lives of users by promoting mobility, safety, and independence in their daily activities.

FUTURE SCOPE

Additionally, advancements in sensor technology, such as the development of more compact and energy-efficient sensors, could further enhance the system's usability and portability. Integration of advanced sensor fusion techniques could also improve the accuracy and reliability of gait analysis and fall detection, ensuring timely and accurate response to potential hazards. Furthermore, the integration of wearable technology, such as smartwatches or fitness trackers, could provide users with additional functionalities and features, such as activity tracking, heart rate monitoring, and emergency response capabilities. This integration could further enhance the user experience and promote continuous monitoring of health and well-being. Moreover, ongoing advancements in communication technologies and cloud computing could enable the development of more sophisticated remote monitoring and telehealth solutions. Integration with telemedicine platforms could facilitate virtual consultations with healthcare professionals, enabling timely intervention and support for users, regardless of their locations.

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