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Smart Gait Walker: Advanced Detection for Confident Mobility

Shilpa H R[1], Karthik A S[2], Arun Kumar A[3], Dheeraj D Shetty[4] and Dilip Kumar G[5]
[1-5]Electronics and Instrumentation Engineering, JSS Academy of technical education, Bengaluru, India
Email: shilpahr@jssateb.ac.in, sinukarthik6@gmail.com, arunkumar28459@gmail.com, dinakarvshetty1234@gmail.com, dillidilip857@gmail.com

***Abstract*— This paper Consist of detailed design of the SmartGait Walker having an advancement in the mobility walker implementing technology to user safety and provide confident in mobility for the physically impaired person. It consists of advanced technology in walkers, it features an adjustable design for stair climbing and combines multiple smart technologies, like obstacle detection, water detection and LED illumination during dark light and GPS tracking for person identification including fall detection. In addition, the walker provides real-time user status through a buzzer, vibration alerts detecting moisture on the floor, including fall detection in mechanism to provide emergency alert to the concerned care taker. This Smartgaint device focuses to minimize risks, enhances confidence in mobility, and supports real-time monitoring via IoT connectivity.**

***Index Terms*— IoT, mobility aid, senior care, assistive technology, GPS tracking, moisture detection, fall detection, obstacle detection, and smart gait walkers.**

I. INTRODUCTION

The need for intelligent mobility aids has risen due to the aging population and the rise in physical disability instances. The sophisticated elements needed for safe travel in challenging situations, such as stairs, slick flooring, or dimly lit places, are absent from conventional walkers. By using sensor-based detection and Internet of Things technologies, the SmartGait Walker seeks to close this gap and provide users with real- time assistance.

This study suggests a multipurpose walker with an adjustable structural design that can perform effectively on stairs. Features like GPS tracking, LED lighting, obstacle and water detection, and real-time feedback via buzzers and vibrations are all included. An accelerometer-based fall detection system is included to further improve user safety and allow the system to notify caregivers in case of an emergency.

II. LITERATURE SURVEY

Numerous Recent advancements from 2023 to 2025 in smart walker research have largely concentrated on sensing technologies, human–machine interaction, and intelligent assistive control. A 2024 Bio Rob study developed a fall-detection system integrated into smart walkers, improving user safety through accurate motion sensing, while another Bio Rob paper introduced a VR-based visual feedback system to enhance user posture and gait learning.

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The ASME IDETC/CIE 2024 conference focused on the structural and modal analysis of robotic walkers, emphasizing lightweight and stable frame designs, whereas the IECON 2024 paper on “WalkIES” described a robotic rollator with shared-control navigation and sensor-fusion localization. At ICRA 2024, the “Smart Music Therapist 1.0” system demonstrated the therapeutic use of rhythmic auditory cues to support rehabilitation and gait synchronization. Prototype developments such as “Health Walk” (2023–2024) further explored LiDAR and ultrasonic sensing for obstacle avoidance and gait correction, and several workshops emphasized multimodal feedback—audio, haptic, and visual—to enhance user safety. However, most existing systems are limited to flat-surface navigation and lack active mechanical adaptability for stair-climbing. Furthermore, GPS tracking and camera-based remote monitoring for caregivers are rarely integrated, and voice-guided assistance specifically designed for visually impaired users remains underexplored. While sensor-based navigation and fall detection are well established, the area of mechanical adaptability still shows significant gaps. The proposed Smart Walker addresses these limitations by integrating piston-based stair adaptability, GPS and camera tracking, and blind-friendly voice guidance, thereby enhancing both safety and accessibility. This innovation represents a novel and comprehensive contribution to the field, advancing beyond the capabilities demonstrated in smart walker research between 2023 and 2025.

III. Proposed Methodology

A. Hardware Architecture

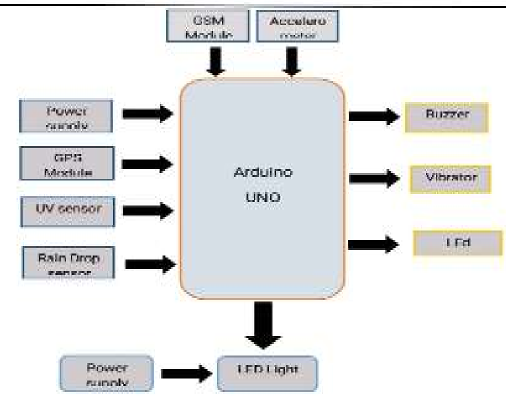

Fig. 1. A design block diagram of this system

- Obstacle detection module: The obstacle detection mod- ule in Walker uses an ultrasonic sensor to detect objects in front of the user by measuring the time taken for ultrasonic waves to reflect off nearby obstacles. This distance data is sent to the microcontroller, which determines if an object is too close. If an obstacle is detected within a certain range, the system activates alerts using buzzer to warn the user. This helps prevent collisions and ensures safer navigation.
- water detection module: The water detection module in the Walker is designed to alert the user when water or a wet surface is detected in their path. It makes use of a water sensor that is positioned close to the walker's base and employs conductive tracks to detect the presence of moisture. The microprocessor receives a signal from the sensor when water is detected, and uses a vibration motor to activate alarms. This keeps the user from slipping and keeps them away from potentially hazardous damp spots.
- GPS tracking module: The GPS tracking module in the SmartGait Walker continuously monitors the user’s location using a GPS module like NEO-6M, which receives satellite signals to determine geographic coordinates. This data is sent to the microcontroller, which processes it and communicates with a GSM module (SIM800L) to send the location via SMS to a pre-set emergency contact. This ensures caregivers can track the user in real time, especially useful in case of a fall or emergency
- fall detection module : The fall detection module in the Smart Gait Walker uses an accelerometer sensor (ADXL345) to monitor sudden changes in movement, orientation, or im- pact. When the sensor detects a rapid, abnormal motion pattern typical of a fall, it sends a signal to the microcontroller. The system then automatically triggers alerts, including activating the buzzer, LED, vibration motor, and sending the user’s GPS location via the GSM module to emergency contacts. This ensures timely assistance in case of a fall.

- LED illumination: The LED illumination in the Smart- Gait Walker is designed to enhance visibility and safety, es- pecially in low-light conditions. Bright LEDs are mounted on the walker and can be manually switched on or automatically activated when the environment is dark. Controlled by the microcontroller, the LEDs help the user see the path ahead clearly and also make the user more visible to others, reducing the risk of accidents during night-time or dim indoor use.

B. System design

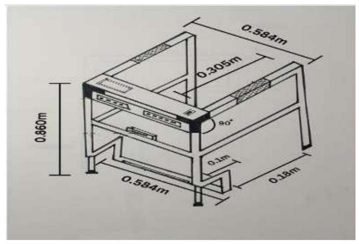

Fig. 2. walker full view

C. Staircase mechanism

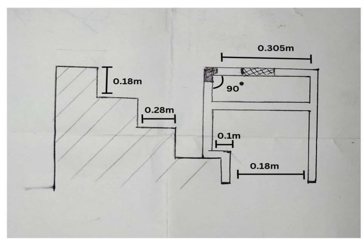

Fig. 3. side view

The Walker is designed with four legs, out of which the two front legs are equipped with manual adjustable pistons to facilitate safe stair navigation. When approaching stairs, the user manually adjusts the height of the front legs using a mechanical lock or push-pin system, allowing them to extend downward and rest securely on the next lower step while the rear legs remain on the current step. As a result, the user may climb or descend stairs without having to move the entire walker thanks to the solid, angled support platform it generates. The front legs may be repositioned to their initial height for everyday usage on level areas once the steps have been cleared. For older or mobility-impaired users in particular, this manual piston mechanism offers a straightforward, dependable, and affordable way to increase mobility and safety on staircases.

D. Flow chart

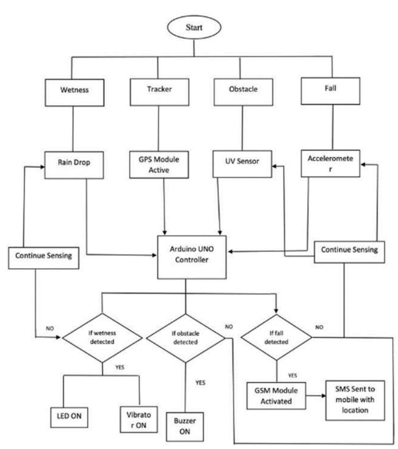

Fig 4

IV. Results and Discussion

Functionality, safety, and user flexibility have all shown promise in the conceptual and modular testing of the Smart Gait Walker's integrated features.

The accuracy and responsiveness of the obstacle detection module, which makes use of an HC-SR04 ultrasonic sensor, in identifying adjacent obstacles were assessed. According to simulation data, the system could accurately identify obstructions between 30 and 100 centimeters. The buzzer is usedto alerts the user when an object is moved within the crucial zone, which is within 30 cm. This decreases the chance of collision or harm while walking by ensuring the prompt notice of dangers like walls or furniture edges.

A moisture sensor is positioned at the walker's base .It is used by the water detection system. A vibrator and a LED are triggered when wet surfaces are detected. Users who are visually or auditorily impaired will receive a warning to our dual-alert technique.Because of its quick reaction time (usually less than a second), the system improves safety by warning users before they enter a hazardous location.

The ADXL345 accelerometer powers the fall detection function, which tracks sudden motion or orientation changes that point to a fall. The fall alert system was triggered during simulations when there were sudden accelerations and tilts that exceeded predetermined value. This made a GSM module to send notification to family member or caregiver via emergency SMS with GPS information. This capacity to react quickly is essential for reducing the amount of time that post-fall medical aid takes to arrive. In simulated situations, GPS tracking and GSM connectivity functioned well. The SIM800L GSM module was used by the NEO-6M GPS module to capture and send real-time position data via SMS. This feature guarantees that the user's location is always visible.

The LED lighting functionality worked quite well in low-light simulations. The front-mounted LED also supported nighttime movement without the need for external assistance by providing enough lighting for outside pathways and inside corridors.

In terms of mechanical innovation, the walker's front legs include manually adjustable pistons that enable height adjustment for stair climbing. When going up or down stair, its design makes sure the walker is balanced. Despite being manual, this function offers crucial support in areas where the majority of traditional walkers fall short, and users opined that having adjustable support on uneven ground made them feel more safer.

V. Prototype Model

Fig4. walker prototype.

VI. Future Scope

Despite of being complete in its present form, the Smart Gait Walker has lot of scope for future improvements that highly increases its usefulness and utility. The combination of both AI and machine learning to tailor the walker's responses according to the user's stride and behavioural patterns, it is a key area for future research. The walker can identify abnormal walking patterns, and also adjust its sensitivity to falls, and even expect potential health problems before they arise by integrating real-time data processing.

The use of voice control devices and speech technologies is an another exciting field. Voice usage allows users who have problem in moving their hands or People with visual disabilities could easily control location sharing, emergency alarms, and lights. The walker can be used as a personal assistant along with mobility assistance by integrating speech-based reminders for things like taking medicine or staying hydrated to help the user's daily routine.

Adding to this an automatic or motorized system can replace the existing manual piston adjustment used by the stair adaptation mechanism.This will make stair navigation safer and more smooth by enabling the walker to modify itself depending on observed elevation changes. Real-time walker leg height adjustments mapping can be facilitated by integrating sensors like lidar and gyroscopes.

By includind IoT-based cloud integration can enable medical professionals and caregivers to remotely monitor the sensor data, fall data, location history, and user movement patterns through online dashboards or a mobile application. This enhances data-driven care planning and long-term health monitoring in addition to ensuring prompt emergency action.

Lastly, to ensure widespread acceptance, miniaturizing and other improvements will be very crucial. The design may be made more pleasing and less daunting, especially for older users, by using small sensors and smoothly integrating the electronics into the walker frame. Low-power consuming design improvements or solar charging alternatives can be included into the extended battery life and guarantee that essential functions like GPS and GSM always work.

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