TITLE

Smart Pendant with Wristband: A Safety and Mobility Enhancement Tool for the Elderly and Visually Impaired

AUTHORS

Mohamad Amir Bin Mohamad Yusoff, Adam Hakimi Bin Shah Nur Haizam, Tengku Nurul Ain binti Tengku Azeezee

Department of Mechatronics Engineering, International Islamic University Malaysia

ABSTRACT

This paper presents the design and development of a Smart Wearable Safety System intended to enhance personal safety and situational awareness for elderly and visually impaired users. The proposed system is composed of two interconnected subsystems: a pendant unit and a wristband unit, each built around an Arduino microcontroller and assigned distinct functional roles. The pendant unit functions as the primary sensing module, integrating a HuskyLens vision sensor, ambient light sensor, MPU6050 motion and fall-detection sensor, and a DHT11 temperature and humidity sensor to continuously monitor environmental and user-related conditions. Sensor data are processed and transmitted to the wristband unit via serial communication.

The wristband unit operates as the master controller, receiving alert signals from the pendant and converting them into intuitive haptic feedback using multiple vibration motors. In addition, a Bluetooth communication module is employed to automatically notify a caregiver's mobile device when abnormal events are detected, including obstacles, excessive brightness, sudden motion changes, temperature anomalies, or emergency button activation. The integration of sensing, processing, haptic feedback, and wireless communication demonstrates effective system

coordination and task distribution. The overall system architecture and operational flow validate the feasibility of a responsive, wearable safety solution capable of delivering timely alerts and reliable assistance for vulnerable users.

1. INTRODUCTION

The visually impaired and the elderly face significant challenges in mobility, environmental awareness, and personal safety. Daily obstacles such as navigating crowded areas, walking in low-light conditions, or responding during emergencies often prove difficult, as users may be unable to act in a timely manner. Conventional assistive tools, such as white canes, provide only ground-level tactile feedback and lack advanced features such as obstacle awareness, light detection, and emergency signalling capabilities. According to global health reports, millions of individuals live with mobility and visual impairments, underscoring the urgent need for superior and accessible assistive devices.

Studies have demonstrated that user safety and awareness can be significantly enhanced by integrating sensors such as ultrasonic or Time-of-Flight (ToF), vibration feedback mechanisms, and emergency communication systems. Blindness or old age reduces the likelihood of noticing dangers, particularly in unfamiliar or poorly developed environments. Conventional canes fail to detect raised or forward obstacles, which is especially hazardous in dimly lit or busy areas. Real-world incidents highlight these risks: visually impaired individuals falling into open manholes undetected by their canes, elderly persons colliding with objects in dark streets, or older adults unable to report medical emergencies due to the absence of alert systems. Slips and falls on wet surfaces, such as supermarket entrances or office floors, further emphasize the need for smarter, more responsive technologies.

To address these problems, this project proposes the development of a wearable assistive system consisting of a smart pendant and a hand band. The pendant serves as the primary sensing and processing unit, integrating multiple sensors including an MPU6050 motion sensor, DHT11 temperature and humidity sensor, light-dependent resistor (LDR), and HuskyLens vision sensor. These components enable continuous monitoring of environmental conditions, detection of obstacles and moving objects, identification of changes in light intensity, and sensing of abnormal temperature conditions. Data is processed by a master microcontroller and transmitted wirelessly via Bluetooth to the hand band.

The hand band functions as the feedback interface, providing tactile or buzzer-based alerts with distinct activation patterns for different hazards. An emergency push button allows users to instantly notify caregivers via mobile devices, while selected sensor data can be transmitted to a cloud platform for monitoring and analysis. This separation of sensing and feedback improves comfort, flexibility, and reliability, ensuring continuous environmental awareness.

Advanced Assistive Technology has gained increasing importance in supporting the mobility, safety, and independence of visually impaired and elderly individuals. Table 1 presents a comparison of several wearable assistive devices and highlights how they differ from the proposed project. Early designs, such as the Wearable Obstacle Detection System [9], introduced compact wearable forms with basic obstacle detection but lacked emergency alerts. The Smart Wearable for Visually Impaired [10] offered hands-free operation and vibration feedback, though it could not detect moving objects or environmental changes. More advanced systems, such as the IoT-Based Wearable Assistive Device [11], incorporated real-time caregiver connectivity but suffered from high power consumption and complex setup. Vision-based approaches like the

Vision-Assisted Wearable Aid [12] improved detection accuracy but introduced latency and higher costs. The Multi-Sensor Wearable Safety Device [14, 2023] expanded sensing capabilities with light and proximity sensors but lacked emergency alerts and motion tracking. Finally, the Wearable Emergency Alert System [14, 2024] ensured reliable emergency communication but was limited to alerts without continuous monitoring.

These innovations demonstrate a clear progression from basic wearable aids to multifunctional smart devices. The proposed system builds upon these foundations by integrating additional sensors, motion detection, and emergency communication features, while maintaining efficiency through modular architecture and low-latency feedback. This evolution reflects a broader shift toward assistive technologies that enhance navigation, safety, connectivity, and independence for visually impaired and elderly users.

Table 1 Table of comparison

Ref/year	Project name	Advantages	Disadvantages	Comparison to my proposal
[9] / 2019	Wearable Obstacle Detection System	Compact wearable design, basic obstacle detection	Limited sensing capability, no emergency alert feature	My project adds more sensors and emergency communication, covering hazards beyond basic obstacle detection.
[10] / 2020	Smart Wearable for Visually Impaired	Hands-free operation, vibration-based feedback	Cannot detect moving objects, lacks environmental sensing	My project includes motion detection and vision-based sensing, giving richer environmental awareness.
[11] / 2021	IoT-Based Wearable Assistive Device	Real-time data transmission and caregiver connectivity	High power consumption, complex setup	My project uses efficient Bluetooth and modular design, avoiding high power use and complex setup.
[12] / 2022	Vision-Assisted Wearable Aid	Camera-based obstacle detection improves accuracy	Processing latency, increased cost	My project balances vision sensing with low-latency feedback using distributed MCUs, keeping it responsive and cost-effective.
[14] / 2023	Multi-Sensor Wearable Safety Device	Integrates light and proximity sensing	No emergency alert or motion tracking	My project adds an emergency button and motion sensor, extending safety beyond light and proximity sensing.
[14] / 2024	Wearable Emergency Alert System	Reliable emergency communication	Emergency-only functionality, no continuous monitoring	My project combines emergency alerts with continuous monitoring, offering proactive and reactive safety.

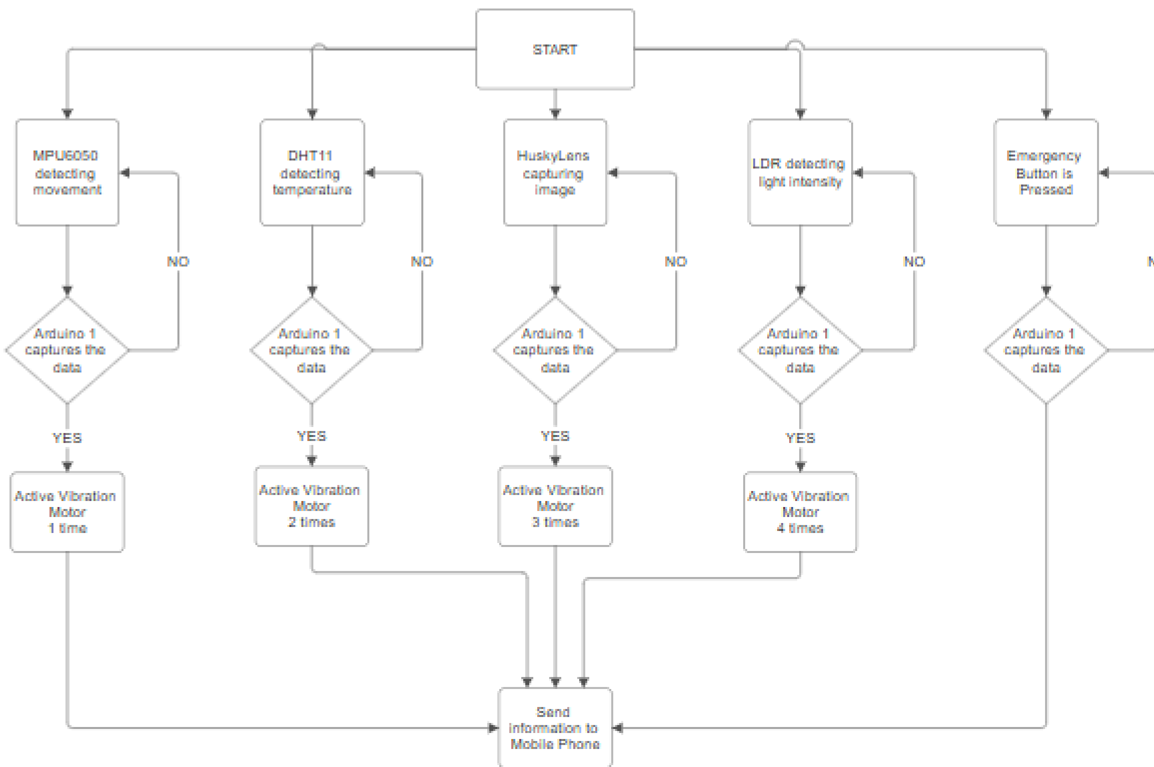
2. METHODOLOGY

2.1 Project Development

Overall, the block diagram provides a complete overview of the Smart Wearable Safety System by illustrating the flow of information between inputs, outputs, and the two Arduino microcontrollers. The project consists of two main subsystems, namely System 1 (Pendant Unit) and System 2 (Wristband Unit), each responsible for different functions within the overall design.System 1 represents the pendant, which houses all the sensing components, including the HuskyLens vision module, ambient light sensor, MPU6050 motion and fall-detection module, and the DHT11 temperature and humidity sensor. These sensors continuously capture environmental and user-related data and send the processed readings to the wristband via serial communication. System 2, the wristband, functions as the master controller. It receives the alerts transmitted by the pendant and translates each sensor activation into a specific vibration pattern across five vibration motors, providing intuitive tactile feedback for the user. Additionally, this subsystem integrates a Bluetooth module that automatically sends notifications to the caregiver’s mobile device whenever abnormal conditions are detected, such as obstacles, bright light, sudden motion changes, temperature anomalies, or emergency button presses.

The combined system diagram illustrates how both subsystems interact to deliver a synchronized, responsive safety solution for elderly and visually impaired users. Fig. 1 presents the flowchart outlining the operational logic of the entire system, showing how each sensor trigger leads to motor activation and caregiver notification. This flow sequence highlights the coordinated functionality between the pendant and wristband, ensuring efficient data processing, timely alerts, and reliable user assistance.

Fig. 1 Block diagram of the system



2.2 Schematic Diagram and Prototype Setup

Fig. 4 illustrates the circuit configuration of the whole system. For System 1, which is the core sensing module housed in the pendant. This subsystem integrates the HuskyLens vision sensor, ambient light sensor, MPU6050 motion and fall-detection module, and the DHT11 temperature-humidity sensor. These components continuously monitor the user's surroundings and physical condition, providing essential environmental and safety data. The pendant operates as the slave system, gathering sensor readings and transmitting them to the wrist-worn master unit through serial communication.

Meanwhile, for System 2, the wristband module, which serves as the master controller. It contains four vibration motors, each programmed to deliver a unique vibration pattern corresponding to specific sensor events received from the pendant. This tactile feedback system enables elderly or visually impaired users to interpret warnings through touch, allowing them to recognize obstacles, abnormal temperatures, impacts, or changes in environmental brightness. In addition, the wristband includes a Bluetooth communication module that automatically sends alert notifications to caregivers whenever any sensor activation is detected, ensuring remote monitoring and timely assistance.

Together, these two wearable subsystems form a smart safety device designed to enhance awareness, mobility, confidence, and emergency responsiveness for seniors and visually impaired individuals.

Fig. 4 Electrical Design of the System

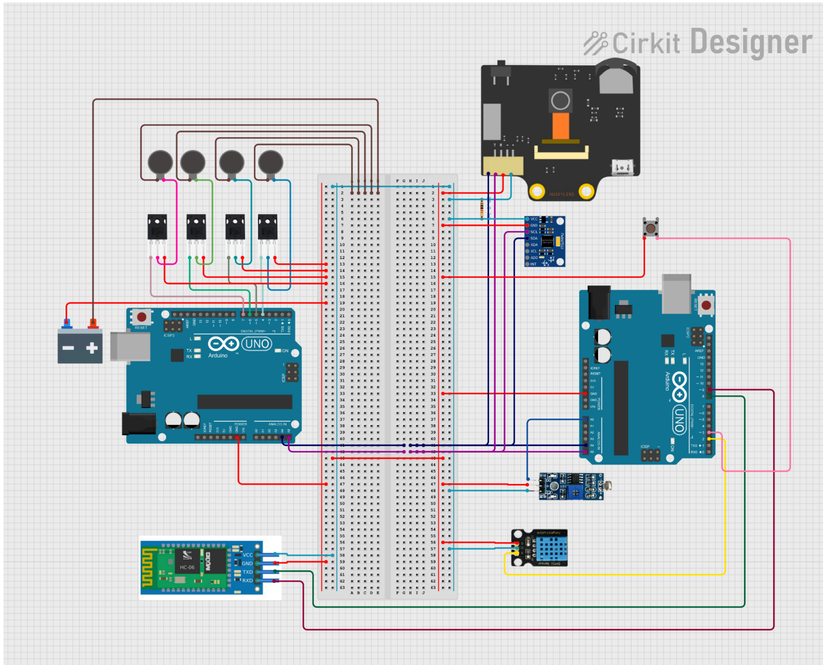


Fig. 5b Smart Wearable Safety System