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Assistive technology for the blind: a wearable system for obstacle detection, vital signs monitoring, and voice interaction

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SDGs

Abstract

Blind individuals face significant challenges in daily life, but wearable technology and the Internet of Things (IoT) can provide practical assistance. This study presents a prototype wearable device designed to support blind users in tasks such as object detection, vital signs monitoring, and real-time data transmission. The system integrates environmental sensors with a Raspberry Pi or NodeMCU-based IoT framework for real-time processing. Experimental tests demonstrated high effectiveness and accuracy, showing advantages in cost and features compared to existing solutions.

Methods & Design

The system is an IoT-enabled wearable that integrates obstacle detection and health monitoring into a single solution.

The methodology focuses on connecting specialized sensors to a central microcontroller for real-time feedback. System Architecture

Dual-Unit Design: The system is split into smart glasses for environmental sensing and a smartwatch for physiological tracking to ensure user comfort.

Microcontrollers: It utilizes the Arduino Nano or NodeMCU (ESP8266) as the "brain" to process sensor data. Sensing Modules: HC-SR04 Ultrasonic Sensor: Detects obstacles within a range of 2cm to 400cm. MAX30102: Monitors heart rate and blood oxygen levels (SpO_2) using infrared technology.

LM35/MLX90614: Tracks body temperature and warns users about hot external surfaces. Software Logic

Prioritized Alerting: The software prioritizes health emergencies; for instance, low oxygen (<92%) overrides standard navigation beeps.

Real-time Processing: Data is updated every 500ms to ensure immediate feedback.

IoT Framework: Using the NodeMCU, data is transmitted to a mobile application for remote monitoring by caregivers.

Results

Detection Accuracy: The ultrasonic sensor provided precise distance measurements with negligible processing delay.

Vital Signs Precision: Testing confirmed high accuracy rates: 99.51% for temperature, 97.90% for heart rate, and 97.69% for blood pressure.

Adaptive Feedback: The buzzer successfully changed frequency based on proximity, moving from a slow beep in the "Warning Zone" (<100cm) to a rapid beep in the "Danger Zone" (<50cm).

Alert Prioritization: The software correctly prioritized health emergencies, overriding navigation beeps if a medical anomaly was detected.

Discussion

The design effectively addresses the dual challenges of safe mobility and independent health monitoring. By separating the system into two units—"smart glasses" for sensing and a "smartwatch" for physiology—the device achieves better weight distribution and user comfort. The integration of IoT bridges the gap between wearable hardware and cloud platforms, allowing for real-time remote safety management. Ultimately, using cost-effective components like the Arduino Nano ensures that this comprehensive life-safety solution can be developed into a widely available product.

References

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