ECHOSTICK - SMART BLIND STICK

by

Maithreyi A – 21BAI1548

Arshiyaa Bhambri – 21BAI1281

Muralidharan V – 21BAI1406

Rahan S – 21BAI1444

Shaik Ahmed Rayyan – 21BAI1686

Rahul kevin Raghu – 21BAI1813

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Chennai – 600127

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ABSTRACT:

The EchoStick is an assistive device designed for the visually impaired, integrating innovative sensor technologies and also Fall Detection to enhance mobility and safety. The Ultrasonic sensor utilizes echolocation principles to detect obstacles in the user's path and provide audible alerts. The IMU sensor Module is used to calculate the Inertia of the stick and can detect if the stick has fallen. Then an SMS message is promptly sent to an aide informing of the fall. The Smart Blind Stick represents a cutting-edge solution, harnessing technology to empower the visually impaired in navigating their surroundings independently.

The EchoStick project introduces an innovative assistive device tailored to address the mobility and safety challenges faced by the visually impaired. Combining state-of-the-art sensor technologies with intelligent fall detection capabilities, the EchoStick aims to revolutionize the independence and confidence of visually impaired individuals in navigating their environments.

At the core of the EchoStick's functionality lies the integration of ultrasonic sensor technology, leveraging principles of echolocation to detect obstacles obstructing the user's path. By emitting ultrasonic waves and analyzing their reflections, the device provides real-time auditory alerts, enabling users to proactively navigate around potential obstacles with enhanced spatial awareness.

Augmenting this obstacle detection capability is the incorporation of an Inertial Measurement Unit (IMU) sensor module within the stick. This module serves a dual purpose: firstly, by continuously monitoring the stick's inertia and orientation, it can accurately detect instances of the stick falling. Upon detecting a fall event, the EchoStick promptly initiates an automated SMS message notification to a designated aide, ensuring timely assistance and intervention in the event of a fall.

The EchoStick represents a paradigm shift in assistive technology, offering not only enhanced mobility support but also critical safety features tailored specifically to the needs of the visually impaired community. By harnessing the power of advanced sensor technologies, the device empowers users to navigate their surroundings with greater confidence and independence, fundamentally transforming the way they interact with their environment.

Furthermore, the EchoStick project underscores a commitment to inclusivity and accessibility, recognizing the importance of leveraging technological innovation to bridge the gap between ability and disability. Through ongoing refinement and iteration, the EchoStick aims to set new standards in assistive device design, fostering greater autonomy and empowerment for visually impaired individuals worldwide.

Keywords: Ardunio, Ultrasonic sensor, Fall detection, ESP32, WiFi, Twilio

INTRODUCTION:

The Smart Blind Stick project is designed to assist visually impaired individuals by providing them with an innovative and reliable navigation tool. This project utilizes the ESP32 module and Ultrasonic Sensors to create a smart and intuitive blind stick that can detect obstacles and guide the user safely through their surroundings. By integrating IoT technology with Arduino programming, this project aims to enhance the independence and mobility of visually impaired individuals, allowing them to navigate with greater ease and confidence.

To establish a secure connection for HTTPS client communication, the creation of a public key is necessary, ensuring authorization to send data securely. This process involves generating a cryptographic key pair, consisting of a public key for encryption and a private key for decryption. By encrypting data using the public key, only the intended recipient possessing the corresponding private key can decrypt and access the information, ensuring confidentiality and integrity during transmission. This cryptographic mechanism safeguards sensitive data exchanged between the Smart Blind Stick and external servers, protecting against unauthorized access or tampering.

The MPU (Motion Processing Unit) plays a pivotal role in the Smart Blind Stick's functionality by measuring acceleration along the x, y, and z axes. This data provides valuable insights into the stick's orientation and movement dynamics, enabling the device to detect potential falls or accidents. Specifically, the MPU is configured to detect changes in the y-axis, which typically corresponds to the force of gravity (approximately 9.8 m/s^2). By monitoring variations in acceleration, the device can determine whether it remains upright or experiences sudden movements indicative of a fall event. Additionally, by applying root mean square (RMS) calculations to the acceleration values from the x, y, and z axes, the device obtains a comprehensive metric for assessing movement intensity and directionality. This data processing step enhances the device's accuracy in distinguishing between normal movements and fall scenarios, minimizing false positives and ensuring reliable fall detection capabilities.

Furthermore, the implementation of threshold values for acceleration thresholds (e.g., 3 m/s^2 for rapid movement detection and 9.8 - 3 m/s^2 for fall detection) further refines the device's sensitivity to relevant events. These thresholds are empirically determined through iterative testing and calibration, ensuring optimal performance across various real-world scenarios. Additionally, to mitigate false positives and enhance the reliability of fall detection, a deliberate delay of 10 minutes is introduced post-fall event detection. This delay allows the device to discern between genuine falls and transient movements, such as raising the stick after a fall, before triggering the notification mechanism. By incorporating these adaptive features and validation mechanisms, the Smart Blind Stick offers robust fall detection capabilities while minimizing unnecessary alerts, thereby enhancing the safety and confidence of visually impaired individuals in navigating their environment.

LITERATURE SURVEY

AUTHORS	YEAR	TITLE	SUMMARY	FOCUSES ON
W. Elmannai and K. Elleithy	2017	Sensor-Based Assistive Devices for Visually-Impaired People: Current Status, Challenges, and Future Directions	Discusses current sensor-based assistive devices for visually impaired people, highlighting challenges and future directions	Assistive technology for the blind (various sensors)
University of Technology Sydney	2023	Vision via sound for the blind	Explains technology using sound to create a sense of surroundings for visually impaired people	Technologies for non-visual perception
Jin, Wenqiang & Xiao, Mingyan & Zhu, Huadi & Deb, Shuchisnigdha & Kan, Chen & Li, Ming	2020	Acoussist: An Acoustic Assisting Tool for People with Visual Impairments to Cross Uncontrolled Streets	Introduces an acoustic tool to help visually impaired people cross streets safely	Navigation assistance for the blind
Nguyen, H.Q., Duong, A.H.L., Vu, M.D., Dinh, T.Q., Ngo, H.T.	2021	Smart Blind Stick for Visually Impaired People.	Discusses design considerations for acoustic assistive devices	General design principles for assistive technology
H. Sharma, M. Tripathi, A. Kumar and M. S. Gaur	2018	Embedded Assistive Stick for Visually Impaired Persons	Introduces an embedded assistive stick for visually impaired people	Assistive technology for navigation (blind cane)
S. -T. Hsieh and C. -L. Lin	2020	Fall Detection Algorithm Based on MPU6050 and Long-Term Short-Term Memory network	Proposes a fall detection algorithm using specific sensors and machine learning	Fall detection for elderly people
Ivana, Radulović & Ivan, Šofranac & Nikola, Ljucovic & Stojanovic, Radovan	2023	Development of Falling Notification System for Elderly Using MPU6050 Sensor and Short Message Service	Discusses a fall notification system for elderly people using sensors and SMS	Fall detection with notification for elderly people
Ren, L. & Peng, Y.	2019	Research of Fall Detection and Fall Prevention Technologies: A Systematic Review	Reviews fall detection and prevention technologies	Technologies to prevent falls in elderly people
Dey, N. et al.	2018	Ultrasonic Sensor Based Smart Blind Stick	Introduces a smart blind stick using ultrasonic sensors	Assistive technology for navigation (blind cane)
Jefiza, A. et al.	2017	Fall detection based on accelerometer and gyroscope using back propagation	Discusses using accelerometers and gyroscopes for fall detection	Technologies to detect falls in elderly people

PROPOSED METHODOLOGY:

1. Ultrasonic Sensor:

The ultrasonic sensor functions as the primary sensory input in the Smart Blind Stick, employing echolocation principles to detect obstacles in the user's vicinity. Emitting high-frequency sound waves, the sensor measures the time taken for these waves to bounce off objects and return, allowing for precise distance calculations. Strategically positioned along the length of the stick to provide comprehensive coverage, the ultrasonic sensors continuously scan the environment, alerting the user to obstacles such as walls or pedestrians. This real-time feedback enables visually impaired individuals to navigate safely and independently, enhancing their mobility and confidence in unfamiliar surroundings.

2. ESP32 Module:

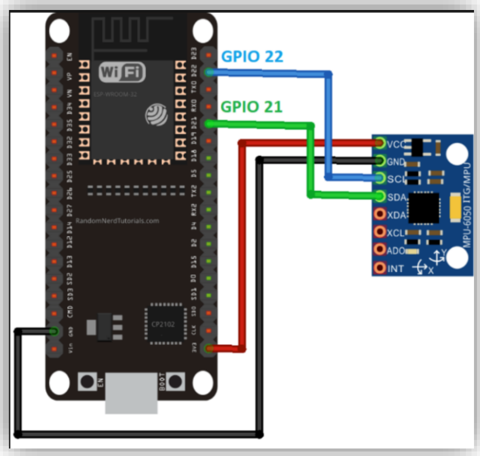
At the heart of the Smart Blind Stick lies the ESP32 module, serving as the central processing unit responsible for managing device functionality and processing sensor data. Leveraging its robust processing capabilities and built-in Wi-Fi and Bluetooth connectivity, the ESP32 facilitates seamless communication between the ultrasonic sensors, user interface components, and external devices. Tasked with interpreting distance measurements from the sensors and generating appropriate feedback signals, the ESP32 ensures prompt and accurate responses to detected obstacles. Additionally, the ESP32 manages power consumption, optimizing battery life for extended use, while also providing a platform for future enhancements and firmware updates to further improve the device's performance and functionality.

3. SMS Subsystem:

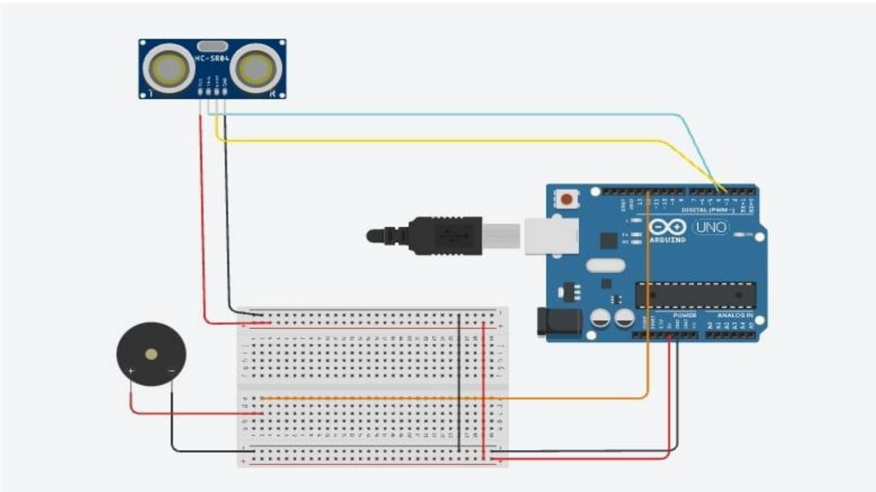
The SMS subsystem of the Smart Blind Stick serves as a vital communication channel for transmitting critical alerts and information to caregivers or emergency contacts in the event of a fall. Integrated with the ESP32 module and leveraging cellular network connectivity, this subsystem enables the device to send automated SMS messages containing relevant details, such as the user's location and situation, to predefined contacts. Triggered by the device's fall detection mechanism, likely utilizing data from an Inertial Measurement Unit (IMU) sensor, the SMS subsystem ensures rapid notification and response, allowing caregivers to provide timely assistance and support to the user in need. This seamless integration of communication technology enhances the safety and peace of mind of visually impaired individuals, offering reassurance and assistance in emergency situations.

CIRCUIT DIAGRAMS:

- **Fall Detection:**

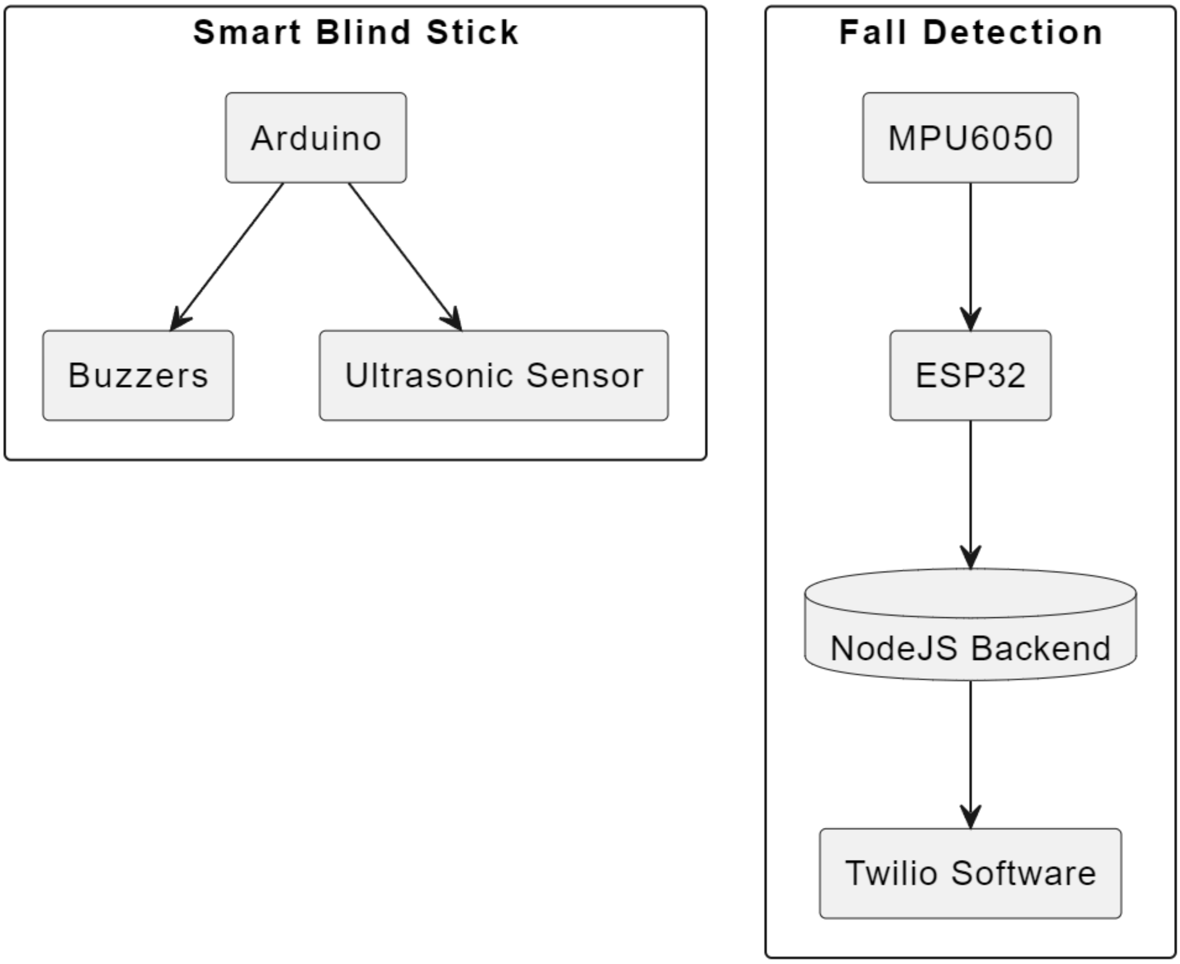


- **Obstacle Detection:**



- **Flowchart:**

Smart Blind Stick with Fall Detection Flowchart



DIFFERENCE BETWEEN PROPOSED METHODOLOGY AND EXISTING METHODOLOGY:

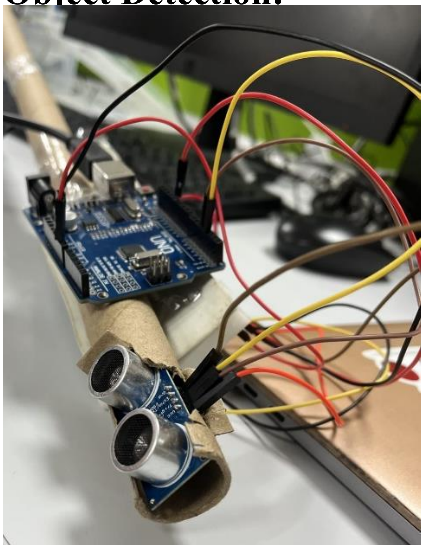
Our methodology for blind stick development involves efficient object detection using an ultrasonic sensor, Arduino board, and buzzer. The ultrasonic sensor identifies obstacles, with the Arduino handling data processing and triggering the buzzer for user alerts. This setup simplifies obstacle detection along the stick's path. In contrast, the existing methodology consolidates functions into an Arduino Nano microcontroller, enhancing efficiency and reducing complexity.

For fall detection, our methodology integrates an ESP32 microcontroller, MPU6050 accelerometer, NodeJS backend, and Twilio for WiFi-based SMS alerts. The accelerometer detects falls via acceleration changes, with the ESP32 managing data processing and communication with the NodeJS backend. Twilio ensures prompt SMS notifications to a mobile device upon fall detection. On the other hand, the existing methodology employs a standalone MPU6050 accelerometer and Arduino Nano, paired with a GSM module for wider coverage and reliability in SMS alerts.

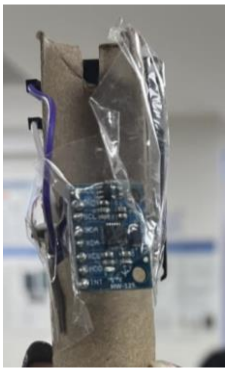
Communication and alerting in our methodology utilize Twilio for SMS notifications and NodeJS for backend processing, providing reliable and timely alerts. While Blynk isn't utilized, Twilio and NodeJS offer robust communication capabilities suitable for our needs. Both methodologies have strengths: ours leverages advanced components and WiFi for scalability and efficiency, while the existing methodology emphasizes streamlined integration, GSM-based reliability, and wider SMS coverage. The choice depends on factors like technical expertise, communication range, and desired system complexity.

<u>EXPERIMENTAL RESULTS:</u>

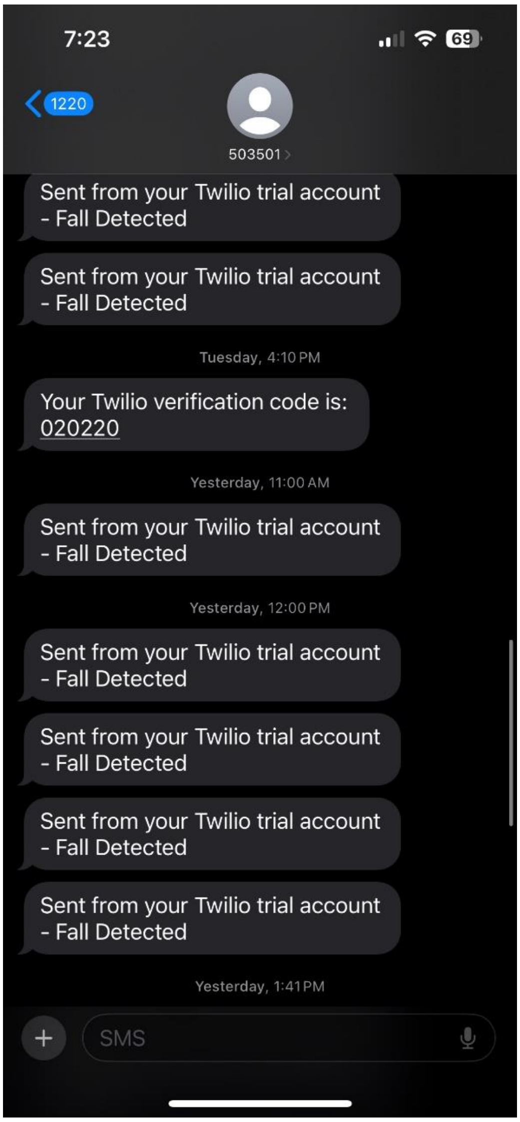
Object Detection:



Fall Detection:



SMS alert:


7:23
1220
503501
Sent from your Twilio trial account - Fall Detected
Sent from your Twilio trial account - Fall Detected
Tuesday, 4:10 PM
Your Twilio verification code is: 020220
Yesterday, 11:00 AM
Sent from your Twilio trial account - Fall Detected
Yesterday, 12:00 PM
Sent from your Twilio trial account - Fall Detected
Sent from your Twilio trial account - Fall Detected
Sent from your Twilio trial account - Fall Detected
Sent from your Twilio trial account - Fall Detected
Yesterday, 1:41 PM
SMS

FUTURE IMPROVEMENTS AND DEVELOPMENTS:

Future improvements and developments for blind stick technology encompass several key areas. Firstly, enhancing object detection involves implementing machine learning algorithms for better obstacle recognition and integrating multiple sensors like infrared sensors or cameras for comprehensive detection. Advanced fall detection could benefit from real-time analysis using machine learning models and exploring additional sensors or technologies for varied fall detection angles. Communication and alerting systems can be improved with a dedicated mobile app for remote monitoring and integration with voice assistants or wearable devices. Accessibility and user interface enhancements may include intuitive interfaces with voice commands and haptic feedback for navigation guidance. Data analytics tools can provide insights for optimizing sensor configurations and system settings based on usage patterns. Integration with smart city infrastructure, such as traffic signals and environmental data, can further enhance navigation and safety. Continuous testing, user feedback, and agile development methodologies will ensure ongoing iteration and incorporation of new technologies for improved functionality and user experience.

CONCLUSION:

The Smart Blind Stick seamlessly integrates ultrasonic sensors, the ESP32 module, and an SMS subsystem to offer visually impaired individuals enhanced mobility and safety. Through echolocation principles, the ultrasonic sensors provide real-time obstacle feedback, while the ESP32 manages data processing and wireless communication. In emergencies, the SMS subsystem swiftly alerts caregivers, ensuring rapid assistance and user peace of mind.

Designed with intuitive interfaces, the Smart Blind Stick is accessible to users of all technical levels, fostering inclusivity and empowerment. This innovative device not only enhances physical mobility but also instills a sense of independence in visually impaired individuals, marking a significant advancement in assistive technology and transforming their navigation experience.

In conclusion, our project aims to provide a comprehensive solution for visually impaired individuals by integrating object detection and fall detection functionalities into a blind stick. The division of the project into two modules, namely object detection and fall detection, allows for focused development and optimization of each aspect. The object detection module, utilizing ultrasonic sensors and Arduino boards, facilitates the detection of obstacles along the user's path, enhancing safety and mobility. On the other hand, the fall detection module, leveraging advanced components such as the ESP32 microcontroller and MPU6050 accelerometer, provides crucial fall detection capabilities to prevent potential accidents. The integration of NodeJS as a backend and Twilio software for SMS alerts over WiFi ensures prompt notifications to mobile devices in case of a fall, further enhancing user safety and peace of mind. Through this methodology, we strive to create a reliable and effective tool that enhances the independence and quality of life for visually impaired individuals.