Saathi : Smart Cane

Mentor: Prof Vishakha Shelke

1st Rishi Shah

Computer Science & Engineering(IoT & Cybersecurity With Blockchain Technology)
D.J.Sanghvi College Of Engineering
Mumbai,India

2nd Aditya Dalvi

Computer Science & Engineering(IoT & Cybersecurity With Blockchain Technology)
D.J.Sanghvi College Of Engineering
Mumbai,India

3rd Swayam Mestry

ComputerScience & Engineering(IoT & Cybersecurity With Blockchain Technology)
D.J.Sanghvi College Of Engineering
Mumbai,India

4th Manasvi Deshmukh

Computer Science & Engineering(IoT & Cybersecurity With Blockchain Technology)
D.J.Sanghvi College Of Engineering
Mumbai,India

5th Parv Karia

Computer Science & Engineering(IoT & Cybersecurity With Blockchain Technology)
D.J.Sanghvi College Of Engineering
Mumbai,India

***Abstract*—**this paper introduces an innovative smart walking stick designed for visually impaired individuals, leveraging machine learning, sensors, and microcontroller technology. By integrating the ESP32-CAM development board, it utilizes object detection algorithms to identify hazards such as potholes in real-time. Through the utilization of TensorFlow Lite or OpenCV libraries, the stick provides alerts through both audible cues and visual feedback, enhancing environmental awareness. This comprehensive solution combines obstacle detection, machine learning, and ultrasonic sensors to enable confident and independent navigation. By addressing the specific challenges faced by visually impaired individuals, this technology showcases the potential of modern advancements to significantly improve quality of life. This smart walking stick represents a tangible example of how cutting-edge technology and user-centric design can harmoniously coexist, demonstrating a practical and efficient means of supporting autonomous and selfassured navigation for those with visual impairments.

Keywords– ESP32-CAM, Machine learning, Microcontroller technology, Object detection, OpenCV

1. Introduction

The smart stick, which is marketed as a ground-breaking aid for people with low vision or limited movement, differs significantly from conventional white canes in that it uses cutting-edge technologies to deliver a full and instantaneous sensory experience. The smart stick offers more than just obstacle detection; it provides the user with sophisticated information about their surroundings thanks to the integration of infrared and ultrasonic sensors with microcontroller units like Arduino and ESP-32. This degree of sophistication seeks to provide accurate information about potential hazards, topographical variations, and various environmental elements in order to significantly improve safety and independence. The smart stick's dedication to user-friendly interaction, which makes use of logical indicators like vibrations and audio messages, is one of its most notable qualities. With timely and useful insights provided by these real-time cues, users can navigate their surroundings with greater assurance. The smooth integration of technology, which enables a customized and adaptive experience catered to individual needs, clearly demonstrates the emphasis on user freedom. Furthermore, the smart stick's innovative design goes beyond its practical uses. The gadget is designed with connectivity features that increase its usefulness by letting users easily connect to a specific smartphone application or additional assistive technologies. New opportunities are created by this interconnected ecosystem, such as the ability to monitor one's location in real time, receive dynamic navigational assistance, and communicate effectively with caregivers or emergency services. As a result, the smart stick becomes more than just a stand-alone gadget—rather, it becomes a portal to a larger support and assistance network. To put it simply, the smart stick is a paradigm-shifting piece of assistive technology that uses the latest developments to empower people who are visually impaired or have limited mobility. This creative solution is evidence of how technology can have a positive and improved impact on the lives of people with mobility challenges by promoting greater confidence and independence At the core of our research lies a commitment to leveraging the latest advancements in microcontroller technology, sensor integration, and machine learning algorithms to develop a smart walking stick that transcends the capabilities of conventional white canes. Building upon prior research, our device incorporates infrared and ultrasonic sensors seamlessly with microcontroller units like Arduino, empowering users with real-time environmental feedback. This lightweight and robust system not only detects obstacles but also offers sophisticated insights into the surrounding environment, including topographical variations and potential threats. Central to our approach is the integration of the ESP32-CAM development board, featuring the ESP32 microcontroller and a camera module, to enhance object detection capabilities. Through rigorous testing and refinement, our system employs machine learning algorithms to analyze captured images and identify objects with remarkable precision, particularly focusing on pothole detection—a critical aspect of safe navigation for individuals with visual impairments. By harnessing the power of machine learning alongside microcontroller technology, our smart walking stick provides users with timely alerts and actionable insights, fostering greater confidence and autonomy in navigation. The algorithm analyzes visual features in the image to pinpoint the location of each pothole. Object detection, a computer vision technique, plays a crucial role in identifying and locating objects in images and videos. Pothole detection, as a specialized form of object detection, can assist in counting and precisely locating potholes in a given scenario. The smart stick's innovative design goes beyond its practical uses. The gadget is designed with connectivity features that increase its usefulness by letting users easily connect to a specific smartphone application or additional assistive technologies. New opportunities are created by this interconnected ecosystem, such as the ability to monitor one's location in real time, receive dynamic navigational assistance, and communicate effectively with caregivers or emergency services. As a result, the smart stick becomes more than just a stand-alone gadget—rather, it becomes a portal to a larger support and assistance network. To put it simply, the smart stick is a paradigmshifting piece of assistive technology that uses the latest developments to empower people who are visually impaired or have limited mobility. This creative solution is evidence of how technology can have a positive and improved impact on the lives of people with mobility challenges by promoting greater confidence and independence At the core of our research lies a commitment to leveraging the latest advancements in microcontroller technology, sensor integration, and machine learning algorithms to develop a smart walking stick that transcends the capabilities of conventional white canes. Building upon prior research, our device incorporates infrared and ultrasonic sensors seamlessly with microcontroller units like Arduino, empowering users with real-time environmental feedback. This lightweight and robust system not only detects obstacles but also offers sophisticated insights into the surrounding environment, including topographical variations and potential threats. Central to our approach is the integration of the ESP32-CAM development board, featuring the ESP32 microcontroller and a camera module, to enhance object detection capabilities. Through rigorous testing and refinement, our system employs machine learning algorithms to analyze captured images and identify objects with remarkable precision, particularly focusing on pothole detection—a critical aspect of safe navigation for individuals with visual impairments. By harnessing the power of machine learning alongside microcontroller technology, our smart walking stick provides users with timely alerts and actionable insights, fostering greater confidence and autonomy in navigation.The algorithm analyzes visual features in the image to pinpoint the location of each pothole. Object detection, a computer vision technique, plays a crucial role in identifying and locating objects in images and videos. Pothole detection, as a specialized form of object detection, can assist in counting and precisely locating potholes in a given scenario.

2. LITERATURE SURVEY

The literature review on current smart stick solutions reveals a growing emphasis on enhancing features such as obstacle detection, GPS navigation, and fall detection to address the challenges faced by individuals with visual impairments. Scholars are actively exploring technologies
like computer vision and ultrasonic sensors to improve obstacle detection, while there is a notable trend towards integrating GPS for precise location tracking and guidance. Despite these advancements, concerns persist, including issues with obstacle detection accuracy and user interface design. The review underscores the ongoing need for research and development, particularly in refining user experience and advancing sensor technologies, to overcome current limitations and further empower individuals with restricted or blind mobility towards increased independence and mobility. ```T. Tirupal, et.al .'s paper employs an experimental design to integrate a UV sensor into a smart stick, enhancing navigation. Strengths include UV sensor functionality, but research gaps exist in optimizing battery life and incorporating user feedback mechanisms[1]. Chokemongkol Nadee, et.al .'s paper uses simulation and field trials, the paper focuses on UV sensor reliability and real-world applicability. Research gaps include integration with existing navigation technologies [2]. Mr. Muhammad Siddique Farooq, et.al. works on IoT integration, this paper offers real-time monitoring and cloud connectivity. However, gaps involve data privacy concerns and user acceptance challenges [3]. Mohapatra, et.al. through user surveys, their paper explores improved emergency response and user satisfaction. Gaps include button accessibility and integration with emergency services [4]. Ghosh et.al. with their field testing reveals strengths in location accuracy and seamless integration. However, challenges include signal strength issues and the need for

support in indoor navigation [5]. P N Sudha does literature review which provides a comparative analysis and identifies trends, but gaps involve the lack of standardized evaluation metrics and consideration of emerging technologies [6]. Sahoo et.al. do the design framework which offers customizable features and accessibility options. Gaps include concerns about long-term durability and cost-effectiveness [7]. Khan I, et.al. employs through user experience studies, the paper gathers usability feedback and user preferences. Gaps involve considerations for inclusive design and cultural variations [8]. Boppana, et.al.'s case study highlights real-world implementation and caregiver feedback, but gaps include considerations for cultural adaptation and scalability issues [9]. Real S, et.al. uses a comparative analysis, the paper explores performance metrics and system reliability. Gaps involve potential interference with electronic devices and the need for systematic user trials [10].```

3. PROPOSED METHODOLOGY

The smart cane system's implementation phase entails turning the theoretical framework and conceptual design into a workable prototype. The A9G board, Xiao C3 ESP32 board, Arduino Uno, ultrasonic sensors, buzzer, vibrator, and SOS button are among the main hardware components that are put together and integrated in accordance with the given specifications. To guarantee smooth interoperability, the connection and communication protocols between these components are carefully designed. An essential part of emergency response, the SOS module is designed to wait for the pressing of the SOS button, at which point it will initiate a series of events that include sending exact GPS.

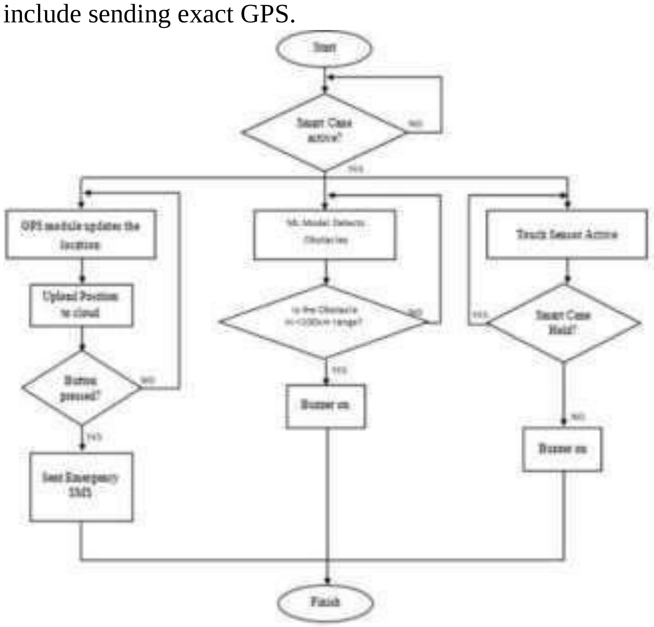

Fig. 3.1. Figure of the System Architecture

An SMS link to a Google Maps location. Additionally, a phone call is placed to a pre-configured emergency contact by this module. It takes careful coding to incorporate GSM, GPS, and emergency response features into the SOS module. This is done by utilizing the A9G module's capabilities and working in tandem with the GPS module. The SOS module's communication functions are programmed to be handled by the A9G module, which has GNSS and GSM capabilities. It reacts to AT commands, effectively uses low-power modes to manage power, and makes it easier for the smart cane system to communicate with other external sources, like emergency services and pre-configured contacts. When the SOS button is pressed, the GPS module—which is tightly integrated with the A9G module—is configured to retrieve exact location data. The user's location is accurately displayed in the SMS thanks to the generation of a Google Maps link based on the extracted latitude and longitude details. In addition the Camera module plays a critical role in object detection and detection of potholes.The camera module is equipped with high- resolution imaging capabilities and real-time video processing functionality, allowing it to capture detailed visual data of the user's surroundings. During operation, the camera module continuously captures images or video frames of the environment as the user navigates. These images are then processed in real-time by the ESP32 microcontroller, leveraging machine learning algorithms for object detection, particularly focusing on pothole detection.The ml model is being trained by using data of potholes collected by us and using tools and softwares like OpenCV, Edge impulse, YOLO. The camera module plays a crucial role in our methodology by providing real-time visual data for object detection, particularly enhancing the accuracy and effectiveness of pothole detection in our smart walking stick system. Its integration into the ESP32-CAM development board ensures seamless operation and enables users to navigate their surroundings with greater confidence and autonomy.

Data set description

Among the 300 photos in our collection are depictions of Potholes and Vehicles. Our technique is examined using a real-time web camera that records the Items. Following preprocessing, the figure 1.2 below displays a few examples of pictures.

Fig. 3.2. Potholes data set

4. TOOLS AND TECHNOLOGIES

<u>A. Hardware Components used</u>:

1) ESP32-CAM: It is a small size, low power consumption, low-cost development board. It has an ESP32-S processor, a microSD card slot and an OV2640 camera. It supports WiFi video monitoring and WiFi image upload. Here, it is used to take image input for our ML Model.
2) A9G Board: The A9G Board serves as the cornerstone of the smart cane system, integrating GPS, GPRS, and GSM functions to provide vital cellular connectivity and location- based services. This module enables real-time tracking and communication, enhancing user safety and autonomy in navigating their environment.
3) Xiao C3 ESP32 Board: Based on the versatile ESP32 microcontroller, the Xiao C3 ESP32 Board offers built-in Bluetooth and Wi-Fi capabilities, facilitating wireless control and communication throughout the smart cane system. This board enhances the system's flexibility and connectivity, enabling seamless interaction with external devices and services.
4) Buzzer: Serving as an auditory signaling device, the buzzer provides users with notifications regarding specific conditions or events within the smart cane system. This feature enhances user awareness and assists in alerting users to potential hazards or changes in their environment.

<u>B. Software Technology used:</u>

1) Python: It is the most widely used programming language in the field of Artificial Intelligence and Machine Learning.
2) OpenCV: The most common Computer Vision and Image Processing is used. All the preprocessing of images in a particular frame is done with the help of functions present in the OpenCV library. The text displayed on the screen is also done with the help of OpenCV.
3) Google Colab: It supplied free GPU and TPU which is very necessary for training any Machine Learning Algorithm. This platform is really helpful for those people who do not have proper resources for training such heavy models.We have also used Google Colab for the custom training of the YOLO algorithm.
4) Arduino IDE: It is available for every operating system like Linux, Windows, MacOs.
5) GSM and GPS Libraries: The smart cane system utilizes pre-written code segments known as GSM and GPS libraries to simplify communication with GSM and GPS modules. These libraries streamline tasks such as obtaining GPS coordinates and enabling data exchange over the cellular network, enhancing the efficiency and reliability of the system's communication capabilities.
6) Edge Impulse: Edge Impulse, an end-to-end platform for embedded machine learning, is employed for developing and deploying machine learning models on the smart cane system. This platform offers tools and resources for training, testing, and deploying machine learning models directly onto embedded devices, enabling real-time inference and intelligent decision making capabilities.

5. RESULTS

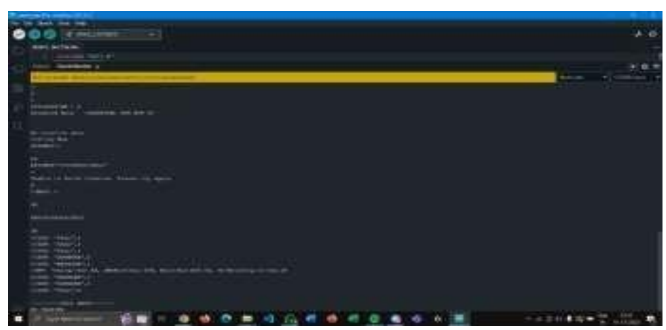

Fig. 5.1. Ultrasonic Results

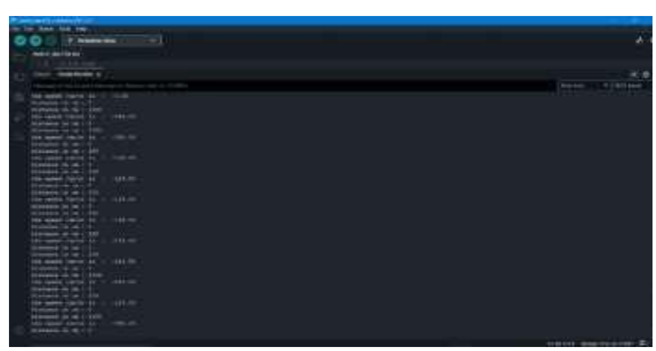

Fig. 5.2. Ultrasonic distance measure

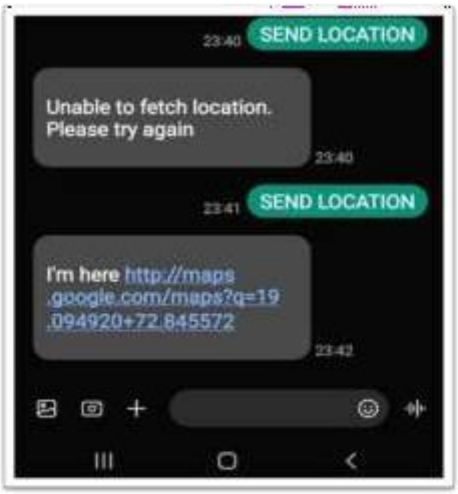

Fig. 5.3. SOS button results

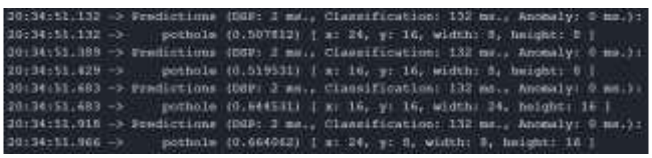

Fig. 5.4. Pothole Detection

Fig. 5.5. Vehicle Detection

6. Future Scope & Conclusion

In conclusion, the smart cane proposed in this article represents a significant breakthrough in solving the problems faced by people with impaired mobility and blindness. This advanced technology provides strong protection, accurate guidance and reliable communication through a combination of GPS navigation, GSM connectivity and ultrasonic sensors. However, there is still a lot of room for improvement, especially through the integration of machine learning. Giving smart sticks the ability to change and learn dynamically from their environment will increase their performance. Additionally, integrated augmented reality (AR) navigation can provide users with the best possible way to navigate a tour, improving user engagement and interaction. Expanded communication options, such as integrated voice-activated interfaces and smartphone apps, will provide users with more flexible options. Solving problems with battery performance and following user recommendations are important for long-term use - practical terms and effective use. Finally, the Smart Stick represents a revolutionary device that, with continued development, has the potential to improve the quality of life of people with vision and mobility problems. Looking ahead, future advances in smart technology will continue to promise to improve accessibility and usability for people with reduced mobility and vision impairments. Research into machine learning algorithms can enable devices to adapt to their environments, enabling better recognition and greater responsiveness. In addition, AR navigation can be integrated and communication options are expanded through voice-activated interfaces and integration. Overcoming problems related to energy consumption and using strategic ideas for adaptation are important in increasing satisfaction and customer satisfaction. Also, following easy-to- use standards and working with medical professionals to conduct real trials are important steps in the success of the brand. Make it more widely accepted and use it wisely. Finally, continued innovation and development will be key to realizing the full potential of AI in improving the lives of people with vision.

Future advancements in smart stick technology aim to enhance accessibility and usability for people with limited movement and vision impairments. Research focuses on utilizing machine learning algorithms for dynamic adaptation and improved situational awareness. AR navigation integration and voiceactivated interfaces promise more engaging and natural interactions, expanding communication choices. Energy efficiency improvements and personalized user feedback mechanisms are essential for long-term use and individualized experiences. Collaboration with medical professionals and adherence to accessibility standards are crucial for wider acceptance, ultimately aiming to significantly enhance the lives of those with visual and mobility challenges.

7. References:

[1] T. Tirupal, B. Venkata Murali, M. Sandeep, K. Sunil Kumar, C. Uday Kumar "Smart Blind Stick Using Ultrasonic Sensor", "Journal of Remote Sensing GIS and Technology" DOI: https://www.researchgate.net/publication/353795465_Smart_Blind_Stick_Using_Ultrasonic_Sensor

[2] Chokemongkol Nadee, Kosin Chamnongthai " An Ultrasonic-Based Sensor System for Elderly Fall Monitoring in a Smart Room," "Journal of Healthcare Engineering" Smart Cane Department of CSE(ICB) 19 DOI:https://www.researchgate.net/publication/365205105_An_UltrasonicBased_Sensor_System_for_Elderly_Fall_Monitoring_in_a_Smart_Room

[3] Farooq, M.S.; Shafi, I.; Khan, H.; Díez, I.D.L.T.; Breñosa, J.; Espinosa, J.C.M.; Ashraf, I., "IoT Enabled Intelligent Stick for Visually Impaired People for Obstacle Recognition",

"Sensors 2022", 22, 8914, doi:https://doi.org/10.3390/s22228914 DOI: https://www.mdpi.com/1424-8220/22/22/8914

[4] Mohapatra, Saurav & Rout, Sub & Tripathi, Varun & Saxena, Tanish & Karuna, Yepuganti. (2018). "Smart Walking Stick for Blind Integrated with SOS Navigation System", 441-447. 10.1109/ICOEI.2018.8553935. DOI:https://www.researchgate.net/publication/329395143_Smart_Walking_Stick_for_Blind_Integrated_with_SOS_Navigation_System

[5] Ghosh, Sourodip & Kudeshia, Ankit & Bose, Moinak. (2021), "GPS and GSM enabled Smart Blind Stick." 10.1007/978-981-33-4866-0_23, doi:10.1007/978-981-33-4866-0_23 DOI: https://www.researchgate.net/publication/350591274_GPS_and_GSM_enabled_Smart_Blind_Stick

[6] P N, Sudha. (2016) "Smart navigation system for visually challenged people", "International Journal of Electronics and Electrical Engineering" , DOI:https://www.researchgate.net/publication/343099328_Smart_navigation_system_for_visually_challenged_people

[7] Sahoo, N.; Lin, H.-W.; Chang, Y.-H. "Design and Implementation of a Walking Stick Aid for Visually Challenged People", "Sensors 2019", 19, 130, doi: https://doi.org/10.3390/s19010130 DOI: https://www.mdpi.com/1424-8220/19/1/130

[8] Khan I, Khusro S, Ullah I. "Technology-assisted white cane: evaluation and future directions", "PeerJ. 2018" Dec 10;6:e6058. doi: 10.7717/peerj.6058. PMID: 30581666; PMCID: PMC6292384. DOI: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6292384/

[9] Boppana, Lakshmi & Jain, Vishal & Kodali, Ravi. (2019), "Smart Stick for Elderly", 259-266.

doi:10.1109/iThings/GreenCom/CPSCom/SmartData.2019.00064.. Smart Cane Department of CSE(ICB) 20 DOI: https://www.researchgate.net/publication/336729308_Smart_Stick_for_Elderly

[10] Real S, Araujo A. "Navigation Systems for the Blind and Visually Impaired: Past Work, Challenges, and Open Problems", "Sensors (Basel)", 2019 Aug 2;19(15):3404, doi: 10.3390/s19153404. PMID: 31382536; PMCID: PMC6696419.DOI: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6696419/