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Smart Assistive Stick for Visually Impaired People

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ABSTRACT: People with visual or physical disabilities often face significant challenges in detecting obstacles while walking, which can pose serious safety risks. This study presents a solution aimed at helping visually impaired individuals navigate their surroundings more safely and independently. It introduces a smart walking stick equipped with advanced technologies to improve mobility and autonomy. The device incorporates several sensors—including ultrasonic, transmitter-receiver, and water sensors—controlled by an Arduino Nano, which serves as the main processing unit. Among these, the ultrasonic sensor is crucial, as it promptly identifies obstacles in the user's path once the system is activated, ensuring timely alerts and safer movement.

I. INTRODUCTION

Visual impairment—also referred to as vision loss or diminished eyesight—is a condition where a person's ability to see is significantly reduced and cannot be fully corrected using conventional methods like eyeglasses. Some individuals are classified as visually impaired even if they do not use corrective lenses such as glasses or contacts. Typically, visual impairment is defined as having a best-corrected visual acuity worse than 20/40 or 20/60. Severe vision loss, including total or near-total blindness, greatly affects daily activities such as driving, reading, socialising, and walking. According to the World Health Organisation (WHO), approximately 80% of vision impairments are either preventable or treatable. As of 2015, around 940 million people experienced some degree of vision loss, 246 million had moderate to severe visual impairment, and 39 million were completely blind. Most of these individuals reside in developing countries, with vision problems especially common among people over the age of 50. Our device aims to address some of the key challenges faced by people with physical disabilities—particularly those with vision loss—in navigating their environments more safely and independently.

Causes of blindness

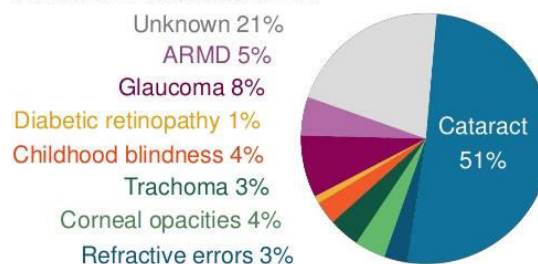


Figure 2: Causes of Blindness

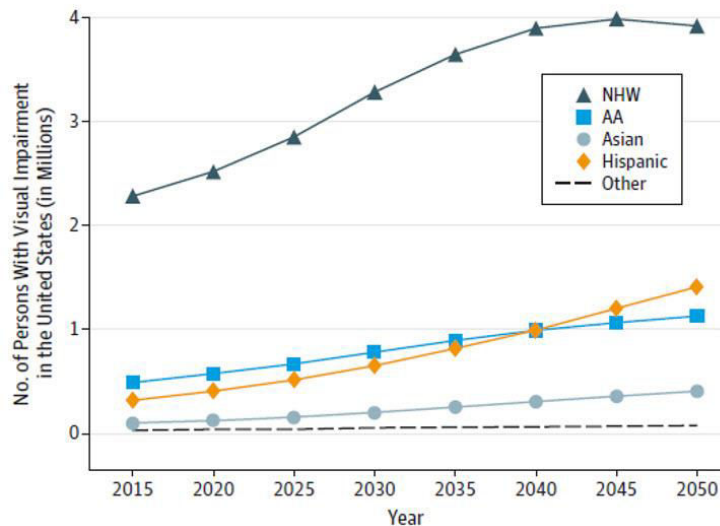
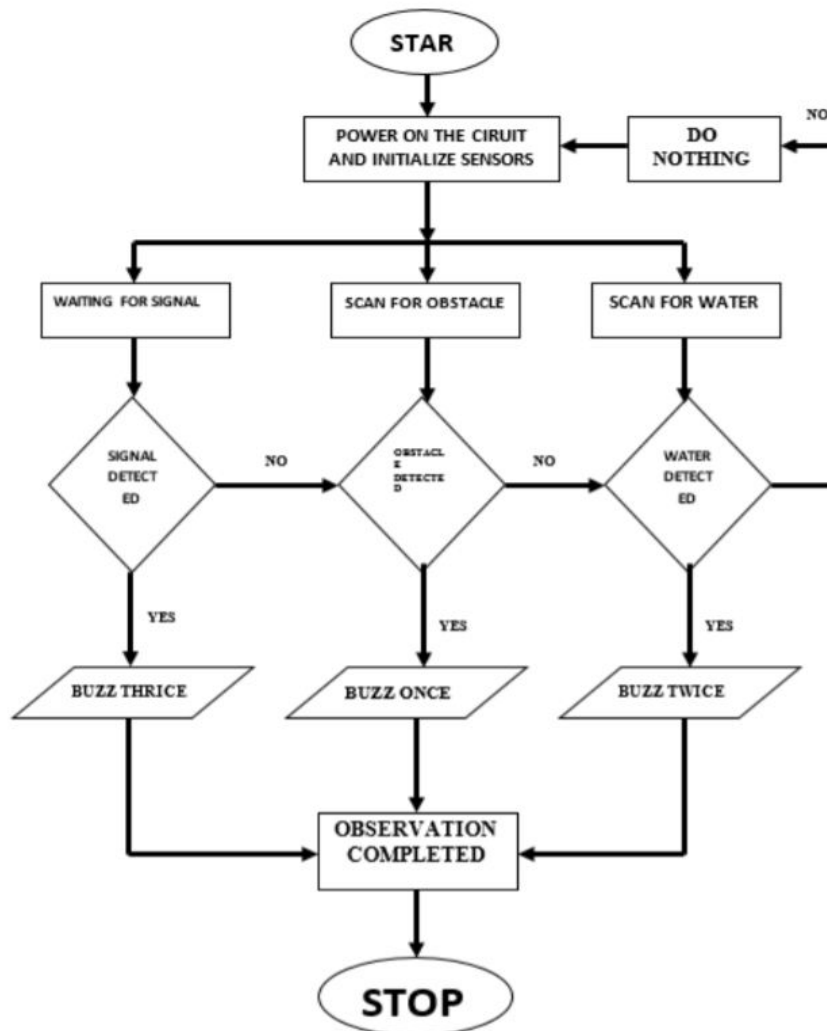
II. FUTURE TRENDS OF BLINDNESS

Figure 3: Future Trends

In today's technology-driven world, where people strive for independence, this project proposes the development of an ultrasonic smart stick to assist visually impaired individuals in gaining greater personal autonomy. Due to its compact and affordable design, it can be used with ease and convenience. According to [1], an intelligent navigation device has been developed to support the visually challenged in reaching their destinations safely, utilising Raspberry Pi, a PIC controller, GPS, ultrasonic sensors, and a mobile application. Similarly, [2] presents an enhanced white cane system equipped with ultrasonic and infrared sensors, Arduino, and GPS modules, offering advanced location tracking and obstacle detection features. In [3], a novel intelligent white cane design incorporates signal reception and navigation capabilities, allowing family members to track the user's location. The cane integrates smart navigation technology to enhance user safety. Reference [4] introduces a cost-effective yet reliable and accurate smart stick designed to assist the visually impaired in navigating both indoor and outdoor environments. It addresses common daily challenges such as walking with confidence in unfamiliar or dynamic settings. As described in [5], another proposed smart stick includes GPS and GSM modules along with ultrasonic and infrared sensors, enabling location tracking and communication features for better mobility support. According to the World Health Organisation [6], more than 2.2 billion people globally are affected by vision impairment, many of which could be prevented or treated. The report highlights the importance of accessible eye care and early detection. In a foundational study [7], Meijer developed a system that transforms visual images into sound, enabling visually impaired users to interpret their surroundings through auditory signals, thus laying the groundwork for sensory substitution technologies. In [8], Sound View is introduced as an auditory guidance system that interprets environmental information and converts it into sound cues, improving real-time mobility for the visually impaired through advanced scene understanding. The system presented in [9] utilises wearable real-time stereo vision to detect obstacles, giving users improved spatial awareness and depth perception for safer navigation. Finally, [10] describes a cognitive assistive system that uses sensor data and cognitive processing to identify and communicate the position and orientation of objects, thereby improving the situational awareness of visually impaired individuals.

The study shows the proposed algorithm for simulation analysis from the literature carried out so far and simulation results and discussion, and finally conclusion drawn from the analysis.

❖ Flow Chart:



The flowchart follows the following steps for proposed simulation analysis.

1. The process begins with the START step, initiating the operation of the smart stick system.
2. The system then proceeds to power on the circuit and initialize all sensors, including those for detecting signals, obstacles, and water.
3. Once the sensors are initialized, the system simultaneously performs three tasks: waiting for a signal, scanning for obstacles, and scanning for water in the environment.
4. The first decision checks whether a signal is detected. If a signal is detected, the device buzzes three times to alert the user and proceeds to the "Observation Completed" step.
5. If no signal is detected, the system continues to the next task: checking for obstacles. If an obstacle is detected, the device buzzes once to alert the user and moves to "Observation Completed".
6. If no obstacle is detected, the system then checks for the presence of water (e.g., puddles or wet surfaces). If water is detected, the device buzzes twice to notify the user and proceeds to the "Observation Completed" step.

7. If none of the conditions (signal, obstacle, or water) are met, the system does nothing and returns to idle mode, waiting for the next detection cycle.
8. Once any detection occurs and the appropriate buzz alert is triggered, the system enters the Observation Completed phase, indicating that the detection and notification process is finished.
9. Finally, the system reaches the STOP step, concluding the current cycle and preparing for the next round of monitoring.

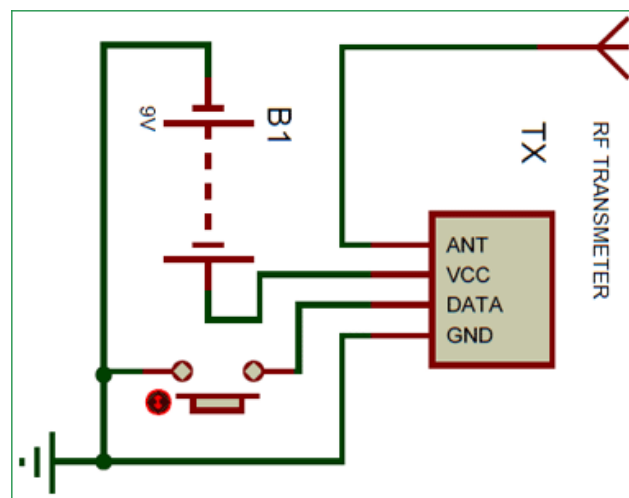


Figure 12: RF Remote Circuit

III. SIMULATION IN PROTEUS

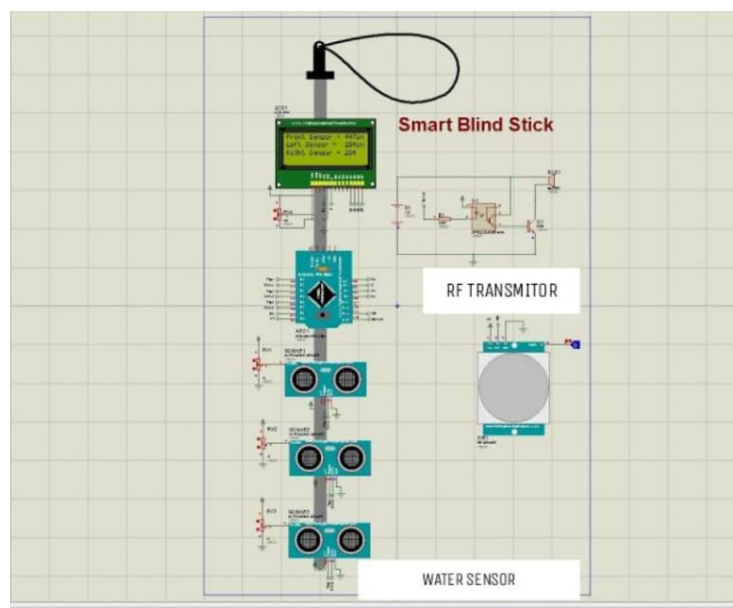


Figure 13: Snapshot of a Simulation in Proteus

IV. RESULT ANALYSIS

The following figure shows the circuit prepared by us, which is to be attached to the stick:

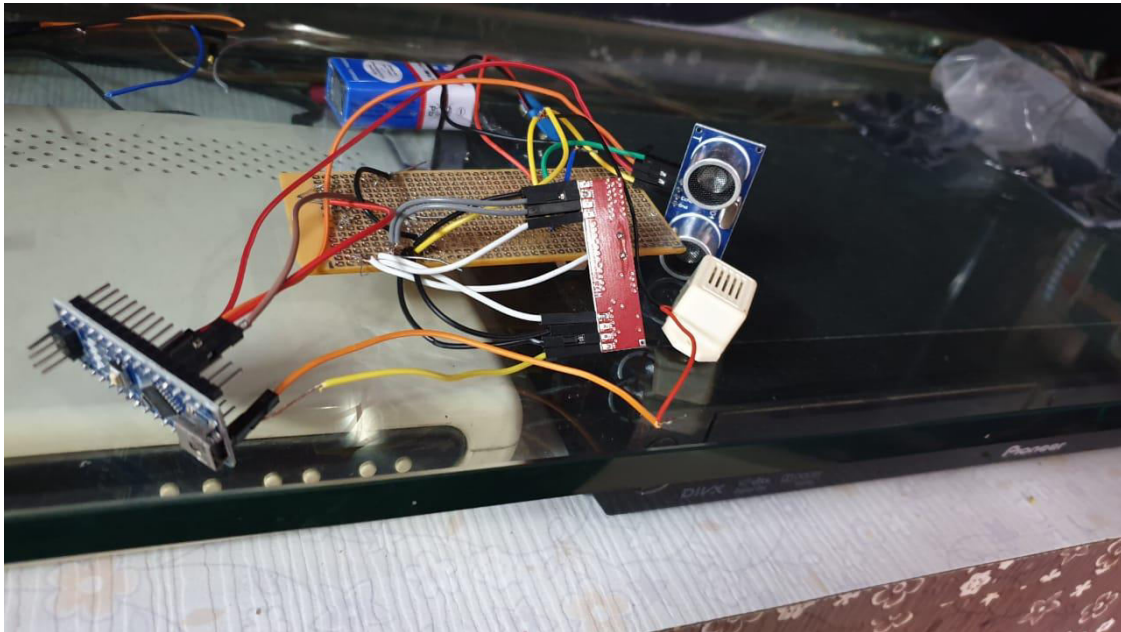


Figure 14: Connection of Arduino with the circuit

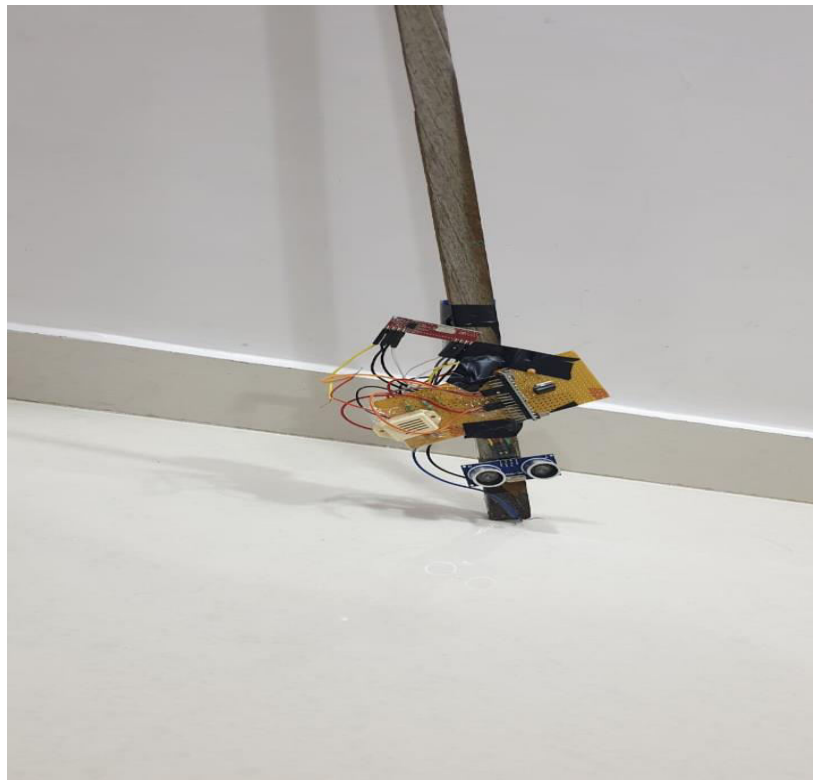


Figure 15: Smart Blind Stick

❖ Performance Analysis of Ultrasonic Sensor

Range (cm)	Measured(mV)
5	46
10	95
15	144
25	247
30	296

Table 1

❖ Detection Range For Various Objects (cm)

Obstacle	Test 1	Test 2	Test 3
Wall	198	210	203
Human Body	100	114	122
Plastic	115	124	145
Metal	210	199	215

Table 2

❖ Comparison with other devices

Devices	Detection Range	Time Response	Power Consumption	Stairs & Water Detection	Portable
Proposed System	High	Fast	Low	Yes	Yes
Vibration and Voice Operated Navigation System for Visually Impaired Person	Low	medium	Low	No	Yes
A Smart Infrared Microcontroller-Based Blind Guidance System	Medium	Fast	Low	No	yes
Ultrasonic Spectacles and Waist-belt for Visually Impaired and Blind Person	High	Fast	Low	No	yes

Table 3

The wall gives high and consistent readings, indicating that it is a large, flat, and dense surface that reflects the sensor signal well. Slight variations in the readings may be due to the angle of incidence, surface roughness, or minor environmental noise. Walls are reliably detected due to their high reflectivity and large surface area. The readings are significantly lower than other materials, reflecting the soft and irregular surface of the human body. Human skin and clothing tend to absorb rather than reflect sensor signals efficiently, leading to lower detection values. Human bodies are detectable but produce weaker reflections, requiring more sensitive calibration or sensor fusion (e.g., thermal or infrared) for robust detection. Plastics reflect signals moderately, giving mid-range values with more noticeable variation between test runs. The variation could be due to differences in plastic thickness, colour, or transparency. Plastics are detectable but can lead to inconsistent readings depending on type and surface characteristics. Metal surfaces reflect signals very strongly, resulting in consistently high readings. The high reflectivity is due to the dense and smooth nature of metal, making it highly detectable. Conclusion: Metals provide the most reliable and strongest signal reflections, ideal for consistent obstacle detection. From the simulation results, it is evident that metal and wall

surfaces are the best detected obstacles, as they produce strong and consistent signal reflections due to their dense and flat surfaces. Plastic materials are moderately detected, showing more variation in readings, likely because of differences in surface texture, thickness, or composition. Human bodies are the least detected, as they tend to absorb sensor signals and have irregular surfaces, resulting in weaker and less consistent reflections. These findings highlight the importance of adjusting sensor sensitivity thresholds or incorporating multiple types of sensors in assistive systems to ensure accurate detection of various obstacle materials in real-world scenarios.

V. CONCLUSION

The Smart Stick lays the groundwork for future assistive technologies aimed at improving mobility and safety for individuals with visual impairments. Designed to be dependable, affordable, and lightweight, the device can accurately identify obstacles—including steps and water hazards—within a four-meter radius. It offers a practical solution that is cost-efficient, durable, energy-saving, and capable of providing rapid responses to enhance safe navigation. While the current prototype uses wired connections between components, it maintains a compact and portable form. Future developments could involve wireless integration, extended detection range for the ultrasonic sensor, and features to assess the speed of approaching objects. From the outset, the project has focused on delivering an accessible and empowering tool for visually impaired users worldwide.

VI. FUTURE SCOPE

This project offers considerable potential for both current applications and future advancements. By utilising specialised sensors, it aims to support visually impaired individuals in navigating their surroundings more effectively. The primary goal is to enhance the confidence and independence of blind users in interacting with their environment. Looking ahead, the system could be upgraded with GPS and GSM modules for real-time location tracking, along with the addition of an emergency button to request immediate help in critical situations. Moreover, the device can be redesigned to be more compact and wearable—potentially integrated into everyday items like clothing or headgear—to improve convenience and usability in daily life.

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