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Innovative Blind Stick for The Visually Impaired

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Abstract

Visual impairment is an appellation that alludes to the state of being visionless. Individuals with optical blockage are likely to have limitations in their independence and movement, as well as a higher risk of falling, fractures, injuries, poor mental health, and social isolation. Thus, we propose the design of a blind stick to help blind people and assist them in familiarizing themselves with a clear path. In our proposed prototype, multiple sensors are attached to the individual's stick. The sensor detects an obstruction, the receiver's output activates, and the microcontroller detects this change since the receiver's outputs are inputs to the microcontroller. This stick detects the impediment in front and reacts by vibrating or mandating the user. Furthermore, a smoke sensor, fall detection sensor, heart rate, SPO2 level sensor, and Temperature sensor are utilized to detect multiple parameters and not only indicate the individual using the blind stick but to the caregiver as well through an application connected to the blind stick. Moreover, GPS tracking is also present which helps the individual with the stick and also informs the caregiver about the location of the blind person. The results of our proposed prototype demonstrate that this electronic device is a sufficient solution for overcoming the difficulties faced by visually impaired people and their caregivers and allowing them to live their lives independently. In conclusion, our innovative blind stick offers a transformative solution for visually impaired individuals, enhancing their mobility and independence. We invite readers to delve into the full paper to discover the full extent of its capabilities and its potential to make a meaningful difference in the lives of millions worldwide.

Keywords: visual impairment; blind stick; ultrasonic sensor; smoke sensor; fall detection; Arduino Nano RP 2040, Artificial intelligence, Application, water level sensor, GPS module.

INTRODUCTION

One of the most crucial features of human physiology is the ability to perceive (Romadhon & Husein, 2020). As our eyes can detect all of the variations in our environment, they are a dominant aspect of our visual system (Budilaksono et al., 2020). Visually impaired people, on the other hand, have difficulty detecting and engaging with their environment (Jadhav, 2016)."Visual impairment" refers to the condition of losing vision. Therefore, this word is most commonly used to denote poor vision in a relative sense (Kumar et al., 2017). People with this condition may find it difficult to figure out where they are and how to get from one place to another, making physical exercise particularly challenging (Supriyadi et al., 2018). Blind people sometimes get lost or have trouble finding their way home since they are unfamiliar with the region. They more presumably have mobility and independent restrictions, and even a heightened risk of tripping, accidents, and bruises (Tirupal & Tirupal, 2021). These circumstances may cause anxiety among the patient's relatives (Romadhon & Husein, 2020). Hence, a smart blind stick can aid visually impaired people in avoiding obstacles and delivering information about their position and whereabouts (Apu et al., 2022). In their daily lives, visually impaired individuals often rely on their hearing senses for navigation, but this is insufficient. Relying solely on their hearing senses for steering is detrimental to their safety (Gouda et al., 2022). According to the latest worldwide statistics, it is reported that hundreds of millions of people worldwide are visually impaired, many of them blind (Gurumoorthy et al., 2021). According to WHO estimates, the world's blind population is between 40 and 45 million (Gbenga et al., 2017).

According to WHO (World Health Organization) survey, over 1% of the global population (about 70 million people) is visually impaired, with about 10% (roughly 7 million people) being completely blind and 90% (roughly 63 million people) having poor eyesight (Iqbal et al., 2009). The most difficult thing for visually impaired people to do is figure out how to get to where they need to go. According to the WHO, 10% of visually impaired people lack functional vision that allows them to move around safely and freely. In the past, blind individuals navigated using traditional sticks, but they didn't fulfill all of the requirements (Iqbal et al., 2009). Hence, there is a vast scope for developing strategies for introducing a smart stick to assist externally challenged people. A mobile stick is the most reliable navigation gadget for the sight impaired (Dey et al., 2018). This gadget has a lot of great features that make life easier for blind people, but there are some drawbacks to using it, such as the lack of basic abilities, the cost, and the preparation time. With technological advancements, it is now possible to create and design mechanical systems that can aid an externally blind individual in readily exploring their surroundings (Dey et al., 2018). As an example, regardless of whether they are outside or indoors, work gives blind persons with visually impaired mobility a simple, efficient, and adaptive electronic guide.

Another study shows that the design of a stick was proposed for handicapped persons. The Arduino-based obstacle stick uses an ultrasonic sensor and DF Player audio to help blind people distinguish obstacles. A blind individual will be alerted to their environment and any hazards (Kumar et al., 2017). Secondly, enormous advances in Artificial Intelligence (AI) (Dambhare & Sakhare, 2011) are also being explored to assist visually impaired people. AI is the only way to generate the requisite features to improve the stick system. This stick system not only employs artificial intelligence but also collects accurate sensor data (Gbenga et al., 2017).

However, subsequent studies into the blind stick have revealed that while there is some lack of necessary features, the stick is also highly expensive (Sheth et al., 2014). Furthermore, previous findings (Gouda et al., 2022) did not provide any solutions for educating others about blindness so that, in a crisis, they can help the affected individual. These circumstances prompted us to develop a blind stick that could easily spread awareness regarding visually impaired people. Meet Sarah, a determined college student who tackles the daily challenge of navigating her campus despite being visually impaired. With her trusty white cane in hand, she faces numerous obstacles and struggles to locate landmarks, impacting not only her mobility but also her overall quality of life and sense of independence. Fortunately, advancements in technology have brought about a transformative solution for individuals like Sarah: smart blind sticks. These innovative devices incorporate ultrasonic sensors, GPS technology, and artificial intelligence to detect obstacles, offer real-time feedback, and provide navigation assistance through audible cues or haptic feedback. Hence, the study aims to propose the design of a smart blind stick that can be utilized by visually impaired people. This electronic device will be the most effective approach to manage stress and help people live their lives successfully and freely (Dey et al., 2018). Therefore, we incorporated some distinguishing characteristics such as smoke detection and a glossy aluminum paper wrapped up on the stick, which will shine and reflect light and will play a very essential function in the dark, as it will cause the stick to glow for others, enhancing the blind person's safety from any sort of nighttime disaster. The goal of these features in the smart stick is to alert the user of suspicious smoke and to signal latency to make the stick itself more visible to others for the blind, allowing others to aid or assist the blind even in the dark.

METHODOLOGY

The smart blind stick's mechanism includes being used as a detecting device for visually impaired people. The rechargeable battery provides a 5V supply to the Arduino Nano RP 2040 consisting circuit and maintains that supply at a constant level, allowing the microcontroller to deliver 5V to the ultrasonic sensor, smoke sensor, water sensor, fall detection sensor, heart rate sensor, SPO2 level indicating sensor, and temperature sensor. Moreover, it also consists of a GPS module for tracking purposes. Ultrasonic sensors are often used to recognize items. If an item is detected, the ultrasonic sensor measures the distance between the object and the user and sends the information to the Arduino Nano RP 2040 (Gbenga et al., 2017). Below the equation shows the distance is measured by calculating the duration while covering the distance through the sensor and then multiplying it by a standard value set based on the sensor used. Moreover, we have also specified the safety distance for the visually impaired individual.

$$Distance = Duration * 0.034/2 \quad (1)$$

$$Safety\ Distance = 30cm \quad (2)$$

For the protection of a blind person, a water sensor is utilized to detect any kind of liquid present. Similarly, the smoke sensor in this case detects any kind of smoke in the air and alerts the blind individual. Moreover, the fall detection sensor, heart rate sensor, SPO2 level sensor, and Temperature sensor give health information of the blind person to the caregiver in his absence through the application connected to the blind stick. An application developed named “E-Assist” connects with the stick to give prompt notification to the caregiver using the device about the temperature, heart rate, SPO2 level, and importantly fall detection. Furthermore, the GPS module connected to the Arduino also provides the current location of the blind stick to the application through the built-in Wi-Fi present in Arduino Nano RP 2040. The software was created using Visual Studio, utilizing JavaScript in conjunction with React Native. React Native was selected due to its intuitive development environment, enabling the creation of applications catering to both iOS and Android users. The graphical user interface (GUI) of the application is depicted in Figure 1.

Figure 1.
Graphical user interface of the application E-SSIST.

The block diagram for the proposed smart blind stick is shown in Figure 2

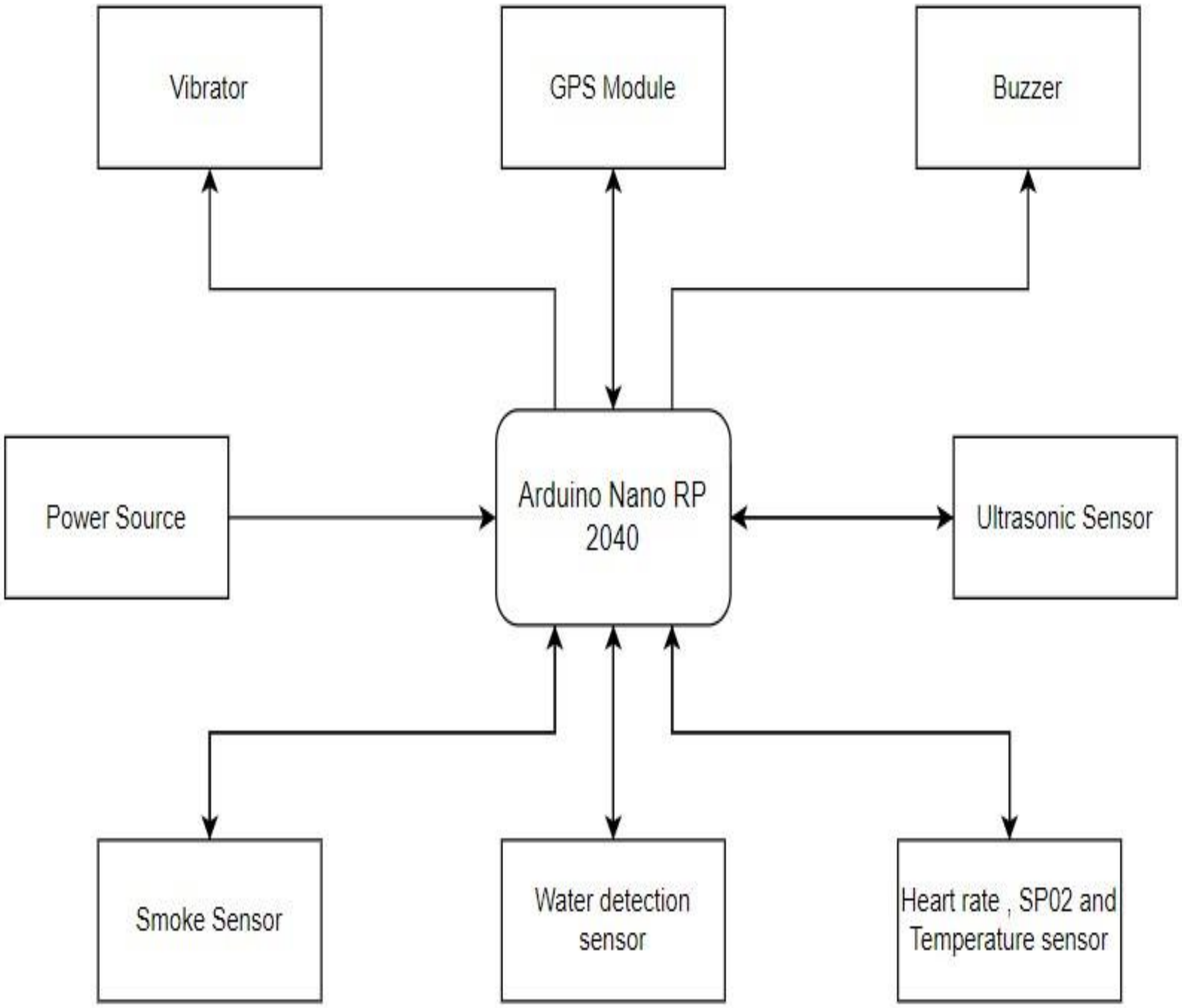

Figure 2.
Block Diagram of the proposed smart blind stick.

In the construction of a smart stick, a microcontroller is utilized and connected with all the sensors giving it all the readings of the sensors and recording it. The project also includes a buzzer and sounds from a speaker to ensure that the blind hear an ultrasonic signal. In this way, the user is notified and has the ability to avoid impediments. The user can press the emergency SOS button present near his grip, a notification will be sent to the caregiver immediately with the location for immediate response. In the past times, even with assistance, such as conventional sticks, it was difficult to guide a blind person on their journey without creating any errors, which can be cumbersome and imprecise, causing obstacles to be encountered. Hence now, to survive in the modern world, a user-friendly device is designed for blinds to prevent them from being in undesirable situations. When an impediment, such as a hanging object, an object in the way occurs, an ultrasonic sensor works on a stick. The flow process is illustrated in Figure 3.

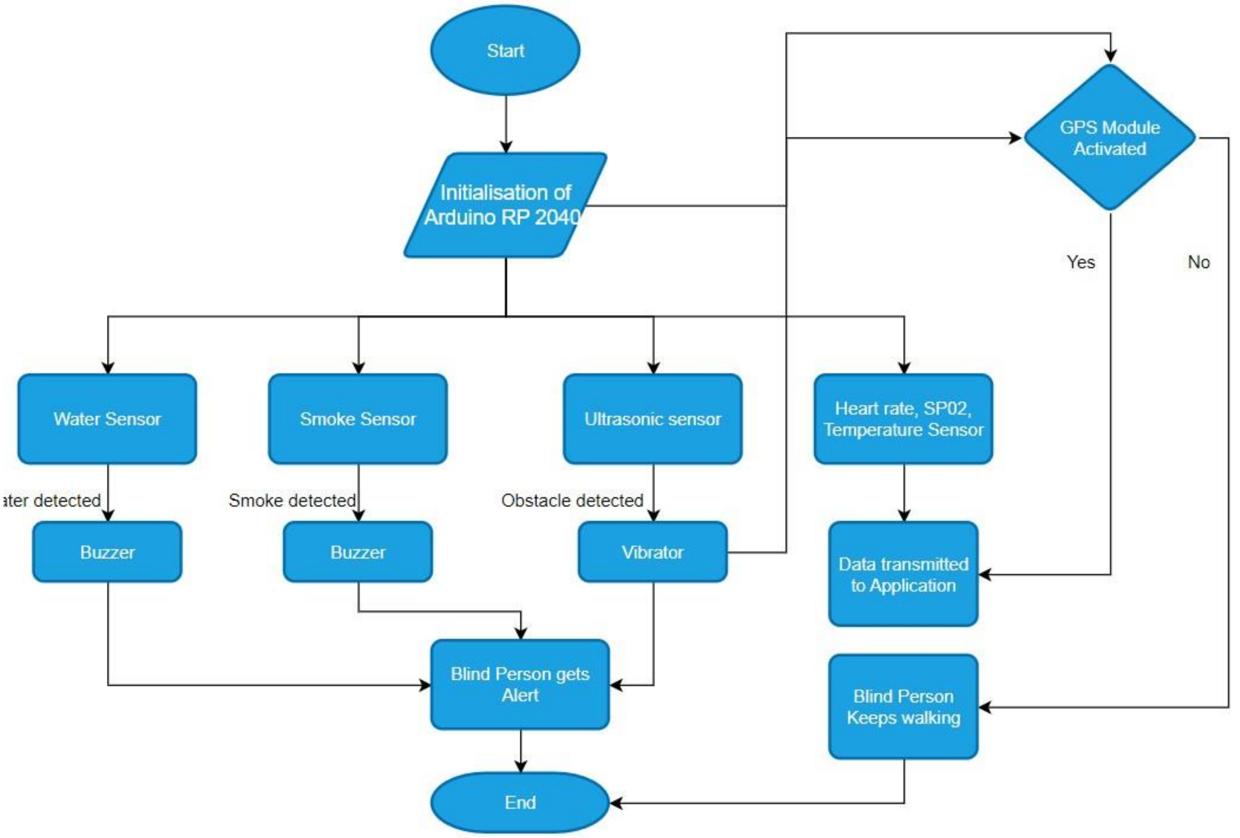

Figure 3.
Flow process of the proposed smart blind stick.

Figure 4 exhibits the design of the smart blind stick.

Figure 4.
Design of the smart blind stick

For the testing of the blind stick, ten subjects volunteered to participate. These ten subjects included five male and five female participants who were visually impaired. In this assessment, visually impaired volunteers were asked to walk for various distances ranging from 30cm to 400cm with the blind stick while various objects were placed in the path so that we could observe the accuracies and errors of the blind stick regarding object sensor at different distances, which can vary from person to person. The blind stick's accuracies demonstrate the efficacy of the blind stick's operation, and throughout this exercise, the volunteers were able to operate the blind stick with these smart features and were acquainted with the functions. The testing methodology involved assessing the blind stick's performance across different scenarios. Visually impaired participants provided valuable insights, noting the stick's effectiveness in detecting obstacles and providing navigation assistance. Anecdotes highlighted instances where the device successfully alerted users to hazards, enhancing their confidence and sense of independence. Figures 5 & and 6 shown below represent the walking pathway for visually impaired people.

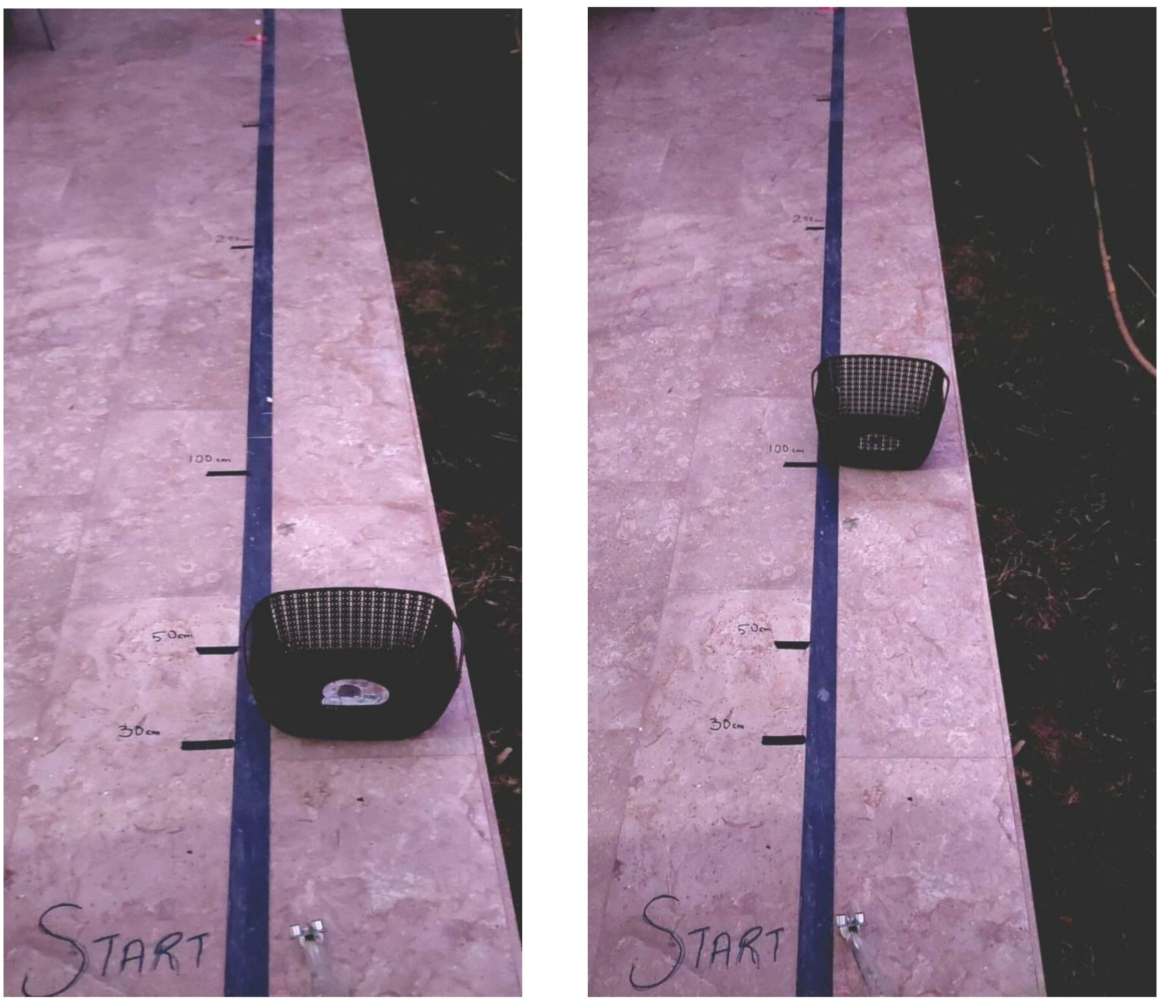

Figure 5 & 6.
Pathway for the testing.

Informed consent was also obtained from each subject before their participation. The ages of the participants are given below in the table.

Table 2.
Ages of Participants

Age Of Participants (years)		
Participants	**Male**	**Female**
1	30	26
2	35	32
3	32	38
4	28	39
5	34	36
Average	31.8	34.2
Standard Deviation	2.561249695	4.749736835

RESULTS

The results of this study helped us to observe the accuracy of the ultrasonic sensor in percentage. Reading from 30cm to 400cm with an unequal difference for males and females has been shown in Table 2 and Table 3, respectively.

Table 2.
Ultrasonic sensor readings in male participants

Distance (cm)	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Average (cm)	Accuracy %	Error %
30	30.03	29.98	29.02	30.07	29.02	29.828	99.36	0.64
50	50.57	49.7	49.07	49.66	49.01	49.502	99	1
100	97.3	98.4	97.09	98.03	97.63	97.63	97.63	2.37
200	195.8	195.1	194.1	195.55	195.44	195.198	97.59	2.41
300	290.3	291.7	292.4	292.67	291.63	291.74	97.24	2.75
400	388.1	386.2	389.87	385.4	388.33	387.58	96.89	3.11

It is clear to observe that as the distance increases, the error values increase, such as at 30 cm, the error is **0.64%** in males and **0.33%** in females, and at 400 cm, the error is **3.11%** for males and **3.54%** for females, which indicates that as the distance increases, accuracy gradually decreases. It also shows different accuracies and errors in male and female subjects.

Table 3.
Ultrasonic sensor readings in female participants.

Distance (cm)	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Average (cm)	Accuracy %	Error %
30	30.96	29.99	29.12	30.27	29.32	29.932	99.77	0.33
50	50.57	9.11	49.77	49.31	48.01	49.354	98.71	1.29
100	97.1	98.2	97.59	98.33	96.33	97.51	97.51	2.49
200	194.8	194.9	195.1	196.01	195.03	195.168	97.58	2.42
300	289.3	289.39	291.64	291.17	290.33	290.366	96.78	3.22
400	385.1	387.01	385.57	384.64	387.03	385.87	96.46	3.54

DISCUSSION

The proposed smart blind stick in this study incorporates a very unique characteristic, which is its fluorescence, without any connection to a power source, and promotes the safety of the blind person in dark areas and assists others in identifying the visually impaired person from a distance. As an aluminum-wrapped stick, it reflects any light that reveals lambency and indicates the blind person to others. This stick is ergonomically ideal for the afflicted individual, being light in weight for holding and moving. After studying we found that this smart stick is less expensive than any other blind stick after evaluating production costs. Several test cases demonstrate the stick's capability. The rapid development of the stick may be beneficial to our society's blind individuals. The cost of manufacturing the smart blind stick is about 16$ each. After calculating the cost, we discovered that the stick is less expensive to produce. as compared to the sticks made previously, which in turn makes it cost-effective. People Visually impaired individuals encounter daily struggles navigating their surroundings, hindered by obstacles and difficulty in locating landmarks.

Conventional aids provide only minimal assistance, underscoring the pressing necessity for advanced tools that can elevate accessibility and enhance their overall quality of life. The smart blind stick has global relevance, offering a universal solution to challenges faced by visually impaired individuals worldwide. Its accessibility features and advanced technology empower users to navigate diverse environments with confidence, transcending geographical barriers and improving quality of life on a global scale.

CONCLUSIONS

An advanced digital directing stick for the blind's design and architecture was proposed in this study. The blind stick presented in this study may aid visually impaired users in navigating varied terrain and obstacles. In the long run, millions of blind people will be able to benefit from the system since it is a low-cost alternative to current technologies. Combining several working components into a real-time system that tracks a user's movement and provides both visual and audible feedback enhances the safety and security of navigation. Sensors of various kinds may be employed to enhance the system's decision-making skills, allowing it to be applied to a wider range of tasks. It is designed to address the issues that blind individuals experience regularly. In addition, safeguards are put in place to keep them safe from the system. In society, blindness is seen as a misfortune. People who are blind face a variety of difficulties in their daily lives. As a result of the hardships they face, blind individuals begin to see themselves as a burden on society. They lose interest in life as a result. Hence, we proposed a multipurpose blind stick that can enable the visually impaired in their everyday lives. For future work, we can improve the blind stick by adding more features, such as integrating it with AI to make it autonomous, i.e., image recognition and voice recognition, which will make it convenient for the visually impaired person to recognize a variety of objects. By improving GPS, we can add a feature that allows the stick to navigate the location and assist the visually impaired person in reaching their destination. Future iterations could leverage advancements in sensor technology and artificial intelligence to address these challenges, further improving the device's functionality and impact.

Ethical Consideration

Ethical considerations in smart blind stick design include user privacy and safety. Measures were implemented to safeguard sensitive data and ensure the device's safe operation, prioritizing user trust and well-being.

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