

# Smart Stick For Visually Impaired Persons Using Multiple Sensors

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**ABSTRACT**— Due to the absence of visual perception, blind people are faced with great difficulties in safe navigation. The traditional white cane is not very helpful. It can only tell you something is in your way after you hit it. This makes it more likely that you will get hurt. We made a Smart Stick to help blind people navigate safely. This Smart Stick uses sensors to help them get around. We used a Raspberry Pi and an ultrasonic sensor to detect things that're in the way and to measure how far away they are. We also use a Pi-Camera to take pictures of what's around them. Then we use methods to look at these pictures and find different kinds of things that might be in their way. The Smart Stick can tell the user what it finds out. It uses Text-to-Speech technology to turn what it detects into sound. For example, it can tell them how away something is or what kind of thing is in their way. Our tests show that the Smart Stick can detect things that're farther away and can tell the user faster than a regular white cane. We want the Smart Stick to be light, inexpensive and work inside and outside. The Smart Stick helps blind people get around easily feel more confident and be safer. This makes it a helpful tool for them to find their way around. The Smart Stick is very useful, for people.

**KEYWORDS** — Smart Stick, Ultrasonic Sensor, Raspberry Pi, Pi Camera, Obstacle Detection, Image Processing and Audio Feedback, For People.

## I. INTRODUCTION

Vision helps people see their surroundings and move around safely every day. For people who cannot see well not being able to see makes it very hard to get around on their own in new crowded or busy places. Things like walls stairs, holes in the road cars and people walking around can be very dangerous if you do not see them coming.

The white cane is the common tool that people who cannot see well use to help them move around. It is cheap, light and easy to use. However, it has some problems. The white cane only finds things when it hits them. It does not tell you how far away which direction or what kind of thing it is. This means that people who use it might bump into things or get hurt, in places with a lot going on.[1], [4]

To make it better researchers have come up with travel aids that use sensors. Many smart sticks use sensors because they are cheap work well and can find things in real time in

different kinds of environments.[3], [4] Just knowing how far away something is might not be enough to stay safe.

Recently small computers like Raspberry Pi have made it possible to add cameras and image processing to devices that help people. Camera-based systems can tell the difference between people, cars and things that are not moving. They can give guidance through audio. Because of these advancements this paper suggests a stick that uses many sensors to find obstacles recognize objects and give audio guidance. This can help people who cannot see well move around safely and on their own. The white cane and smart sticks help people who cannot see well. The white cane is a tool. Smart sticks use sensors. Camera-based systems give guidance. The goal is to improve the safety and independence of impaired individuals, with a smart stick. The smart stick uses sensors. It provides real-time obstacle detection. It provides object recognition. It provides guidance.

## II. PROBLEM STATEMENT

People who are impaired have a hard time getting around safely by themselves. This is because they cannot see the things that're in their path. In life impaired individuals have to deal with many things. They have to deal with sidewalks and stairs and potholes and walls and cars and people who are walking around. Impaired individuals really struggle to get around because they cannot see these things. If they do not find out about these things before they get to them, they are more likely to run into something or get hurt in places they do not know well or where there are a lot of people.

The white cane is still the common tool that visually impaired people use to get around but it does not do a very good job. It only tells them about things when they actually touch them and it does not give them any information about how away something is, which direction it is in or what it is [1], [5]. Because of this people who use canes can have a time feeling confident when they are walking around in complicated places.

To make things better people have come up with devices and smart canes. A lot of these devices use one sensor and warn the user with a beep or a vibration. These devices do help people find things that're in their way but they usually cannot tell what the thing is or give the user any extra help figuring out what to do.

Some of the smart canes have cameras, GPS and special computers that can look at pictures but they are often too

expensive, too complicated and use too much power, which means people do not want to use them every day. So, what we need is a device that's affordable and works well and that can use multiple sensors to find things in the way figure out what they are and give the user instructions all in real time so that visually impaired individuals can get around safely and on their own both inside and outside.

The main goal is to help impaired individuals, with their daily mobility. Impaired individuals need a device that can help them with obstacle detection and object identification. Impaired individuals should be able to get around safely with the help of such a device.

### III. PROPOSED SYSTEM

The smart assistive stick is a tool that helps people who're visually impaired. It is made to help them move around safely on their own. The smart assistive stick uses parts that work together to find things that are in the way figure out what they are and tell the user about them in real time with audio feedback. The main goal of the assistive stick is to make traditional walking aids better by finding things that are in the way before the user gets to them and helping them know what is around them.

The smart assistive stick uses a sensor to find things that are in the way. This sensor sends out waves and gets them back when they bounce off things that are nearby [3], [4]. The smart assistive stick can tell how away something is by how long it takes for the sound wave to come back. This helps the user know when something is in the way before they touch it which reduces the chance of running into things.

The Raspberry Pi is the brain of the assistive stick. It gets information from the sensor and controls everything the smart assistive stick does. The Raspberry Pi was chosen because it can process information quickly work with different types of hardware and handle audio and images well [1], [6]. This makes it a good choice for putting the parts that sense things and the parts that think.

The smart assistive stick also has a camera that takes pictures of what's around the user. The camera helps the smart assistive stick know what things are, like people, cars and things that do not move. The smart assistive stick uses the information from the sensor and the camera to tell the user what to do with audio instructions[6], [7]. The user can hear these instructions through a speaker or earphones which helps them move around.

The smart assistive stick is made to be light not too expensive and good for use inside and outside. This makes it a helpful tool for people who're visually impaired to use every day. The smart assistive stick is a solution, for people who need help moving around[8].

Figure 1 shows the block diagram of the proposed stick system. This diagram shows how the smart stick system is set up. The smart stick system has a few important parts, including the sensor, the Raspberry Pi, the Pi Camera and the audio module and these parts are all connected to each other. The smart stick system uses these parts to get information, about obstacles. Then it gives the user audio guidance. The smart stick system is designed to help the user by providing this guidance.

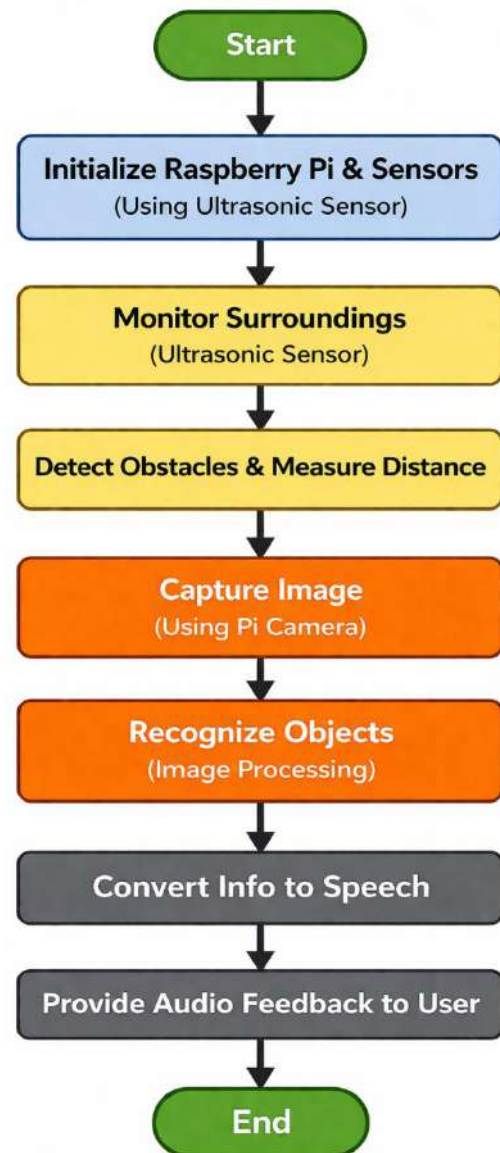


Figure 1: Block diagram of the proposed smart stick

### IV. METHODOLOGY

The smart stick is a device that helps people who cannot see. It explains how it works to assist these people when they are moving around. The smart stick uses sound waves takes pictures and gives feedback to tell the person if something is in their way.

When you turn on the stick the Raspberry Pi starts up all the parts that are connected to it. This includes the sound wave sensor, the camera and the speaker. The Raspberry Pi also loads the software it needs to work with these parts. To convert text into speech.[1], [6].

The sound wave sensor is always checking the area around the person. It sends out waves and listens for the waves to bounce back. The smart stick calculates how away something is by how long it takes for the sound wave to come back. If the thing is enough away the smart stick keeps checking. If the thing is too close the smart stick does more to help the person [3], [4].

When the smart stick finds something in the way the camera takes a picture of what's in front of the person. The smart stick looks at the picture to figure out what the thing is. This

helps the smart stick tell the person more about what's, in their way like if it is a person, a car or something that is not moving. The smart stick can then give the person helpful audio feedback [6], [7].

Based on how away something is, which is measured by a special sensor and what the thing is, which is figured out by looking at pictures the system makes audio messages. These

messages are made using a technology that reads out text. The audio messages are then played for the user through a speaker or earphones. This helps the user make choices, about where to go next. The system keeps doing this over to help the person move around safely on their own. The ultrasonic sensor keeps track of distance. Image processing identifies objects.

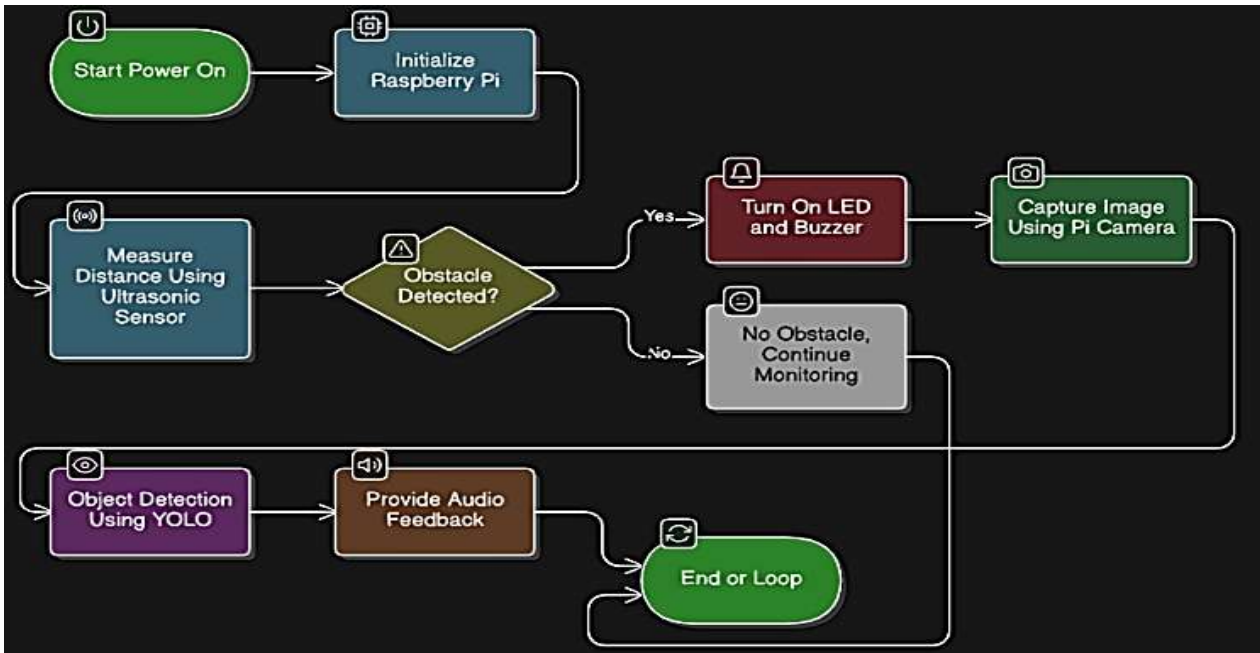


Figure 2: Flowchart illustrating the working of the proposed smart stick system.

Figure 2 shows how the smart stick system works. The smart stick system has a lot of steps. It starts with the sensors being set up. Then the smart stick system looks for things that're in the way. The smart stick system takes a picture when it finds something. After that the smart stick system makes a sound to tell you something is there. The smart stick system is effective, at helping you.

**V. RESULTS AND DISCUSSION**

This section shares the test results of our stick system and how well it works in different situations. We looked at how

it detects obstacles responds quickly and works accurately overall.

**A. How Well the Smart Stick Detects Obstacles**

We tested the sensor to see how good it is at finding obstacles at different distances. The results show that our smart stick can detect obstacles farther away, than a regular white cane. This means the user gets a warning before they hit something, which helps prevent accidents. This test proves that using sensing is a good and reliable way to help people navigate [4].

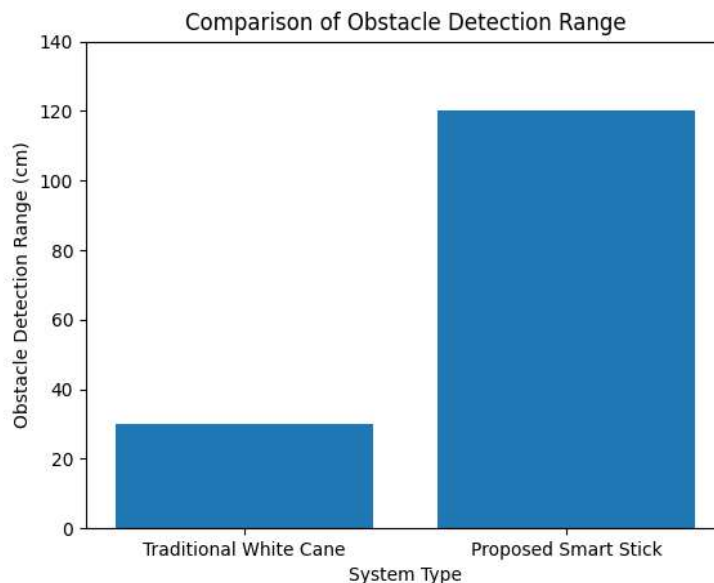


Figure 3: Comparison of Obstacle Detection Range graph

In the above Figure 3 Shows how well the traditional white cane and the new smart stick work, at detecting obstacles. The smart stick can spot obstacles from away. This means it can warn the user earlier.

Table 1: Comparison of Obstacle Detection Range

System Type	Obstacle Detection Range (cm)
Traditional White Cane	30
Proposed Smart Stick	120

Table 1 shows that the proposed smart stick can detect things that're in the way from a longer distance than the regular white cane. This makes it a lot safer for people to move around with the stick. The smart stick is effective at helping

people navigate because it can find obstacles, from a distance.

**B. Response Time Analysis**

We looked at how the system takes to respond when there are obstacles, at different distances. What we found out is that the system takes a little longer to respond when the obstacles farther away. The good thing is that the system always gives us feedback quickly enough to be useful when we are navigating. The results we got show that the system we proposed does not take long to respond and it gives the user audio alerts on time. The system gives the user feedback in time which is what we need for navigation to be practical. The results also show that the proposed system maintains a response time that's acceptable and it provides audio alerts to the user in a timely manner as seen in the work of [3], [8] .

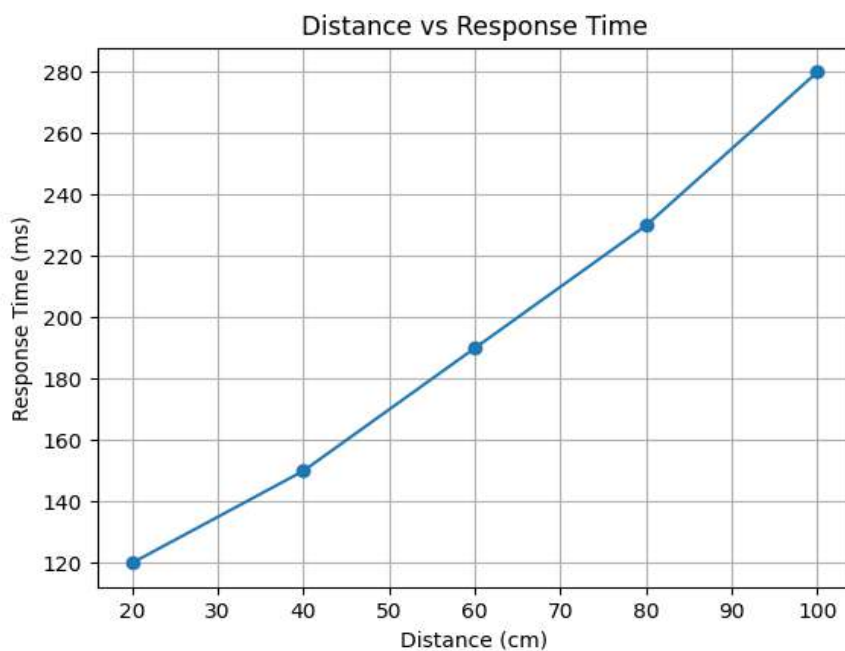


Figure 4: Distance vs Response Time graph

Figure 4 shows how the distance of an obstacle affects the time it takes for the system to respond. When the obstacle is really away it takes a little longer for the system to respond. Even when the obstacle is really far away the system response time is still good enough, for navigating in real time.

Table 2: Distance Versus Response Time

Sr. No.	Distance (cm)	Response Time (ms)
01	20	120
02	40	150
03	60	190
04	80	230
05	100	280

Table 2 shows the response time measured at distances from obstacles. The numbers prove that our system performs steadily when detecting obstacles. We got results, for system performance during this process. The response time values are indicators of how well the system works.

**C. Module-Wise Success Rate**

Each part of the stick was tested separately. These parts include sensing, controlling GPIO, the camera module detecting objects and playing audio. Most parts worked well almost 100% of the time which shows they are stable and reliable. The camera had some problems finding objects in tricky lighting. Overall, the results show that all the different parts of the system work well together. The results also match with studies[6], [8].

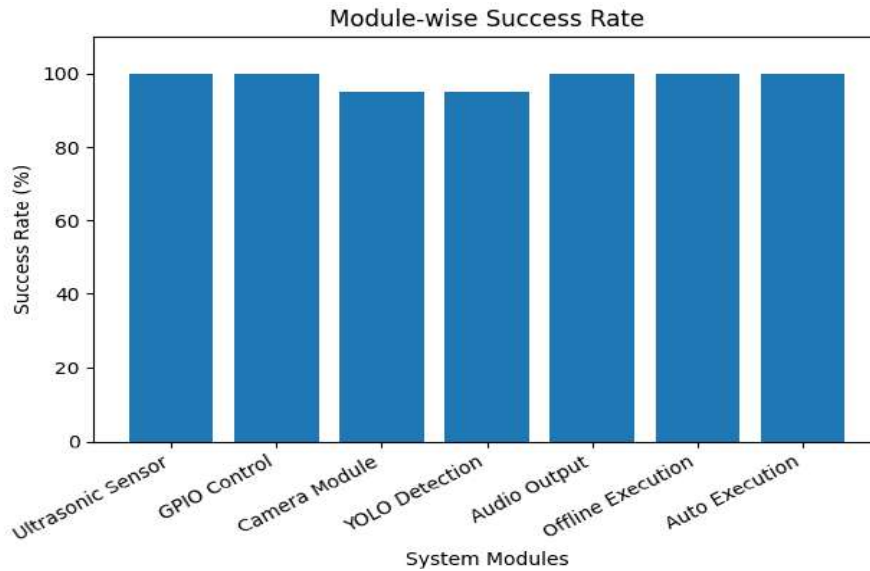


Figure 5: Module-wise Success Rate bar chart

In the above Figure 5 shows how well the different parts of the smart stick system work. Most parts of the stick system work really well but the part that uses the camera to detect things does not work as well when things are tough.

Table 3: Module-Wise Success Rate

SR.no	System Module	Success Rate (%)
1	Ultrasonic Sensor	100
2	GPIO control	100
3	Camera Module	95
4	YOLO Detection	95
5	Audio Output	100
6	Offline Execution	100
7	Audio Execution	100

Table 3 shows how well each hardware and software part works.

The results are good. Show that the whole system works well together. The integrated system performs steadily.

#### D. Object Detection Accuracy

The system was tested for object recognition in situations like indoor lighting, outdoor daylight, low light and moving objects. It worked well in lighting conditions. In low light it did not work as well. This shows that camera-based object recognition is effective. It also needs to be improved with better image processing. The results for object recognition were good, but low-light environments still need algorithms.

The systems object recognition capability was good, in scenarios. It can detect objects accurately in lighting. However low-light conditions affect its performance. So advanced image processing algorithms are required [6], [7]. In the below Figure 6 shows how well the object detection system works in situations. The object detection system works well when it is clear and the lighting is normal. When it is dark the object detection system does not work as well as it does in normal lighting conditions. The object detection system is not as good at detecting objects, in light.

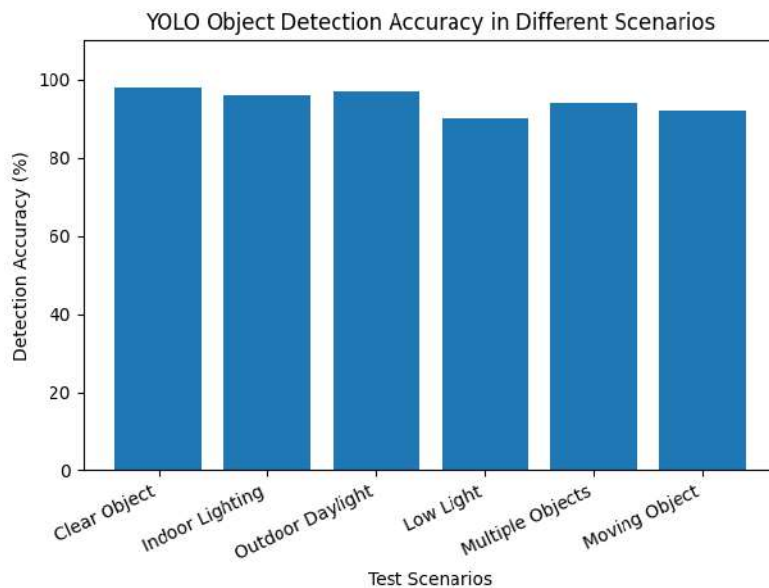


Figure 6: Object Detection Accuracy bar chart

Table 4: Object Detection Accuracy in Different Scenarios

SR.no	Test Scenario	Detection Accuracy (%)
1	Clear object	98
2	Indoor lighting	96
3	Outdoor lighting	97
4	Low Light	90
5	Multiple objects	94
6	Moving objects	92

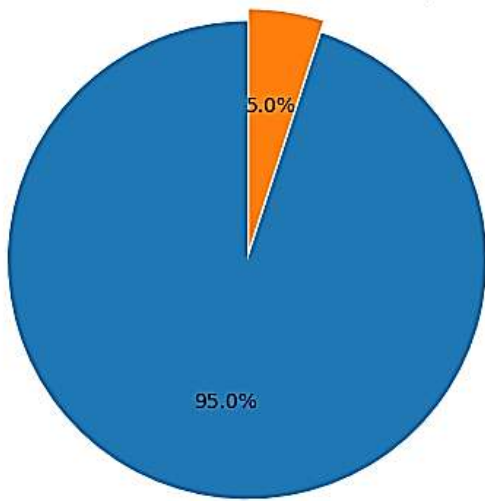
In the above Table 4 shows how good the detection is in situations.

We can see that the light in a room has an impact, on how well the camera can recognize things.

**E. Overall System Performance**

The system was checked by trying out different tests. Most of the tests worked well. A few had some small problems when it was dark or when things were moving really fast. This shows that the system we are talking about is good and can be used in life. When we compare it to the kind of walking aids the smart stick is better because it helps people stay safe be more aware of what is, around them and feel more confident when they are using it [6], [8].

Overall System Performance Distribution  
Minor Issues (Low Light / Motion)



Successful Test Cases

Figure 7: Overall Performance Pie Chart and Test Cases vs Success Rate

Figure 7 shows how well the proposed smart stick works based on the results of the test cases. The smart stick did a job in most of the test cases, which means the system works well under different conditions [3] [6]. The smart stick was able to perform which is what we wanted to see.

Table 5: Overall System Performance Distribution

SR.no	Test Outcome	Percentage (%)
1	Successful Test Cases	95
2	Minor Issues (Low Light/Motion)	5

Table 5 shows us the percentage of test cases that were successful and the ones that had issues. This tells us that the system is really reliable overall. The system reliability is very strong which is great to see from the results of the test cases, in Table 5.

Table 6: Test Cases Versus Success Rate

SR.no	Test Case	Success Rate (%)
1	TC1	100
2	TC2	100
3	TC3	100
4	TC4	100
5	TC5	95
6	TC6	95
7	TC7	100
8	TC8	100
9	TC9	100
10	TC10	100

Table 6 shows how well the test cases did. The test cases did well when we looked at them one, by one. Most of the test cases had good results when we checked them.

**VI. CONCLUSION AND FUTURE SCOPE**

**A. Conclusion**

This paper is about a stick that helps people who are blind or cannot see very well. The stick has a sensor that uses waves a Raspberry Pi and a Pi Camera to find things that are in the way measure how far they are and see what they are. The stick also talks to the person using it so they know what is going on around them.

The people who made this stick tried it out. Found that it is effective at finding things that are in the way. It is better than a white cane. The camera on the stick can also see what is in front of the person so they know what things are around them. This stick is not too heavy it does not cost much money and it works well inside and outside so it is a very helpful tool, for people who are blind or cannot see very well to use every day.

**B. Future Scope**

The system we have now works well but there are some things we can do to make it better in the future. We can add a GPS module to the system so it can tell people where they are and help them get around. This will be really helpful for people who use the system.

We can also add a GSM module to the system so people can call for help if they need it. This way they can share their location with the people who take care of them or their family members. The system can also be made to recognize things even when it is dark or there are a lot of people around [7]. If we want to make the system really useful, we can make some changes. We can design a circuit board just for the system make the battery last longer and make the outside of the system stronger. We can also make an app for the system. Combine the information, from all the sensors. This will make the smart stick more reliable and better for people to use every day.

**CONFLICTS OF INTEREST**

The authors declare that they have no conflicts of interest.

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