The Development of a Smart Stick with SMS Emergency Location Feature for the Blind

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Abstract: As humans tend to be reliant on their sense of sight to gather information about their surroundings, this allows them to feel safe and connected. White canes have been a common solution to visual impairment concerns however it was shown that such tools are still unable to resolve problems pertaining to obstructions on height level. This paper aims to create a smart stick which is able to resolve such concerns while including an emergency button feature that will inform emergency contacts via SMS of the location of the user once pressed. The gathered results will answer the following (a) reliability of the smart stick's detection of obstructions, (b) effect of the environment to the performance of the device, and (c) effect of the distance between the user and emergency contact to the speed of transmission if the emergency button is pressed. It was found that the smart still is reliable in terms of detection with a high accuracy percentage and is able to determine if stairs are going up or down, the environment has little effect on the performance of the smart stick, and if the distance is farther the speed of transmission is more consistent.

Keywords: Smart Stick, Visually Impaired/Blind, GPS, Ultrasonic Sensor, Arduino Nano, Visual Assistance, Visual Alternatives

I. Introduction

Huumans have the tendency to be more reliant on their sight than the other senses. This is because vision is responsible for most of the information one can gather about their environment which keeps individuals safe and more connected with their surroundings [1]. The main organ responsible for sight is the eyes as light reflects off of shapes and objects to which the eyes focus on the light and send a signal to the brain [2]. However, just like every other organ, the eyes are also susceptible to damage which leads to visual impairments.

According to the World Health Organization, visual impairments, especially blindness, come from uncorrected refractive errors, cataracts, age-related macular degeneration, glaucoma, diabetic retinopathy, corneal opacity, and trachoma [3]. Moreover, it was stated that in 2015, there were an estimated 253 million people with visual impairment worldwide and 55 percent or 139 million were women [4].

The most common problem of people with visual impairment in their daily lives is navigating around places, especially those places they are not familiar with. People with vision impairment are more prone to experiencing dangerous life-changing events due to a lack of visual information. According to the research in [5], all of their respondents experienced accidents due to their vision. Many of the respondents experienced accidents with vehicles, falling from the stairs, falling into holes or pits, bumping into objects in footpaths, falling onto underground rails, falling into gaps buses and their platforms, and bumping into building scaffolds and glass doors.

The more traditional solution for individuals grappling with visual impairments is the use of a stick that aids them in determining if there are obstacles in their way. These sticks are called “white canes” and are considered to be mobility devices to assist the blind or visually impaired. There are different types of white canes which depend on severity of the individual's impairment; an example would be a long cane which is the most well-known variant and is dependent on the height of the user as its common length extends from the floor to the user's sternum or breastbone; however, some users would also opt to have the cane to be much longer [6]. However, there are some drawbacks to using white canes which can cause the user to be prone to injury. White canes are ineffective at detecting head-height objects and objects located at a distance over a meter. Furthermore, longer white canes can be obstructive to passersby when used in public as they take up more space. The short range that the white canes provide gives the users a limited amount of time to react to their surroundings which increases their risk of tripping, falling, or hitting their head.

With the advanced technology society has developed, assistive gadgets like sensory substitution gloves, detachable long cane accessories for mobility assistance, and smart sticks; there are also other more popular solutions available in the market but they are not affordable nor cost-effective. In 2015, a stick solution using IR sensors was proposed. The use of IR sensors was under the impression that infrared technology can provide a fast response, low-consumption, and lightweight product. A pair of infrared sensors can detect stair-cases and other obstacles present in the user's path within a range of two meters [7]. The research however does have gaps as infrared is ineffective in certain conditions. Infrared supports a shorter range and can get blocked by common objects. The essence of infrared sensors is that it makes use of light so if a material absorbs the light the sensor transmits, it will not be able to detect the object. Similarly, environmental conditions such as rain, fog, dust, pollution, sunlight, and other similar factors can affect the transmission and reception of the signals sent by the sensor which decreases its effectiveness. This further supports the study to improve the white canes being used by those with visual impairments through more cost-effective technological solutions.

This motivates the researchers to develop a smart stick that uses ultrasonic sensors instead of infrared sensors to ease the problem of visually impaired people regarding obstacles and its effectiveness against environmental factors. Moreover, to provide users with assurance that they will have someone to help them in emergencies, a feature present in the researchers' solution is the emergency button which is equipped with GPS tracking and SMS sending to read the user's location and immediately send an emergency message of the location to the contact person for easier search and response to the emergency. The goal of the researchers is to give visually impaired people the assurance of being secure in times of emergency.

Statement of the Problem

The aim of the study was to develop a Smart Stick equipped inside with an Emergency GPS tracker, location SMS sender, and Haptic Feedback for those people with vision impairment for greater security in case of emergencies while also easing their daily struggles with obstacles along the way.

Specifically, this study aimed to answer the following questions:

1. How reliably can the Smart Stick detect obstructions?
2. How does the environment affect the performance of the ultrasonic sensor?
3. How does the distance between the user and the emergency contact impact the speed of data transmission and the promptness of feedback when the emergency button is pressed?

Conceptual Framework

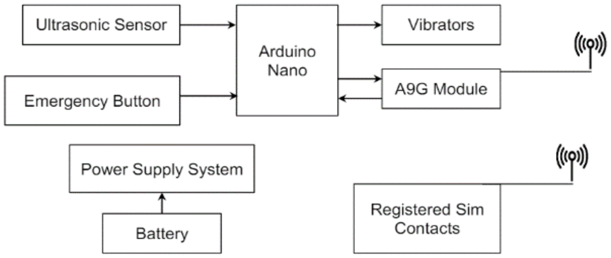


Fig 1. Research Conceptual Framework

In obstacle detection, the ultrasonic sensor would detect obstacles that are in range and send the signal into the Arduino Nano to which the Arduino Nano then relays the signal into the vibrators found on the handle of the stick held by a user causing the user to be alerted of the obstacle.

In case of emergencies, if a user presses the emergency button, it immediately sends the signal to the Arduino Nano. Then the Arduino Nano reads the location of the user through the GPS feature of the A9G module and gives that information to the Arduino Nano. It automatically sends a message containing the location of the user to the emergency contact person.

On Smart Stick

The smart stick is a device that guides the user by sensing obstacles in the range of the stick. The smart stick would identify the obstacles in the path with the help of the sensors installed [8]. The microcontroller will retrieve the data and pass it on as vibrations that would notify the user about the obstacles along the path.

Moreover, IR sensors are used along with ultrasonic range finder circuits for obstacle detection. Bluetooth module, GPS technology, and an Android mobile application will provide voice assistance for the blind in the desired Location [9].

Blind people do have a big problem when they are walking on the street or stairs using a white cane, however, they have sharp haptic sensitivity. So they came up with an electronic walking stick that will help the blind with convenience and aims to contribute knowledge and services in regards to the blind and the PWD society [10].

To support the idea, researchers stated that blind sticks are long straight stick tools used for the mobility of persons who are visually impaired [11]. The sticks are mostly hollow aluminum tubes with a 6 mm outer radius, a radius of 4 mm and a density of 103 kg. The lower end of the stick is covered with a material made of plastic that is usually colored white, and red as a marker that shows people with disabilities.

Additionally, the smart blind stick is an alternative to the traditional stick. The stick consists of Arduino UNO, ultrasonic sensor, IR sensor, voice playback module, LCD display and voltage regulator. The ultrasonic sensor is used to detect in front of the person by measuring the distance between the sensor and the stick. The IR sensor detects objects that are very close. Lastly, the voice playback module will assist the user through the command or microphone in order to reach the destination.

The blind stick is developed by using hardware and software applications. The ultrasonic stick aids the people with visual impairment in their daily lives to achieve individual independence. The stick consists of an ultrasonic sensor that detects the presence of the obstacle and calculates between the source and the target, a water sensor to detect water and a fire sensor to detect fire and send the information through alarm, vibration and sound.

In addition, the Smart blind stick is a fully automated as well as manually operated device. It is an innovative device designed for people with visual impairment for navigation and obstacle detection. The blind stick is integrated with three ultrasonic sensors used to detect obstacles ahead using ultrasonic waves and relays the message to the user through the microphone device. The navigation process is implemented by smart stick using Global Positioning System or GPS for the people with visual impairment which will detect the obstacles and also determine the location through GPS coordinates.

The Smart Stick serves as a flexible interface for simple and convenient enabling those who are blind to move comfortably. It is inexpensive and secure. Despite the system being hardwired. It weighs little even when equipped with sensors and other parts. It provides effective navigation at a cheap power cost. "Smart Stick" serves as a foundation for the upcoming generation of more assisting technologies that make the visually impaired more safe. When creating such a strong solution, those who are blind or visually impaired in all developing Top of our list of priorities were countries. Wireless Connectivity between the device's parts will improve the instrument's extra features.

In the light of the above related literature and studies discussed, this research aimed further expand the idea based on the research project KITA: An Assistive Equipment for the Visually Impaired wherein this research aims to address the gaps specifically on; battery charge duration, component and circuitry housing, avoid or lessen component and battery rising to high temperatures.

This research aimed to improve the assistance provided to the users by implementing tracking and notification devices, specifically; GSM (Global System for Mobile) Module, GPS (Global Positioning System), Battery Percentage Detector/Notifier.

On Blind People

The World Health Organization (WHO) reported that there are 285 million visually-impaired people worldwide. Among these individuals, there are 39 million who are blind in the world. More than 1.3 million are completely blind and approximately 8.7 million are visually-impaired in the USA. Of these, 100,000 are students, according to the American Foundation for the Blind and National Federation for the Blind. Over the past years, blindness that is caused by diseases has decreased due to the success of public health actions. However, the number of blind people that are over 60 years old is increasing by 2 million per decade. Unfortunately, all these numbers are estimated to be doubled by 2020.

Research has shown that blind people have heightened senses in terms of hearing, smell and touch, as well as cognitive functions to make new connections due to the absence of visual information [12]. This research revolved around people who were born blind as throughout the years they would have to adapt and learn based on how they sense the world which is possible through the process of neuroplasticity. The significant changes based on the MRI results were not only in the occipital cortex which is where the vision is being processed, rather also in the memory, language processing, and the sensory motor functions. This indicates structural and functional connectivity change in those aspects which includes evidence of enhanced connections where in such information that is sent back and forth between areas of was not observed in the normally sighted group.

Although the said research was conducted among people who were born blind, the same applies to individuals who lost sight early on as they can develop enhanced senses due to neuroplasticity; however, it would only take a longer amount of time.

On White Canes

White canes primarily allow their users to scan their surroundings for obstacles or orientation marks. It comes with different tips made of different materials which can change the sound and vibration pattern it produces when it comes into contact with an object; these tips may often affect their mobility. Examples of these tips are the marshmallow tip which is made of solid nylon, the pencil tip, and the metal glide.

The tips mentioned have their pros and cons with different factors to be considered prior to picking the best or most appropriate one for the area. However, what is most important to note are the hand grips utilized for holding such canes. There are three common ways to properly hold a white cane — Index-finger Grip, Pencil Grip, and Handshake Grip The proper holding of the white cane is incredibly important as this ensures that the user is mobile, comfortable, and not straining their wrists.

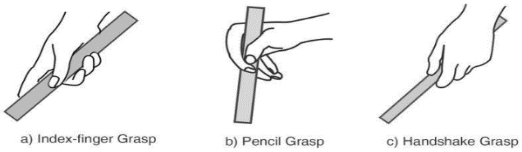

a) Index-finger Grasp b) Pencil Grasp c) Handshake Grasp

Fig 2. Three Different Grasping Postures of White Canes

The index finger grip is also known as the standard grip and it is the most common way to hold the cane. This grip is popular and commonly used as it is comfortable and considering the movement needed to use the cane properly to get a grasp on one's surroundings, the wrist naturally moves this position is ergonomically the best and prevents straining the wrist of the user, reducing the risk of pain and issues. The pencil and handshake grip are still popular options for holding the white cane but the index finger grip is most commonly used.

II. Research Methodology

The development of the prototype has undergone 5 phases. Since this research utilized the DDR research design, the researchers had made adjustments to the design of the prototype until it passed the efficacy tests of the researchers. Similarly, these alterations to the design did not necessarily mean that the researchers started from scratch. Rather this could simply mean that some components or features may be adjusted accordingly to respond to the requirements of the objectives.

Phase 1**-** First Prototype Design and Casing Development: This phase involves the development of the prototype based on the original design and casing. Here, the researchers utilized the components that were recommended to be used based on previous papers and research.

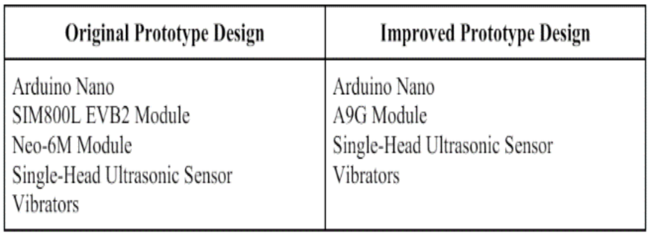
Phase 2 **-** Testing of Equipment and Components: During this phase, the researchers already had all the components on hand. Since this paper sought to develop the device to be as effective as possible, the components were tested. During the testing, when a certain component was found to be incompatible or there would be a better solution, the design to the prototype would then be altered accordingly.

To make sure the prototype is as compact and small as possible, the researchers deemed it best to keep the number of components at a minimum to prevent the device from becoming too bulky for the casing.

Phase 3 **-** Alterations to Design and Utilized Components: After the testing of the components and ensuring they were working, alterations and changes to the design and utilized components if necessary were done in this phase. The researchers reviewed their original prototype design, assessed what and where these changes to be made, and planned out the newer and improved design.

The researchers found that it was best to utilize a single A9G module which has both SMS and GPS capabilities rather than utilizing the SIM800L EVB2 and Neo-6M modules. Similarly, the researchers considered utilizing the double-head sensor as they are more stable compared to the single-head; however, because of the higher distance range that the single-head offers and its outdoor capabilities, it was ultimately decided that it is the better option and the algorithm for the single-head could be altered or improved upon to make the readings more stable. This was then assessed during the testing.

Phase 4 **-** Improved Prototype Design and Casing Development: After all alterations had been finished, the improved prototype design was fabricated and developed. This served as the final design that had undergone the trials necessary to fulfill the objectives of this paper.



Original Prototype Design	Improved Prototype Design
Arduino Nano SIM800L EVB2 Module Neo-6M Module Single-Head Ultrasonic Sensor Vibrators	Arduino Nano A9G Module Single-Head Ultrasonic Sensor Vibrators

Fig 3. Original and Improved Prototype Design

Phase 5 – Official Testing of the Prototype: In this phase, the researchers started with their tests and data gathering. The prototype at this point was fully functional and had been crafted according to the design based on the improved prototype.

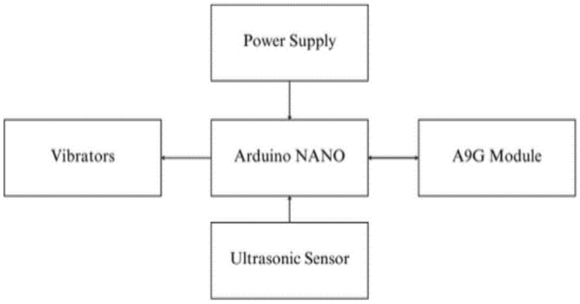


Fig 4. Connection of the Components

Based on the figure above, the power supply is connected to the Arduino Nano and provides it with sufficient power to run the system and the other components. The Arduino Nano receives a signal from the Ultrasonic Sensor while it both sends and receives data using the A9G Module. The vibrators on the other hand receive a signal from the Arduino Nano and produce an output to inform the user.

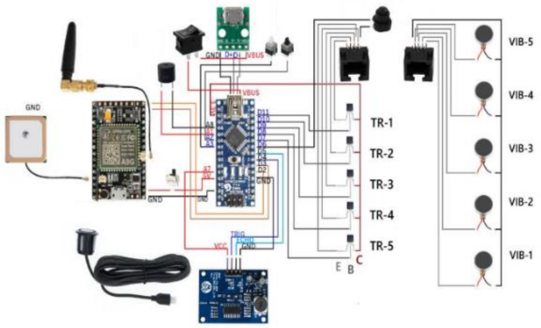


Fig 5. Schematic Diagram of the Smart Stick Prototype

The figure above shows the pin connectivity of the different components for the final prototype. As illustrated in Figure 10, all the peripherals are connected to the Arduino Nano as this serves as the main board. The transmit (TX) and receive (RX) pins of the A9G are connected to the digital, D2 and D3, pins of the Arduino Nano, respectively, to allow the A9G to communicate with the Arduino Nano. There are 5 transistors connected to the vibrators, Arduino Nano, and power supply to aid the control of the vibrators. As the ultrasonic sensor is a single head outdoor sensor, it has its own module board and its Trig and Echo are connected to the digital pins, D4 and D5, of the Arduino Nano.

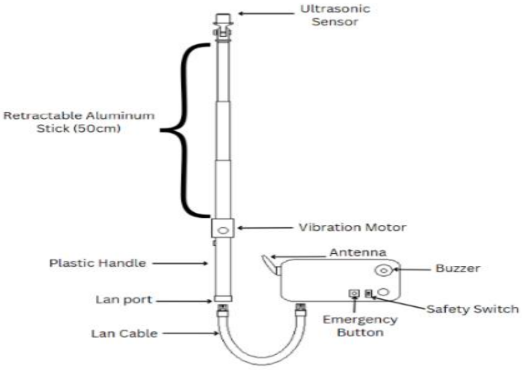


Fig 6. Sketch of thee Smart Stick

The smart stick prototype was constructed out of a 50 cm Selfie Stick. For a lightweight feeling when holding the stick, the GPS and SIM modules are kept inside a small plastic case which is attached to the waist of the user and then connected to the LAN port of the stick via LAN cable. To attach the ultrasonic sensors and give the smart stick a tidy appearance, they are put at the tip of the selfie stick. To prevent the stick from readily scratching any potential obstructions it may come across and to prevent the user from slipping when using Smart Stick, a plastic bulb cap has been added. Based on the distance detected by the ultrasonic sensors, vibrations are inevitable from the vibration motor found at the handle of the stick that provides haptic feedback to inform the user of such obstacles. In case of emergencies, the user can use the small plastic case that has an "emergency button" by pressing it, and by doing so, this sends a message to the emergency contact which is saved in the SIM module.

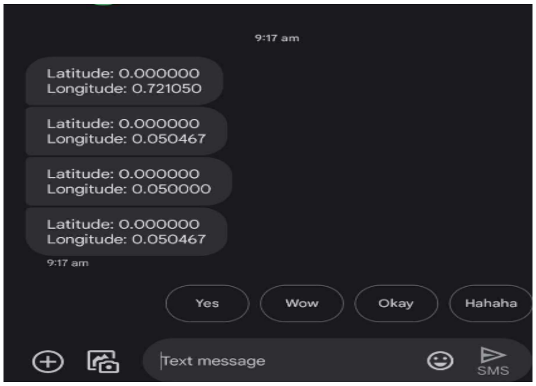
Data Gathering Procedures

In gathering the data, the researchers played as the participants, hereinafter known as the users, who tested the smart stick.

There are two tests done for the ultrasonic sensor namely: testing its accuracy and consistency in detecting obstructions at set distances and testing the sensor for changes of its accuracy and consistency in different kinds of environmental conditions. In emergency location SMS sending, the researchers set a local number by inputting it in the code of the system. Then, the researchers would press the button in the smart stick and wait for the message to arrive in the receiver.

Testing the Functionality of the Smart Stick: This section of the study focuses on testing the functions of the main components of the stick, which are as follows: the capability of the Smart Stick to detect obstructions, the range of distance for obstacle detection of the Smart Stick, the capability of the Smart Stick to detect objects under different environmental factors, and the speed of data transmission of the GPS and SIM module at varied distances.

Fig 7. Testing of Smart Stick for Object Detection



9:17 am

Latitude: 0.000000
Longitude: 0.721050

Latitude: 0.000000
Longitude: 0.050467

Latitude: 0.000000
Longitude: 0.050000

Latitude: 0.000000
Longitude: 0.050467

9:17 am

Fig 8. Testing of GPS and SMS Capabilities

Detection of Smart Stick in Obstructions: In this test, the results determine the capability of the smart stick in detecting obstructions with varied surfaces and distances — specifically tiles, wood, cement, plastic, metal, water, glass, and land. The user points the smart stick at the obstacles or objects at the midpoint of each set of distances to be tested, and the results of the test are then recorded.

Fig 9. Testing of Smart Stick Detection on Wood

Detection of Smart Stick in Stairs: In this test, the researchers tested the functionality of the smart stick in stairs, both in going up and in going down. There were three (3) stairs tested namely: the stairs in Cody Building, the stairs outside College Library, and the stairs SE building. For each stair there are 3 sets of data that correlate with the height of the user of the stick, the chosen height to be tested are 5’3”, 5’5”, and 5’7”.

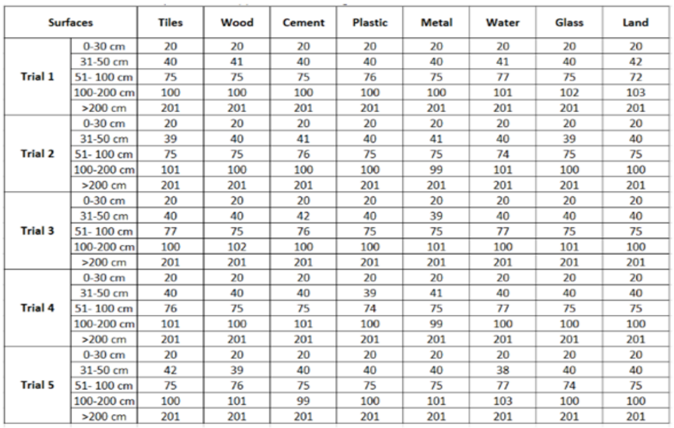
Vibration Pattern of Smart Stick in Stairs: The test configurations were done similarly in the test done in Detection of Smart Stick in Stairs, but this time the vibration function of the Smart Stick was tested. There are 10 steps in each trial to be tested and the user determines what kind of pattern he/she feels when doing each step would be measured by the number of vehicles which is the road length divided by the average car length. The average car length is 4.5 meters and the road length that would be measured is 80 meters.

III. Results and Discussion

Reliability of Smart Stick

This portion answers the first objective in terms of the reliability of the Smart Stick’s performance.

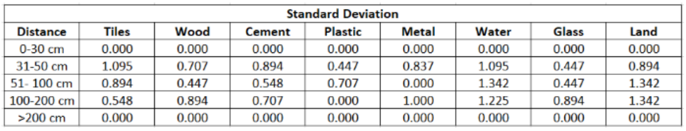
Table 1: Raw Data for Objective 1



Surfaces		Tiles	Wood	Cement	Plastic	Metal	Water	Glass	Land
Trial 1	0-30 cm	20	20	20	20	20	20	20	20
	31-50 cm	40	41	40	40	40	41	40	42
	51- 100 cm	75	75	75	76	75	77	75	72
	100-200 cm	100	100	100	100	100	101	102	103
	>200 cm	201	201	201	201	201	201	201	201
Trial 2	0-30 cm	20	20	20	20	20	20	20	20
	31-50 cm	39	40	41	40	41	40	39	40
	51- 100 cm	75	75	76	75	75	74	75	75
	100-200 cm	101	100	100	100	99	101	100	100
	>200 cm	201	201	201	201	201	201	201	201
Trial 3	0-30 cm	20	20	20	20	20	20	20	20
	31-50 cm	40	40	42	40	39	40	40	40
	51- 100 cm	77	75	76	75	75	77	75	75
	100-200 cm	100	102	100	100	101	100	101	100
	>200 cm	201	201	201	201	201	201	201	201
Trial 4	0-30 cm	20	20	20	20	20	20	20	20
	31-50 cm	40	40	40	39	41	40	40	40
	51- 100 cm	76	75	75	74	75	77	75	75
	100-200 cm	101	100	101	100	99	100	100	100
	>200 cm	201	201	201	201	201	201	201	201
Trial 5	0-30 cm	20	20	20	20	20	20	20	20
	31-50 cm	42	39	40	40	40	38	40	40
	51- 100 cm	75	76	75	75	75	77	74	75
	100-200 cm	100	101	99	100	101	103	100	100
	>200 cm	201	201	201	201	201	201	201	201

The role of objective 1 is to determine the consistency and accuracy of the smart stick in reading the distance when there are obstructions made of varied materials. The distances are categorized into different ranges: 0-30, 31-50, 51-100, 101-200, and 200 and above in cm; these ranges indicate the proximity of the object or material being measured with from the sensor. Table 1 shows the readings of our smart stick after going through five trials

Table 2: Standard Deviation of the Results

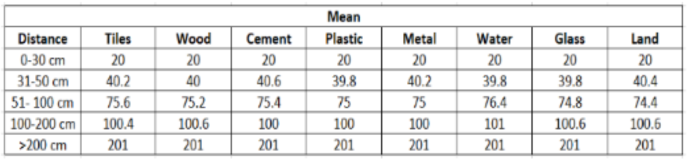


Standard Deviation								
Distance	**Tiles**	**Wood**	**Cement**	**Plastic**	**Metal**	**Water**	**Glass**	**Land**
0-30 cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31-50 cm	1.095	0.707	0.894	0.447	0.837	1.095	0.447	0.894
51- 100 cm	0.894	0.447	0.548	0.707	0.000	1.342	0.447	1.342
100-200 cm	0.548	0.894	0.707	0.000	1.000	1.225	0.894	1.342
>200 cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

101-200, the results are above 1 with the highest deviation value being at 1.342; although at 31-50 land was able to have a deviation of 0.894.

Despite this variability in measurements, the results still exhibit consistency with the readings as the maximum result value was not able to reach 2 which would indicate a high deviation.

Table 3: Mean of Results



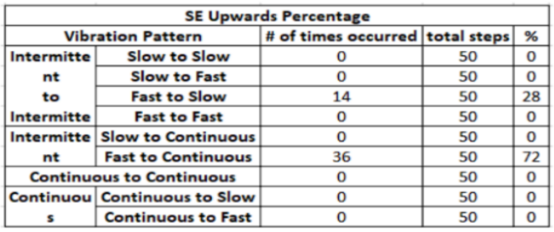
Mean								
Distance	**Tiles**	**Wood**	**Cement**	**Plastic**	**Metal**	**Water**	**Glass**	**Land**
0-30 cm	20	20	20	20	20	20	20	20
31-50 cm	40.2	40	40.6	39.8	40.2	39.8	39.8	40.4
51- 100 cm	75.6	75.2	75.4	75	75	76.4	74.8	74.4
100-200 cm	100.4	100.6	100	100	100	101	100.6	100.6
>200 cm	201	201	201	201	201	201	201	201

The mean values on the other hand represent the average distance at which the smart stick detected the objects made of the different materials which can then be compared to the actual distance to ensure its accuracy while the consistency in the mean values indicates a stable performance.

For distances from 0-30 cm and above 200 the mean detection was consistent across all materials indicating uniform accuracy in such proximity. Furthermore, across 31-50, 51-100, and 101-200 cm, the mean detection distances were slightly varied but still remained within a close range from each other and the actual value. This indicates a consistent performance across the moderate distances.

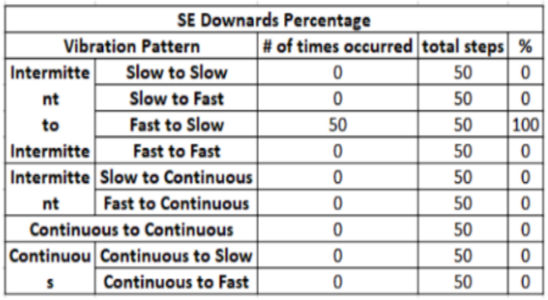
These results suggest that the smart stick demonstrates reliable detection capabilities across the different materials, especially in close and far proximity. The observed variability across the distances among the materials can be attributed to the material's properties that influenced the detection reliability.

Table 4: Stair Test Vibration Pattern Results (Upwards)



SE Upwards Percentage				
Vibration Pattern		**# of times occurred**	**total steps**	**%**
Intermittent to Intermitte	**Slow to Slow**	0	50	0
	Slow to Fast	0	50	0
	Fast to Slow	14	50	28
	Fast to Fast	0	50	0
Intermittent	**Slow to Continuous**	0	50	0
	Fast to Continuous	36	50	72
Continuous to Continuous		0	50	0
Continuous	**Continuous to Slow**	0	50	0
	Continuous to Fast	0	50	0

Table 5: Stair Test Vibration Pattern Results (Downwards)



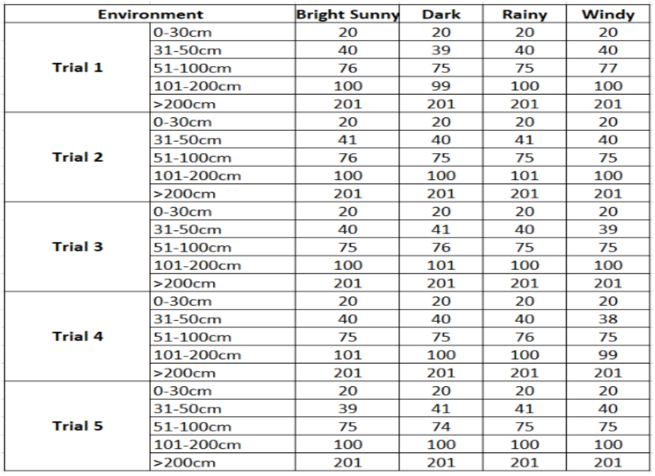
SE Downards Percentage				
Vibration Pattern		# of times occurred	total steps	%
Intermittent to Intermitte	Slow to Slow	0	50	0
	Slow to Fast	0	50	0
	Fast to Slow	50	50	100
	Fast to Fast	0	50	0
Intermittent	Slow to Continuous	0	50	0
	Fast to Continuous	0	50	0
Continuous to Continuous		0	50	0
Continuous	Continuous to Slow	0	50	0
	Continuous to Fast	0	50	0

Tables 4 and 5 show the percentages of the specific vibration pattern occurs upwards and downwards. For upwards the pattern that should occur is intermittent fast to continuous which occurred 72% for the 5’3” height trial while the remaining percentage occurred for a pattern of intermittent fast to slow. For downwards, the expected pattern is intermittent fast to intermittent slow which garnered a percentage of 100% throughout the trials.

Effect of the Environment to the Performance of the Smart Stick

This portion answers the second objective on how different environmental factors affect the performance of the Smart Stick.

Table 6: Raw Data for Objective 2

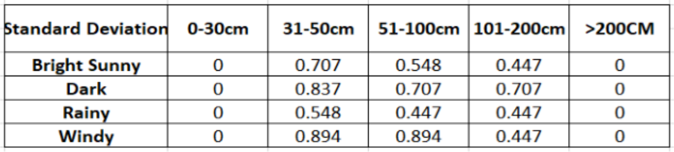


Environment		Bright Sunny	Dark	Rainy	Windy
Trial 1	0-30cm	20	20	20	20
	31-50cm	40	39	40	40
	51-100cm	76	75	75	77
	101-200cm	100	99	100	100
	>200cm	201	201	201	201
Trial 2	0-30cm	20	20	20	20
	31-50cm	41	40	41	40
	51-100cm	76	75	75	75
	101-200cm	100	100	101	100
	>200cm	201	201	201	201
Trial 3	0-30cm	20	20	20	20
	31-50cm	40	41	40	39
	51-100cm	75	76	75	75
	101-200cm	100	101	100	100
	>200cm	201	201	201	201
Trial 4	0-30cm	20	20	20	20
	31-50cm	40	40	40	38
	51-100cm	75	75	76	75
	101-200cm	101	100	100	99
	>200cm	201	201	201	201
Trial 5	0-30cm	20	20	20	20
	31-50cm	39	41	41	40
	51-100cm	75	74	75	75
	101-200cm	100	100	100	100
	>200cm	201	201	201	201

Table 6 presents the results to answer objective 2 of the study. Rather than the mere materials or surfaces being tested to determine the accuracy of the readings, the environmental factors were checked whether the smart stick’s detection changes as the environment varies.

The data collected by the smart stick suggest that there are some variations in the reading of the distance under the different environmental conditions that the researchers simulated or tested it in. Such varied results are mostly within the range of each other.

Table 7: Standard Deviation of Results



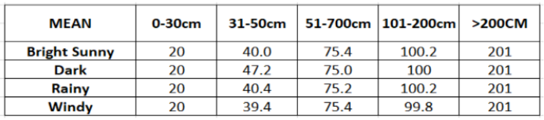
Standard Deviation	0-30cm	31-50cm	51-100cm	101-200cm	>200CM
Bright Sunny	0	0.707	0.548	0.447	0
Dark	0	0.837	0.707	0.707	0
Rainy	0	0.548	0.447	0.447	0
Windy	0	0.894	0.894	0.447	0

Under the 101-200 cm, the standard deviation remains consistent at 0.447 across all the environmental conditions except for dark which has a deviation of 0.707. This indicates consistent readings for the stated distance range.

It can be observed that the rainy condition was able to produce the lowest standard deviation values across all distance ranges while windy was the highest in 31-50 and 51- 100 cm with both at 0.894 while dark was the highest in 101-200 at 0.707.

The standard deviation remained at values below 1 which indicates low variability making the smart stick’s performance consistent across varied environmental conditions

Table 8: Mean of Results



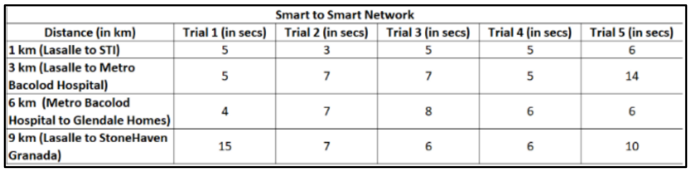
MEAN	0-30cm	31-50cm	51-700cm	101-200cm	>200CM
Bright Sunny	20	40.0	75.4	100.2	201
Dark	20	47.2	75.0	100	201
Rainy	20	40.4	75.2	100.2	201
Windy	20	39.4	75.4	99.8	201

The results of the mean are at similar values, except for dark at 31-50 cm as it is at 47.2 which is at a value that is at least 5 cm higher than the other environmental conditions within that range. Although it is relatively higher than the others, it still falls within the 31- 50 cm which is not a significant concern. The rest of the results have a 1 cm discrepancy brought about by the different environmental conditions across the distance ranges.

Effect of the Distance between the User and Emergency Contact to the Speed of Data Transmission

This portion answers the third objective which focuses on how the distance between the user and the emergency contact affects the speed or duration of the data transmission when the emergency button is pressed.

Table 9: Raw Data for Objective 3 (Smart to Smart Network Transmission)



Smart to Smart Network					
Distance (in km)	Trial 1 (in secs)	Trial 2 (in secs)	Trial 3 (in secs)	Trial 4 (in secs)	Trial 5 (in secs)
1 km (Lasalle to STI)	5	3	5	5	6
3 km (Lasalle to Metro Bacolod Hospital)	5	7	7	5	14
6 km (Metro Bacolod Hospital to Glendale Homes)	4	7	8	6	6
9 km (Lasalle to StoneHaven Granada)	15	7	6	6	10

The data from the Smart to Smart network transmission times, recorded over five trials for each distance (1 km, 3 km, 6 km, and 9 km), reveal insights into the performance of the network across varying distances.

For the 1 km distance between Lasalle and STI, transmission times ranged from 3 to 6 seconds across trials, suggesting consistent performance over short distances.

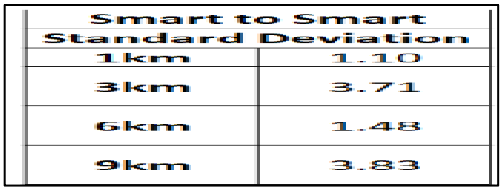
At the 3 km distance from Lasalle to Metro Bacolod Hospital, transmission times vary more noticeably, with a range of 5 to 14 seconds. This variability indicates potential challenges in maintaining reliable communication as distances increase within the network.

Moving to the 6 km distance from Metro Bacolod Hospital to Glendale Homes, transmission times showed relative stability, with less variability compared to the 3 km distance. However, there were still fluctuations among trials, suggesting potential factors affecting transmission reliability.

At the longest distance of 9 km from Lasalle to Stone Haven Granada, transmission times increased significantly, ranging from 6 to 15 seconds.

This suggests potential difficulties in maintaining prompt communication over extended distances within the Smart network.

Table 10: Standard Deviation of Results



Smart to Smart	
Standard Deviation	
1km	1.10
3km	3.71
6km	1.48
9km	3.83

The standard deviation data for Smart to Smart network transmission times provides additional insights into the consistency and variability of data transmission across different distances.

At the 1 km distance, the standard deviation is relatively low at 1.10 seconds. This suggests that transmission times are relatively consistent over short distances, with minimal variability among trials.

Moving to the 3 km distance, the standard deviation increases to 3.71 seconds. This higher value indicates greater variability in transmission times compared to the shorter 1 km distance, suggesting potential challenges in maintaining consistent communication over moderate distances within the network.

At the 6 km distance, the standard deviation decreases to 1.48 seconds compared to the 3 km distance. While still indicating some variability, this suggests relatively stable transmission performance over this distance, with less fluctuation among trials.

However, at the longest distance of 9 km, the standard deviation increases notably to 3.83 seconds.

This indicates a significant level of variability in transmission times highlighting potential difficulties in maintaining consistent communication over extended distances within the Smart network.

Table 11: Mean of Results

Mean (in secs)	
1km	4.80
3km	7.60
6km	6.20
9km	8.80

The mean transmission time data for Smart to Smart network communication sheds light on the average time taken for data transmission across varying distances.

At the 1 km distance, the mean transmission time is relatively low at 4.80 seconds. This suggests that data transmission occurs relatively quickly over short distances within the Smart network.

Moving to the 3 km distance, the mean transmission time increases to 7.60 seconds compared to the 1 km distance. This indicates a longer average time required for data to travel over moderate distances within the network.

At the 6 km distance, the mean transmission time decreases slightly to 6.20 seconds compared to the 3 km distance. This suggests that, despite the increase in distance, data transmission times may stabilize or even improve over certain distances within the Smart network.

However, at the longest distance of 9 km, the mean transmission time increases notably to 8.80 seconds. This indicates a significant increase in the average time required for data transmission over extended distances within the network.

IV. Conclusion and Recommendation

Conclusion

This research aimed to develop a smart stick that may serve as an alternative to white canes utilized by the blind. As it was stated on the background of the study and supported by previously conducted studies that white canes have a tendency to be unable to provide the blind with enough information on their surroundings while providing then with full mobility, smart sticks have been developed over the years however there are also gaps in such studies which compelled the researchers to develop this paper.

An ultrasonic sensor was utilized in contrast to the IR or present smart sticks. The results of the data that has been gathered by the researchers showed that at different ranges of distances and materials, the sensor is still able to detect and inform the user as it is expected to. In objective 1, the means have shown that the values remain at a similar range, suggesting stability and accuracy on its read values. Similarly, the standard deviation is low which indicates a consistency despite the differences in the surfaces of the materials.

When it comes to the stair tests done by users with heights of 5’3”, 5’5”, and 5’7”, results show that the vibration pattern for downwards is 100% consistent and accurate as it works the way it is expected to while in upwards at least 68% the vibration pattern is correct. Similarly, the height of the steps influences the results and readings as compared to the Cody and library stairs, the SE stairs have a different expected reading.

In Objective 2, the environmental factors were considered. This is where smart sticks that utilize IR sensors encounter problems; however, based on the results, the ultrasonic sensor has no issues as it was deemed to be stable, consistent, and accurate. In Objective 3, the speed in the transmission of data from the Smart Stick to a contact or receiver was tested. This was done with the user (sender) and the contact (receiver) being at different distances away from each other. The networks utilized were Smart to Smart and Smart to Globe. The standard deviation for both categories was high, indicating inconsistency in the speed of the transmission. However, it can be observed from the results that as the distance between the user and contact increased, the standard deviation decreased; thus, this indicates the possibility that the farther they are, the speed of transmission is more consistent.

Recommendation

The results of this study has shown that there is still much to improve in the devices and tools that blind individuals utilize. The emergency button is a crucial feature that can truly help such individuals in times of emergency as they are able to send a distress message or signal to their emergency contact for them to attend to. However, as the feature in this paper utilizes SMS, it takes a long time for the emergency contact to receive such a message. With this, it is recommended that future studies relating to this research may make use of 4G or data communication.

It would also be beneficial if a mobile application may be made for real time GPS tracking and notification. Through such mobile applications, emergency contacts may be updated easily rather than depending on the content or written contact information on the sim card in the system; the emergency notification that the contacts may receive will also be easily seen as it can be made as a pop up notification on the home screen.

In terms of the detection, the portion that would be best to improve upon is the smart stick's capability to detect slopes and stairs which will assist users better. Although the current design of the smart stick is able to cater to this need, it would be best to improve this feature through the use of a different algorithm or sensor.

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References

1. Sprouse, S. (2022, July 20). Making sense of your five senses. Ask The Scientists. https://askthescientists.com/senses/#toggle-id-1.
2. Blakely, M. (2023, April 10). The importance of sight and Vision – Molly blakely. Marvel Optics. https://marveloptics.com/blog/scholarship-program/the-importance-of-sight-and-vision-molly-blakely/#:~:text=Sight%20and%20vision%20are%20important,eyes%20then%20focus%20this%20light.
3. World Health Organization. (n.d.). Vision Impairment and blindness. World Health Organization. Retrieved September 24, 2022, from https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment
4. Ackland, P., Resnikoff, S., & Bourne, R. (2017). World blindness and visual impairment: Despite many successes, the problem is growing. Community eye health. Retrieved September 24, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC582068/
5. Riazi, A., Riazi, F., Yoosfi, R., & Bahmeei, F. (2016, May 2). Outdoor difficulties experienced by a group of visually impaired Iranian people. Journal of Current 133 Ophthalmology. Retrieved September 24, 2022, from https://www.sciencedirect.com/science/article/pii/S245223251530055X
6. Nichols, Allan (1995), Why Use the Long White Cane? https://www.blind.net/g42w0001.htm.
7. Nowshin, N., Shadman, S., Shadman, S., Joy, S., Joy, S., Aninda, S., … Minhajul, I. M. (2017). An Intelligent Walking Stick for the Visually-Impaired People. International Journal of Online and Biomedical Engineering (iJOE), 13(11), pp. 94–101. https://doi.org/10.3991/ijoe.v13i11.7565
8. Agrawal, M. P., & Gupta, A. R. (2018, September 27). Smart stick for the blind and visually impaired people. IEEE Xplore. Retrieved October 3, 2022, from https://ieeexplore.ieee.org/abstract/document/8473344.
9. Arora, A. S., & Gaikwad, V. (2017, June 15). Blind aid stick: Hurdle recognition, simulated perception, Android integrated voice based cooperation via GPS along with a panic alert system. IEEE Xplore. Retrieved from https://ieeexplore.ieee.org/abstract/document/7947957
10. Bele, S., Ghule, S., Gunjal, A., & Anwat, N. (2020, July 9). Design and implementation of smart blind stick. SSRN. Retrieved November 27, 2022, from https://papers.ssrn.com/sol3/papers.cfm?abstractid=3645413
11. Budilaksono, S., Bertino, B., Suwartane, Rosadi, A., Suwarno, Purtiningrum, Sari, Y., Suhandono, E., Sakti, Gustina, D., & Riyadi, A. (2020, January 1). Designing an Ultrasonic Sensor Stick Prototype for Blind People. IOP Publishing. Retrieved from https://iopscience.iop.org/article/10.1088/1742-6596/1471/1/012020/pdf
12. Bauer CM, Hirsch GV, Zajac L, Koo B-B, Collignon O, Merabet LB (2017) Multimodal MR-imaging reveals large-scale structural and functional connectivity changes in profound early blindness. PLoS ONE 12(3): e0173064. https://doi.org/10.1371/journal.pone.0173064