**DRAFT COPY OF PROJECT REPORT**

**DESIGN AND IMPLEMENTATION OF A SMART NAVIGATION SYSTEM FOR A BLIND STUDENT**

BY

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**CHAPTER 1: INTRODUCTION**

* 1. **BACKGROUND TO THE STUDY**

Our sight is a natural gift extremely essential in our daily activities. Blindness ensues when an individual experiences a loss of vision attributed to physiological or neurological factors. Complete blindness denotes the absence of any visual light perception, while partial blindness indicates a deficiency in the development of the optic nerve or the visual center of the eye [1]. According to World Health Organization (WHO) figures, an estimated 2.2 billion people globally have near or distant vision impairment [2]. That's about 28% of the world's population out of which 1.1 billion people are estimated to be living with vision loss [3]. A substantial amount of this population are students. Visually challenged students are posed with a lot of difficulties, one of which is navigating a school environment easily. The conventional means for navigation include a white cane which is usually swung around to detect obstacles, and a human aid to guide them throughout their journey. A guide dog that is already trained for navigation may be used but is quite rare in Nigeria. these methods however are not very efficient. The white cane may not effectively detect drop-offs or stairs, posing a risk in situations where elevation changes are not readily apparent. The white cane does not provide route planning assistance or navigation guidance. Users may need additional tools or technologies for efficient route planning and navigation. A human aid might give the visually challenged individual a sense of being a burden and may also lead to privacy concerns and loss of personal dignity, particularly in situations where the individuals may prefer to navigate independently. A human aid may not always be available which makes it a very impractical solution, especially in situations where immediate assistance is needed or when the visually challenged individual is alone. Guide dogs on the other hand are very expensive to acquire, train, and maintain. They also have a finite working lifespan. Hence, the need for a more efficient means of navigation involving ultrasonic sensors and a microcontroller for obstacle detection, water detection, map integration, and GPS for the location of the device in case of emergencies. A lot of smart navigation systems have been implemented already but this will be tailored to directing the individual from a hostel named Mariere Hall to the faculty of engineering entrance at the University of Lagos.

* 1. **PROBLEM STATEMENT**

Conventional means of navigation and guidance for visually disabled students are posed with a lot of shortcomings which include but are not limited to:

1. Lack of autonomy and privacy in the case of human aid.
2. Limited obstacle detection range in the case of a white cane
3. Lack of route planning assistance or navigation guidance.
4. Very costly with a finite working lifespan as in the case of a guide dog.

This project attempts to answer the problem statement “How might we improve the autonomy, safety, and navigational skills of individuals with visual impairments in a school setting through the creation of a cutting-edge smart walking stick system that incorporates features like environmental awareness, navigation, and GPS tracking capabilities?”

* 1. **PROJECT AIM**

This project aims to create a **smart navigation device** for a blind student at the University of Lagos with the following features:

1. Obstacle detection with vibrational feedback to protect against obstacles.
2. Water detection via an alarm sound to prevent accidents.
3. Navigation instructions from Mariere Hall to the Faculty of Engineering via audio feedback.
4. An emergency system with GPS that will send the location of the person to a loved one in the case of emergencies.

**1.4 PROJECT OBJECTIVES**

The objectives of this project are to:

1. Research about various smart navigation systems from previous works and relevant literature.
2. Research about indoor navigation technologies and techniques required to navigate visually impaired people.
3. Develop a suitable algorithm based on the chosen technique and implement it using relevant sensors.
4. Select a suitable microcontroller that can handle the required features.
5. Develop the obstacle and water detection features using ultrasonic sensors and water sensors respectively.
6. Develop of a GPS feature that can track the location of the stick and send a message to a loved one with the location in the case of an emergency.
7. Connect all the systems to the microcontroller unit.
8. Test and analyze the system.

**1.5 SCOPE OR LIMITATION OF PROJECT**

This project focuses on the design and implementation of **a smart walking stick** for a blind student, providing map guidance using a small case study from the hostel to the engineering faculty. This poses a limitation as the stick cannot direct the student past the two locations in the university. However, the project can serve as a blueprint for a more robust application and other features of the stick work in any environment.

**1.6 REPORT OUTLINE**

The report consists of four chapters. The first chapter gives an introduction to the project, its problem statement, aim and objectives, and scope. The second chapter provides a review of previous works related to the project and serves as a theoretical background for the project. The third chapter details the proposed methodology to achieve the objectives in chapter one. The last chapter highlights the work yet to be done.

**CHAPTER 2: LITERATURE REVIEW**

This section gives a review of the previous works that have been done related to the project. The review identifies a few limitations and suggests modifications to the previous works carried out.

In Paper [1], A solar-powered navigation technology was designed and implemented for the visually impaired. The design incorporates a PVC pipe as the cane, 1sheeld for communication with the smartphone, Arduino Uno as the microcontroller, ultrasonic and water sensors for obstacle detection, a buzzer, and a vibration motor to provide warnings through sound and vibration. These components are housed within a circuit box. The system is powered by a portable mini solar panel with a rechargeable battery. The blind individual’s phone is connected to the 1sheeld board through a Bluetooth link and the 1sheeld app is installed on the individual’s mobile phone. The system undergoes testing for emergency-calling and SMS features to ensure effective communication with guardians during panic situations. Usability tests are conducted in real-world outdoor settings to evaluate the system's accuracy in obstacle detection and navigation assistance for visually impaired individuals. The main objective of the research is to develop a safe navigation system that enables visually impaired individuals to navigate their surroundings effectively and communicate with their environment and guardians in case of emergencies. The system has limitations such as power supply dependency, sensor detection challenges, and complexity in GPS/SMS processing. The system however did not provide a means of directing the blind individual from one place to another and is unable to notify its users of fast-moving vehicles. Also, the use of vibration and sound to notify the individual of danger ahead is not optimal and can be confusing for the individual to decipher. The use of a vibration and voice-operated feedback system which informs the person on the nature and direction of impending danger would be more efficient.

In [4], A vibration and voice-operated navigation system for the visually impaired was implemented. Its features include the detection of obstacles using three ultrasonic sensors to detect barriers in the user's path. These sensors help in sensing the immediate surrounding environment against obstacles. Its feedback mechanism involves the use of vibrational alert and voice feedback system. A vibrator motor is used to create vibrational alerts when obstacles are detected. The intensity of vibration varies based on the distance between the person and the obstacle. For the voice feedback system, an ISD2560 ChipCorder is interfaced to produce speech output, providing verbal directions and warnings about obstacles. The system uses recorded voice prompts to guide the user. The microcontroller used here is the PIC 16F877A microcontroller. It measures the distance between the person and the obstacle using input from the ultrasonic sensors. The microcontroller also controls the motor circuitry for vibrational alerts and interfaces with the ISD2560 ChipCorder for voice feedback. When obstacles are detected, the system provides vibration and voice feedback to alert the user about the obstacle's direction and distance. The system can detect obstacles in three directions (front, left, right) and provide corresponding feedback. The user can move in any direction within a 70cm range without obstacles, indicated by inactive vibration and voice feedback. The system achieves a high accuracy of 95% when the white cane is tilted at a 45-degree angle. The ultrasonic sensor has a range of 10-200cm, but for maximum accuracy, a 70cm range is utilized Finally, the proposed method aims to create a portable, cost-effective, and user-friendly navigation aid for visually impaired individuals, combining vibration and voice feedback to enhance their mobility and safety in both indoor and outdoor environments. The system failed to provide a means of directing the blind individual from one place to another and cannot notify its users of fast-moving vehicles.

The authors in [5] propose a means of autonomous navigation through the city for the blind. This paper explores the use of easy-to-access audio-based GPS software to assist in the autonomous navigation of the city for people with visual disabilities. The study discusses the effect of the software on the stimulation of orientation and mobility skills in blind people, without the need for prior information about the environment. The paper also highlights the limitations of traditional verbal descriptions of the environment provided by sighted people and other developments in the field of GPS technology designed to aid the orientation and mobility of blind people. The research concludes that the audio-based software application can stimulate and strengthen navigation skills for blind people while supporting decision-making during navigation. Unfortunately, the software does not provide enough information to be able to detect certain obstacles in the path.

In Paper [6] a system that consists of ultrasonic sensors, infrared sensors, water sensors, a GPS module, a GSM module, and an audio module, connected to the microcontroller unit was proposed. Whenever an obstacle is encountered, the system transmits audio messages. It also has provisions made for a panic button which can aid the user to send panic messages to predefined emergency contacts in the case of an emergency. The message relays the GPS coordinates of the user to the emergency contact. This proposed solution uses ultrasonic sensors mounted 835mm away from each other on the stick. The user can also adjust this distance. Calculation of the real-time distance from the proposed stick to a detected obstacle is done by the ultrasonic sensors. The calculated distance is compared with the reference distance that was set at 50cm. To prevent the occurrence of an accident, the user hears a recorded message stating that an obstruction has been detected if the calculated distance is less than the threshold distance. Its bottom ultrasonic sensor is in charge of identifying items that are lying low in its path. The infrared sensor, whose shorter range makes it primarily responsible for detecting stairs, is situated at half the distance from the ground. Puddles and water pools are detected by the water sensor at the blind stick's base. The ISD 1820, which interfaces with the Arduino UNO, plays a message to the user indicating when such impediments are encountered. When the user presses the panic button attached to the stick, a GSM module attached to the Arduino UNO via UART connection transmits a message to the emergency contact. The GPS module interfaced with the Arduino UNO helps to send the user's coordinates to the designated emergency contact. In the event of such an emergency, a buzzer is activated so that onlookers can be warned and assistance can be sought. This is a cost-effective and lightweight system that easily detects obstacles and gives verbal cautions to avoid them. The system does not provide navigation information. A modification to the project would be to include a live tracking system where the individual can be tracked in real-time by his loved ones.

Reference [7] proposed and developed ALVU (Array of Lidars and Vibrotactile Units), a wearable device designed to assist visually impaired individuals in navigating their surroundings safely. ALVU utilizes time-of-flight sensors and haptic feedback to provide users with real-time information about obstacles and boundaries in their immediate environment. The methods employed in the development of ALVU involved integrating an array of sensors and feedback motors into a discreet wearable system to create an assistive navigation device for visually impaired individuals. The device consists of a sensor array with distance sensors and a haptic array with feedback units. Users wear ALVU with a haptic strap around their upper abdomen, allowing them to receive feedback about their distance from surfaces and obstacles in their surroundings. The primary reason behind the project was to create a contactless, intuitive, hands-free, and discreet wearable device that enables visually impaired users to detect obstacles and boundaries in their immediate environment for safe navigation. The goal was to provide users with detailed feedback about their surroundings to enhance their independence and mobility. One limitation of the project is the lack of extensive testing with blind users to verify the effectiveness of the device in real-world mobility tasks. While studies with blind subjects were conducted to assess the performance and effectiveness of ALVU, further testing with a larger sample size and in various environments could provide more robust insights into its usability and impact on users' mobility. Possible modifications to enhance the ALVU device could include improving the accuracy and range of the sensors to detect obstacles more effectively, refining the haptic feedback system to provide clearer and more intuitive cues to users, and incorporating additional features such as voice guidance or connectivity to mobile applications for enhanced navigation assistance.

The system proposed in [8] is an RFID-based system designed to assist blind individuals in navigating indoor spaces. The system consists of three main components: the track infrastructure, the navigation device, and the navigation server. RFID tags are embedded in the environment, such as in footpaths, to provide location information to users. The navigation device, equipped with an RFID reader, helps users navigate by detecting the RFID tags. Additionally, a navigation server assists in calculating the shortest path from the user's current location to a destination and can help users find a new route if they get lost. The system relies on RFID technology's passive communication circuit, enabling tags to store location information and transmit it to the reader within a proximity range.

The system aims to improve the independence and mobility of blind individuals within indoor environments by providing them with real-time location information and guidance. It is highlighted that the system can also be beneficial for other user groups, such as tourists in museums or firefighters in emergencies. This paper discusses related work in the field of indoor navigation systems and presents experimental results demonstrating the functionality of the proposed RFID-based navigation system. Limitations of the system may include communication delays due to the cold start cycle of the GPRS modem and voice playback delays from the MMC module. These delays can impact the system's real-time responsiveness and user experience. Additionally, the size of the system prototype may be a limitation in terms of portability and practicality for everyday use by blind individuals. This system also provided no room for obstacle and water detection and may not be entirely efficient for blind people. Possible modifications to enhance the system could include:

Reducing communication delays by optimizing the GPRS module's startup cycle.

Improving voice playback efficiency by storing frequently used words in ROM or pre-loading words in RAM for faster speech transfer.

Exploring the integration of speech synthesizers for generating voice prompts, potentially improving the overall user experience.

Exploring the integration of obstacle detection sensors to make the navigation device more suited to visually impaired people.

The Paper [9], presents a novel solution developed to assist visually impaired students in independent navigation of their university campus. The main goal was to create a navigation system that would enable visually impaired students to lead a normal university life without relying on assistance from others. The proposed system, COMPASS, consists of three main components: an Android application, a smart bracelet, and smart shoes. The Android application utilizes Proximi indoor navigation technology to guide students to their classes. The smart bracelet and smart shoes provide obstacle avoidance and location monitoring features to ensure the safety and accuracy of visually impaired students while moving around the campus. The methods employed in the development of the COMPASS system included testing the individual components independently and then integrating them to form a complete system. The system utilized Bluetooth beacons for indoor positioning, image processing for capturing and processing images, and obstacle avoidance sensors for detecting obstacles. The integration of these technologies aimed to provide a low-cost, re-configurable, and scalable solution for visually impaired students. However, the project faced certain limitations during implementation. Challenges included selecting the appropriate microcontroller for the smart bracelet, limitations in the coverage area of the system, the large size of the bracelet due to the selected microcontroller, and issues with capturing clear and accurate data from images. Modifications and future work proposed for the COMPASS system include enhancing Arabic text capture and recognition capabilities, extending the coverage area to include the complete campus, and introducing additional environmental sensors for safety alarms during emergencies.

Paper [10] presents a smart wearable device (smart glass) aimed at assisting visually impaired individuals in navigating indoor and outdoor environments. The project addresses the challenges faced by visually impaired individuals in traveling independently by utilizing ultrasonic sensors, NodeMCU, and a custom Android application. The primary motivation behind the project is to provide visually impaired individuals with a reliable and efficient tool for navigating their surroundings. By incorporating ultrasonic sensors for obstacle detection and a custom Android application for navigation assistance, the project aims to enhance the mobility and independence of visually impaired individuals. The hardware design includes three ultrasonic sensors mounted on a spectacle, connected to NodeMCU, and powered by an external battery. Communication with the application is facilitated through the ESP8266 Wi-Fi module. An ultrasonic sensor is mounted on the left side, another on the right side, and the last one in front of the wearable device. This is done to ensure that obstacles can be detected from all three sides. When an obstacle is found to be within 5 metres of the blind individual, the obstacle distance is measured by the ultrasonic sensors, and the value is sent to the microcontroller NodeMCU. The software design involves an Android application supplied with navigation information using Google API, enabling indoor navigation within a college campus. The system allows users to input desired locations through speech, which is then processed for navigation instructions. One limitation of the proposed system is the inability to detect ground-level obstacles and wet surfaces. Additionally, the system may have constraints in detecting obstacles in certain environmental conditions such as dust, smoke, or electromagnetic interference. The current model may also have limitations in terms of the range of obstacle detection and the accuracy of navigation instructions. Possible Modifications include: Future research work could focus on enhancing the obstacle detection capabilities of the system, possibly by implementing image recognition technology. Improvements in the wireless system could also be explored to enhance the overall responsiveness and efficiency of the device. Additionally, modifications to address the limitations in obstacle detection and navigation accuracy could be considered to further optimize the system for visually impaired users.

The writers in [11] proposed a smart guide for blind students called NavEye that consists of two major integrated modules which are a mobile application and a smart cane. The application module on the smart handheld device receives its input via user voice or QR code. A voice recognition module converts the user’s voice to text and a QR code module is used to detect and capture the QR image and converts it to text. When the user gives a command by voice or by scanning a QR code assuming that there are QR code tags on classroom doors with the classroom number, the system will ask the user to supply its current location the application checks if the starting location is included in the map or not. In case it does not exist, an error voice message will respond otherwise the application will store the current location and ask the user to give the desired destination. Following that, the system checks the destination. If the destination is known, the navigation process will start and if it is unknown, an error voice message will respond forcing the system to go back to the initial state. The cane module is used for obstacle detection via the use of ultrasonic sensors (HC-SR04), a microcontroller (Atmel Atmega8), and a DC motor to generate vibrations when an object is detected. The cane module was linked to the application module via Bluetooth. The cane was designed to keep the individual on the right path as the mobile application uses a compass to detect if the user goes out of the prescribed path and immediately alerts the cane. The use of QR codes may not be advisable for blind individuals because they cannot see the codes nor can they determine the exact location of the codes to be scanned. A modification to this project would be the integration of smart wheels into the smart cane to steer the person away from danger.

In Paper [12]], The writers propose a multi-sensor obstacle detection system for a smart cane via a model-based state-feedback control strategy to regulate the detection angle of the sensors and reduce the false alerts to the user. To accomplish this, the system was restructured into a state-space model and a linear quadratic regulator (LQR) controller was utilized. Dynamic feedback compensators were integrated to increase the accuracy of user alerts. Real-time experiments were performed and showed significant improvements in error reduction compared to conventional methods. This paper gives no information about navigation but purely focuses on sensor error optimization.

Ref [13] proposes a framework for map data representation for indoor navigation by blind people. This was done to promote indoor navigation by visually challenged individuals to give them a greater sense of autonomy. This paper also tabulates the problems that visually challenged people experience while navigating inside unfamiliar spaces and buildings, including the limitations and proposed solutions. This paper also groups objects into their various categories and gives a holistic view of the creation of a map for the visually impaired.

The proposed system in [14] employs the use of Google Directions API for outdoor navigation of visually impaired pedestrians. For this, a braille input system was established on a smartphone and a vibration belt called Blind’s Eye Vibration belt is used for navigation purposes. The system is summarized in five steps. In the first step, the blind user uses the power button of the smartphone to run the Blind’s Eye application by pressing it twice. In the next step, the system makes use of Google Fused Location Provider API to determine the user’s current location (latitude, longitude), which is then converted into the user’s street address. The system gives voice feedback to the user, informing him about his current location. Afterward, with the use of the customized touch screen Braille Keyboard, the blind person inputs different letters to establish his destination location. The system uses voice feedback only in the first three steps to interact with the user. In the next step, the system uses Google Directions API to find out the path from the user’s current location to the destination location entered by the user. Finally, in the last step, the application begins to navigate the blind person via the three vibration motors attached to the vibration belt that is worn by the blind person. In this last step, the smartphone is connected to the Arduino board by using a USB OTG cable. However, a wireless approach would have been more convenient for the connection. Several test cases were performed to evaluate the braille keyboard and evaluate the source to destination navigation. The entire system is an innovative approach to help a blind person navigate through the outdoor environment with the use of a smartphone. A major limitation is its lack of obstacle detection which makes it inefficient for a blind person to navigate independently. The paper also covers some limitations of using the Google Map API.

The invention proposed in [15] utilizes an ultrasonic sensor and water sensors to detect obstacles and water. The sensors are connected to a microcontroller together with two different buzzers. Different sounds for different types of obstacles, solid or liquid. The device does not provide a means to direct the blind individual from one place to another.

In [16], A wearable device was designed and implemented with features that include object recognition and identification of faces of choice with the aid of a camera Logitech C270. Ultrasonic sensors were also added at three fixed positions for obstacle detection during navigation. The system employed the use of optical character recognition and Google Translate to read text from images and convert the user’s speech to text respectively. The speech to text module aids in blind to deaf communication. The microcontroller used was Raspberry Pi. The system also included a GPS and GSM module to locate or track the user. The GSM and GPS modules are controlled with the atgmega328p microcontroller. The limitations of this device are its heavy reliance on the internet together with its size and weight. It also does not direct its user from place to place.

This paper [17] proposes a unique solution to the navigation problem of students and visitors on campuses. This solution involves the installation of BLE (Bluetooth Low Energy) transmitters in various locations on the campus and the use of a BLE terminal app on a smartphone or tablet to direct its users from their current location to their desired destination on campus. The BLE beacons do not require an internet connection to operate. This system was designed as a solution to the shortcomings involved in the traditional methods of navigation on campuses especially in unfamiliar environments. This project opens the door to a whole lot of possibilities using Bluetooth Low Energy. The paper did not give information about the tests performed.

The proposed smart stick in [18] utilizes ultrasonic sensors, Raspberry Pi, a vibration motor, a buzzer, RF module transmitter, a USB camera, and GPS. With the aid of these components, the smart stick is meant to detect obstacles and capture them using the camera. The picture is sent to the Raspberry Pi for processing to determine the nature of the obstacle and the Raspberry Pi warns about the obstacle using an ear pad. The RF transmitter has two buttons, one to locate the stick and the other reads the current location of the stick via GPS. To locate the stick in an event where the stick is lost, the button is pressed and a beep sound is produced. The writer does not give any information about tests carried out or the schematic of the design. The system also does not direct its user from place to place.

This paper [19] narrates the shortcomings of the GPS, Geographical Information System (GIS) data and map matching techniques in pedestrian navigation and proposes a solution based on adapted GSM with the combination of GPS and vision-based positioning. The paper also outlines several materials and means of navigation for blind people highlighting their advantages and disadvantages. The paper gives very little information about the proposed solution.

The proposed solution here [20] is an affordable approach. An application with all possible locations the user can go to is used with the aid of google assistant for voice input. Two coin motors were used to give feedback to the blind person. One coin vibrator indicates left and the other indicates right. They also employed the use of graphhopper API which is based on open street maps API for the mapping.

Reference [21] proposes the Implementation of a Smart Stick for Obstacle Detection and Navigation. The smart stick implemented in this paper consists of ultrasonic sensors, infrared sensors, water sensors, A GPS module, a GSM module, and an Arduino Uno microcontroller for processing. The ultrasonic sensors are utilized to detect obstacles in front of the blind from the ground level height to the head level height of the stick in the range of 400cm ahead. The infrared sensors are utilized for the detection of upward and downward stairs. The water sensor utilized here was three wire probes fixed at the base of the stick to detect wet surfaces like water pits and puddles. The GPS module was installed for navigation purposes. The GSM module was used to send emergency messages to stored emergency contacts. The proposed system was designed to store the current location of the stick which is received from the GPS and uses this location to calculate the distance to the destination location. However, the paper did not explain how the user will input the desired destination location. Once the sensors detect an obstacle, the user is warned by a beep sound whose intensity increases as the user draws closer to the obstacle. The drawbacks of this system are that it does not provide a means of directing the blind individual from one place to another and the stick is not designed to be foldable making it difficult to keep. A few modifications to the system would be the integration of an interface to direct the user from place to place, the integration of a braille input for the user to input the desired destination address easily, and programmable wheels to steer the person out of dangerous obstacles.

Reference [22] designed and implemented a smart walking stick for visually impaired people using ultrasonic sensors and Arduino. Their proposed system utilizes ultrasonic sensors, moisture sensors, and the Arduino Uno microcontroller for obstacle detection, water detection, and processing respectively. The ultrasonic sensor was connected to the microcontroller and codes were written with the Arduino sketch using C programming language. The moisture sensor used in this system was two wire probes that depend on the specific resistance of water to detect its presence when they are in contact. An RF transmitter was interfaced with the microcontroller together with an LCD. The sensors are constantly scanning for obstacles and sending real-time data to the microcontroller for processing. Immediately obstacles are detected, the microcontroller activates a buzzer. The system was designed using the proteus software. Several tests and simulations were carried out to determine the efficiency of the proposed system. This system is a low-cost and lightweight system designed to overcome the problems associated with independent navigation by the blind. The system has some drawbacks which include the inability to detect holes and the nature of the obstacles, the absence of a means to communicate the location of the individual to a relative or caregiver, and the lack of a means to give directions to the individual from one place to another. A few modifications to the system would be: Implementing a technology to determine the speed of incoming obstacles, integrating sensors for hole detection and detection of upward and downward stairs, employing an audio-based system for direction and alerting the user of obstacles in the path, and the integration of an emergency alert technology to alert the loved ones of the blind individual when the person is in danger.

This paper [23] aims to provide an overview of the state-of-the-art indoor positioning systems (IPS) for visually impaired individuals. The authors focus on analyzing the advantages and disadvantages of existing systems to enhance accuracy and usability for this user group. The review covers various technologies such as radio-based, inertial, sound-based, light-based, and computer-based systems, as well as hybrid approaches. The methodology involves classifying and reviewing individual IPSs, comparing different studies, and proposing future research directions. Limitations include the need for more independent evaluations of system performance and the challenge of balancing accuracy and speed in delivering information to users. Future modifications could involve adapting algorithms for different user positions, addressing hardware heterogeneity, improving energy efficiency, and integrating indoor and outdoor location services.

The study in [24] presents an indoor navigation system designed to assist visually impaired individuals in navigating indoor environments. The system focuses on maximizing usability, allowing users to identify their position, calculate movement velocity and direction, detect obstacles, and receive navigation information. Key components include a white cane with infrared LEDs, Wiimotes for capturing data, and a software application for managing environment information. The system aims to provide real-time navigation services, natural usability, useful information delivery, and affordability. Experimental evaluations with blindfolded participants showed promising results, indicating the system's potential to guide visually impaired individuals effectively. Further testing with visually impaired individuals in real environments is recommended to enhance the system's functionality and address limitations.

**2.1 REVIEW SUMMARY**

The methods discussed in most of the papers often involved the integration of software and hardware technologies to assist in navigating blind individuals. The software technologies involved the use of a mobile application. This project will involve the use of a standalone device with all the technologies embedded in it. A lot of previous works also failed to either provide a means of navigating the individual from one place to another [6] [15] [16]or did not provide a means to detect obstacles [8]. This project will provide a means to direct the student from a hostel location to the faculty of engineering. Finally, some works did not implement an emergency messaging system [4] which will be taken into account in this project to provide the blind student with a holistic solution.

**CHAPTER 3: PROPOSED METHODOLOGY**

This chapter discusses the proposed methodology for the implementation of the smart navigation device. This approach proposed here is based on works done in [4], [6], and [23]A review of various indoor navigation system techniques written in [23] elaborated on the use of inertial sensors for navigating through indoor environments. The peculiarity of navigating blind people was a factor involved in this proposed method coupled with the cost of implementation. The proposed methodology for the navigation system involves the use of IMUs (Inertial measurement units) to determine the distance traveled by the student and his orientation and compare it with the dimensions of the desired path from the hostel to the faculty interfaced with a microcontroller unit for processing.

**3.1 DESIGN OVERVIEW**

The approach that will be used in the design involves the following steps:

**Definition of the system requirements:** Definite establishment of the requirements and constraints of the project. Considering factors such as the accuracy of navigation instructions, device portability, battery life, user-friendliness, and cost.

**Hardware Selection:** Selection of suitable hardware components based on the requirements.

**Software Development:** Programming the microcontroller to process input from the sensors and provide appropriate audio instructions to the user. Codes will be written to calculate distances, trigger audio instructions, and handle user interactions.

**Distance Mapping:** A distance map of the route from Mariere Hall to the faculty of engineering will be created. Specific points where instructions will be providedwill be marked out.

**Prototype Implementation and Testing:** a functional prototype of the device will be built and extensive testing will be conducted to ensure its reliability and accuracy. It will be tested in various real-world scenarios to validate its effectiveness in providing accurate navigation instructions.

**Iteration and Refinement:** Based on user feedback and testing results, the device will be refined to address any shortcomings or improve its usability.

**3.2 DESIGN CONSIDERATIONS**

A stick is chosen to house all the components. A vibrotactile approach using haptic feedback was considered, but it will not be as accurate as using audio feedback attached to a stick. Also considering affordability and the fact that a stick can be used by anyone irrespective of their size or weight.

A PVC pipe is chosen to be used as the stick [1] because it is lightweight and can provide a means to house the wires that will be used to connect the components.

Since blind people are more sensitive to vibration, a vibration motor will be attached to the handle of the stick so that whenever an obstacle is detected the user is informed via the vibration. Whenever water is detected, a beep alarm will be produced. This distinction is made to ensure that the user is not confused.

The navigation guidance will be given via voice feedback. An ISD chip (IC) [4] will be incorporated into the navigation system to give voice output to the blind person. Upon receiving signals from the IMU (Inertia Measurement Unit: Consisting of a gyroscope, accelerometer, and magnetometer), the recorded direction information at that particular point stored in the addressing memory of the ISD chip will be played.

For the Emergency system, A GSM module interfaced with a GPS module was considered. But it won’t be optimal because GSM networks can be unreliable and the message may not be sent. To eliminate this shortcoming, an IoT approach using a web app connected to the Wi-Fi module of the microcontroller unit is proposed. The web app is regularly updated with the GPS coordinates of the stick. This serves a dual purpose as it can be used by a loved one to locate the stick if it is missing. So, when the user is in a precarious situation, a button that is provided will be pressed which will inform the microcontroller to send a notification to the web app.

All of these capabilities will require a powerful microcontroller unit for processing and more power so a suitable microcontroller that can handle the operations and a suitable rechargeable battery with the required capacity will be chosen.

**3.3 SYSTEM COMPONENTS**

The following components were chosen to achieve the specific design considerations:

* Microcontroller unit (ESP 32)
* Ultrasonic sensors
* Water sensor
* Infrared sensor
* GPS module
* IMU (Inertial Measurement Unit)
* Buzzer
* Power supply unit
* ISD Chip
* GSM module (Optional)
* Vibration motor

The distance map from Mariere Hall reception to Faculty of Engineering entrance has been measured and is displayed below without the distances.

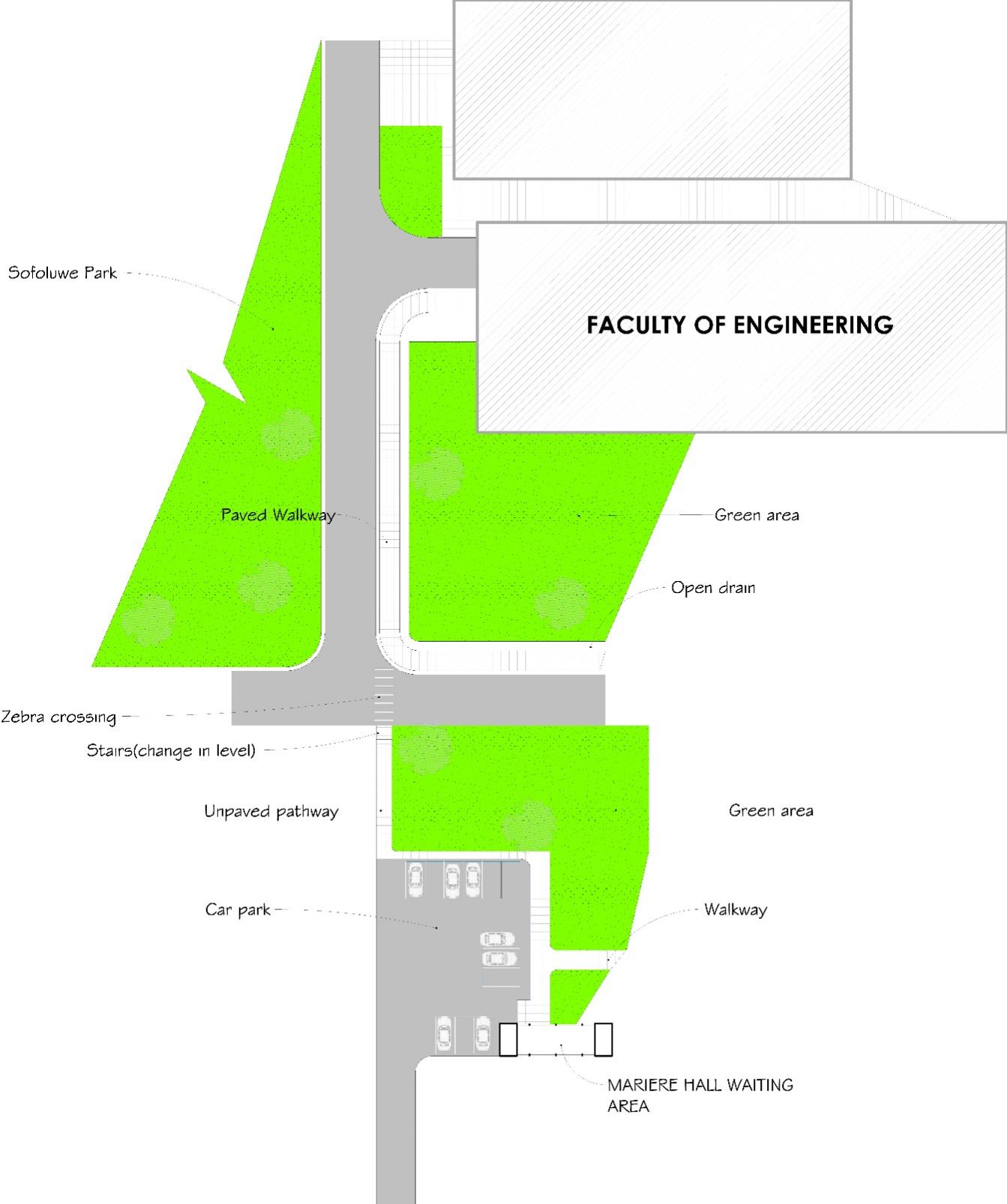


Fig 3.1: Map from Mariere Hall reception to Faculty of Engineering entrance.

**CHAPTER 4: WORK YET TO BE DONE**

For the design and implementation of the device, the following work is yet to be done:

1. Obtaining the required hardware components.
2. Research on the calibration of the IMUs against errors.
3. Developing the algorithm for navigation based on the map distances.
4. Development of the emergency system.
5. Circuit design and integration.
6. Testing and refinement.

**CONCLUSION**

In conclusion, this project aspires to design and implement a smart navigation device for a blind student with enhanced features that will make navigation and locomotion easier. This project is not only a standalone solution but also a foundational starting point, offering more opportunities for improvement on a larger scale.

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