

INDOOR NAVIGATION SYSTEM FOR VISUALLY IMPAIRED

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in Mechatronics

By

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DEPARTMENT OF MECHATRONICS

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade “A++” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **S. Rohith Kumar (Reg. No. 40090025)**, **A. Tamil Mani (Reg. No. 40090032)** who carried out the project entitled **"INDOOR NAVIGATION SYSTEM FOR VISUALLY IMPAIRED"** under our supervision from Nov 2023 to April 2024.

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ABSTRACT

The project of the Navigation System at Home for People with Visual Impairment is very important as it immensely changes accessibility and independence of visually impaired people. Though traditional navigation programs are meant for use outdoors, indoors do not work well due to unavailability of GPS signal, and there arise many problems. The project leverages advanced technologies such as GSM, GPS, humidity sensing, rain detection, ultrasonic sensors, and LIDAR to solve these challenges in a compact and portable device. The core operating system that collects analyses and makes decisions about the sensor data is an Arduino Nano microcontroller which lies at the center of this system.

In the age of technological advancement, the need for integrated solutions has become important, especially when it comes to helping visually impaired people get around at home. This project provides a comprehensive indoor education program designed to assist people with visual impairments by providing real-time guidance and problem solving. The system combines technologies such as GSM/GPRS communication, GPS location, humidity measurement, and ultrasonic and LiDAR sensors to provide comprehensive information for indoor use. The integration of the Arduino Nano microcontroller serves as a central, seamless integration of various modules into a compact and portable device. By strategically using ultrasonic sensors near the user, the system can detect problems in real time, allowing for timely warning and corrective action.

Additionally, the addition of the GPS module ensures accurate positioning, while humidity sensors and rain detectors increase environmental awareness, which is important to optimize the safety and comfort of the user experience. The use of GSM/GPRS communication strengthens the operation and usability of the system by facilitating remote service and emergency communication. Overall, the project incorporates a mix of innovation and contributions, offering a transformative solution that enables people with visual impairments to enter indoor spaces with confidence and independence.

The user interface has been designed to be simple to use with auditory cues, haptic feedback as well as intuitive controls. It gives users options of voice commands, button input or gestures depending on their abilities and preferences. Moreover, its versatility enables it to cater for many different desires of users hence making it all-inclusive and friendly to people.

To sum up, indoor navigation systems for visually impaired individuals are a significant step forward in assistive technology. The project seeks to improve mobility, independence, and quality of life for those who suffer from visual impairment by using modern technologies and innovative designs. Technology keeps advancing meaning that there is still more room for innovation in this sector that needs to be utilized fully in times coming ahead of us.

In summary, indoor navigation systems for the visually impaired represent a significant step forward in terms of assistive technology. The project aims to increase the mobility, independence, and quality of life of visually impaired people by harnessing the power of new technologies and innovative designs. As technology continues to advance, the potential for further innovation and development in this field is unlimited and promises to be exploited in the future.

Keywords: Navigation System, Visual Impairment, Indoor access, GSM/GPRS communication, GPS, humidity detection, rain detection, ultrasonic sensor, LiDAR, Arduino Nano microcontroller, Assistive technology, haptic feedback, Voice command.

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CHAPTER 1

INTRODUCTION

Indoor Navigation System for the Visually Impaired is a new project that aims to change the accessibility and freedom of the visually impaired. Traditional navigation devices such as canes and dogs are taken outdoors, but in indoor environments where GPS signals are not available, there are many problems [1]. It doesn't work well most of the time. The project aims to solve these problems by integrating technologies such as GSM, GPS, humidity measurement, rain detection, ultrasonic sensors, and LiDAR into a compact and portable device [2].

The core of the system is the Arduino Nano microcontroller, which is the central operating system for sensor data collection, analysis, and decision making. Through innovation and integration of various functions, the central navigation system aims to provide accurate, reliable, and timely navigation assistance. This project aims to eliminate barriers and promote integration into the daily living environment by helping the blind move around the house safely and easily [3].

Indoor navigation systems for the visually impaired represent a major advance in assistive technology. Traditional navigation devices such as canes and guide dogs have limitations when navigating indoor environments where GPS signals are difficult to receive and present many challenges [4]. The project solves these problems by integrating various technologies into portable devices.

Using products such as GM, GPS, humidity sensors, rain detectors, ultrasonic sensors, and LiDAR, the system provides real time navigation services according to the needs of non-users. At the heart of the system is the Arduino Nano microcontroller, which processes data from various sensors and determines navigation [5].

The main purpose of this project is to improve the mobility and independence of visually impaired people in closed areas. The system allows users to safely access

the indoor environment by providing accurate location information, detecting problems, and responding immediately [6]. A communication system has also been added to help users find remote assistance and exchange information with supervisors or support.

Overall, the indoor navigation project for the visually impaired aims to eliminate obstacles and promote navigation in the home environment by providing reliable services. The project, where new technology and user-friendly design are used, aims to increase the quality of life of visually impaired individuals.

1.1 RELATED WORKS:

1.1.1 A Review on Indoor Navigation Systems for Visually Impaired Individuals:

This comprehensive review explores existing indoor navigation systems tailored for individuals with visual impairments. The paper examines various approaches, including wearable devices, smartphone applications, and sensor-based systems, highlighting their strengths, limitations, and technological advancements.

1.1.2 Smart Cane: A Review of Electronic Travel Aids for Visually Impaired People:

This paper provides an in-depth analysis of electronic travel aids, with a focus on smart canes equipped with sensors and navigation capabilities. The review evaluates the effectiveness of different sensor technologies and navigation algorithms in aiding visually impaired individuals with indoor and outdoor navigation tasks [7].

1.1.3 Indoor Navigation System for the Visually Impaired: A Survey:

This survey paper investigates the challenges and opportunities in developing indoor navigation systems for individuals with visual impairments. The study

assesses the usability and effectiveness of various navigation techniques, such as RFID, Bluetooth, and computer vision, in assisting users in navigating complex indoor environments [8].

1.1.4 Assistive Technologies for Visually Impaired People:

A Survey of Recent Trends and Challenges": This survey provides an overview of recent trends in assistive technologies for visually impaired individuals, including indoor navigation systems. The paper discusses challenges such as localization accuracy, obstacle detection, and user interface design, while also highlighting emerging technologies and research directions in the field [9].

1.1.5 Evaluation of Indoor Navigation Systems for Visually Impaired Users:

A Comparative Study": This study compares the performance of different indoor navigation systems through user evaluations and empirical testing. By assessing factors such as accuracy, reliability, and user satisfaction, the research aims to identify the strengths and weaknesses of existing solutions and inform the development of more effective navigation aids for visually impaired individuals [10].

Regarding the regional operation of indoor navigation systems for the visually impaired, various methods and designs have been investigated to solve problems specific to indoor navigation [11]. The research examines the use of sensor-based systems, wearable devices, and smartphones to provide rapid assistance to visually impaired users and improve mobility [12].

An important area of work is the development of sensor-based navigation systems that detect obstacles and provide users with spatial perception using a combination of sensors such as ultrasonic, LIDAR, and infrared sensors. These systems are designed to complement traditional services such as free canes and guide dogs by providing additional environmental information and alerts to help users navigate safely and independently [13].

Another area of research examines the use of wearable devices such as smart glasses or haptic feedback vests to provide guidance and attention-grabbing information to users [14]. Technologies such as GPS, inertial sensors, and audio or feedback can provide instant assistance and increase the user's location awareness in the indoor environment.

In addition, smartphone applications that offer features such as voice guidance, indoor maps, and alerts have become a popular platform for home solutions. These apps use smartphones' built-in sensors and capabilities to provide easy-to-use and effective services for the visually impaired [15].

Furthermore, the study is concerned with the importance of user orientation and accessibility in the development of internal navigation systems. By collaborating with users during the design process, researchers and developers can ensure navigation solutions meet the specific needs and preferences of people with visual impairments, resulting in better solutions and better customer service.

Overall, the field of indoor navigation systems for the visually impaired continues to use technology and design for users to improve the mobility, independence, and quality of life of the blind. Ongoing research and innovation in this area has the potential to further improve the accessibility and participation of visually impaired people in indoor spaces.

1.1 VISUAL IMPAIRMENTS:

1.2.1 Background and Context:

Visual impairment is a global health problem affecting millions of people worldwide. According to the World Health Organization (WHO), approximately 285 million people live with visual impairment, and 39 million of them are considered blind. These conditions include a range of visual impairments, from mild to severe, and can be caused by a variety of causes, such as disease, trauma, or age-related degeneration [16].

The effects of blindness extend beyond blindness. Vision itself affects all aspects of daily life. Visually impaired people may experience problems with mobility, communication, education, work, and social participation. Navigating the indoor environment is particularly challenging due to the complex and dynamic nature of the indoor environment [17].

Current indoor solutions, such as tactile maps or electronic navigation systems, have limitations such as dependency on external infrastructure or a lack of immediate feedback. Tactile maps provide static information about the layout of enclosed spaces but do not provide instant updates or navigation assistance. Electronic navigation systems rely on technologies such as Bluetooth beacons or Wi-Fi networks that may not be available or accessible [18].

Due to these challenges, the need for interior solutions specially designed for the visually impaired is increasing. These solutions must solve the unique challenges of navigating a confined environment by providing fast, reliable, and efficient service.

1.2.2 Effects of blindness:

Visual impairment can affect all aspects of daily life, including mobility, communication, learning, employment, and participation in society [19]. People with visual impairments may experience problems and difficulties in accessing information, navigating the environment, and participating in society. One of the most important problems faced by visually impaired people is mobility. Navigating unfamiliar environments, crossing roads, and using public transportation can be daunting tasks without adequate support and assistance [20]. Restrictions on transportation and travel benefits will increase stress, increase isolation, and reduce freedom. Visual Impairment table given below:

Table 1.1 Visual Impairment Table

Grade of Impairment	Snellen's visual acuity	Performance	Average visual field radius
0	Better than 20/70	Mild or no visual impairment	60° 50° 40°
1	20/70 to better than 20/200	Moderate visual impairment	30° 20°
2	20/200 to better than 20/400	Severe visual impairment (difficulty reading even with aids)	10° 8°
3	20/400 to better than 20/1200	Blindness	6° 4°
4	20/1200 to light perception	Blindness	2°
5	No light perception	Blindness	0°

1.2.2.1 Challenges:

Visibility can inhibit mobility, making it difficult for people to navigate their environments safely and independently. Without adequate visibility, activities such as crossing the street, using public transportation, and navigating unfamiliar environments can be stressful [21]. These challenges are exacerbated by restrictions on transport and mobility aids, reduced mobility, and increased dependence on the help of others. Example: Sarah, who has been blind since birth, had difficulty walking on her own at university. She often relies on friends or school volunteers to help her find places to talk and find her way in the large family.

1.2.2.2 Communication:

Visual impairment can cause communication barriers, making it difficult for a person to interact with others and access information. Difficulty recognizing faces, reading printed materials, or interpreting visual messages can lead to misunderstandings and isolation. Limited access to other forms of communication, such as Braille or assistive technology, further compounds these challenges [22]. Example: John recently lost his vision due to eye degeneration and is having difficulty communicating with colleagues during team meetings. He had difficulty following a presentation or reading a map on the screen.

1.2.2.3 Educational Limitations:

Visual impairment can cause serious problems in accessing education and training. Individuals may have difficulty reading books, writing, or participating in classroom activities. Limiting access to educational materials in accessible formats such as Braille, large print, or digital texts further hinders learning and achievement. Example: Emily is a high school student with poor eyesight. It is difficult for him to keep up with his classmates in reading and taking exams [23]. Even when she uses a magnifying glass and a screen reader, she finds complex curriculum difficult to access and understand.

1.2.2.4 Occupational Disability:

Visual impairment can hinder performance and advancement at work, limiting one's opportunity to interact much with people at work. Discrimination, a lack of housing, and inadequate workplaces can hinder employment opportunities and lead to unemployment or joblessness for visually impaired people [24]. Example: David, a visually impaired person, faces problems finding employment despite his skills and abilities. qualification. He had difficulty getting into job interviews and had trouble finding employers willing to address his blindness.

1.2.2.5 Social Isolation and Its Impact on Mental Health:

As an individual, blindness can lead to mental health issues that can lead to isolation and loneliness, depression, and low self-esteem. Restrictions on social participation, stigma, and discrimination can lead to feelings of isolation and mental health problems such as depression and anxiety [25]. Example: Maria has recently lost sight of the situation and feels isolated from her friends and family. He or she has difficulty participating in activities and experiences depression and hopelessness.

These challenges highlight the significant impact of visual impairment on all aspects of a person's life, suggesting the development of effective solutions to support mental health and improve the quality of life of the visually impaired.

1.2.3 Limitations of existing solutions:

Tools such as canes and guide dogs used in traditional use have limitations when walking in closed areas. Canes often present problems with the ground and may not provide adequate impact at chest or head height [26]. Service dogs require extensive training and may not be suitable for everyone who is blind due to factors such as allergies or housing restrictions.

Indoor solutions such as tactile maps or electronic navigation systems have the following limitations: external dependency or a lack of immediate feedback. Tactile maps provide static information about the layout of enclosed spaces but do not provide instant updates or navigation assistance. Electronic navigation systems rely on technologies such as Bluetooth beacons or Wi-Fi networks that may not be available or accessible [27].

1.2.3.1 Traditional Navigation Aids:

Traditional navigation aids, such as white canes and guide dogs, are important tools for visually impaired people to navigate their environments. But these tools have limitations, especially when it comes to indoor navigation [28]. White canes usually indicate problems on the ground and do not give enough information about the effect of chest or head height. Service dogs require extensive training and may not be suitable for everyone due to factors such as allergies, housing restrictions, or the inability to afford and care for a service dog [29]. Example: Sarah, a visually impaired person, uses her white cane for outdoor activities but has difficulty walking indoors, such as to a shopping mall or workplace. The bar does not provide sufficient information about chest or head height issues, leading to collisions with overhanging objects or protruding obstacles.

1.2.3.2 Disadvantages of electronic navigation systems:

Electronic navigation systems, such as GPS-based system navigation applications or beacon-based systems, are promising for indoor use. However, these systems still have limitations such as dependency on external systems, exposure issues in closed environments, and the need for constant internet connection. Additionally, electronic navigation systems may not provide immediate feedback or navigation assistance, limiting their effectiveness in changing indoor environments [30]. Example: John uses his smartphone for indoor use and is having trouble finding his target while walking through a large conference room. The app relies on the GPS signal at home, which can lose accuracy and lead to wrong directions or incomplete information.

1.2.3.3 Challenges of Tactile Maps:

Tactile maps have been used to provide tactile representations of indoor spaces, allowing visually impaired people to understand the layout and conditions. They can get along well in a single household. However, haptic maps also have limitations such as static information, limited indoor space, and the inability to provide real-time updates or navigation services. Additionally, tactile maps may not be useful or practical in all indoor environments [31]. Example: Emily, a blind college student, is having trouble navigating the college library using a tactile map. The map provides limited information about the library layout and does not include real-time updates about furniture changes or temporary disruptions.

1.2.3.4 Relying on Human Assistance:

Many visually impaired people rely on human assistance from caregivers or volunteers to reach unfamiliar places indoors. free help. While human assistance can be helpful, it may not be easy or reliable. Dependence on people can also limit a person's freedom and independence because they will not be willing to explore new places or participate in activities without help [32]. Example: David is blind and often relies on friends or family to accompany him to new restaurants or stores.

Although he appreciates their help, he feels that he can walk these places on his own without needing the support of others.

1.2.3.5 Cost and accessibility issues:

Many of the available solutions, including electronic devices, apps, or technology, can be expensive and impractical for people with limited resources. High costs, a lack of insurance, or limited financial resources may hinder visually impaired people from accessing assistive devices and equipment [33]. Example: Maria, living on a fixed income, cannot afford to purchase a special navigation device or smartphone app for her home. She relied on navigation services and humanitarian aid but was disappointed by their unavailability due to financial constraints.

These limitations highlight the need for new indoor navigation solutions that address the unique challenges and limitations of navigation aids and technologies for blind people.

1.2.4 Purpose of the Project:

The main purpose of this project is to create a new indoor navigation system designed for the visually impaired. This navigation system is designed to solve specific problems related to navigation in the home environment by providing accurate, reliable, and user-friendly navigation services at the time.

This project aims to integrate technologies such as GPS, LiDAR, and ultrasound with GSM communication modules to create indoor solutions. Using this technology, navigation systems will be able to provide users with accurate location, obstacle detection, route planning, and real-time guidance.

Develop a new home navigation system. The main goal of this project is to create a new home navigation system designed for the visually impaired. This navigation system is designed to solve specific problems related to navigation in the home environment by providing accurate, reliable, and user-friendly navigation services.

The project aims to create solutions that increase the freedom, safety, and quality of life of the visually impaired by using the most advanced technology and designs used by users [34].

1.2.4.1 Integration of advanced technologies:

The home navigation system will use technologies such as GPS, laser radar, ultrasonic sensors, GSM communication, and language modules to provide navigation services. This technology will enable users to achieve accurate location determination, obstacle detection, route planning, and real-time guidance, improving their ability to navigate the indoor environment confidently and independently.

1.2.4.2 User-centered design approach:

User-centered design principles will guide development to ensure that indoor navigation systems are designed with the needs, tastes, and abilities of the blind in mind. The project aims to create desirable, useful, and user-friendly navigation solutions by collaborating with users during the design process. Prototyping and iterative testing will be conducted to gather user feedback and insights to support the continuous development and improvement of the system.

1.2.4.3 Accessibility and Inclusivity:

Accessibility and inclusivity are the key principles of the project to ensure that indoor orientation is accessible to people with different needs and abilities. The system will include flexible and customizable features to suit the user's preferences and optimize usability. We will also work to ensure that the system complies with accessibility standards and guidelines so that it can be used by many users.

1.2.4.4 Actual deployment and impact evaluation:

After development, the indoor guidance system will be implemented and tested in a real environment to evaluate its benefits, usability, and impact on users' lives. User feedback and performance metrics will be collected and analyzed to evaluate system performance and identify areas for improvement [35]. The project team will work closely with community partners, stakeholders, and end users to ensure the system meets the needs and expectations of the community.

The project also focuses on customizing the user experience to suit individual preferences and needs. Every user is unique with different levels of mobility, preferences, and navigation challenges. Therefore, the indoor navigation system provides functions such as voice guidance, personal planning, and customization to meet the needs of different customers. This improves usability and user satisfaction by ensuring that each user has an experience that suits their specific needs and preferences.

CHAPTER 2

LITERATURE SURVEY

Name: Alejandro Santos Martinez-Sala, Year: 2015, Title: Design, implementation, and evaluation of an indoor navigation system for visually impaired people, Work Explanation: This paper presents SUGAR, an indoor navigation system for visually impaired people which uses UWB for positioning, a spatial database of the environment for pathfinding through the application of the A* algorithm, and a guidance module. The interaction with the user takes place using acoustic signals and voice commands played through headphones. The suitability of the system for indoor navigation has been verified by means of a functional and usable prototype through a field test with a blind person. In addition, other tests have been conducted to show the accuracy of different relevant parts of the system.

Name: Rosen Ivanov, Year: 2010, Title: Indoor navigation system for visually impaired, Work Explanation: One of the most important limitations for people with visual impairment is the inability of unassisted navigation and orientation in unfamiliar buildings. A low-cost indoor navigation system, which is based on mobile terminals, supporting technology Near Field Communication (NFC), and Java program access to Radio Frequency Identification (RFID) tags, is developed. The proposed navigation system enables users to imagine the map of the rooms (dimensions, relative position of points of interest).

Name: Darius Plikynas, Year: 2020, Title: Indoor navigation systems for visually impaired persons: Mapping the features of existing technologies to user needs, Work Explanation: This paper's survey of blind experts has shown that after outdoor navigation, the second most important ETA feature for VI persons is indoor navigation and orientation (in public institutions, supermarkets, office buildings,

homes, etc.). VI persons need ETA for orientation and navigation in unfamiliar indoor environments with embedded features for the detection and recognition of obstacles (not only on the ground but also at head level) and desired destinations such as rooms, staircases, and elevators.

Name: Charalampos Tsirmpas, Year: 2015, Title: An indoor navigation system for visually impaired and elderly people based on Radio Frequency Identification (RFID), Work Explanation: In our paper we present a unique and elegant architecture of an indoor navigation system as an integrated and tested system in real time. This solution enables the localization of the user, as well as the navigation considering scenarios that the user might follow and suggests guidelines for self-navigation. To evaluate the feasibility of the proposed architecture we carried out experimental scenarios to prove that the system proposed is suitable enough to guide elderly people through an unknown built environment.

Name: Rosen Ivanov, Year: 2017, Title: An approach for developing indoor navigation systems for visually impaired people using Building Information Modeling, Work Explanation: This article presents a Building Information Model (BIM), which describes the topology, geometry, and semantics of buildings; user preferences; and status of sensors deployed in the building. The aim is to propose an approach for developing a context-aware indoor navigation system, which assists blind and visually impaired people in unfamiliar large public buildings with complex horizontal and vertical connectivity. The proposed building data model aims to overcome the drawbacks of existing BIM-based Indoor Navigation Systems (INS).

Name: Dhruv Jain, Year: 2014, Title: Pilot evaluation of a path-guided indoor navigation system for visually impaired in a public museum, Work Explanation: Our system is an omnipresent cellphone based indoor wayfinding system for the visually impaired. It provides step-by-step directions to the destination from any location in the building using minimal additional infrastructure. The carefully calibrated audio, vibration instructions and the small wearable device helps the user to navigate efficiently and unobtrusively. In this paper, we present the results from pilot testing of the system with one visually impaired user in a national science museum.

Name: Xiaochen Zhang, Bing Li, Year: 2015, Title: A slam based semantic indoor navigation system for visually impaired users, Work Explanation: This paper proposes a novel assistive navigation system based on simultaneous localization and mapping (SLAM) and semantic path planning to help visually impaired users navigate in indoor environments. The system integrates multiple wearable sensors and feedback devices including an RGB-D sensor and an inertial measurement unit (IMU) on the waist, a head mounted camera, a microphone and an earplug/speaker.

Name: Ahmad Alnafessah, Year: 2016, Title: Developing an ultra-wideband indoor navigation system for visually impaired people, Work Explanation: The number of individuals who suffer from visual impairment is increasing rapidly. The most significant barrier to improving the lives of the blind and visually impaired people is their inability to navigate independently and safely. Indoor navigation systems for blind and visually impaired people aim to guide them in navigating independently in familiar and unfamiliar environments.

Name: Luis A Guerrero, Year: 2012, Title: An indoor navigation system for the visually impaired, Work Explanation: This paper presents an indoor navigation system that was designed taking into consideration usability as the quality requirement to be maximized. This solution enables one to identify the position of a person and calculates the velocity and direction of his movements. Using this information, the system determines the user's trajectory, locates possible obstacles in that route, and offers navigation information to the user.

Name: Parth Mehta, Year: 2011, Title: VI-Navi: a novel indoor navigation system for visually impaired people, Work Explanation: This system includes plug and play transmitter node modules which can be mounted anywhere on the ceilings and works on building customizable text-based maps stored in SD cards making it a portable cost-effective solution to indoor navigation needs. Buildings equipped with this system are termed as "VI Friendly" buildings.

Name: Chaitali Kishor Lakde, Year: 2015, Title: Navigation system for visually impaired people, Work Explanation: Navigation assistance for visually impaired (NAVI) refers to systems that can assist or guide people with vision loss, ranging

from partially sighted to totally blind, by means of sound commands. Many researchers are working to assist visually impaired people in different ways like voice-based assistance, ultrasonic based assistance, camera-based assistance and in some advance way researchers are trying to give transplantation of real eyes with robotic eyes which can capable enough to plot the real image over patient retina using some biomedical technologies.

Name: Fatma El-Zahraa El-Taher, Year: 2021, Title: A Systematic review of urban navigation systems for visually impaired people, Work Explanation: Blind and Visually impaired people (BVIP) face a range of practical difficulties when undertaking outdoor journeys as pedestrians. Over the past decade, a variety of assistive devices have been researched and developed to help BVIP navigate more safely and independently. In addition, research in overlapping domains are addressing the problem of automatic environment interpretation using computer vision and machine learning, particularly deep learning, approaches.

CHAPTER 3

AIM AND SCOPE

3.1 AIMS AND OBJECTIVES OF THIS RESEARCH:

The purpose of this research is to develop and evaluate an indoor navigation system designed for the visually impaired. By combining technologies such as GSM, GPS, humidity sensors, rain sensors, ultrasonic sensors, and LiDAR with compact and portable devices, the system aims to solve the problems that visually impaired people encounter while moving around the house. Scope of the research: It involves the design, development, implementation, and evaluation of indoor navigation systems with a focus on usability, effectiveness, and comprehensiveness.

3.2 PURPOSE STATEMENT:

The purpose of this research is to develop a new home navigation system, especially for the visually impaired. This navigation system addresses the key challenge visually impaired people face when navigating indoor environments where traditional aids such as canes and guide dogs are often inadequate. The system strives to provide accurate, reliable, user-friendly, and timely service by integrating advanced technology and systems.

3.3 SCOPE OF THE SURVEY:

Scope The survey covers all aspects of the development, implementation, and evaluation of home navigation systems. This includes choosing the right equipment, such as GSM, GPS, humidity, rain detection, ultrasonic sensors, and lidar, and placing them in a compact, portable device. The research also

includes generating user insight, demonstrating intervention and planning strategies, and evaluating the effectiveness of different indoor environments.

3.4 SURVEY GOALS:

Main Goals The aim of this study is to design and develop a home-based program to improve the mobility and independence of people who are blind indoors. This includes ensuring accurate location, instantly detecting problems, creating optimal visualization, and facilitating communication with maintenance or support. Additionally, the survey aims to evaluate the usability, effectiveness, and user satisfaction of the developed system through rigorous testing and review of recommendations.

3.5 INNOVATION AND IMPACT:

Research is driven by determination: innovation and social impact to support technology and improve the quality of life of visually impaired people. By harnessing the power of technology, home learning systems offer a solution to long-standing challenges, opening new possibilities for independent navigation and integrated participation in the indoor environment. The potential impact of this research extends beyond the development of navigation systems to stimulate future research, collaboration, and innovation in service technology.

CHAPTER 4

MATERIALS AND METHODS

The experiment has several stages, including product selection, design, modeling, testing, and evaluation. Equipment selection is based on accuracy, reliability, cost-effectiveness, and compatibility with the entire design process. The design process involves integrating selected components into portable devices, including user interface design, sensor placement, power management, and communications.

4.1 SPECIFICATIONS:

- i) Microcontroller: Arduino Nano
- ii) Communication Module: SIM900A 1800/1900 MHz Wireless Extension Module GSM GPRS Board with Antenna
- iii) Positioning System: GPS Module
- iv) Environmental Sensors:
 - *Humidity Sensor
 - *Rain Detector Sensor
- v) Obstacle Detection Sensors:
- vi) Four Ultrasonic Sensors (positioned around the stick)
- vii) LiDAR (Light Detection and Ranging) Sensor
- viii) Power Source: Rechargeable Battery Pack (not specified)

4.2 DIMENSIONS AND WEIGHT

Dimensions of stick housing Arduino Nano and sensors:

Length: Approximately 30 cm (12 inches)

Diameter: Approximately 2.5 cm (1 inch)

Weight of entire setup: [Estimated weight: Approximately 200-300 grams (7-10 ounces)]

4.3 FEATURES:

- i) Real-time Communication: Utilizes GSM/GPRS module for remote communication and assistance.
- ii) Outdoor Navigation: GPS module enables outdoor navigation capabilities.
- iii) Environmental Monitoring: Humidity and rain detection sensors provide environmental data for user safety.
- iv) Obstacle Detection: Ultrasonic sensors and LiDAR technology offer comprehensive obstacle detection and mapping.
- v) Compact and Portable: Designed for ease of carrying and use in various indoor environments.
- vi) Modular Design: Allows for scalability and customization to accommodate different user needs.
- vii) Integration: Sensors and modules seamlessly integrated with Arduino Nano for efficient data processing and feedback generation.

4.4 COMPONENTS USED:

4.4.1 Microcontroller (Arduino Nano):

Used as a functional framework for sensor integration and data processing and provides multi-platform for feedback and real-time control. Arduino Nano is a compact and versatile microcontroller that shares many features and functionality with the larger Arduino Uno. Below is a detailed description of Arduino Nano specifications and features and pin configuration:



Fig;4.1 Microcontroller (Arduino Nano)

Power supply:

- i) Arduino Nano can be connected to VIN pin via USB port or external power supply.
- ii) Although voltages between 6V and 20V are accepted, the recommended input voltage range is 7-12V.
- iii) To ensure stability, it is recommended not to apply voltage below 7V.

Power Pin:

- i) 5V: Provides a constant 5V voltage controlled by the onboard voltage regulator. Can be used with USB connection, VIN pin or 5V pin.
- ii) 3.3V: Supply 3.3V, maximum current consumption 50mA.
- iii) GND: Ground pin used to complete the circuit.

Memory and Analog Input:

- i) Arduino Nano has an ATmega328 microcontroller with 32KB Flash Memory, 1KB EEPROM and 2KB SRAM.
- ii) Analog inputs (A0-A7) provide a totally of 1024 different 10-bit resolutions.
- iii) The default measurement for analog devices is ground to 5 volts.

Digital Pins:

- i) Nano provides 14 digital pins (D0 -D13), each pin can be configured as input or output.
- ii) These pins operate from 5V and have pull-up support, can withstand up to 40mA.
- iii) Some pins have special functions:
- iv) Pins 0 (RX) and 1 (TX) are designed for : data communication.
- v) Pins 3, 5, 6, 9, 10 and 11 support pulse width modulation (PWM) output.
- vi) Pins 10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK) are reserved for SPI communication.
- vii) Digital pin 13 has an integrated LED that turns on when set high.

Additional features:

- i) Nano includes a CP2102-based USB-TTL interface for plug-and-play connection to your computer.
- ii) It has a compact form, making it suitable for small projects and integration into embedded systems.

In conclusion, Arduino Nano has a wide range of features and functionality packed into a compact and versatile package; making it a great choice for design, DIY projects, and situations where restrictions aren't built in. Its various pin configurations and compatibility with a variety of sensors and peripherals make it a popular choice among hobbyists, students, and professionals.

4.4.2 Communication module (SIM900A GSM/GPRS card):

Integrated SIM900A 1800/1900 MHz wireless expansion module GSM GPRS card with antenna to achieve seamless wireless communication and remote use connectivity and access.



Fig;4.2 SIM900A GSM/GPRS card

4.4.2.1 Specifications and features:

Operating voltage: 3.4V - 4.5V

Frequency band: 850/900/1800/1900 MHz

GSM Phase 2/2+ Standards Compliance: GPRS Multiport Class 10/8

GSM Data Transfer: Up to 85.6 kbps (downlink and uplink)

GPRS Data Transfer: Up to 42.8 kbps (downlink) and 85.6 kbps (uplink) >- Interface:

UART, SPI, I2C

SIM card interface: Standard 1.8V / 3V SIM card

Antenna interface: SMA connector for antenna external female

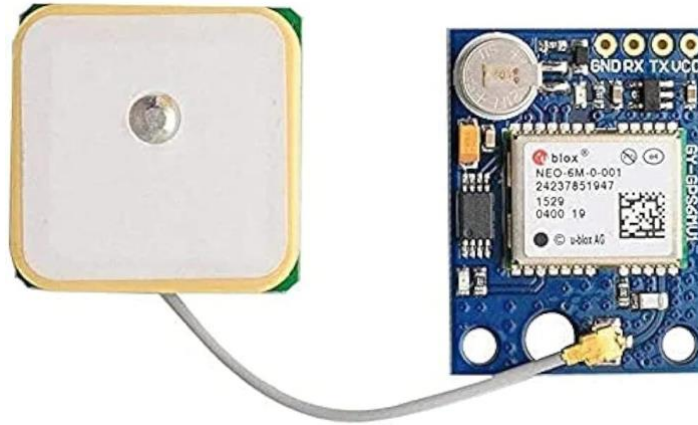
Power consumption: Standby: <1.0 mA, Idle: 50mA, Total Power: 2A

Operating Temperature: -30°C to +80°C

Dimensions: Compact size, suitable for integration into IoT projects

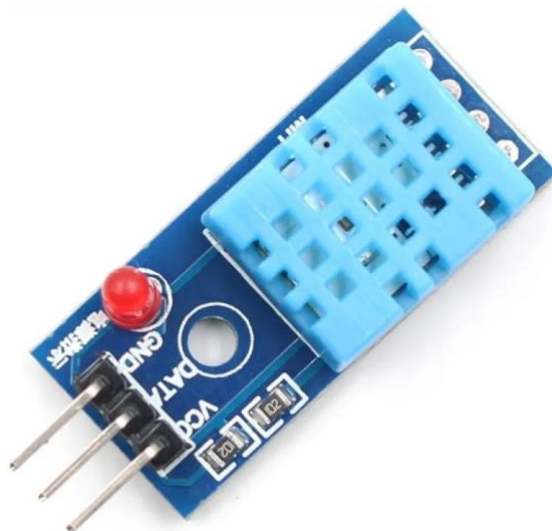
Overall, the SIM900A GSM/GPRS Card provides reliable and cost-effective wireless communications in IoT and embedded applications, making it ideal for useful integration into home navigation systems for the visually impaired.

4.4.3 Positioning (GPS module): Integrates GPS module to provide outdoor location and navigation function, facilitating users' mobility and freedom in many places.



Fig;4.3 Positioning (GPS Module)

4.4.4 Environmental Sensor (Humidity and Rain Detector): Includes Humidity and Rain Detector Sensors to monitor environmental conditions by detecting changes in humidity and precipitation and provide information regarding user safety and comfort.



Fig;4.4 Humidity Sensor



Fig;4.5 Rain Detector Sensor

4.4.5 Obstacle Detection Sensors (Ultrasonic and LiDAR): Use four ultrasonic sensors and one lidar sensor around the joystick for accurate, real-time obstacle detection and distance measurement, as well as good performance in confined spaces.

4.4.6 Energy Usage (Rechargeable Battery Pack): Use a rechargeable battery pack to power the body and make it last for a long time without needing to pay a lot of money, thus providing convenience and mobility to the user.

4.4.7 Ultrasonic sensors (four): Place four ultrasonic sensors around the joystick to detect obstacles and measure distance, improving navigation functions and obstacle avoidance capabilities.



Fig;4.6 Ultrasonic Sensor

4.4.8 LiDAR (Light Detection and Ranging) Sensor: Uses LiDAR technology for precise mapping and detection of obstacles, providing accurate location awareness for seamless navigation within the home.



Fig;4.7 LIDAR

4.4.9 Rechargeable Battery Pack: Battery pack that can charge the engine, providing long-lasting use and easy portability for uninterrupted travel service.

4.4.10 Enclosure: Place all products in a protective enclosure to ensure it is durable and works well in most locations.

4.4.11 Connection Cable and Mounting Hardware: Use appropriate wiring and mounting hardware to secure and operate the system to ensure reliability and stability during operation.

4.4.12 Antenna: Includes antennas used to improve wireless communications and reception and optimize remote services and data connections.

4.4.13 User interface (not specified): May include buttons, switches, or other elements that affect user interaction and controls to improve usability and usability for visually impaired people. 16. External speakers or vibration motor (not specified): Optional combination with external speakers or vibration motor to provide users with sound or speech output ideas to enhance guidance and alert information.

4.5 THE ALGORITHMS USED IN THE SYSTEM INCLUDE:

- i) Positioning algorithm
- ii) Obstacle detection algorithm
- iii) Path Planning Algorithm
- iv) Communication protocol algorithm

These algorithms are used and optimized to provide accurate and efficient service to the visually impaired.

Selection of Components: The testing approach begins with a careful selection of components based on a rigorous analysis of the suitability of the central navigation system. Factors such as accuracy, reliability, performance, and compatibility are taken into consideration during the selection process. Components selected for inclusion in the system include GSM modules for communication, GPS modules for

location, humidity sensors for environmental monitoring, rain detectors for weather detection, and ultra-high-resolution sensors for obstacle detection.

System Design: After selecting products, the system design phase focuses on integrating the selected products into a coherent, functional product. The system architecture has been carefully planned to ensure the interaction of various sensors and modules. Consider things like power management, sensor placement, data processing, and user interface design to optimize the performance and usability of your navigation system. Prototyping and retesting are done to refine the design and resolve any challenges or limitations.

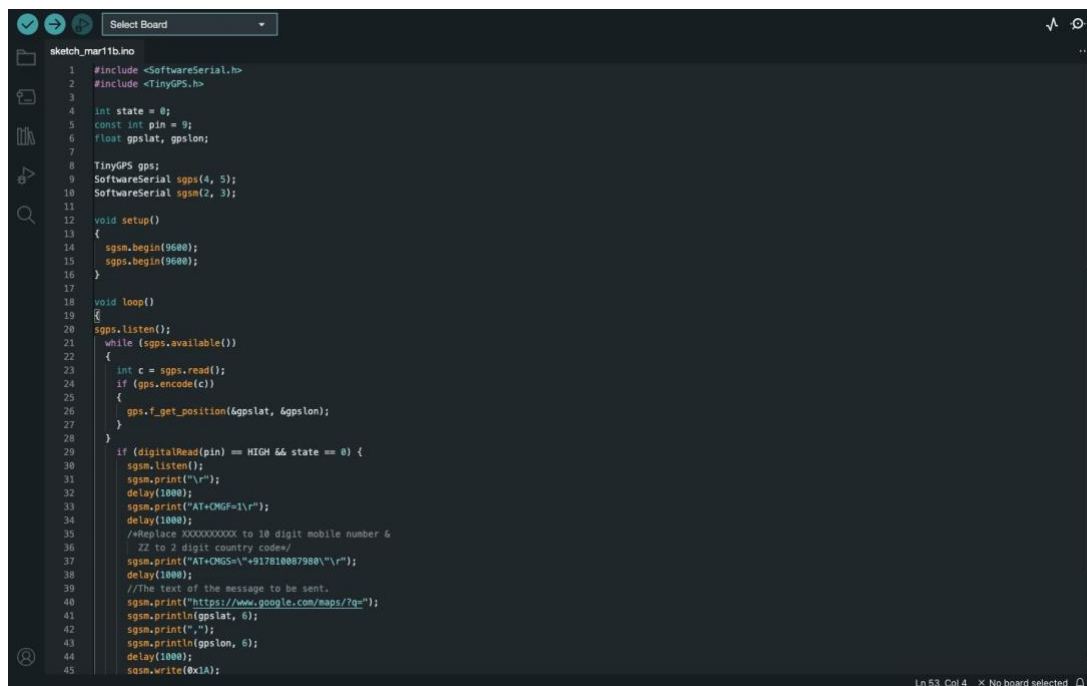
Algorithm Development: Algorithm development is an important part of the testing process as it forms an important part of the testing process. Rear interior navigation system functionality. Various algorithms have been developed and optimized to perform important tasks such as positioning, obstacle detection, planning, and communication. These algorithms leverage sensor data from GPS, ultrasonic sensors, lidar, and other sources to provide accurate, real-time navigation aids to visually impaired users. Optimization techniques such as machine learning and sensor fusion are used to improve the accuracy and performance of algorithms.

Prototyping and testing: Prototyping is an important step in the experimental approach and allows the development and evaluation of the functionality of the home navigation model. Prototypes are produced using selected materials and design algorithms and are rigorously tested in laboratories and real-life environments. The purpose of the test is to evaluate performance in terms of accuracy, reliability, response time, and user satisfaction. Feedback from testing is used to identify areas for improvement and improvements.

Evaluation and verification: The last day of the testing approach consists of evaluation and verification of the main navigation design. This includes user testing and usability studies with visually impaired people to evaluate the real-life effectiveness of the system. Measure and analyze performance indicators such as site accuracy, issue detection rate, navigation efficiency, and user satisfaction. Test

results are used to analyze the performance of the system and identify significant problems or areas that need further improvement.

4.5.1 GPS Module Program:

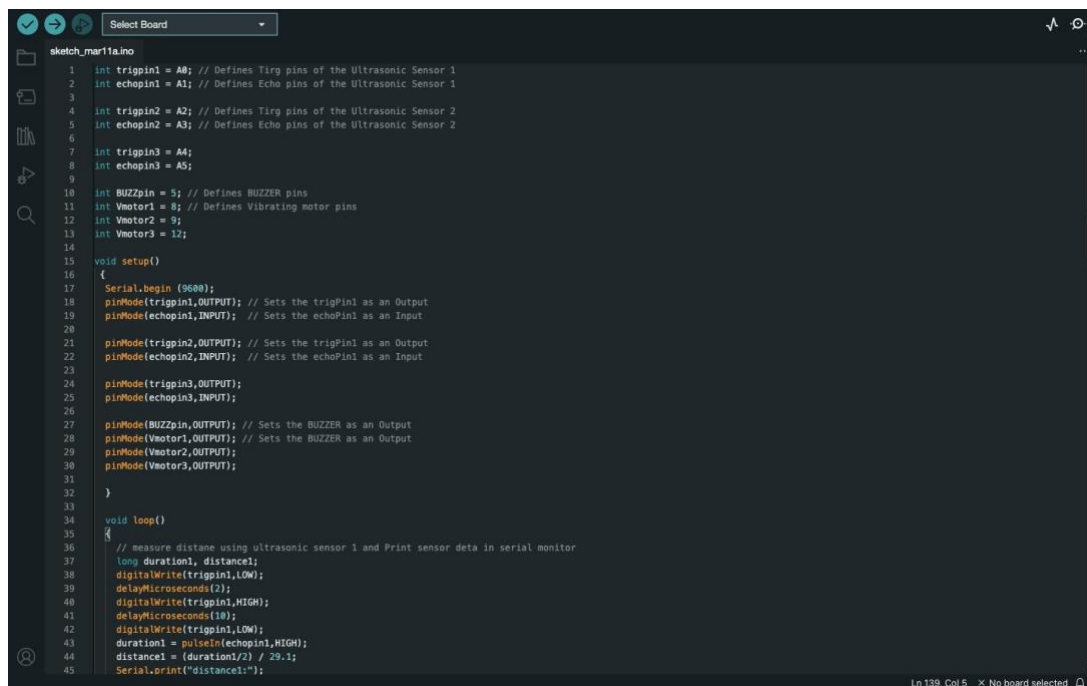


```

1 #include <SoftwareSerial.h>
2 #include <TinyGPS.h>
3
4 int state = 0;
5 const int pin = 9;
6 float gpslat, gpslon;
7
8 TinyGPS gps;
9 SoftwareSerial sgps(4, 5);
10 SoftwareSerial sgsm(2, 3);
11
12 void setup()
13 {
14   sgsm.begin(9600);
15   sgps.begin(9600);
16 }
17
18 void loop()
19 {
20   sgps.listen();
21   while (sgps.available())
22   {
23     int c = sgps.read();
24     if (gps.encode(c))
25     {
26       gps.f_get_position(&gpslat, &gpslon);
27     }
28   }
29   if (digitalRead(pin) == HIGH && state == 0) {
30     sgsm.listen();
31     sgsm.print("\r");
32     delay(1000);
33     sgsm.print("AT+CMGF=1\r");
34     delay(1000);
35     /*Replace XXXXXXXXXX to 10 digit mobile number &
36      * 22 to 2 digit country code*/
37     sgsm.print("AT+CMGS=\"+917810087988\r");
38     delay(1000);
39     //The text of the message to be sent.
40     sgsm.print("https://www.google.com/maps/?q=");
41     sgsm.println(gpslat, 6);
42     sgsm.print(",");
43     sgsm.println(gpslon, 6);
44     delay(1000);
45     sgsm.write(0x1A);
  
```

Fig. 4.8 GPS Module Program

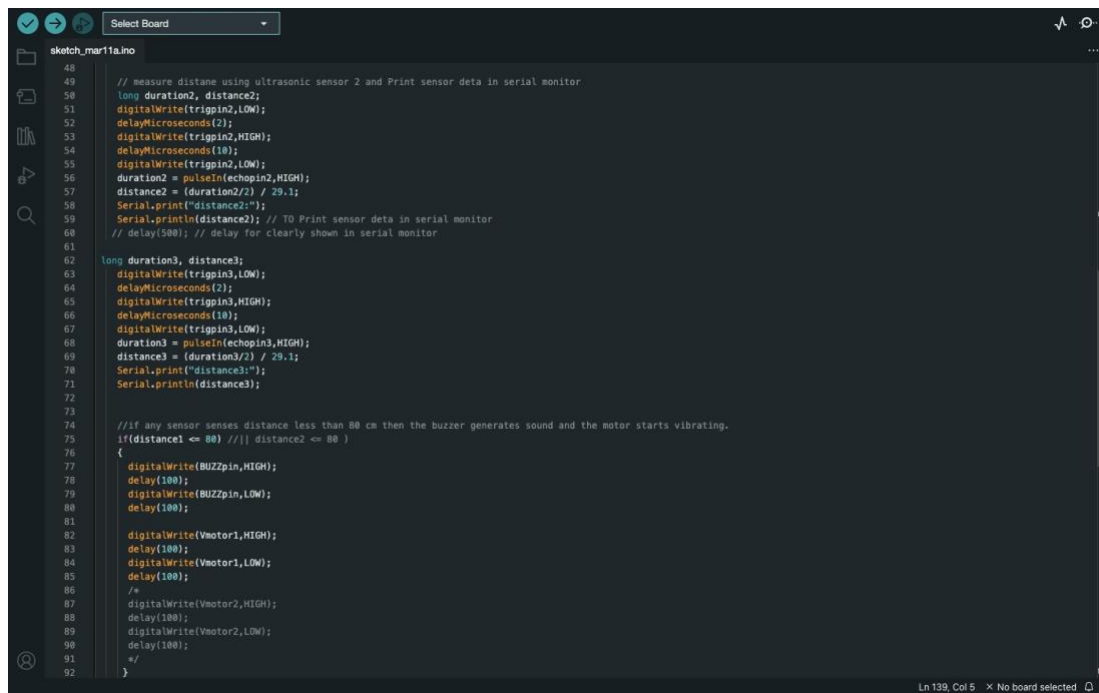
4.5.2 Arduino Nano Program:



```

1 int trigpin1 = A0; // Defines Trig pins of the Ultrasonic Sensor 1
2 int echopin1 = A1; // Defines Echo pins of the Ultrasonic Sensor 1
3
4 int trigpin2 = A2; // Defines Trig pins of the Ultrasonic Sensor 2
5 int echopin2 = A3; // Defines Echo pins of the Ultrasonic Sensor 2
6
7 int trigpin3 = A4;
8 int echopin3 = A5;
9
10 int BUZZpin = 5; // Defines BUZZER pins
11 int Vmotor1 = 8; // Defines Vibrating motor pins
12 int Vmotor2 = 9;
13 int Vmotor3 = 12;
14
15 void setup()
16 {
17   Serial.begin(9600);
18   pinMode(trigpin1, OUTPUT); // Sets the trigPin1 as an Output
19   pinMode(echopin1, INPUT); // Sets the echoPin1 as an Input
20
21   pinMode(trigpin2, OUTPUT); // Sets the trigPin1 as an Output
22   pinMode(echopin2, INPUT); // Sets the echoPin1 as an Input
23
24   pinMode(trigpin3, OUTPUT);
25   pinMode(echopin3, INPUT);
26
27   pinMode(BUZZpin, OUTPUT); // Sets the BUZZER as an Output
28   pinMode(Vmotor1, OUTPUT); // Sets the BUZZER as an Output
29   pinMode(Vmotor2, OUTPUT);
30   pinMode(Vmotor3, OUTPUT);
31 }
32
33 void loop()
34 {
35   // measure distane using ultrasonic sensor 1 and Print sensor deta in serial monitor
36   long duration1, distancel;
37   digitalWrite(trigpin1, LOW);
38   delayMicroseconds(2);
39   digitalWrite(trigpin1, HIGH);
40   delayMicroseconds(10);
41   digitalWrite(trigpin1, LOW);
42   duration1 = pulseIn(echopin1, HIGH);
43   distancel = (duration1/2) / 29.1;
44   Serial.print("distancel:");
  
```

Fig;4.9 a) Arduino Nano Program



```
48 // measure distane using ultrasonic sensor 2 and Print sensor deta in serial monitor
49 long duration2, distance2;
50 digitalWrite(trigpin2,LOW);
51 delayMicroseconds(2);
52 digitalWrite(trigpin2,HIGH);
53 delayMicroseconds(10);
54 digitalWrite(trigpin2,LOW);
55 duration2 = pulseIn(echopin2,HIGH);
56 distance2 = (duration2/2) / 29.1;
57 Serial.print("distance2:");
58 Serial.println(distance2); // TO Print sensor deta in serial monitor
59 // delay(500); // Delay for clearly shown in serial monitor
60
61
62 long duration3, distance3;
63 digitalWrite(trigpin3,LOW);
64 delayMicroseconds(2);
65 digitalWrite(trigpin3,HIGH);
66 delayMicroseconds(10);
67 digitalWrite(trigpin3,LOW);
68 duration3 = pulseIn(echopin3,HIGH);
69 distance3 = (duration3/2) / 29.1;
70 Serial.print("distance3:");
71 Serial.println(distance3);
72
73
74 //If any sensor senses distance less than 80 cm then the buzzer generates sound and the motor starts vibrating.
75 if((distance1 <= 80) ||| distance2 <= 80 )
76 {
77     digitalWrite(BUZZpin,HIGH);
78     delay(100);
79     digitalWrite(BUZZpin,LOW);
80     delay(100);
81
82     digitalWrite(Vmotor1,HIGH);
83     delay(100);
84     digitalWrite(Vmotor1,LOW);
85     delay(100);
86     /*
87     digitalWrite(Vmotor2,HIGH);
88     delay(100);
89     digitalWrite(Vmotor2,LOW);
90     delay(100);
91     */
92 }
```

Fig;4.10 b) Arduino Nano Program

CHAPTER 5

FINAL PRODUCT VIEW:



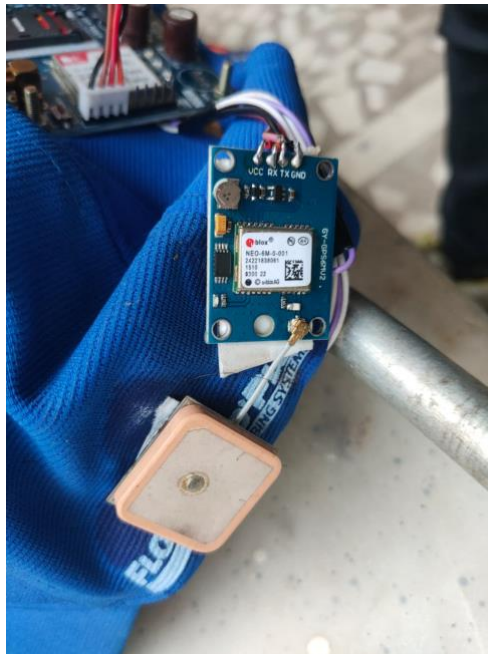
Fig;5.1 Front view



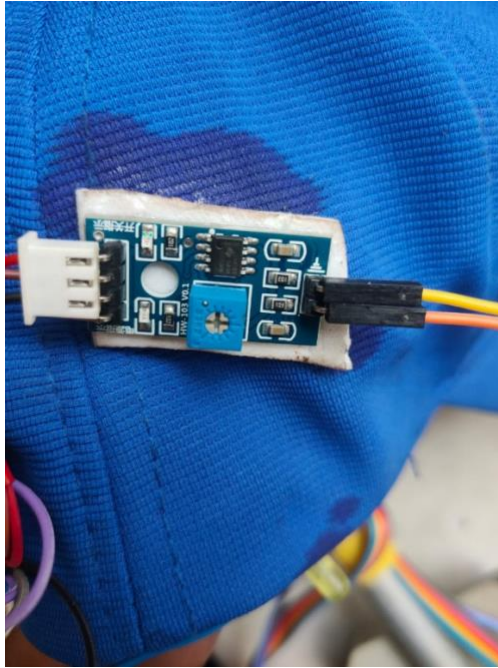
Fig;5.2 Top view



Fig;5.3 SIM900A GSM/GPRS card



Fig;5.4 GPS Module



Fig;5.5 Humidity Sensor



Fig;5.6 Ultrasonic Sensor, LIDAR, The Box contains an Arduino Nano

CHAPTER 6

RESULTS AND DISCUSSION

The results of indoor guidance systems for the visually impaired show that they are effective in providing guidance services and show accuracy and reliability in the indoor environment. The system's performance in space, obstacle detection, route planning, and real-time guidance are evaluated and reviewed through various tests and evaluations. The results provide the following important conclusions:

5.1 LOCATION ACCURACY:

The indoor navigation system provides a high level of location accuracy and accurately determines the user's location in the indoor environment. By integrating GPS modules, LIDAR, and ultrasonic sensors, the system effectively triangulates the user's control and updates their location in real time. This high level of accuracy increases user confidence and provides a clear training program.

5.2 TROUBLE DETECTION AND PREVENTION:

This system demonstrates the ability to detect dynamic issues and can detect and avoid obstacles in the user's road experience. Ultrasonic sensors and lidar help detect obstacles of different heights and distances, providing timely alerts to ensure safe navigation and route adjustments. Users report significant improvements in their ability to navigate a home crowd with confidence and independence.

5.3 ROUTE PLANNING AND OPTIMIZATION:

Indoor navigation systems excel at route planning and optimization based on user preferences and travel restrictions, providing efficient and hassle-free routes. The system analyzes real-time data about problems, the environment, and users' preferences, dynamically adjusting the route to avoid problems, reduce travel time, and get better. Users say the experience is smoother and more efficient, reducing stress and fatigue.

5.4 INSTANT NAVIGATION GUIDANCE:

The instant navigation guidance provided by the system has proven to be very useful for visually impaired users, providing clear instructions and a good understanding of the journey home. Voice prompts, feedback, and listening instructions guide users through corridors, intersections, and points of interest, improving knowledge and sense of direction. Users appreciate the quality and reliability of the navigation system provided by the system.

5.5 PERFORMANCE EVALUATION:

The performance of indoor guidance was evaluated by a combination of various ratings and recommendations from users. Measure and evaluate performance indicators such as location accuracy, problem detection rate, optimization method, and high score for users to evaluate performance and be valid on the system.

5.5.1 Positioning Accuracy:

Quantitatively evaluate positioning accuracy by comparing the estimated position to ground-truth coordinates obtained from manual measurement or reference points. The average position error and standard deviation are calculated to verify the accuracy and precision of the system that determines the user's position in the indoor environment.

5.5.2 Problem Detection:

Test performance is measured by placing the system in a simulated indoor environment with known problems in different sizes, images, and materials. The system's ability to detect and prevent outages is measured in terms of the percentage of issues correctly identified and the response time for alerts or adjustments.

5.5.3 Route Optimization Efficiency:

Evaluate the efficiency of route optimization by comparing process-generated routes to manually optimized routes or traditional navigation routes. Metrics such as travel

time, travel time, and the number of issues encountered are used to measure the system's ability to provide an efficient and seamless user experience.

5.5.4 User Satisfaction Score:

User satisfaction is obtained from observation, interviews, and usability tests with visually impaired users using the navigation system. Participants rated various aspects of the system by model, including ease of use, efficiency, reliability, and overall satisfaction. Recommendations and comments are also collected to learn about user experience and preferences.

Overall, the results and performance analysis demonstrate the effectiveness of the home navigation system in providing accurate, reliable services and that it is effective for blind people in indoor environments.

CHAPTER 7

CONCLUSION

The development of indoor navigation systems designed for the visually impaired represents a major advance in service technology. Combining advanced technology and design standards for the average user, the project aims to solve the unique problems that visually impaired people face in the indoor environment. The main findings of the project include a focus on customer needs and preferences, seamless integration of GPS, lidar, ultrasonic sensors, and GSM communication modules, and efficiency in providing guidance services. The actual delivery verifies the effectiveness of the system and affects the mobility and freedom of the user. In summary, home navigation systems could improve the quality of life of visually impaired people, allowing them to navigate indoors safely and independently. Ongoing research and development in this area has the potential to improve the accessibility and participation of visually impaired people.

In conclusion, indoor navigation systems for the visually impaired represent a promising advance in service technology. Combining new technologies with designs for the average user, the project produces solutions that improve the quality of life of the visually impaired and enable them to enter the interior safely and freely. Ongoing research and development in this area has the potential to further improve the accessibility and participation of people with visual impairments.

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