THIRD EYE FOR VISUALLY CHALLANGED

PROJECT REPORT

Submitted in the fulfilment of the requirements for
the award of the degree of

Bachelor of Technology

in

Electronics and Communication Engineering

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VIGNAN'S
Foundation for Science, Technology & Research
(Deemed to be University)
-Estd. u/s 3 of UGC Act 1956

(ACCREDITED BY **NAAC** WITH **'A+'** GRADE)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

(ACCREDITED by **NBA**)

VIGNAN'S FOUNDATION FOR SCIENCE, TECHNOLOGY AND RESEARCH

(Deemed to be University)

Vadlamudi, Guntur, Andhra Pradesh, India– 522213

May 2024

CERTIFICATE

This is to certify that project report entitled "**THIRD EYE FOR VISUALLY CHALLANGED**" that is being submitted by D. Kaivalya[201FA05008], G. Sanjay[201FA05015] and M. Vishnu Teja[211LA05022] in fulfilment for the award of B. Tech degree in Electronics and Communication Engineering Vignan's Foundation for Science Technology and Research University, is a record of bonafide work carried out by them under the guidance of Dr. G. S. R Satyanarayana of ECE Department.

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Signature of Head of the Department
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DECLARATION

We hereby declare that the project work entitled **"THIRD EYE FOR VISUALLY CHALLANGED"** is submitted to Vignan's Foundation for Science Technology and Research (Deemed to be University) in fulfilment for the award of B. Tech degree in Electronics and Communication Engineering. This work was originally designed and executed by us under the guidance of Dr. G. S. R Satyanarayana at Department of Electronics and Communication Engineering, Vignan's Foundation for Science Technology and Research (Deemed to be University) and was not a duplicate work done by someone else. We hold the responsibility of the originality of the work incorporated into this project.

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We would like to specially thank **Dr. T. Pitchaiah**, Head of the Department, ECE for his valuable suggestions.

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Finally, we would like to thank our parents and friends for the moral support throughout the project work.

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ABSTRACT

Millions of humans rely on corrective lenses, but for the blind, current assistive technologies offer limited support. This project proposes a low-cost, wearable device to empower them with improved navigation. This unobtrusive device, mountable on canes, glasses, on clothes or gloves, utilizes two key sensors LiDAR and Ultrasonic. The acquired sensor data is transmitted via Bluetooth to a user-friendly smartphone app. This app translates complex readings into clear information, offering audio alerts about object distances or integrating with other apps for image recognition or navigation assistance. This newfound awareness of surroundings empowers blind users to navigate with greater confidence and freedom. The focus on affordability, achieved through readily available components and efficient design, makes the device accessible to a wider range of users. This has the potential to be a significant advancement, granting increased independence and a sense of security to those with visual impairments.

Major Design (Final Year Project Work) Experience Information

Student Group	D. Kaivalya (201FA05008)	G. Sanjay (201FA05015)	M. Vishnu Teja (211LA05022)

Project Title	THIRD EYE FOR VISUALLY CHALLANGED
Program Concentration Area	Embedded systems
Program Concentration Area	Electronic devices and circuits
Constraints - Examples	
Economic	Fixed Budget (limited) and affordable materials.
Environmental	Eco-Friendly, it should not affect the surrounding environment.
Sustainability	A rechargeable battery-operated device seamlessly works for at least 12 hours. Battery replacement at least after 3 years and helps for blind people.
Manufacturability	Yes. Components are easily available to manufacture the product.
Ethical	Following the necessary steps and designs
Health and Safety	Safe System, no harmful materials are necessary. Low power class 1 lasers need to be used which will not impact on health and safety.
Social	The designed work is very helpful to blind people.
Political	N/A
Other	Real time monitoring, alerts made.
Standards	
1. IEEE-802.15.1-2005	To establish the communication with the mobile phone with the help of bluetooth.
2. IEC 60825-1	Class 1 laser for eye safety
Prerequisite courses for the Major Design Experience	1.Microcontrollers 2.Digital design 3.Sensors and Instrumentation

G.S.R.S [signature]
Supervisor

Project Co-Ordinator

Head of the department ECE
23/5/24.

CONTENTS

PAGE NO

TABLE OF FIGURES

LIST OF ACRONYMS

CPU	Central Processing Unit
ETA	Electronic Travel Aid
EEPROM	Electrically Erasable Programmable Read-Only Memory
GND	Ground
GFSK	Gaussian Frequency Shift Keying
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HC SR04	High-Conductance Ultrasonic Sensor
HC 05	Host Controller
IR	Infrared
I2C	Inter- Integrated Circuits
LiDAR	Light Detection And Ranging
ML	Machine Learning
PWM	Pulse Width Modulation
SRAM	Static Random Access Memory
TTL	Transistor-Transistor Logic
Uno	One in Italian
UAV	Unmanned Ariel Vehicles
VCC	Voltage at the Common Collector
UART	Universal Asynchronous Receiver/Transmitter

CHAPTER 1

1.1Introduction

Imagine a world where navigating unfamiliar environments becomes achievable and independent movement a reality for the visually challenged. This report presents the development of a "Third Eye," an assistive device built with accessibility in mind. This system leverages the power of Arduino UNO, a user-friendly microcontroller, to process data from multiple sensors and provide crucial spatial awareness.

The core obstacle detection relies on an ultrasonic sensor, which emits sound waves and measures their echo to determine the distance to nearby objects. For enhanced precision and detailed object recognition, a LiDAR sensor can be integrated, creating a more comprehensive picture of the user's surroundings.

Real-time feedback is paramount for this assistive device. The Third Eye utilizes a Bluetooth module to wirelessly transmit sensor data to a custom smartphone application. This application, designed as a serial monitor, translates the data into a user-friendly format. Through a combination of audible alerts or vibrations, the user receives immediate notifications about potential obstacles, empowering them to navigate with greater confidence.

This report will explore the hardware components chosen, delve into the software development process for the Arduino platform, and detail the design of the smartphone application. Additionally, it will discuss the implemented testing procedures used to evaluate the Third Eye's effectiveness and its potential to revolutionize independent navigation for visually challenged individuals.

1.2 Motivation

The inability to see presents a significant barrier to navigating the world freely. Individuals with visual impairments often rely on assistance or limited tools for movement, hindering their independence and mobility. This project, the development of a "Third Eye," aims to bridge this gap and empower individuals with visual challenges.

The motivation for this project stems from a desire to create a more inclusive and accessible world. By utilizing readily available technologies like Arduino UNO, ultrasonic sensors, and LiDAR, the Third Eye offers a cost-effective and adaptable solution. This system goes beyond basic obstacle detection, potentially incorporating LiDAR for detailed object recognition, creating a richer understanding of the environment.

Furthermore, the open-source nature of the Arduino platform allows for future customization and development by the user community, fostering innovation and ensuring the Third Eye can adapt to individual needs and environments.

Real-time feedback is crucial. The Bluetooth module and a dedicated smartphone application ensure clear communication. The application, designed as a serial monitor, translates sensor data into user-friendly alerts, empowering individuals with the information needed to navigate with confidence. This project seeks to break down the walls of limitation and provide a sense of freedom through improved spatial awareness.

The Third Eye goes beyond basic obstacle detection. Its modular design allows for future expansion with additional sensors, like cameras for object identification. This flexibility positions it as a platform for continuous improvement, promoting a future where assistive technology seamlessly integrates with daily life.

Developing the Third Eye is not just about creating a technological solution; it's about fostering independence, building confidence, and promoting a more inclusive world for those who experience visual impairment. By offering a cost-effective and adaptable system, the Third Eye has the potential to significantly improve the lives of many.

1.3 Objective

1.3.1 Broad Objective

The third eye aims to empower visually challenged individuals with a low-cost CPU based assistive device combining ultrasonic and potential LiDAR sensors for obstacle detection and distance estimation. Real-time data is wirelessly transmitted to a smartphone app, providing immediate feedback through audible alerts. This modular, cost-effective solution seeks to enhance independent navigation and can be expanded with additional sensors like cameras for advanced object identification.

1.3.2 Specific Objective

The Third Eye enhances navigation for the visually challenged with reliable obstacle detection (1-5 meters) using ultrasonic sensors, and potential LiDAR for precise object recognition. Seamless Bluetooth communication (10-meter range) provides real-time feedback via customizable audio or vibration alerts on a smart phone app.

1.4 Organization of Thesis

Chapter 1 describes about the “THIRD EYE FOR VISUALLY CHALLANGED” which includes Introduction, Motivation, and the specific, broad objectives.

Chapter 2 describes about the Literature work that has been studied and mentioning of the different existing solutions along with the pros and cons.

Chapter 3 describes about the Components and their descriptions, the proposed system along with the sample block diagram will be developed.

Chapter 4 describes the operational Flowchart of the prototype.

Chapter 5 describes about the design implementations, interfaces and working of the prototype.

Chapter 6 describes about the results and the discussions.

Chapter 7 concludes the work and given future scope.

CHAPTER 2

2. Literature survey

[1] Challenges: Existing navigation solutions (GPS, guide dogs) have limitations for the blind.

Infrared (IR) Sensors as a Solution: IR offers promise due to low power consumption, object detection capabilities, and compact size for wearable devices.

Existing Research: Studies like "A Smart Infrared Microcontroller-Based Blind Guidance System" (2013) explore IR for basic obstacle detection.

Limitations: Current IR solutions have limited range/detail and can be affected by the environment.

Future Directions: Research could focus on sensor fusion with ultrasonics, advanced signal processing for better object recognition, and user interface design for clear data interpretation.

Conclusion: IR sensors hold promise for low-energy navigation systems. By addressing limitations, IR has the potential to become a valuable tool for the blind.

[2] Smart sticks are a growing assistive technology for the visually impaired. Common sensors include ultrasonic (affordable, good range) and LiDAR (precise object recognition, but expensive). Existing solutions like WeWALK and UltraCane use these sensors for obstacle detection with vibration or voice feedback. Limitations include:

Sensor Range: Ultrasonic/infrared might have a shorter range than LiDAR.

Basic Detection: Some solutions only provide basic obstacle detection.

Cost: LiDAR integration can be expensive.

Future directions include:

Sensor Fusion: Combining sensors for wider range and richer information.

Advanced Feedback: Developing more sophisticated feedback mechanisms.

Cost-Effective Design: Making LiDAR integration more affordable. By addressing these limitations, future smart sticks can empower visually impaired individuals with even greater independence.

[3] Visually impaired individuals face challenges navigating unfamiliar environments. Traditional tools like canes offer limited information, while guide dogs are expensive and require training. Existing electronic aids include:

Ultrasonic ETAs: Use ultrasonic sensors for obstacle detection with audio/vibration alerts.

LiDAR Navigation Systems: Offer more precise object recognition but can be costly and complex.

Smartphone Navigation Apps: Provide audio guidance and location information but rely on pre-existing data.

These solutions have limitations:

Limited range (ultrasonic), Lack of object recognition (basic ETAs), Cost and complexity (LiDAR), Reliance on external infrastructure (smartphone apps).

This project, the Third Eye, aims to address these issues by:

Combining ultrasonic and LiDAR sensors for better range, affordability, and recognition.

Using a real-time feedback smartphone app for customization and potential mapping integration. Utilizing a modular design for future expansion with additional sensors.

The Third Eye has the potential to be a more comprehensive and adaptable assistive device.

[4] Visually impaired individuals rely on alternative methods like echolocation (requires extensive training) to navigate. This paper explores assistive technologies using LiDAR for spatial sensing. Existing Solutions:

Canes: Limited information beyond contact.

ETAs (Electronic Travel Aids): Improved range but limited object recognition.

Camera-based systems: Computationally expensive, struggle in low light.

LiDAR for Spatial Sensing: LiDAR offers advantages over traditional methods:

Improved obstacle detection: Greater distance and accuracy.

Object recognition: Potential to classify objects (doorways, furniture).

Real-time environment mapping: Crucial for navigation planning.

Performance Analysis in Literature: Existing studies on LiDAR for spatial sensing often evaluate: Accuracy of obstacle detection, Object recognition capabilities, Usability, and user experience.

This paper contributes by presenting a LiDAR-based system's development and performance analysis for visually impaired individuals.

[5] Current assistive technology often offers limited obstacle detection for the visually impaired. While short-range LiDAR or ultrasound provide some navigation aid, complex environments demand more.

Research in autonomous vehicles highlights the potential of sensor fusion (LiDAR with cameras/radar) for a more comprehensive picture of surroundings. The INSPEX project exemplifies this with their "smart white cane" integrating long-range LiDAR for a more detailed obstacle detection system. However, advancements are needed:

Lighting Variation: LiDAR performance can be limited in bright or low-light conditions.

Wearability: Sensor miniaturization and reduced power consumption are crucial for lightweight, portable solutions.

User Interface Design: Translating LiDAR data into clear and actionable user feedback requires robust processing algorithms and user-centered interface design.

By addressing these challenges, long-range LiDAR has the potential to transform obstacle detection for the visually impaired. Future research focused on miniaturization, light adaptability, and user-centered design will pave the way for next-generation assistive technology, empowering greater independence and navigation freedom.

[6] Traditional white canes offer limited functionality. Research explores advancements:
Ultrasonic Sensors: Common for short-range obstacle detection (up to 5 meters) but lack detail for complex situations.
Laser Canes: Offered longer range but were bulky and impractical.
Sensor Fusion: Combining sensors (LiDAR, cameras) creates a more comprehensive understanding of surroundings.
Existing smart canes integrate features like:
GPS/GSM: For location tracking and emergency assistance.
Multi-Sensor Integration: Projects like INSPEX utilize long-range LiDAR for detailed obstacle

detection.

The Nav-Cane can contribute by focusing on (mention unique features).

[7] Traditional canes offer limited obstacle detection for the blind. Research explores ultrasonic sensors, like those in [previous citation], for navigation assistance. These emit sound waves to measure object distance. Commercially available ultrasonic blind sticks exist, but with limitations: short range, potential for inaccurate readings, and lack of object recognition.

Future advancements are needed:

Multi-sensor integration (e.g., LiDAR) for a more comprehensive environment picture.

Advanced signal processing for improved accuracy. Object recognition features using machine learning for specific feedback.

By addressing these limitations, ultrasonic technology can be a valuable tool in developing more effective assistive devices for the visually impaired.

CHAPTER 3

3.1 Proposed System

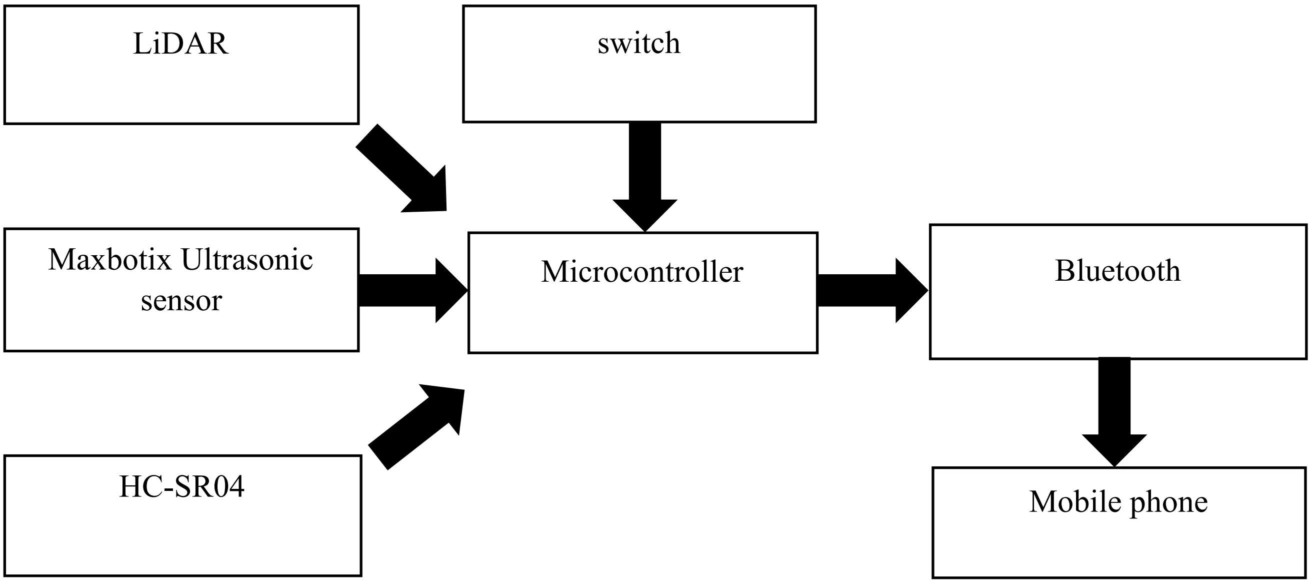


FIG 3.1 Proposed system

The proposed system is an advanced obstacle detection and notification system designed to assist visually impaired and blind individuals. It integrates multiple sensors, a microcontroller, and wireless communication using Bluetooth standard to provide real-time obstacle detection information via a mobile phone.

Components and Functionality:

Sensors:

LiDAR: Utilized for long-range obstacle detection, the LiDAR sensor accurately measures the distance to objects using laser pulses. It is ideal for detecting obstacles that are farther away, providing precise distance measurements.

Maxbotix Ultrasonic Sensor (MB1200 XL-MaxSonar-EZ0): This medium-range sensor emits ultrasonic waves and measures the echo return time to calculate distances. It offers reliable detection of obstacles at moderate distances, enhancing the system's ability to sense the environment effectively.

HC-SR04 Ultrasonic Sensor: Employed for short-range detection, the HC-SR04 sensor operates on similar principles as the Maxbotix sensor but is optimized for closer objects. It ensures the system can detect nearby obstacles accurately.

Microcontroller: The microcontroller is the central processing unit of the system, receiving input from all three sensors. It processes the sensor data to determine the presence and distance of obstacles. The microcontroller is also responsible for managing the input from the switch and controlling the Bluetooth module.

Switch: The switch allows the user to activate or deactivate the system. When turned on, the microcontroller begins processing the input from the sensors to detect obstacles.

Bluetooth Module: The Bluetooth module works based on the IEEE-802.15.1-2005 standard enables wireless communication between the microcontroller and a mobile phone. After processing the sensor data, the microcontroller sends relevant obstacle information to the Bluetooth module, which then transmits it to the connected mobile phone.

Mobile Phone: The mobile phone receives the data from the Bluetooth module and provides auditory or tactile feedback to the user about detected obstacles. This real-time notification helps visually impaired individuals navigate their surroundings more safely and effectively.

System Operation:

When the user activates the system via the switch, the microcontroller starts collecting data from the LiDAR, Maxbotix, and HC-SR04 sensors. The processed information about obstacle distance and presence is then transmitted via Bluetooth to the user's mobile phone, which provides immediate feedback. This integrated approach ensures comprehensive obstacle detection across different ranges, enhancing the mobility and safety of visually impaired and blind individuals.

3.2 Components

3.2.1 HC-SR04 Ultrasonic sensor

The HC-SR04 is a widely used ultrasonic sensor designed for measuring distances accurately and affordably. It employs ultrasonic waves to detect the distance between the sensor and an object, making it suitable for various applications, including obstacle detection, robotics, and range finding.

Technical Specifications:

Operating Voltage: 5V DC

Operating Current: 15mA

Measurement Range: 2cm to 400cm

Measurement Accuracy: ±3mm

Operating Frequency: 40 kHz

Output: Digital pulse

Interface: 4-pin (VCC, Trig, Echo, GND)

Dimensions: 45mm x 20mm x 15mm

Working Principle: The HC-SR04 ultrasonic sensor operates based on the principle of echolocation, similar to how bats navigate. It consists of two main components: a transmitter and a receiver.

1. Triggering: The sensor is triggered by sending a 10-microsecond HIGH pulse to the Trig pin.

2. Emitting Ultrasonic Pulse: Upon receiving the trigger signal, the sensor's transmitter emits an 8-cycle burst of ultrasonic sound waves at a frequency of 40 kHz.

3. Echo Reception: These sound waves travel through the air and, upon encountering an object, get reflected towards the sensor. The sensor's receiver detects the reflected waves (echo).

4. Distance Calculation: The time interval between the transmission of the sound waves and the reception of the echo is measured. The distance to the object is calculated using the formula:

$$Distance = \frac{time\ x\ speed\ of\ sound}{2}$$

The speed of sound in air is approximately 343 meters per second.

Pin Configuration

1. VCC: Power supply pin, connected to a 5V DC source.

2. Trig : Trigger pin, connected to a microcontroller's digital output pin to initiate measurement.

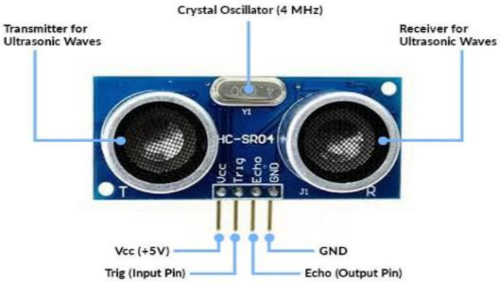


FIG 3.2.1 HC-SR04 Ultrasonic sensor

3.2.2 Maxbotix Ultrasonic sensor(MB1200 XL-MaxSonar-EZ0)

The Maxbotix MB1200 XL-MaxSonar-EZ0 is a high-performance ultrasonic distance sensor designed for a wide range of applications requiring accurate and reliable distance measurements. It is particularly noted for its versatility, ease of use, and robust performance in various environments.

Technical Specifications:

Operating Voltage: 2.5V to 5.5V DC

Operating Current: 2.1mA

Measurement Range: 20cm to 765cm (7.65 meters)

Resolution: 1cm

Beam Angle: 20 degrees

Output Options: Analog Voltage Output, Pulse Width Output, Serial Output

Operating Frequency: 42 kHz

Communication: TTL Serial, Analog, PWM

Dimensions: 22mm x 22mm x 22mm

Weight: 4.3 grams

Working Principle: The MB1200 XL-MaxSonar-EZ0 uses ultrasonic waves to measure the distance to an object. The sensor emits a high-frequency sound pulse and then listens for the echo that reflects back from the target. The time taken for the echo to return is used to calculate the distance to the object based on the speed of sound.

Triggering :The sensor can be triggered by supplying power or via a command from a microcontroller.

Emitting Ultrasonic Pulse: The sensor emits a 42 kHz ultrasonic pulse.

Echo Reception: The sensor listens for the echo of the pulse that bounces back from the target object.

Distance Calculation: The time between the emission of the pulse and the reception of the echo is measured. The distance is calculated using the formula:

$$Distance = \frac{time\ x\ speed\ of\ sound}{2}$$

The sensor provides this distance information through analog, pulse width, or serial output.

Pin Configuration

1. V+: Power supply pin, connected to 2.5V to 5.5V DC source.

2. GND: Ground pin, connected to the ground of the power supply.

3. AN: Analog voltage output.

4. PW: Pulse width output.

5. TX: Serial output pin.

6. RX: Serial input pin.

7. BW: Bandwidth selection pin.

Applications:

The MB1200 XL-MaxSonar-EZ0 is suitable for a variety of applications including:

Robotics: For obstacle detection and avoidance in robotic systems.

Distance Measurement: Accurate distance measurement for industrial automation.

Level Sensing: Liquid level measurement in tanks and containers.

Security Systems: Intrusion detection by monitoring distance changes.

Drone Altitude Holding: Maintaining stable altitude by measuring the distance to the ground.

Automated Parking Systems: Assisting vehicles in parking by detecting nearby objects.

Advantages:

Long Range: Capable of measuring distances up to 7.65 meters.

Multiple Output Options: Flexibility in interfacing with different systems via analog, PWM, and serial outputs.

High Resolution: Provides high resolution of 1cm for precise measurements.

Low Power Consumption: Energy-efficient, making it suitable for battery-powered applications.

Easy Integration: Simple to integrate with various microcontroller platforms.

Limitations:

Environmental Sensitivity: Performance can be affected by environmental conditions such as temperature and humidity.

Surface Dependency: Best performance with flat and hard surfaces; accuracy may decrease with soft or irregular surfaces.

Beam Angle: The 20-degree beam angle might not be suitable for applications requiring wider coverage.

The Maxbotix MB1200 XL-MaxSonar-EZ0 ultrasonic sensor is a reliable and versatile tool for distance measurement applications. Its long-range capability, multiple output options, and high resolution make it suitable for a wide array of applications, from robotics to industrial automation. While environmental conditions and surface types can affect its performance, its overall advantages make it a valuable sensor for projects requiring precise and accurate distance measurements.

FIG 3.2.2 Maxbotix MB1200 XL-MaxSonar-EZ0

3.2.3 TF-Mini Micro LiDAR

The TF MINI Micro LiDAR is a compact and cost-effective laser distance sensor that offers high accuracy and reliability for distance measurement. It is designed for applications requiring precise and continuous distance detection in a small form factor.
Technical Specifications:

Operating Voltage: 5V DC

Operating Current: ≤ 120mA

Measurement Range: 30cm to 12m

Resolution: 1cm

Accuracy: ±6cm (30cm to 6m); ±1% (6m to 12m)

Frame Rate: 100 Hz

Wavelength: 850 nm

Field of View: 2.3°

Output Options: UART, I2C

Dimensions: 42mm x 15mm x 16mm

Weight: 10 grams

Working Principle: The TF MINI Micro LiDAR uses time-of-flight (ToF) technology to measure distance. The sensor emits a near-infrared laser pulse and calculates the time taken for the pulse to reflect back from the target object. This time difference is used to determine the distance to the object.

Emitting Laser Pulse: The sensor emits a laser pulse at 850 nm wavelength.

Reception of Reflected Pulse: The sensor detects the reflected laser pulse that bounces back from the target object.

Distance Calculation: The time taken for the laser pulse to travel to the object and back is measured. The distance is calculated using the speed of light and the formula:

$$Distance = \frac{time\ x\ speed\ of\ light}{2}$$

The sensor provides this distance information through UART or I2C output.

Pin Configuration:

1. VCC: Power supply pin, connected to a 5V DC source.
2. GND: Ground pin, connected to the ground of the power supply.
3. TX: UART transmission pin for distance data output.
4. RX: UART reception pin for configuration and commands.

Applications: The TF MINI Micro LiDAR is versatile and suitable for various applications, including:

Robotics: For obstacle detection and navigation in robotic systems.

Drones: Altitude holding and terrain following in UAVs.

Automated Guided Vehicles (AGVs): Navigation and obstacle avoidance.

Distance Measurement: Precise measurement in industrial automation.

Security Systems: Intrusion detection and monitoring.

Smart Parking: Vehicle detection and parking assistance.

Advantages:

Compact Size: Small and lightweight, making it easy to integrate into space-constrained applications.

High Accuracy: Provides accurate distance measurements with a high resolution of 1cm.

Multiple Interface Options: Supports both UART and I2C communication for flexible integration.

High Frame Rate: Capable of 100 Hz frame rate for real-time distance measurement.

Low Power Consumption: Energy-efficient design suitable for battery-powered applications.

Limitations: Limited Range: Effective measurement range is up to 12 meters, which may be insufficient for some long-range applications.

Environmental Sensitivity: Performance can be affected by environmental factors such as ambient light and weather conditions.

Narrow Field of View: The 2.3° field of view might limit its use in applications requiring wider area coverage.

The TF MINI Micro LiDAR is an efficient and reliable sensor for short to medium-range distance measurement applications. Its compact size, high accuracy, and multiple interface options make it ideal for integration into various systems, from robotics to drones and industrial automation. While its range and field of view limitations should be considered, its overall advantages provide significant value for precise distance sensing in a small package.

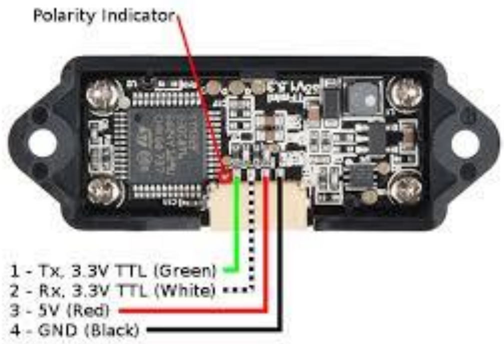


FIG 3.2.3 TF-Mini Micro LiDAR

3.2.4 HC-05 Bluetooth module (IEEE-802.15.1-2005)

The HC-05 Bluetooth module is a popular, versatile, and cost-effective solution for wireless communication between devices. It operates using the Bluetooth Serial Port Protocol (SPP) and is designed to establish a transparent wireless serial connection. This module is widely used in various applications including robotics, home automation, and wireless data transfer systems.

Technical Specifications:

Operating Voltage: 3.3V to 5V DC

Operating Current: 30mA (average), 40mA (peak)

Bluetooth Protocol: Bluetooth V2.0+EDR (Enhanced Data Rate)

Frequency: 2.4GHz ISM band

Modulation: GFSK (Gaussian Frequency Shift Keying)

Sensitivity: -80dBm

Range: Up to 10 meters (30 feet)

Data Transfer Rate: Up to 3Mbps (asynchronous), 2.1Mbps (synchronous)

UART Interface: 3.3V logic level, 9600 baud rate (default)

Dimensions: 34mm x 15mm x 2.2mm

Working Principle: The HC-05 Bluetooth module operates by creating a wireless serial communication link between two devices. It can be configured either as a master or slave device, allowing it to initiate a connection or wait for another device to connect to it.

Powering Up: Connect the VCC pin to a 3.3V to 5V power supply and the GND pin to the ground.

Initialization: The module initializes and is ready to be paired with another Bluetooth device. It can enter AT command mode for configuration.

Pairing: In slave mode, the module waits for a pairing request from a master device.In master mode, it searches for available slave devices and initiates pairing.

Data Transmission: Once paired, data sent from one device is wirelessly transmitted and received by the other, effectively acting as a serial link.

Pin Configuration

1. EN: Enable/disable pin (active HIGH). When pulled high, the module is enabled.
2. VCC: Power supply pin, connected to 3.3V to 5V DC.
3. GND: Ground pin, connected to the ground of the power supply.
4. TXD: Transmit pin, sends serial data to the connected device.
5. RXD: Receive pin, receives serial data from the connected device.
6. STATE: Connection status pin, goes high when connected.
7. KEY: Used to enter AT command mode for configuration (connected to 3.3V or left floating).

Applications: The HC-05 Bluetooth module is versatile and can be used in numerous applications, such as:

Wireless Data Transmission: Transmitting data wirelessly between microcontrollers or other devices.

Robotics: Enabling remote control of robots via Bluetooth.

Home Automation: Controlling home appliances wirelessly.

Health Monitoring Systems: Transmitting data from medical sensors to smartphones or computers.

Bluetooth Beacons: Used in positioning systems and asset tracking.

Advantages:

Ease of Use: Simple to interface with microcontrollers and other devices.

Cost-Effective: Affordable solution for adding Bluetooth capability.

Versatile: Can operate in both master and slave modes.

Compact Size: Small form factor suitable for integration into various projects.
Reliable: Stable wireless communication with good range and data rate.
Limitations:

Range: Limited to around 10 meters, which may be insufficient for some applications.
Interference: Can be affected by interference from other 2.4GHz devices.
Power Consumption: Consumes more power compared to other low-energy Bluetooth modules.
Configuration Complexity: Requires AT commands for configuration, which may be challenging for beginners.
The HC-05 Bluetooth module is a powerful and flexible tool for implementing wireless serial communication in a wide range of applications. Its ease of use, affordability, and reliable performance make it an excellent choice for hobbyists and professionals alike. Despite some limitations, such as range and power consumption, it remains a popular module for projects involving wireless data transmission and control.

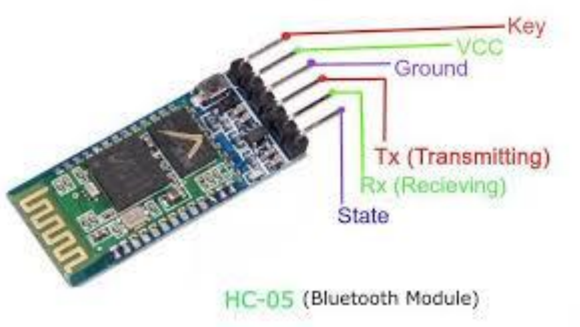


FIG 3.2.4 HC-05 Bluetooth module

The HC-05 Bluetooth module has two operating modes: Command and Data. The HC-05 is in Data mode by default, and you can switch to Command mode by pressing the onboard push button. The Bluetooth standards are IEEE-802.15.1-2005.

In Data mode, the HC-05 can send and receive data from other Bluetooth devices. The default baud rate in Data mode is 9600.
In Command mode, you can use AT commands to change the HC-05's settings and parameters, such as the baud rate, module name, and whether it's a master or slave device. You can use a serial to TTL converter and a PC running terminal software to change the system parameters,

and these changes will remain even after you turn off the power. The default baud rate in Command mode is 38400.

3.2.5 Arduino UNO

The Arduino UNO is one of the most popular and widely used microcontroller boards in the Arduino family. It is based on the ATmega328P microcontroller and is designed for beginners and hobbyists, as well as for more advanced users who need a flexible and powerful platform for their projects. The Arduino UNO is known for its ease of use, robustness, and extensive community support.

Technical Specifications:- Microcontroller: ATmega328P

Operating Voltage: 5V

Input Voltage (recommended): 7-12V

Input Voltage (limits): 6-20V

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 6

DC Current per I/O Pin: 20 mA

DC Current for 3.3V Pin: 50 mA

Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader

SRAM: 2 KB (ATmega328P)

EEPROM: 1 KB (ATmega328P)

Clock Speed: 16 MHz

LED_BUILTIN: 13

Length: 68.6 mm

Width: 53.4 mm

Weight: 25 g

Key Components:

Microcontroller: The ATmega328P is the brain of the board, handling all processing tasks.

Power Supply: The board can be powered via a USB connection or an external power supply (barrel jack or Vin pin).

Digital I/O Pins: These pins can be configured as inputs or outputs for interfacing with other components.

Analog Input Pins: Used to read analog signals from sensors.

PWM Pins: Six digital I/O pins can generate PWM signals for controlling devices like motors and LEDs.

USB Interface: The USB connection is used for programming the board and for serial communication with a computer.

Reset Button: Resets the microcontroller.

Power LED Indicator: Indicates that the board is powered on.

Built-in LED: Connected to digital pin 13, useful for basic tests and debugging.

Pin Configuration:

Digital Pins (0-13): Can be used for general-purpose I/O, with pins 3, 5, 6, 9, 10, and 11 providing PWM output.

Analog Pins (A0-A5): Can be used for reading analog sensors, each providing 10-bit resolution.

Power Pins:

Vin: Input voltage to the Arduino when using an external power source5V: Regulated 5V from the regulator on the board.

3.3V: A 3.3V supply generated by the onboard regulator.

GND: Ground pins.

Special Pins:

AREF: Reference voltage for the analog inputs.

Reset: Used to reset the microcontroller.

The Arduino UNO is a powerful, flexible, and user-friendly microcontroller board that is ideal for a wide range of applications. Its ease of use, robust design, and extensive community support make it an excellent choice for both beginners and experienced users. Despite its limitations, the Arduino UNO remains one of the most popular platforms for electronic prototyping and education.

FIG 3.2.5 Arduino UNO

CHAPTER 4

4. Flow chart

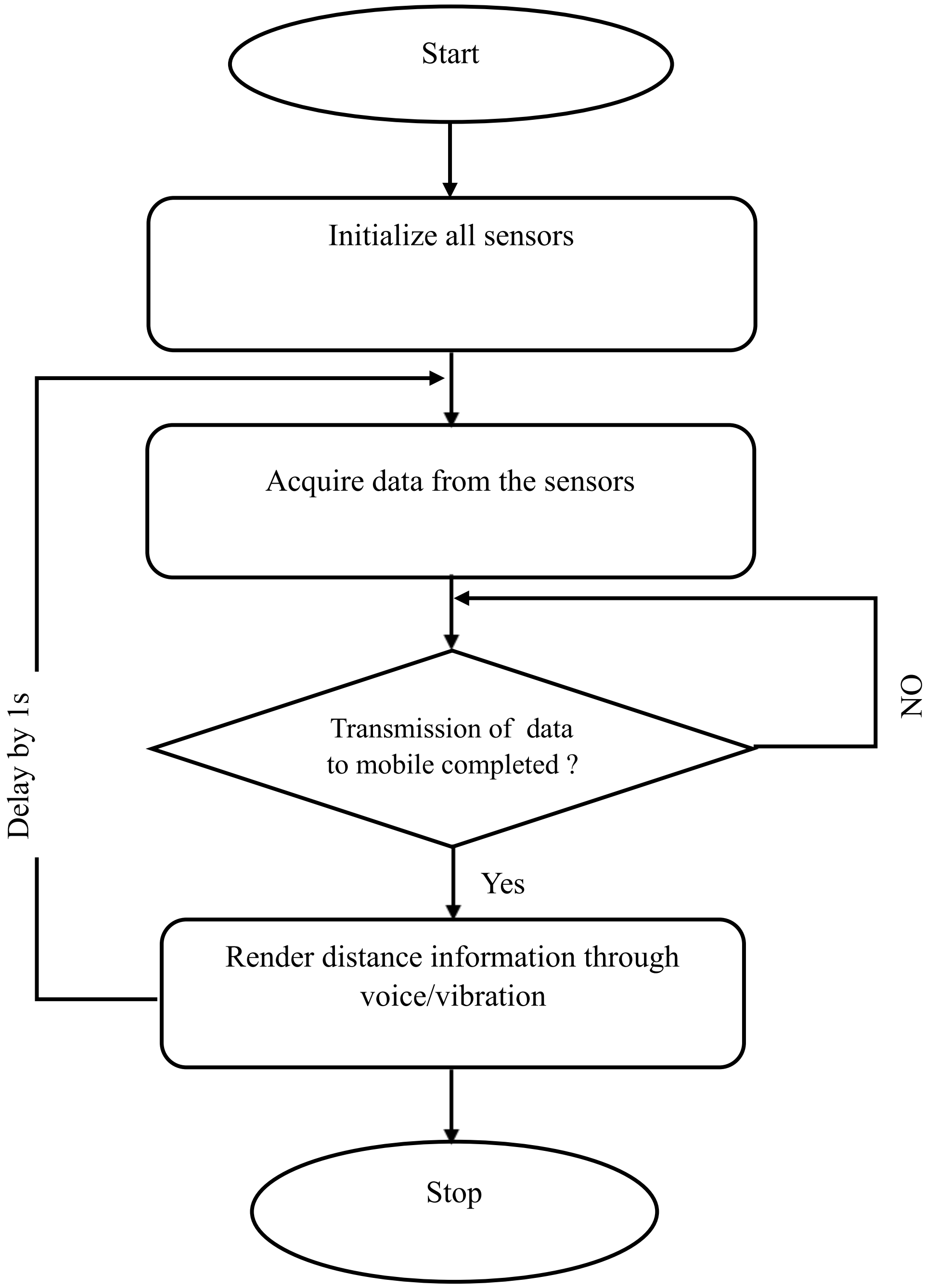


FIG 4: Flowchart

CHAPTER 5

5.1 Design Implementation

5.1.1 Interface of Arduino with HC-05

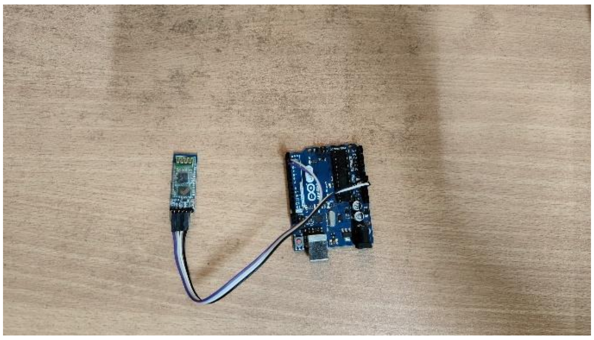


FIG 5.1.1 Arduino with HC-05

The image shows an Arduino board connected to an HC-05 Bluetooth module. To ensure proper functionality, here is a brief overview of the connections needed between the Arduino and the HC-05 module:

Connections:

HC-05 VCC to Arduino 5V

HC-05 GND to Arduino GND

HC-05 TXD to Arduino RX (Digital Pin 0)

HC-05 RXD to Arduino TX (Digital Pin 1)

5.1.2 Interface of Arduino with LiDAR

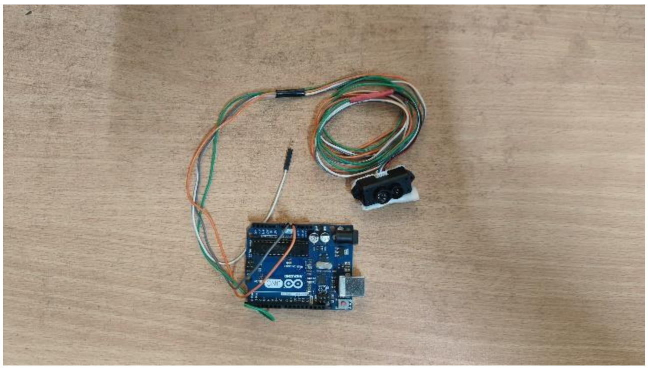


FIG 5.1.2 Arduino with LiDAR

The image shows an Arduino board connected to a TF-Mini micro LiDAR. To ensure proper functionality, here is a brief overview of the connections needed between the Arduino and the LiDAR module:

Connections:

LiDAR Rx to Arduino Rx

LiDAR to Tx Arduino Tx

LiDAR VCC to Arduino VCC

LiDAR GND to Arduino GND

5.1.3 Interface of Arduino with HC-SR04 Ultrasonic sensor

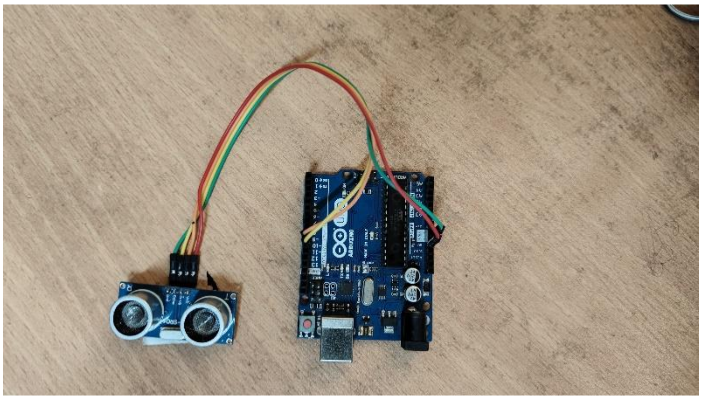


FIG 5.1.3 Arduino with HC-SR04

The image shows an Arduino board connected to an HC-SR04. To ensure proper functionality, here is a brief overview of the connections needed between the Arduino and the LiDAR module:

Connections:

HC-SR04 Trigger pin to Arduino pin 9

HC-SR04 to Tx Arduino pin 10

HC-SR04 VCC to Arduino VCC

HC-SR04 GND to Arduino GND

5.1.4 Interface of Arduino with MB1200 ultrasonic sensor

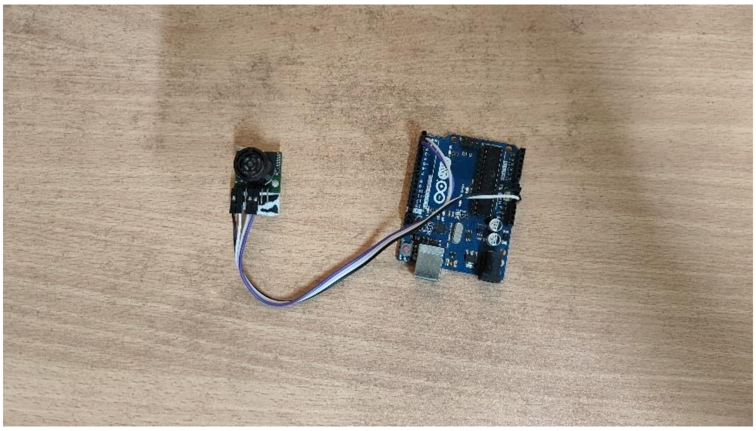


FIG 5.1.4 Arduino with MB1200 ultrasonic sensor

The image shows an Arduino board connected to an MB1200 Ultrasonic sensor. To ensure proper functionality, here is a brief overview of the connections needed between the Arduino and the MB1200 ultrasonic sensor module:

Connections:

MB1200 VCC to Arduino VCC

MB1200 GND to Arduino GND

MB1200 AN to Arduino A0

5.1.5 Interface of all components

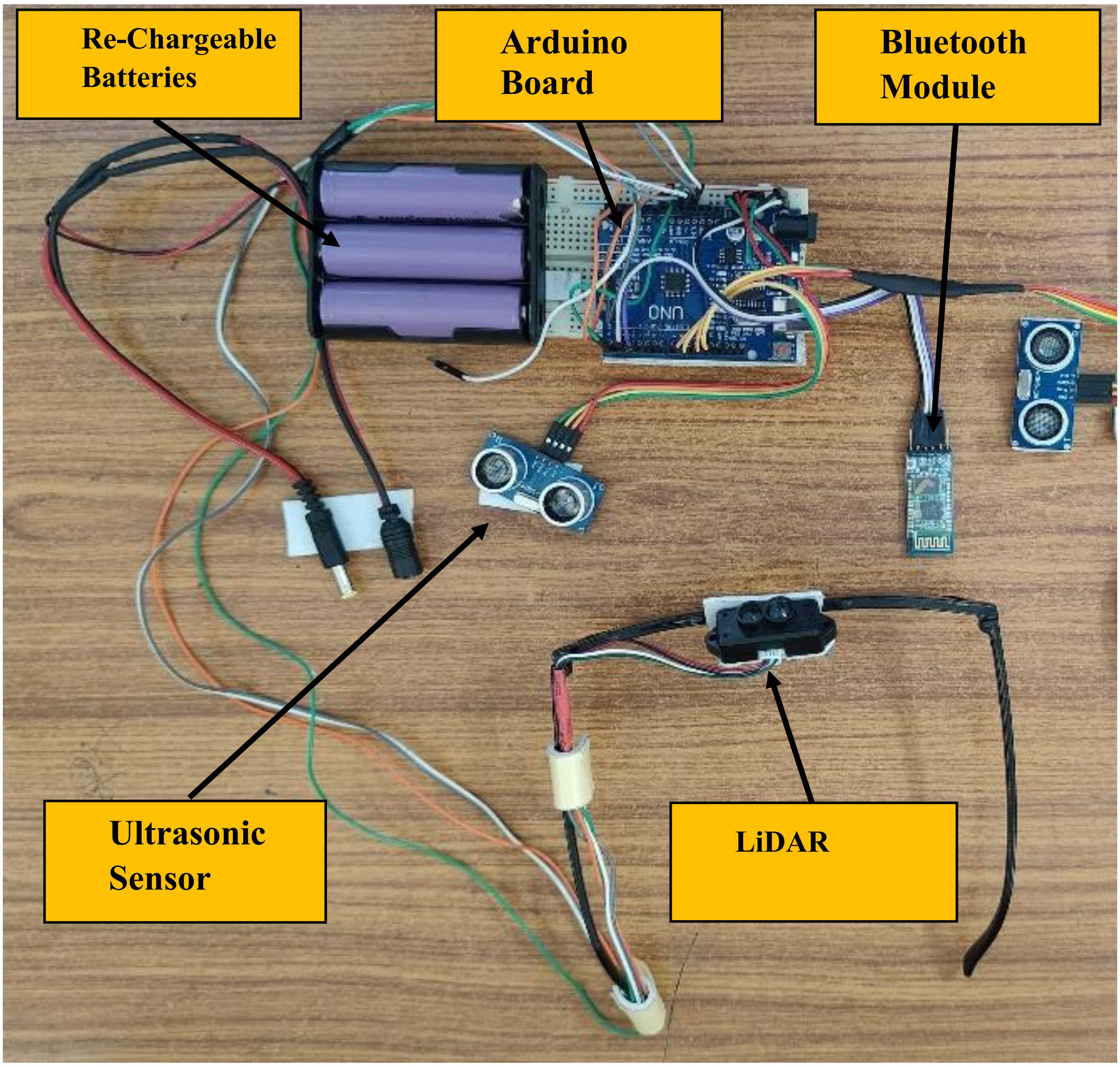


FIG 5.1.5 Interface of all components

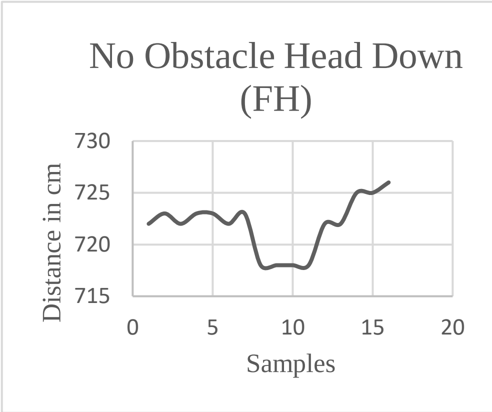
5.1.6 Hardware setup

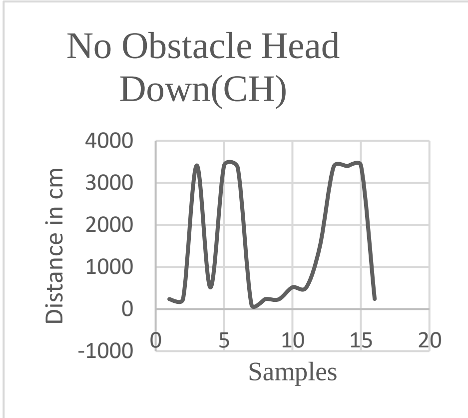
FIG 5.1.6 Developed prototype

The developed prototype is a wearable device that is as shown in the figure. It is designed in a way that a blind person can carry it easily. It is portable.

CHAPTER 6

6.1. Results and Discussions





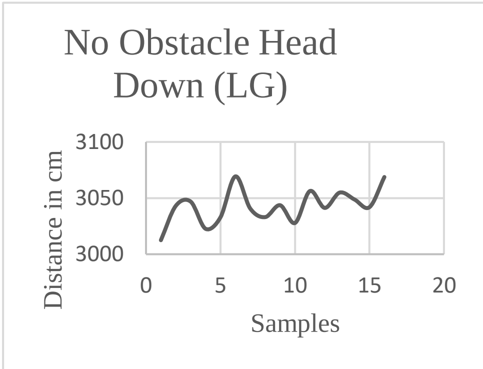


FIG 6.1.1 No obstacle Head down

FH: Forehead Sensor

CH: Chest Sensor

LG: Leg Sensor

FH: Here fore head is facing towards the ground some distance is varying is very less but any path hole or any steps are coming its distance increases or decreases.

CH: Here we can see that with no obstacle near to the Chest sensor, so distance is very high.

LG: From leg sensor the moment we can clearly observe that moment with graph changing the small values. where some pics are due to path rough ness.

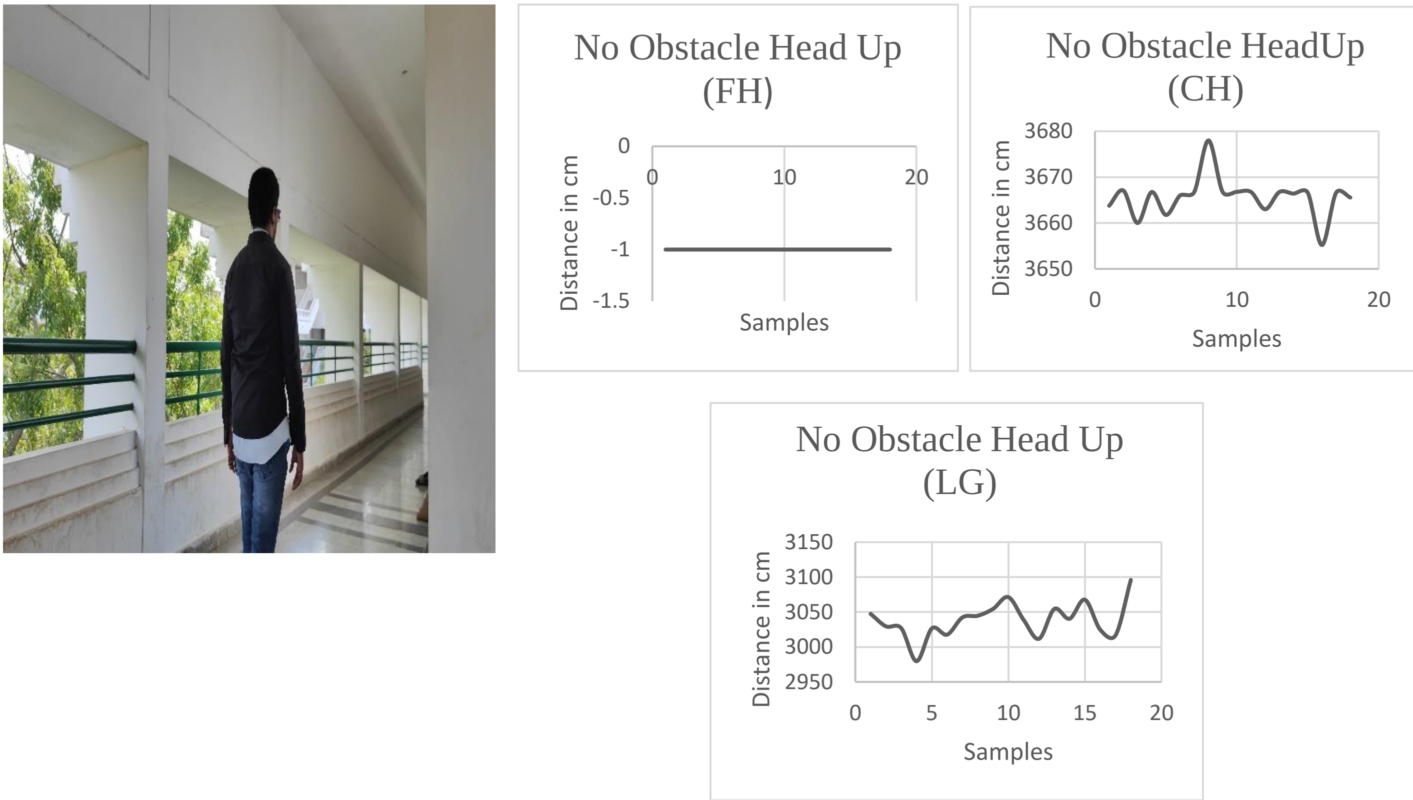
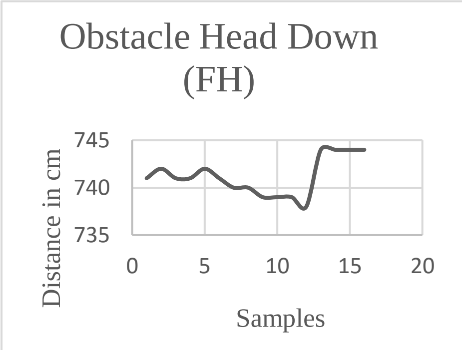


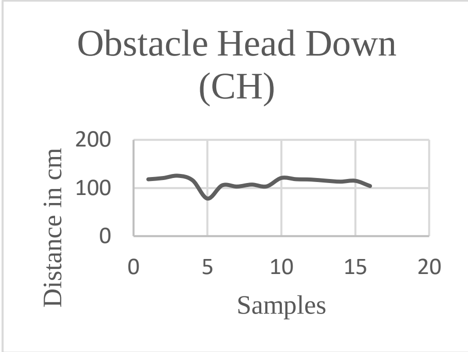
FIG 6.1.2 No obstacle Head up

FH: when head is facing straight with no obstacle then the distance is beyond the range of sensor therefore the sensor gives the output as -1 by default.

CH: Here we can see that a clear no obstacle from the chest in long range. But something from long we can see the obstacle with less change is distance value.

LG: From leg sensor the moment we can clearly observe that moment with graph changing the small values. Where some pics are due to path rough ness.





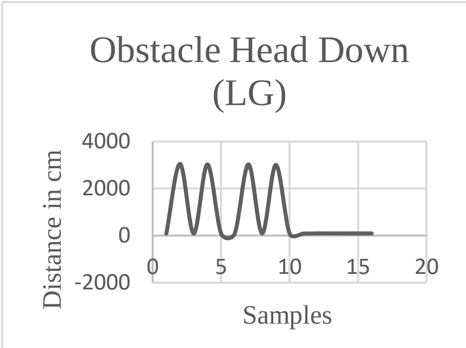
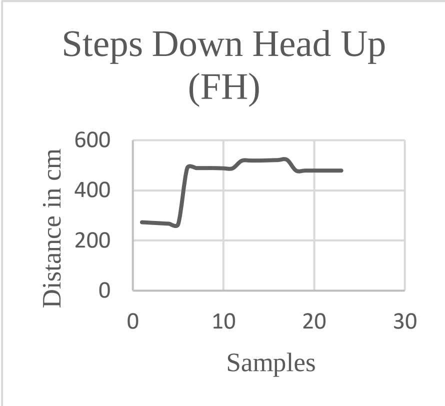


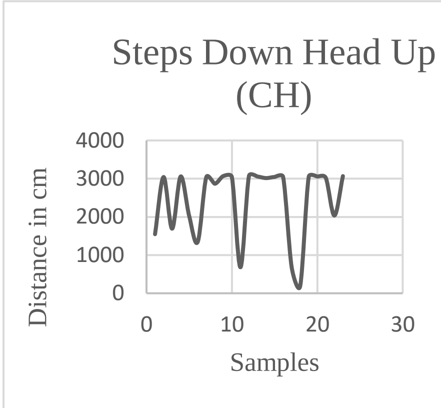
FIG 6.1.3 obstacle Head up

FH: From Forehead sensor we can see that clear obstacle. with some obstacle is moving and then distance varying in the graph.

CH: Same thing in chest sensor before obstacle distance is somewhat high. When the obstacle is arrived a clear graph of distance to the target.

LG: In leg sensor we can detect only towards the ground distance by the time of walking it is varying very high, when it is showing this much high is no obstacle but when it is low this shows an obstacle is ahead. finally, from leg it detects very low accuracy for straight targets.





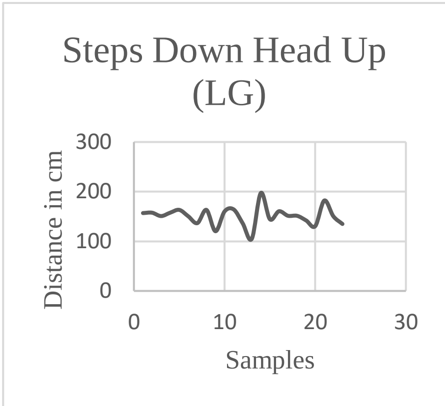
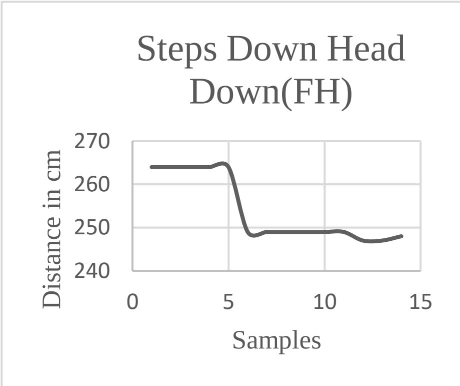


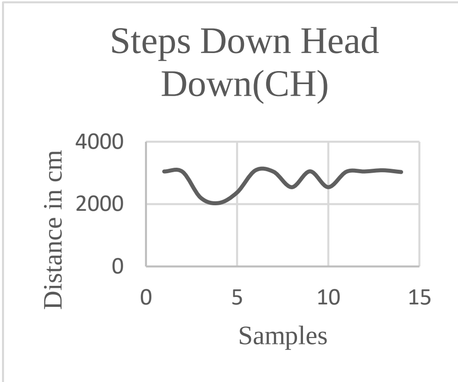
FIG 6.1.4 Step Down Head Up

FH: When the steps toward down stairs with head up. there is no distance is detected. But the distance is measured is the distance of rooftop of the upstairs.

CH: Here we the distance of rooftop while steeping down the distance of free space or down stair is detected.

LG: Here we can see the distance is detected between two values, but it is not very effective due to down stairs.





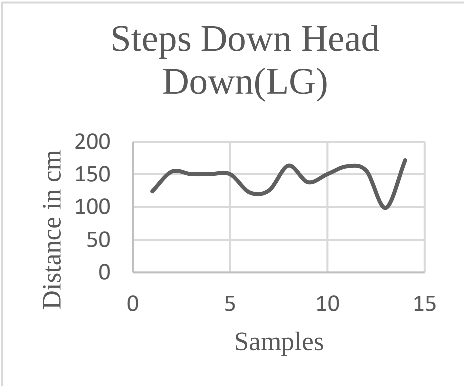


FIG 6.1.5 Step Down Head Down

FH: By the time of steeping down with head down a clear-cut distance is detected of the steps.

CH: Here we the distance of rooftop while steeping down the distance of free space or down stair is detected.

LG: Here we can see the distance is detected between two values but it is not very effective due to down stairs.

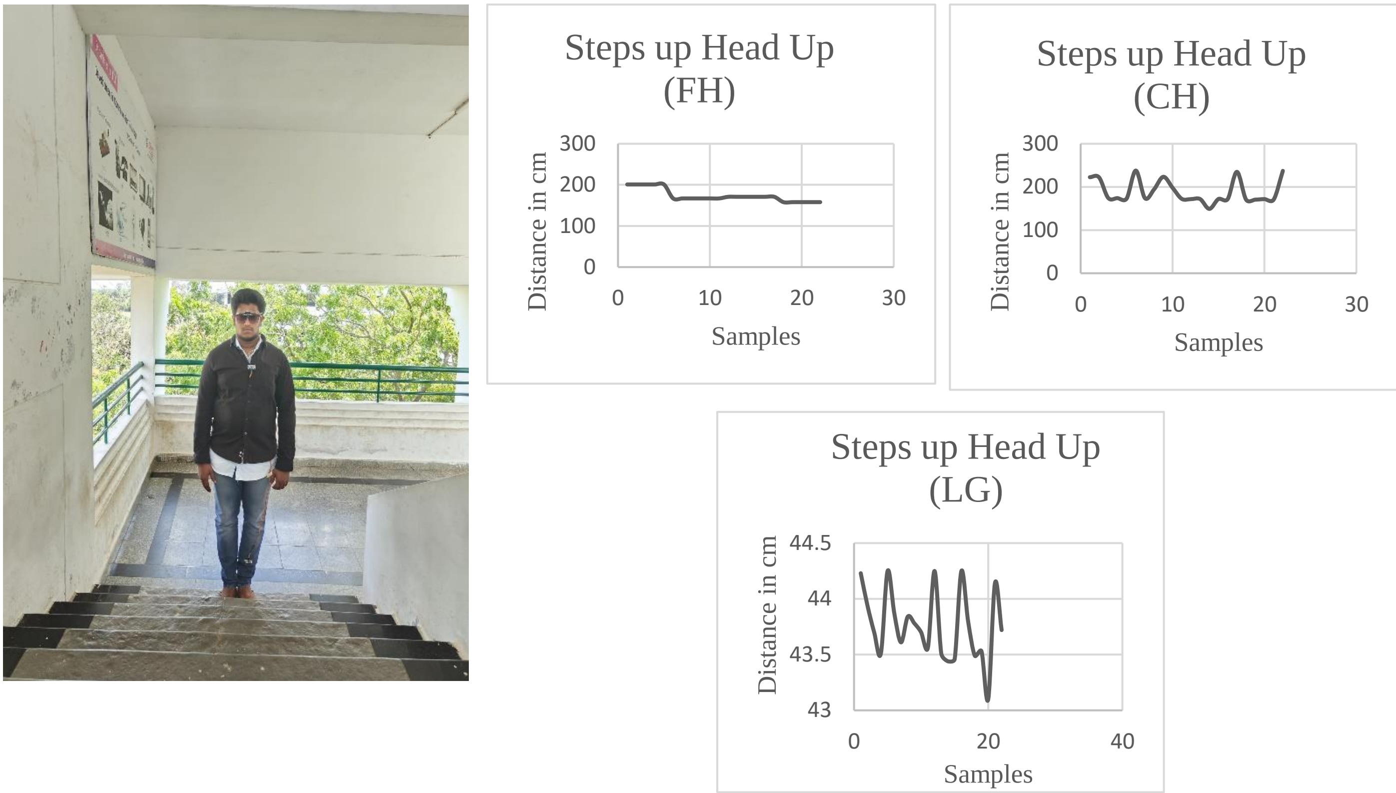


FIG 6.1.6 Step Up Head Up

FH: When the steps toward upstairs we can see the distance of the end of the steps is decreasing when it reaches to very less, we take it as an end of steps.

CH: By the time of steps toward upstairs the chest sensor is varying, but the variation is very less. when it reaches to very low, we can sense that an end of wall.

LG: Here we can see that between two (2) values distance is varying from leg sensor so, we can classify this as a step toward upstairs.

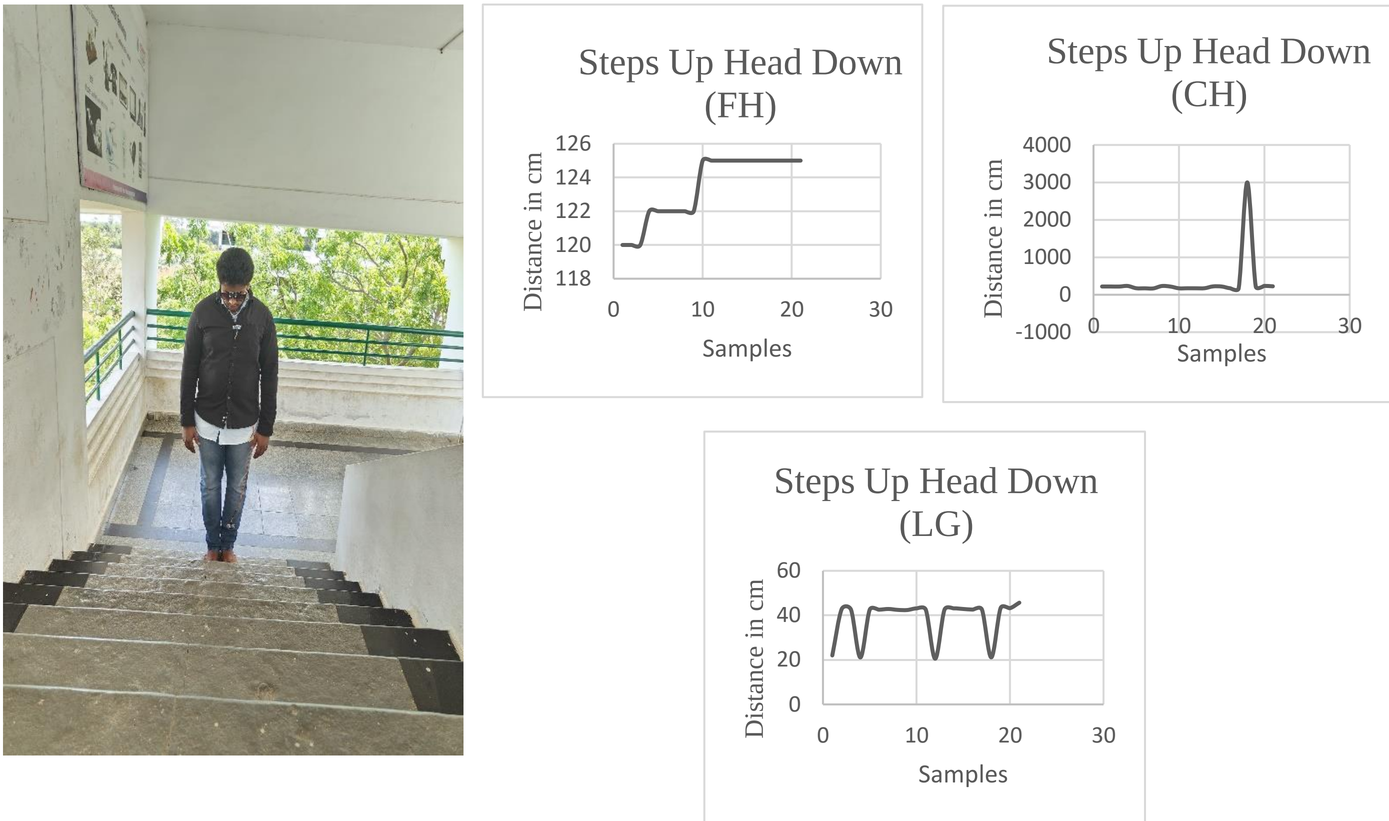
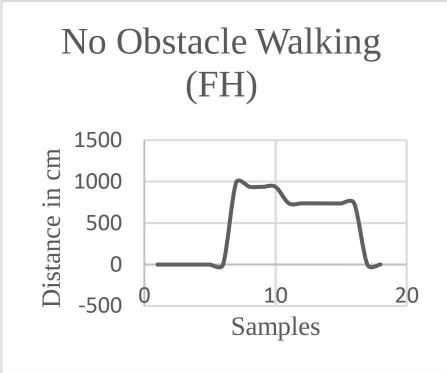


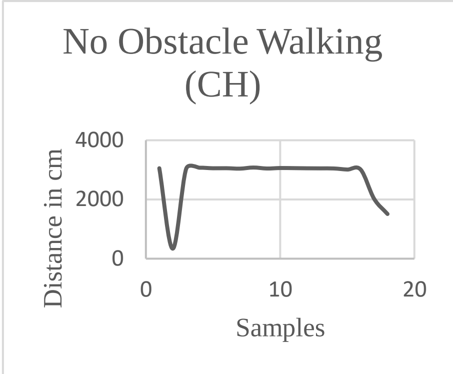
FIG 6.1.7 Steps Up head down

FH: When the steps toward upstairs with head down. We get a sharp value of distance from forehead to steps, so we can detect towards upstairs.

CH: By the time of steps toward upstairs the chest sensor showing no distance until unless an end or obstacle is detected.

LG: Here we can see that between two values distance is varying from leg sensor. So we can classify this as a steps toward upstairs.





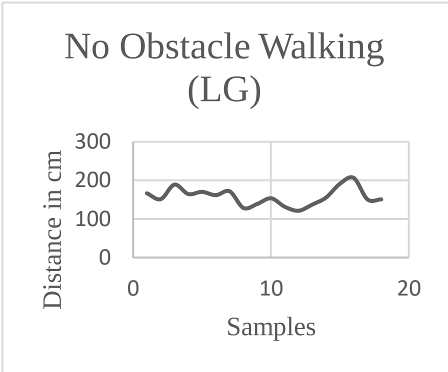


FIG 6.1.8 No Obstacle Walking

FH: Here we can see that no obstacle with sometime later target is detected then the distance is decreasing, because moving towards to obstacle.

CH: From chest the data is not detected for long time until obstacle is detected. here the detection spike is due to his hand.

LG: Here the sensor is detected the leg moment of for distance measurement.

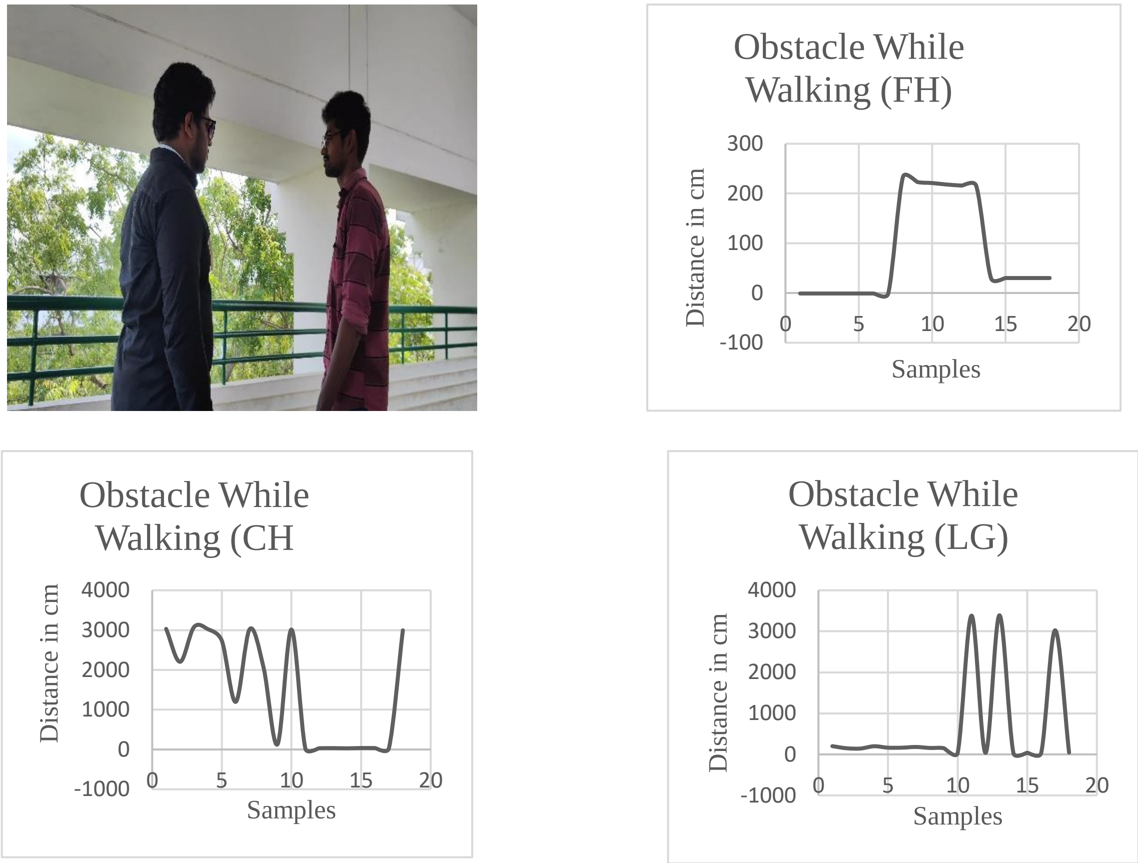


FIG 6.1.9 Obstacle while walking

FH: We can see a clear obstacle detection when a person is walking from forehead. when there is no obstacle then the distance is zero (0).

CH: We can see a clear obstacle detection when a person is walking from for Chest, but in the time of walking the values are fluctuating due to moment. when there is no obstacle then the distance is zero (0).

LG: Here when there is no obstacle to leg sensor it detects as zero. Until unless obstacle is detected.

6.2 Power Analysis

1. Calculate the total voltage of the batteries in series:

- Each battery is 3.7 volts.
- batteries in series add their voltages: 3.7V +3.7V+3.7V = 11.1V.

2. Determine the current drawn by the device:

- The power P of the device is 1.17 watts.
- Using the formula P=Vx I, where V is voltage and I is current, we can solve for current I:

$$I = \frac{P}{V} = \frac{1.17W}{11.1V} \approx .1054A \quad \text{or} \quad 105.4\text{mA.}$$

3. Calculate the capacity of the batteries in terms of time:

- The capacity of each battery is 2600mAh
- Since the batteries are in series, the voltage adds up, but the capacity (in mAh) remains the same at 2600mAh.
- To convert this capacity into hours of operation at a current of 105.4mA, we use the formula

$$Time = \frac{battery\ capacity}{current} = \frac{2600mAH}{105.4mA} \approx 24.67\ hours$$

So, the 3 batteries connected in series can power the 1.17-watt device for approximately 24.67 hours. Therefore, the designed system needs recharge after 24 hours. The chosen batteries can charge for 1000 cycles therefore life time of the batteries are approximately 3 years.

CHAPTER 7

7. Conclusions and Future Scope

Conclusion:

The designed prototype utilizes a combination of LiDAR, Ultrasonic Sensors, and interfaced with a microcontroller, to gather distance measurements. The processed data is then transmitted via Bluetooth to a mobile phone. This configuration aims to provide a flexible and accurate distance measurement system, leveraging the strengths of each sensor for different scenarios. LiDAR offers high precision low field of view for long-range measurements, while the Ultrasonic Sensors are cost-effective solutions for shorter ranges. The Bluetooth module ensures wireless data communication, enabling real-time monitoring and analysis on a mobile device.

Future Scope Using ML Algorithms:

Incorporating machine learning (ML) algorithms can significantly enhance the capabilities and applications of this project. The future scope could include:

1. Sensor Fusion and Data Accuracy: ML algorithms can be used to fuse data from the LiDAR, and Ultrasonic Sensor. By training models to learn the characteristics and accuracy of each sensor in various environments, the system can provide more accurate and reliable distance measurements, mitigating the limitations of individual sensors.

2. Anomaly Detection: ML can help in identifying anomalies or outliers in the sensor data. This is particularly useful in detecting malfunctioning sensors or unusual environmental conditions that might affect measurements.

3. Adaptive Algorithms: ML models can adapt to new environments and conditions by continuously learning from new data. This adaptability can improve the system's performance in diverse and changing conditions, making it more robust and versatile.

By integrating ML algorithms, the proposed system can evolve into an intelligent, adaptable, and highly reliable distance measurement solution with wide-ranging applications in robotics, autonomous vehicles, and industrial automation.

CHAPTER 8

8. References

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