Smart Helmet Using LiDAR Sensors

Submitted In Fulfillment of Requirements
For the Degree Of

Bachelor of Technology
(Computer Engineering)

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Certificate

This is to certify that the dissertation report entitled **Smart Helmet Using LiDAR Sensors** submitted by Vedansh Avlani, Anubroto Dasgupta, Jinay Jain and Manan Sayar at the end of semester VIII of LY B. Tech is a bona fide record for fulfillment of requirements for the degree Bachelor of Technology (Computer Engineering) of Somaiya Vidyavihar University

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This project is approved for the award of Degree of Bachelor of Technology (Computer Engineering) of Somaiya Vidyavihar University.

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Abstract

In a revolutionary endeavor, we redefine motorcycle safety by integrating LiDAR sensors with an Arduino microcontroller. Focused on elevating rider safety, this project brings real-time obstacle detection to the forefront. Mounted on a motorcycle helmet, LiDAR sensors offer unmatched accuracy in distance measurement. At the heart of this initiative is the aim to fortify safety measures during motorcycle journeys, addressing the increasing number of accidents and advancing rider situational awareness.

The project's inception committed to merging LiDAR technology with motorcycle safety, leveraging sensors for real-time obstacle detection. The meticulous methodology involves integrating LiDAR sensors into the motorcycle helmet, orchestrated by the versatile Arduino microcontroller. This streamlined system aligns with the overarching goal of advancing rider safety through cutting-edge technology. The successful implementation demonstrates LiDAR integration's efficacy, with the Arduino microcontroller processing data in real-time and providing crucial feedback to the rider.

As hardware and software seamlessly interact, LiDAR sensors prove instrumental in detecting obstacles, enhancing rider situational awareness and contributing to traffic safety. In the face of increasing accidents, this project emerges as a beacon of hope, introducing a proactive solution to mitigate risks on the road. Looking ahead, the project sets the stage for future enhancements, envisioning refined sensor placements, advanced obstacle recognition through machine learning, and potential for wireless communication functionalities. This fusion of LiDAR technology and motorcycle safety signifies a significant leap toward safer riding experiences, addressing the critical issue of rising accidents.

In conclusion, the integration of LiDAR sensors with a motorcycle helmet represents a pioneering leap beyond conventional safety measures. This essay encapsulates the innovative journey undertaken, emphasizing its relevance in the context of traffic safety and the imperative to address the surge in accidents. The fusion of technology and safety showcased in this project promises a more secure future for motorcycle enthusiasts, underscoring the urgency of proactive solutions in the face of growing safety concerns.

***Key words*:** LiDAR, Arduino, Helmet.

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Chapter 1

Introduction

The chapter introduces the Smart Helmet, motivated by a commitment to enhance motorcycle safety. It outlines the scope, which covers comprehensive exploration, integration, and implementation. The project is organized to encompass research, technology selection and meticulous testing, contributing to safer motorcycle journeys.

1.1 Background

In contemporary urban environments, road safety remains a paramount concern, particularly for individuals navigating through bustling traffic on two-wheelers. Motorcycle accidents, often caused by limited awareness, pose a significant threat to riders. Recognizing this critical issue, the project aims to address road safety challenges through the development of a Smart Helmet equipped with LiDAR sensors.

LiDAR technology, known for its precision, serves as the cornerstone of the project. By integrating three LiDAR sensors strategically into the helmet, the system provides real-time information about obstacles in three crucial directions: right, left, and back. This innovative approach enhances situational awareness, acting as a proactive safety measure to mitigate the risks associated with blind spots and unexpected obstacles.

The Arduino microcontroller acts as the central nervous system, orchestrating the acquisition of data from the LiDAR sensors and processing it in real-time. This intelligent integration allows the helmet to relay pertinent information to the user, ensuring that the rider remains informed about potential hazards in their immediate surroundings.

The significance of this project lies in its potential to revolutionize motorcycle safety, offering a technological solution to mitigate the inherent risks associated with urban commuting. The Smart Helmet aligns with the broader vision of fostering a safer environment for two-wheeler enthusiasts. This project exemplifies the fusion of cutting-edge technology with everyday safety concerns, representing a proactive step towards leveraging innovation to save lives on the road.

1.2 Motivation

The driving force behind our pursuit of the Smart Helmet with LiDAR Sensors project is rooted in a deep commitment to enhancing motorcycle safety. India, home to a dynamic landscape of roadways, unfortunately, grapples with a high frequency of motorcycle accidents. The statistics are more than mere numbers; they represent lives affected and a pressing need for innovative solutions.

Many of us on this project team are avid motorcycle riders ourselves, intimately acquainted with the joy and challenges of traversing urban streets and highways. It is this firsthand experience that compels us to address the safety concerns faced by our fellow riders. The Smart Helmet project is a response to the real-world issues we've encountered, particularly the prevalence of blind spots that pose significant risks to motorcyclists.

India's roadways are teeming with motorcycles, and the vulnerability of riders is evident in the accident rates. The motivation for this project stems from the belief that technology can be a transformative force in mitigating these risks. The Smart Helmet is more than a technical innovation; it's a testament to our collective responsibility to contribute to the greater good. As we delve into the intricacies of the project report, let us be driven by the understanding that our work has the potential to save lives. The motivation lies in envisioning a future where every motorcycle rider can navigate the roads with an added layer of safety, thanks to the intelligent technology we are pioneering.

Through this project, we are not merely presenting a technical solution; we are advocating for a safer and more secure riding experience for our fellow citizens. This project report is not just a documentation of technical details; it is a narrative of our commitment to a safer future on the roads we traverse daily.

1.3 Scope of the Project

The scope of our project report encompasses the comprehensive exploration and documentation of the development and implementation of the Smart Helmet with LiDAR Sensors.

The project involves the integration of three LiDAR sensors strategically positioned on a motorcycle helmet. These sensors, capable of precise distance measurement and environmental scanning, will be connected to an Arduino Microcontroller. The Arduino Microcontroller will serve as the central processing unit, orchestrating the real-time acquisition and interpretation of data from the LiDAR sensors.

A crucial component of our scope involves the incorporation of an OLED display into the system. This display, also connected to the Arduino, will present the real-time results obtained from the three LiDAR sensors. The OLED display ensures that riders receive instant and clear feedback regarding obstacles in their vicinity, promoting quick and informed decision-making.

The integration process will extend beyond the technological components to include the physical assembly of the system onto a motorcycle helmet. Utilizing 3D printing technology, we will design and manufacture custom parts to securely mount the LiDAR sensors, Arduino Microcontroller, and OLED display onto the helmet.

To make the Smart Helmet self-sufficient, an internal power source will be incorporated. This power source will supply energy to the OLED display, LiDAR sensors, and Arduino Microcontroller, ensuring uninterrupted functionality during motorcycle journeys.

In essence, the project's scope encompasses the entire lifecycle of the Smart Helmet, from the integration of LiDAR sensors and Arduino components to the physical mounting on a motorcycle helmet using 3D printed parts. The inclusion of an OLED display and an internal power source aims to provide a holistic solution for motorcycle safety, combining technological innovation with practical usability. The project report will delve into the intricacies of each component, the integration process, challenges faced, and the envisioned impact of the Smart Helmet on enhancing rider safety.

1.4 Organization of the Project

1. Initiation:
   - Establish project objectives and assemble a dedicated team.
   - Conduct a kickoff meeting to align team members and set expectations.

2. Research and Requirements:
   - Investigate LiDAR sensor technologies and define project requirements.

3. Technology Selection:
   - Finalize LiDAR sensor and Arduino Microcontroller selection.

4. 3D Printing Design and Prototyping:
   - Design 3D-printable parts for secure helmet integration.
   - Prototype parts to ensure functionality and comfort.

5. Integration and Assembly:
   - Connect LiDAR sensors, Arduino, OLED display and power source.
   - Assemble the Smart Helmet using 3D-printed parts.

6. Testing and Quality Assurance:
   - Conduct rigorous testing under various conditions.
   - Ensure compliance with safety standards and user requirements.

7. Documentation and Reporting:
   - Prepare detailed project documentation and a comprehensive report.

8. Presentation:
   - Develop a concise presentation for stakeholders.

9. Deployment and Future Considerations:
   - Plan for Smart Helmet deployment and real-world testing.

Chapter 2

Literature Survey

This chapter presents the literature survey that delves into existing knowledge on motorcycle safety, aiming to build upon insights and address gaps. It encompasses a comprehensive exploration and analysis, forming a crucial foundation for the project.

2.1 Introduction

In the pursuit of advancing road safety for cyclists and pedestrians, the integration of cutting-edge technology, particularly LIDAR sensors, into bike helmets has gained prominence. This literature survey delves into the realm of LIDAR sensor utilization within bike helmets specifically for vehicle detection purposes.

The survey navigates through a diverse range of scholarly works and technical reports, exploring the feasibility and efficacy of employing LIDAR sensors embedded in bike helmets to detect surrounding vehicles. By synthesizing insights from existing studies, this survey aims to uncover the evolving landscape of LIDAR-based vehicle detection systems, serving as a foundation for the development of a robust safety system tailored for vulnerable road users.

This exploration aims to elucidate the current advancements, challenges, and potential solutions in integrating LIDAR technology into bike helmets for enhanced road safety, focusing specifically on vehicle detection capabilities.

2.2 Review of Literature

LIDAR-Based Road and Road-Edge Detection by Wende Zhang, *Member, IEEE*

Main Findings:

- Introduces a LIDAR-based method for swift and reliable road and road-edge detection in autonomous vehicles.
- Efficiently processes LIDAR range data by identifying and validating road candidate regions from elevation information.

Methodology:

- Relies on a forward-looking LIDAR sensor capturing a wide field-of-view and two-dimensional point arrays.

  Cascade processing:

- Identifies potential road regions through elevation data filtering.
- Classifies road segments using ground elevation variance and point distribution.
- Reduces false positives via rule-based schemes and validates road edges using top-down analysis.

Gaps and Opportunities:

- Acknowledges potential errors in single-scan detection, suggesting the use of temporal smoothing like Kalman Filtering.
- May face challenges in highly complex urban scenarios with cluttered environments.
- Opportunities for improvement through sensor fusion, combining LIDAR with cameras for enhanced accuracy.

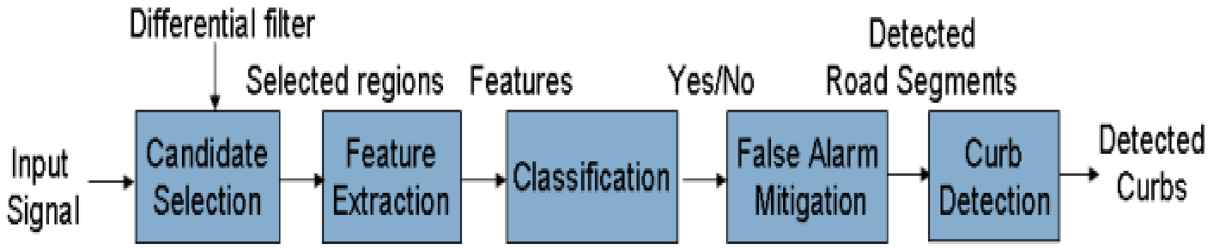


Fig.2.1 - Flowchart of road/road-edge detection algorithm [2]

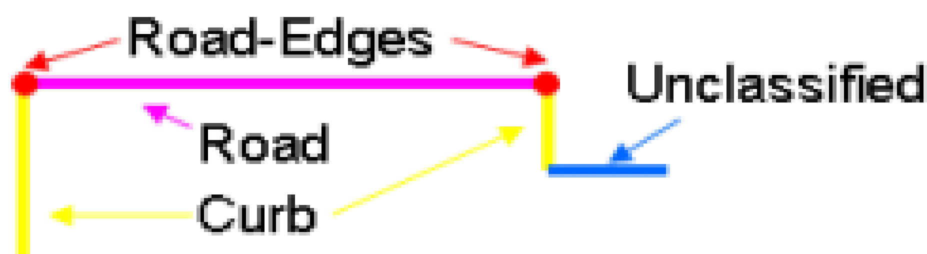


Fig.2.2 - Road Curb Detection [2]

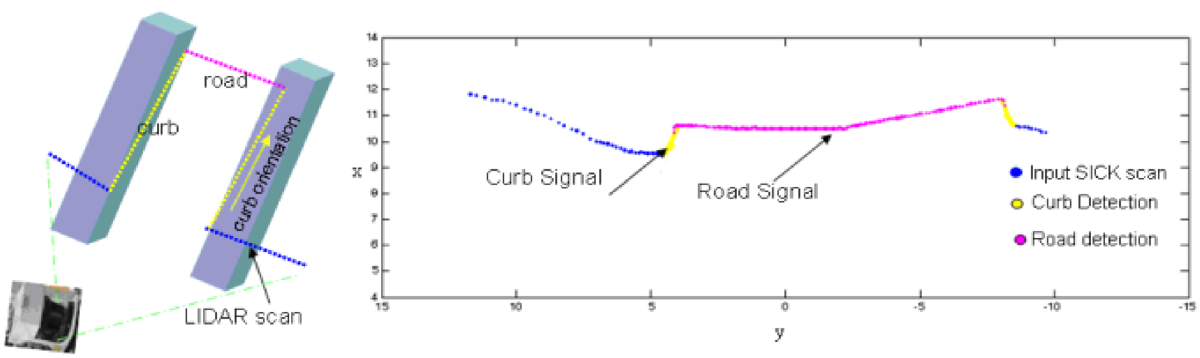


Fig.2.3 - Curb detection in x-y space [2]

Smart Helmet with Motorbike unit for Accident and Rash Driving Detection by Pranav Pathak, Electrical Engineering Department, Veermata Jijabai Technological Institute at the 2020 IEEE International Conference

Main Findings:

- Demonstrated the reliability of pulse rate sensors over traditional IR or switch-based methods for helmet detection.
- Successfully created a standalone system not reliant on a rider's mobile phone, ensuring functionality even without the phone's presence.
- Emphasized the importance of rider alerts for reckless driving, potentially preventing accidents by making riders aware of risky driving behavior and approaching vehicles.

Methodology:

- Integrated two units, Helmet Unit (HU) and Motorbike Unit (MU), communicating via RF using NRF24L01 Module.
- HU monitored pulse rate, alcohol levels, and vibration, while MU comprised GPS, GSM, LIDAR, IR, ultrasonic sensors, buzzer, and OLED display.
- Utilized continuous communication between HU and MU for various safety measures, including ignition control, alcohol detection, accident monitoring, and alerts for risky riding positions or approaching vehicles.

Gaps in the Paper:

- Lacks extensive evaluation or statistical analysis of the system's effectiveness in accident prevention or reduction.
- Limited discussion on the feasibility or challenges of implementing the system in real-world scenarios, such as environmental factors, user acceptance, or regulatory compliance.

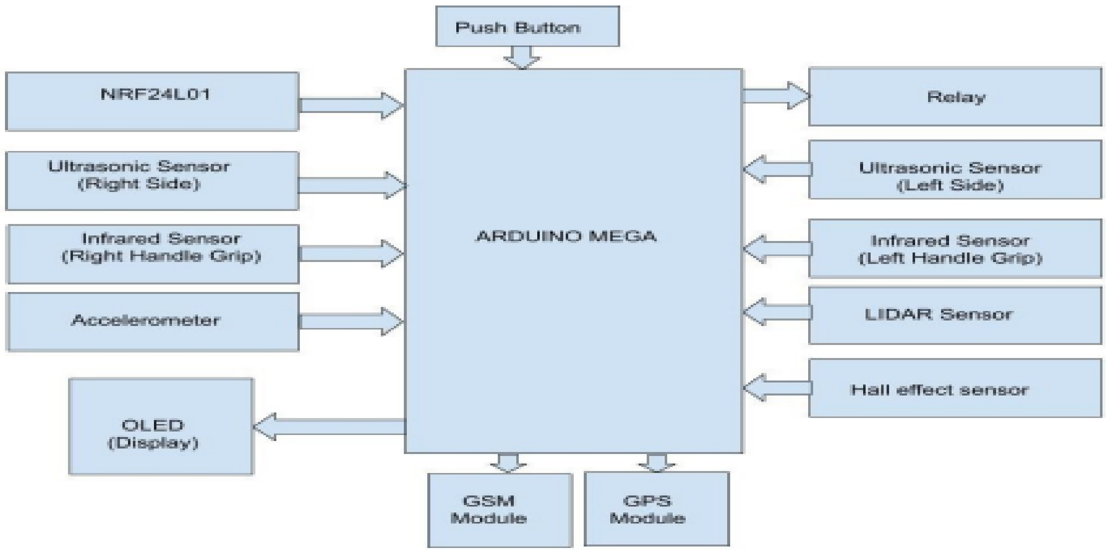


Fig.2.4 - Block Diagram of Motorbike unit used in research paper - Smart Helmet with Motorbike unit for Accident and Rash Driving Detection [3]

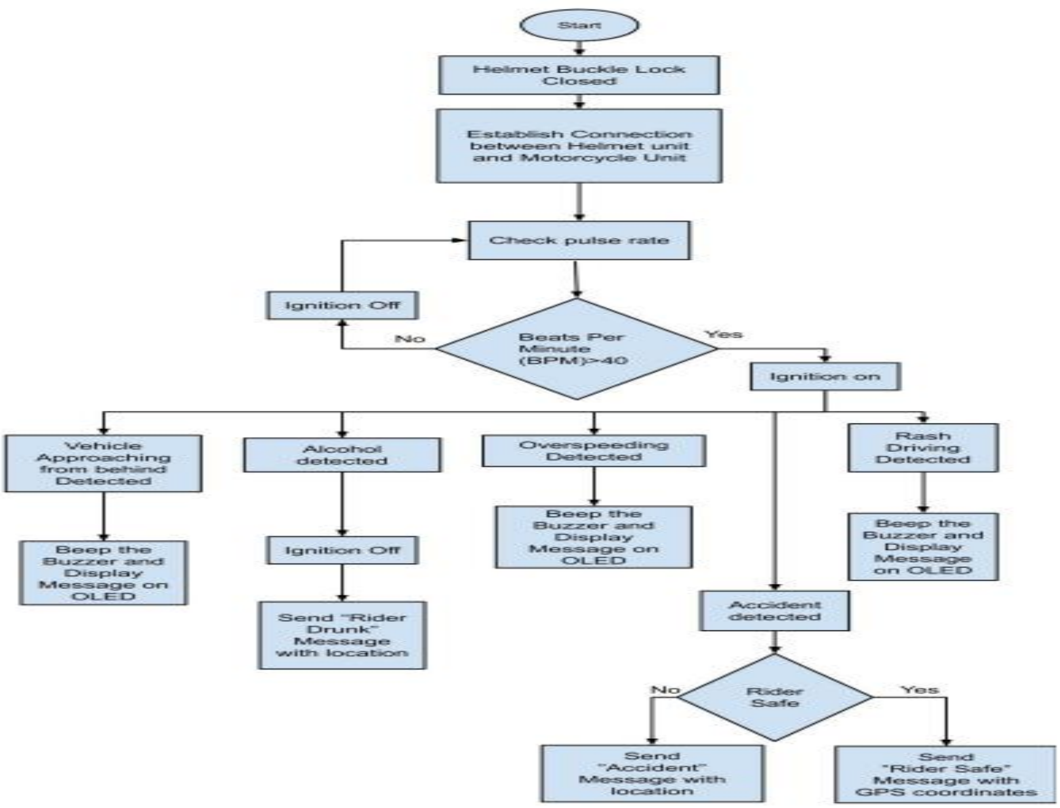


Fig.2.5 - Flow Chart of Motorbike unit used in research paper - Smart Helmet with Motorbike unit for Accident and Rash Driving Detection [3]

Design and Implementation of an Intelligent Motorcycle Helmet for Large Vehicle Approach Intimation by Wan-Jung Chang, Member, IEEE, and Liang-Bi Chen, Senior Member, IEEE

Main findings and Methodology

- The paper proposes a helmet that can detect and warn motorcyclists of approaching large trucks/buses using IR sensors, image sensor, and image processing techniques. The helmet aims to prevent rear-end collisions and enhance road safety for motorcyclists.
- The paper designs and implements two different modes for recognizing the vehicle registration plate of large trucks/buses in day and night conditions. The modes use different IR transceivers, image sensor settings, and image processing algorithms to achieve optimal accuracy and performance.
- The paper tests the proposed helmet on 600 images of rear-approaching trucks/buses on an actual road from 10 motorcyclists during day and night conditions. The paper reports that the helmet can successfully recognize the vehicle registration plate of a large truck/bus in Taiwan within a distance of 5 meters. The accuracy of the recognition is up to 75% during the day and 70% at night.

Gaps and limitations

The paper acknowledges some gaps and limitations in the proposed helmet, such as the need for more testing data, the difficulty of distinguishing between large and small vehicles, the interference of ambient light and noise, and the lack of feedback from motorcyclists. The paper suggests some possible improvements and future directions for the helmet.

Fatality Rate		Motorcycles	Passenger Cars	Light Trucks
1997	Per 100,000 Registered Vehicles	55.30	17.81	15.23
	Per 100 Million Vehicles Miles Traveled	20.99	1.45	1.24
2007	Per 100,000 Registered Vehicles	72.48	12.06	12.34
	Per 100 Million Vehicles Miles Traveled	38.01	1.03	1.06
Percent Change, 1997-2007	Per 100,000 Registered Vehicles	31.07	-32.28	-19.00
	Per 100 Million Vehicles Miles Traveled	81.09	-28.76	-14.79

TABLE.2.1 - OCCUPANT FATALITY RATES IN THE UNITED STATES BY VEHICLE TYPE, 1997 AND 2007 [1]

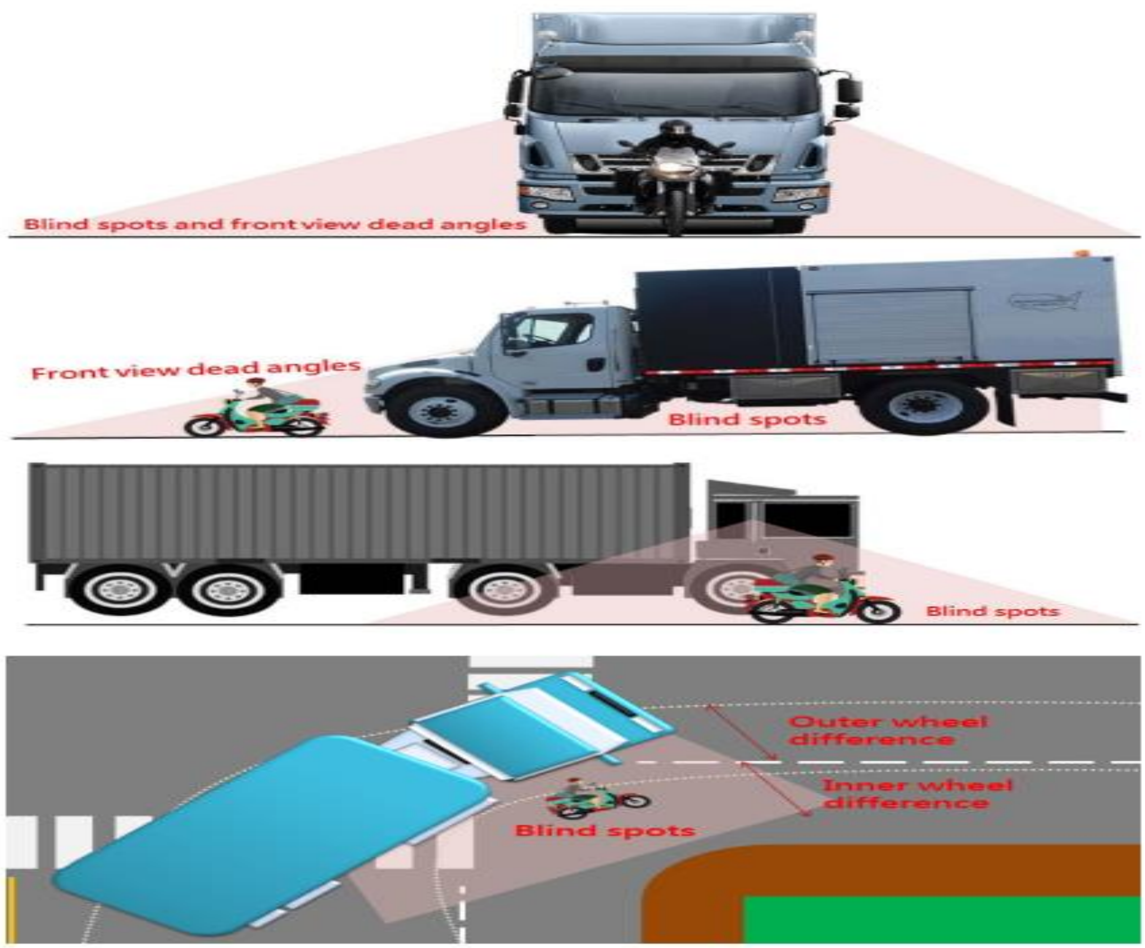


Fig.2.6 - Blind Spots faced by Motorcyclists [1]

Smart Helmet with Sensors for Accident Prevention by Mohd Khairul Afiq Mohd Rasli, Nina Korlina Madzhi, Juliana Johari in 2013 IEEE Conference

Main Findings:

- The paper presents a system integrated into motorcycle helmets to enhance rider safety.
- Utilizes Force Sensing Resistors (FSR) and a Brushless Direct Current (BLDC) fan to detect helmet usage and monitor motorcycle speed.
- The system ensures the motorcycle engine starts only if the rider wears the helmet and buckles the safety belt. It also alerts the rider when the speed exceeds 100 km/hour.
- Employs a 315 MHz Radio Frequency Module for wireless data transmission between the helmet and motorcycle.

Methodology

- FSRs placed in the helmet detect if it's worn, while the BLDC fan functions as a speed sensor.
- PIC16F84a microcontroller manages the system's operations.
- Utilizes the 315 MHz RF Module for wireless data transmission between helmet and motorcycle.
- Conducted experiments to establish the relationship between BLDC fan voltage output and motorcycle speed.
- Utilizes ICs like LM311 and IC Timer 555 for signal comparison and timing.

Identified Gaps:

- The RF module facilitates one-way data transmission, limiting interaction from the motorcycle back to the helmet system.
- The system primarily relies on visual alerts (LED flashing) for speed limit breaches; there's a suggestion for adding an audible alert (buzzer) for better rider attention.

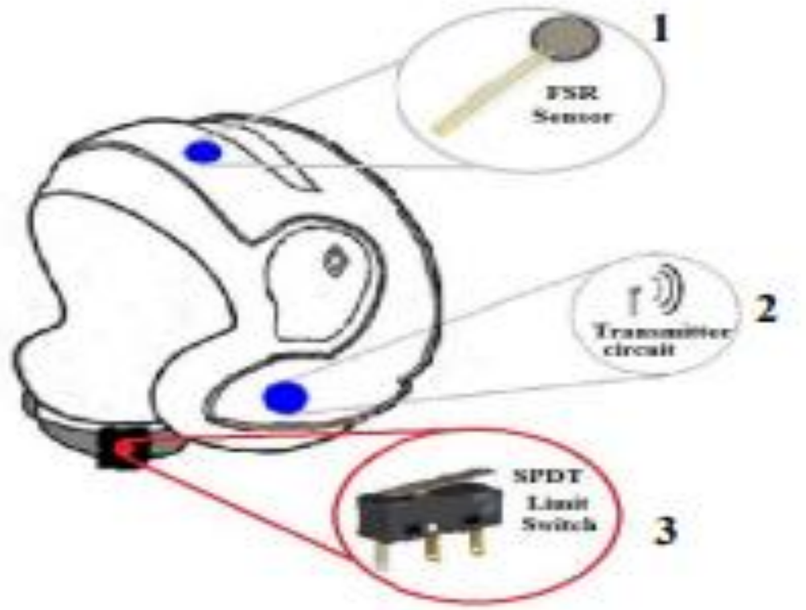


Fig.2.7 - Proposed Hardware Design in the research paper - Smart Helmet with Sensors for Accident Prevention [4]

Vehicle Detection Techniques for Collision Avoidance Systems: A Review Amir Mukhtar, Likun Xia, Member, IEEE, and Tong Boon Tang, Member, IEE

Findings:

- Significant progress in classifying vehicles due to better computing, pattern recognition, and machine learning.
- Active sensors withstand varied weather, while 3D laser scanners excel in vehicle type classification despite high costs. Cameras emerge as cost-effective, high-resolution options.
- Promising strides in both motion/appearance-based methods and appearance-based approaches, yet they need leveraging recent statistical and machine learning advancements.
- Specific attention to motorcycle detection due to unique size and shape requirements, especially in regions with high motorcycle usage.
- Proposes combining optical sensors, appearance-based cueing, and classifier-based verification for a reliable, cost-effective CAS.

Gaps:

- Varied vehicle shapes, cluttered environments, changing illumination, and driving behaviors pose ongoing challenges to robust detection.
- Despite progress, ensuring reliable collision avoidance systems in diverse on-road scenarios remains a challenge.
- Current tech lacks robust motorcycle detection and classification within identified targets, requiring specialized schemes for future CAS.
- Need to effectively integrate recent statistical and machine learning advances into detection techniques (HG and HV).
- The sensor assessment may not cover all capabilities thoroughly, potentially missing key aspects beyond cost, range, and performance.

Sensor Type	Specific Sensor	Distance	Cost	Advantages	Disadvantages
Acoustic [30]	SONY ECM-77B	Depends on sound waves amplitude and mic sensitivity	≈ 350 USD	• Omni-directional microphone • An economical solution • Real time	• Interference problem • Noise sensitive • Short range
Radar [21, 22, 25, 26]	Delphi Adaptive Cruise Control	175 m	2,000 USD	• Measure distance directly with less computing resources • Longer detection range than acoustic and optical sensor • Robust in foggy or rainy day, and during night time.	• Interference problem • Higher cost than Acoustic • Classification issue • More Power consumption than acoustic and optical sensor
Laser/Lidar [23, 24]	Velodyne HDL-64E Laser Rangefinder (3D LIDAR)	120 m	75,000 USD	• Longer detection range than acoustic and optical sensor • Independent of weather conditions • Modern lidar/laser scanners acquire high resolution and 3D information	• Road infrastructure dependency • More Power consumption than other sensors • High speed 3D scanners are expensive
	SICK LMS511-10100 (2D)	80 m	7,000 USD		
Optical (camera) [31-40]	SV-625B	100m for day 12m for night (Depth of focus)	160 USD	• Low cost, easier to install and maintain • Higher resolution and wider view angle • Extensive information in images • Independent of any modifications to the road infrastructure. • Accumulate data in nonintrusive way	• Image quality depends on lighting and weather conditions • Requires more computing resources to process the images
Fusion of Sensors [48-73]	Not Applicable	Depends on sensors fused	Depends on sensors fused	• Increases system robustness and reliability • Broadens the sensing capabilities • Collect maximum information of surroundings	• Separate algorithms for each sensor • Expensive

TABLE.2.2 - SUMMARY ON VARIOUS SENSORS FOR CAS(Collision Avoidance Systems) [5]

Fig.2.8 - LiDAR sensor for cars and the same mounted on TOYOTA Prius [5]

SMART HELMET Nitin Agarwal, Anshul Kumar Singh, Pushpendra Pratap Singh, Rajesh Sahani International Research Journal of Engineering and Technology (IRJET)

- Helmet Safety Focus: Addresses rising bike accidents, emphasizing helmet usage for safety.
- Smart Helmet Proposal: Introduces an RF-based system to mandate helmet usage for bike ignition.
- Safety Objectives: Aims for prompt medical care post-accident and bike safety with a mandatory helmet.
- RF System Implementation: Details an ASK-based RF system and technical encoder/decoder aspects.
- Application Scope: Extends to school students, promoting safety and rule adherence.

Methodology:

- System Overview: Highlights Smart Helmet operations through a block diagram.
- RF Transmitter & Receiver: Explains HT12E and HT12D functions in serial-parallel conversion.
- Usage Scenarios: Illustrates practical applications for safety improvement.

Gaps:

- Limited Evaluation Data: Lacks real-world performance data or diverse scenario assessments.
- Missing Comparative Analysis: Absence of comparisons with similar safety technologies.
- Limited Technical Depth: Requires more detailed technical explanations or schematics.
- Deployment Insights: Missing plans for real-world testing or deployment strategies.
- Inadequate System Evaluation: Lacks analysis of limitations or potential issues.

Law breakers	Two wheelers	Four wheelers
Signal jumping	2,20,859	1,46,945
Drunken Driving	36,727	17,237

Table.2.3 - Statistics of Law Breaker [8]

Mini-LED, Micro-LED and OLED displays: present status and future perspectives

Main Findings

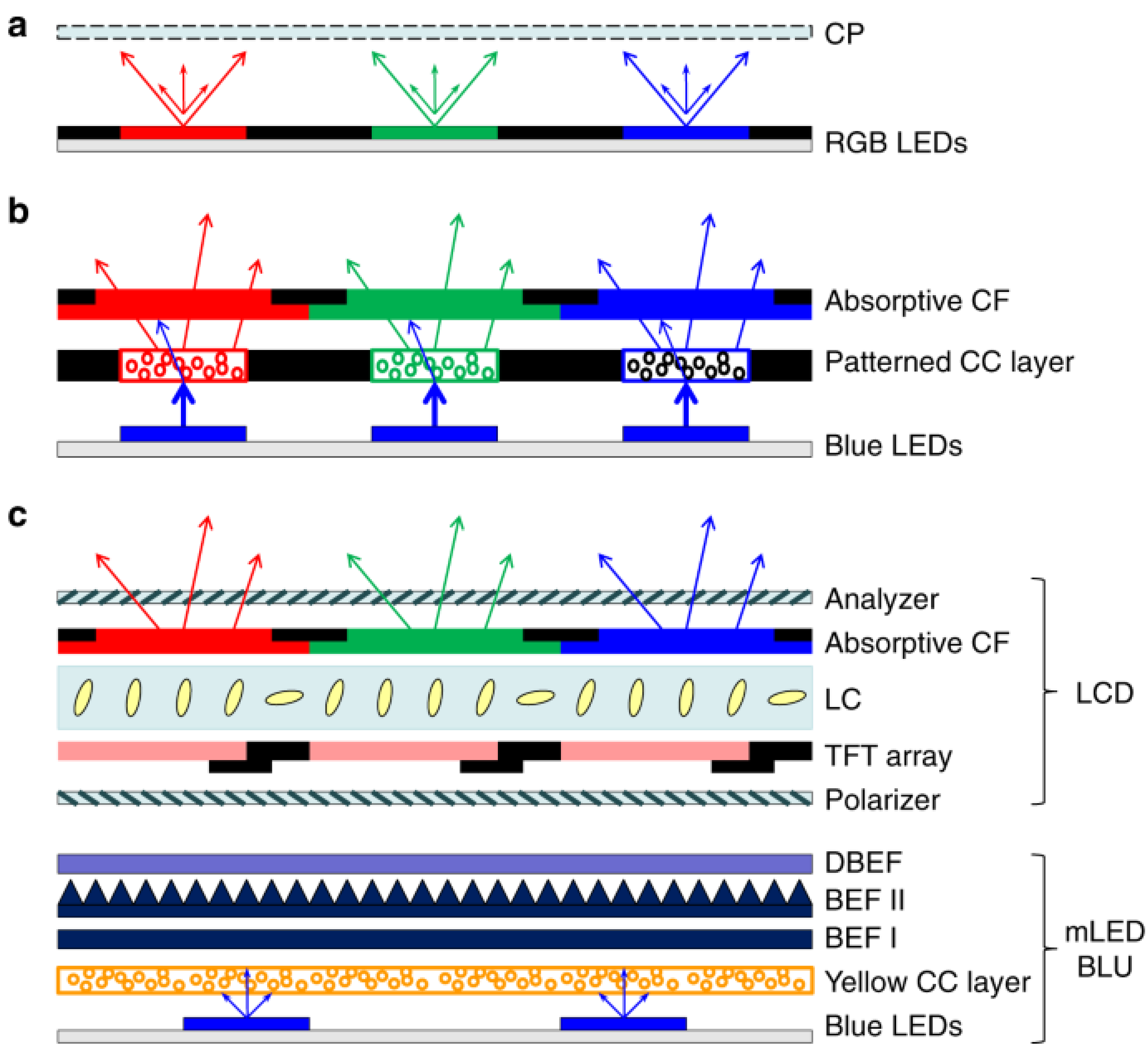
- Recent advancements and future prospects of emissive microLED (mLED), micro-OLED (μLED), and OLED displays, as well as mLED backlit LCDs, are discussed.
- These technologies offer fast response times, high pixel density, contrast ratio, and color depth, along with excellent dark states and wide viewing angles.
- Challenges include thermal management for mLED-LCDs and trade-offs between OLED lifetime and brightness.
- Evaluation includes power efficiency and Absolute Colorimetric Accuracy (ACR), with mLED-LCDs showing comparable efficiency to certain OLED configurations.
- OLEDs and mLED-LCDs hold cost and maturity advantages.
- Anticipation of OLED and mLED-LCD technologies gaining prominence alongside mainstream LCDs, with mLED/μLED displays gradually taking a central role in the near future.

Methodology

- Comparative analysis of mLEDs, OLEDs, and μLEDs based on key performance metrics such as HDR, ambient contrast ratio (ACR), resolution density, color gamut, viewing angle, motion picture response time (MPRT), power consumption, form factor, and cost.
- In-depth evaluation of power consumption and ACR for each display technology.
- Systematic comparison of dynamic range, MPRT, and suitability for flexible and transparent displays.
- Analysis of the strengths and weaknesses of mLEDs, μLEDs, and OLEDs, along with discussion of their future prospects.

Gaps and Opportunities

- Limited discussion on the specific challenges and advancements related to mLEDs, OLEDs, and μLEDs, such as mass transfer yield, defect repair, burn-in, and lifetime issues.
- The introduction doesn't address potential biases or limitations in the analysis, such as industry sponsorships, technological constraints, or research biases.

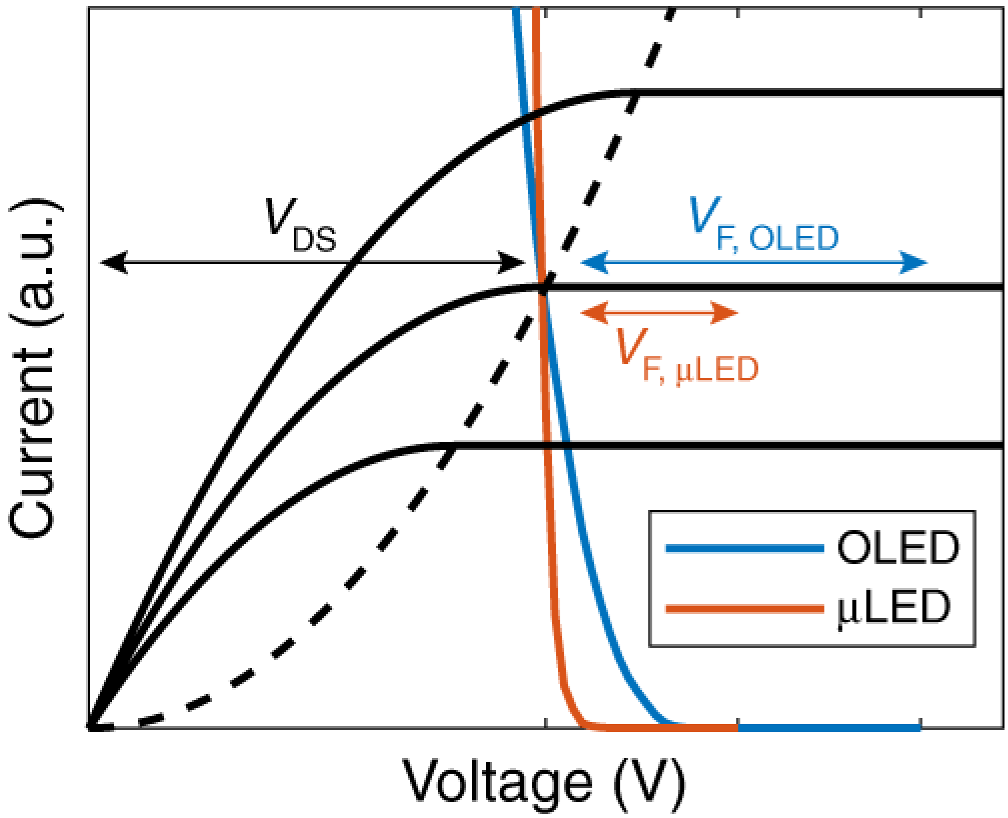


a) RGB-chip mLED/µLED/OLED emissive displays.

b) CC mLED/µLED/OLED emissive displays.

c) mini-LED backlit LCDs

Fig.2.9 - Display system configurations [9]



VDS: the TFT drain-to-source voltage.

VF, OLED: the OLED forward voltage.

VF, µLED: the µLED forward voltage

Fig.2.10 - Operating spots of OLED displays and µLED displays [9]

Chapter 3

Project Design

The project design chapter introduces the conceptual framework, highlighting the identified issues and presenting a problem statement. It features a circuit diagram and integrates essential code libraries, focusing on a streamlined approach for a robust foundation.

3.1 Introduction

The project design serves as the blueprint for the Smart Helmet with LiDAR Sensors, providing a structured approach to address identified challenges in motorcycle safety. This section introduces the conceptual framework, emphasizing the necessity to tackle real-world issues related to rider awareness and road safety. The problem statement articulates the specific challenges the design aims to overcome, setting the stage for a targeted and effective solution.

In presenting the circuit diagram, a visual representation of the proposed system is offered, illustrating the intricate connections between LiDAR sensors, the Arduino Microcontroller, and the OLED display. This visual guide enhances the understanding of the project's technical intricacies. Moreover, the integration of relevant code libraries is highlighted, showcasing the software aspect of the design and emphasizing the importance of utilizing established programming resources to streamline development.

Throughout this section, the project design is portrayed as a meticulous and strategic process, grounded in the identified challenges and driven by a commitment to enhance motorcycle safety. The introduction sets the tone for a comprehensive exploration of the design's intricacies, aiming to provide a robust foundation for the subsequent phases of implementation and experimentation.

3.2 Problem Statement

Motorcycle riders face unique challenges, especially when navigating through densely populated urban areas or negotiating complex traffic scenarios. Traditional safety measures, such as helmets, provide essential protection, but the need for enhanced situational awareness remains a critical concern. Herein lies the problem that LIDAR-equipped helmets aim to address:

Limited Field of Vision: Motorcycle riders often contend with restricted visibility, particularly in blind spots or when surrounded by larger vehicles. Conventional mirrors and vision alone may not suffice to detect nearby obstacles, creating a need for a comprehensive solution that expands the rider's field of vision.

Dynamic Urban Environments: Urban environments pose unpredictable challenges for riders, including sudden lane changes, pedestrian crossings, and obstacles appearing unexpectedly. A lack of awareness of the immediate surroundings can lead to accidents and collisions, necessitating a technology that can dynamically adapt to these changing conditions.

Vulnerability in Traffic: Motorcycles, being smaller and more maneuverable than other vehicles, can be vulnerable in traffic. The ability to detect and respond to nearby vehicles, pedestrians, or potential hazards in real-time is crucial for avoiding collisions and ensuring the rider's safety.

Helmet Integration Challenges: Embedding LIDAR sensors within a motorcycle helmet presents engineering and design challenges, such as ensuring lightweight construction, aerodynamics, and rider comfort. Balancing the need for advanced safety features with practical usability is a key consideration in the development of LIDAR-equipped helmets.

Power Consumption and Battery Life: LIDAR sensors require energy to operate, and managing power consumption while ensuring an adequate battery life is a critical aspect. The helmet should provide continuous, reliable proximity detection without compromising the rider's safety due to power-related issues.

By addressing these challenges, LIDAR-equipped motorcycle helmets aim to revolutionize rider safety by providing an intelligent, real-time proximity detection system. This technology has the potential to significantly reduce accidents, enhance rider confidence, and pave the way for a safer and more enjoyable riding experience.

3.3 Circuit Diagram

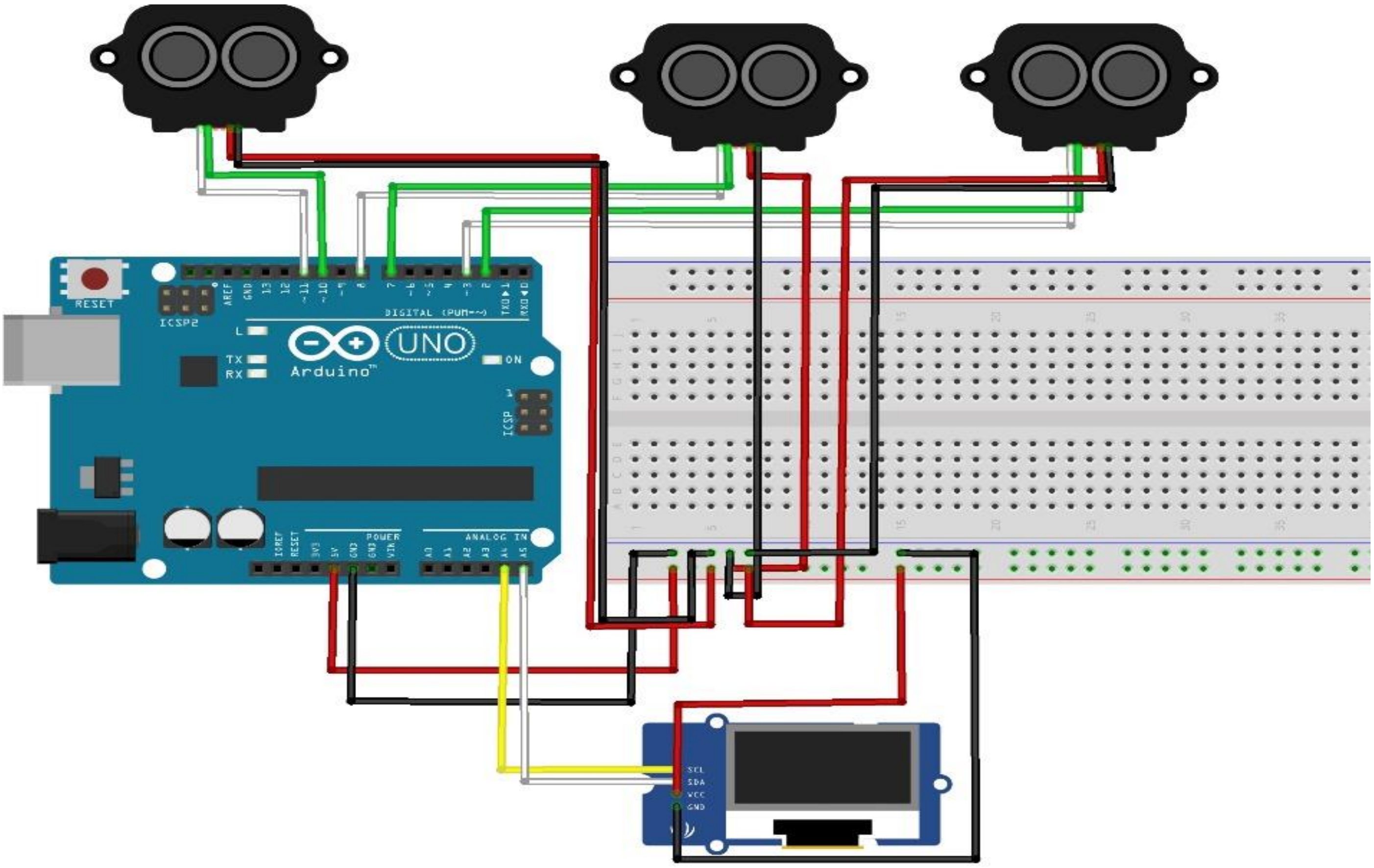


Fig.3.1 - Circuit Diagram for Current implementation

3.4 Code Libraries

3.4.1 SoftwareSerial.h

The SoftwareSerial.h library in Arduino is a valuable tool for enabling serial communication on digital pins that do not natively support hardware serial functionality. This library allows Arduino users to create additional software-based serial ports, expanding the capacity for communication with multiple peripherals. One of its primary use cases is particularly relevant for boards with only one hardware serial port, such as the Arduino Uno. By utilizing SoftwareSerial, users can emulate additional serial ports on different digital pins, facilitating connections to multiple devices like sensors, displays, or communication modules. This library features support for both full-duplex and half-duplex communication, making it versatile for a range of applications. The simplicity of its implementation and compatibility with various Arduino boards make SoftwareSerial.h a crucial asset for projects requiring additional serial communication channels beyond the hardware limitations of the chosen Arduino board.

3.4.2 SPI.h Library:

The SPI.h library in Arduino is an essential tool for facilitating communication using the Serial Peripheral Interface (SPI) protocol. SPI is a synchronous serial communication protocol commonly used for high-speed, full-duplex communication between microcontrollers and peripheral devices. This library enables Arduino boards to communicate with a wide range of SPI-compatible devices such as sensors, displays, and memory chips. It provides functions to initialize the SPI interface, configure communication parameters such as clock speed and data format, and send and receive data packets over the SPI bus. With SPI.h, Arduino users can seamlessly integrate SPI devices into their projects, enabling advanced applications requiring fast and efficient data transfer over short distances.

3.4.3 Wire.h Library:

The Wire.h library in Arduino is a fundamental tool for enabling communication over the Inter-Integrated Circuit (I2C) protocol. I2C is a popular serial communication protocol used for connecting multiple devices on a shared bus, facilitating simple and efficient communication between microcontrollers and peripheral devices. This library allows Arduino boards to act as both master and slave devices on an I2C network, enabling communication with various sensors, displays, and other peripherals. It provides functions for initializing the I2C bus, transmitting and receiving data, and controlling I2C communication parameters. With Wire.h, Arduino users can easily interface with a wide range of I2C-compatible devices, expanding the capabilities of their projects and enabling sophisticated sensor networks and communication protocols.

3.4.4 Adafruit_GFX.h Library:

The Adafruit_GFX.h library serves as a graphics core library for displays in Arduino projects, offering a comprehensive set of common graphics functions. These functions include drawing shapes, text, and images, which can be used with compatible display libraries to create graphical user interfaces and visual feedback in Arduino projects. The library abstracts low-level display operations, simplifying the process of creating custom graphics and animations without directly manipulating display hardware. It supports a wide range of display resolutions and configurations, allowing Arduino users to create rich and interactive graphical interfaces for their projects. With Adafruit_GFX.h, Arduino enthusiasts can unleash their creativity, designing captivating visual experiences for various applications, from simple data displays to complex user interfaces.

3.4.5 Adafruit_SSD1306.h Library:

The Adafruit_SSD1306.h library is a display driver library tailored for OLED (Organic Light-Emitting Diode) displays based on the SSD1306 controller chip. OLED displays offer several advantages, including high contrast, wide viewing angles, and low power consumption, making them ideal for battery-powered and portable Arduino projects. This library provides functions to initialize OLED displays, set display parameters such as brightness and contrast, and draw graphics and text on the screen. It supports both monochrome and color OLED displays of various sizes, offering Arduino users flexibility in choosing the right display for their projects. With Adafruit_SSD1306.h, Arduino enthusiasts can easily integrate crisp and vibrant display output into their projects, from simple status indicators to complex graphical interfaces, enhancing user interaction and visual feedback.

3.4.6 Arduino IDE

The Arduino Integrated Development Environment (IDE) is a robust software platform designed for programming and uploading code to Arduino boards. It serves as a comprehensive toolset, offering an intuitive interface for writing, compiling, and uploading sketches to Arduino microcontrollers. One of its key features is the extensive library support, providing a vast collection of pre-written code snippets and functionalities that simplify and accelerate the development process.

The Arduino IDE is known for its user-friendly interface, making it accessible for beginners while offering advanced features for experienced developers. Its compatibility with a wide range of Arduino boards and the ability to seamlessly integrate with various hardware components make it a go-to platform for both prototyping and developing complete projects. With built-in serial monitoring, code verification, and a straightforward upload process, the Arduino IDE plays a pivotal role in fostering a collaborative and dynamic environment for Arduino enthusiasts and developers alike.

3.5 Project Components

- TFMini-S Micro LiDAR Distance Sensor

Fig.3.2 – LiDAR Sensor

- Arduino Uno R3

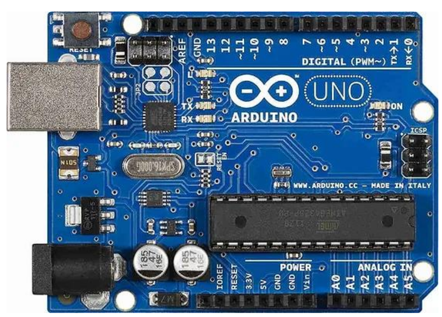


Fig.3.3 – Arduino

- 128x64 OLED Display

Fig.3.4 – OLED

- Breadboard

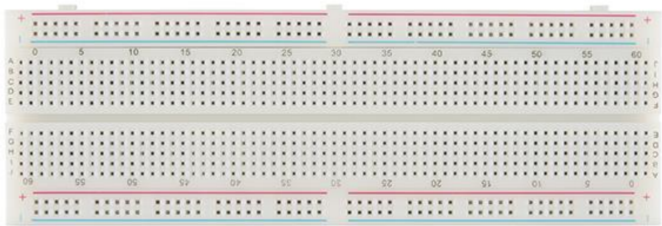


Fig.3.5 - Breadboard

- Jumper Wires

Fig.3.6 – Jumper Wires

- Power Supply

Fig.3.7 – Battery

* 3-D Printer Filament for the Mounts

Fig.3.8 – 3d Printer Filament

3.6 Financial Statements

₹9802 (3 TF Mini-S Micro LiDAR Sensors)

Order details

Product	**Total**
TFMini-S Micro LiDAR Distance Sensor for Drones UAV UAS Robots (12m) **× 3**	₹ 9,777.00
Subtotal:	₹ 9,777.00
Shipping:	STANDARD SHIPPING
Cash Handling Charges:	₹ 25.00
Payment method:	Cash on Delivery
Total:	₹ 9,802.00

Billing address

Vedansh Avlani
Flat No. 17, 4th Floor, Kamla Niwas Bldg., Morvi Cross Lane, Chowpatty Sea Face
Mumbai 400007
Maharashtra
9029113009

vedansh.avlani@gmail.com

Shipping address

Vedansh Avlani
Flat No. 17, 4th Floor, Kamla Niwas Bldg., Morvi Cross Lane, Chowpatty Sea Face
Mumbai 400007
Maharashtra

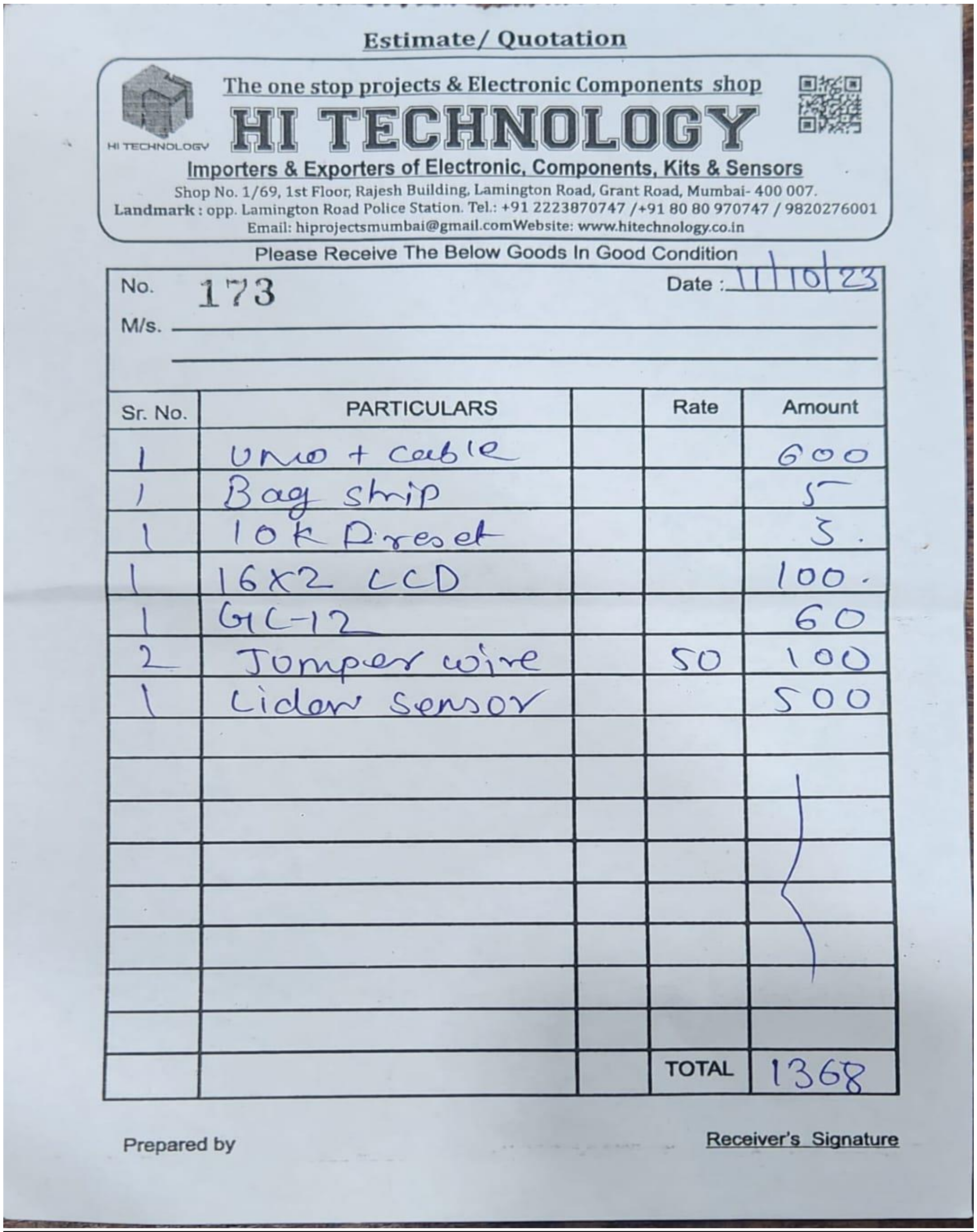
Fig.3.9 – Invoice 1

- **₹268 (OLED Display)**

Product	Quantity	Price
0.96 Inch I2C/IIC 4pin OLED Display Module BLUE	1	₹ 169.00
Subtotal:		₹ 169.00
Shipping:		₹ 99.00 via Bluedart Air
Payment method:		UPI | Credit | Debit Card | NetBanking | Wallets | EMI | Amazon Pay
Total:		₹ 268.00

Fig.3.10 – Invoice 2

₹1368 (Rest of the Equipment)



Estimate/ Quotation

The one stop projects & Electronic Components shop

HI TECHNOLOGY

Importers & Exporters of Electronic, Components, Kits & Sensors

Shop No. 1/69, 1st Floor, Rajesh Building, Lamington Road, Grant Road, Mumbai- 400 007.

Landmark : opp. Lamington Road Police Station. Tel.: +91 2223870747 /+91 80 80 970747 / 9820276001

Email: hiprojectsmumbai@gmail.comWebsite: www.hitechnology.co.in

Please Receive The Below Goods In Good Condition

No. 173 Date : 11/10/23

M/s.

Sr. No.	PARTICULARS		Rate	Amount
1	Uno + cable			600
1	Bag strip			5
1	10k Preset			3.
1	16X2 LCD			100.
1	GL-12			60
2	Jumper wire		50	100
1	Lidar sensor			500
			TOTAL	1368

Prepared by Receiver's Signature

Fig.3.11 – Invoice 3

Helmet (Price is unknown)

Miscellaneous (₹500)

Chapter 4

Implementation and Experimentation

The implementation and experimentation section delves into the project's practical realization. It includes concise details on implementation, showcases prototypes, and discusses discarded ideas. This section provides insights into the tangible development process and critical decision-making throughout the project.

4.1 Implementation Details

The current implementation seamlessly integrates three TFMini-S Micro LiDAR sensors with an Arduino Uno microcontroller and an OLED display. The configuration involves assigning digital pins 2, 7, and 10 as the TX (transmit) pins and pins 3, 8, and 11 as the RX (receive) pins for the sensors, while the OLED display's SDA pin connects to A4 and the SCL pin to A5. These pin assignments establish robust communication channels between the Arduino Uno and each TFMini-S Micro LiDAR sensor, ensuring reliable data exchange. Leveraging the SoftwareSerial library, distinct serial instances are created for each sensor, enabling concurrent data retrieval and processing.

This setup enables the Arduino Uno to independently interact with each LiDAR module, facilitating functionalities like real-time distance measurement, obstacle detection, and environmental mapping. Through meticulous pin mapping and library integration, the current implementation optimizes the communication protocol, ensuring precise data acquisition and enabling diverse applications within the Smart Helmet framework.

Fig.4.1 - Final Assembled Helmet

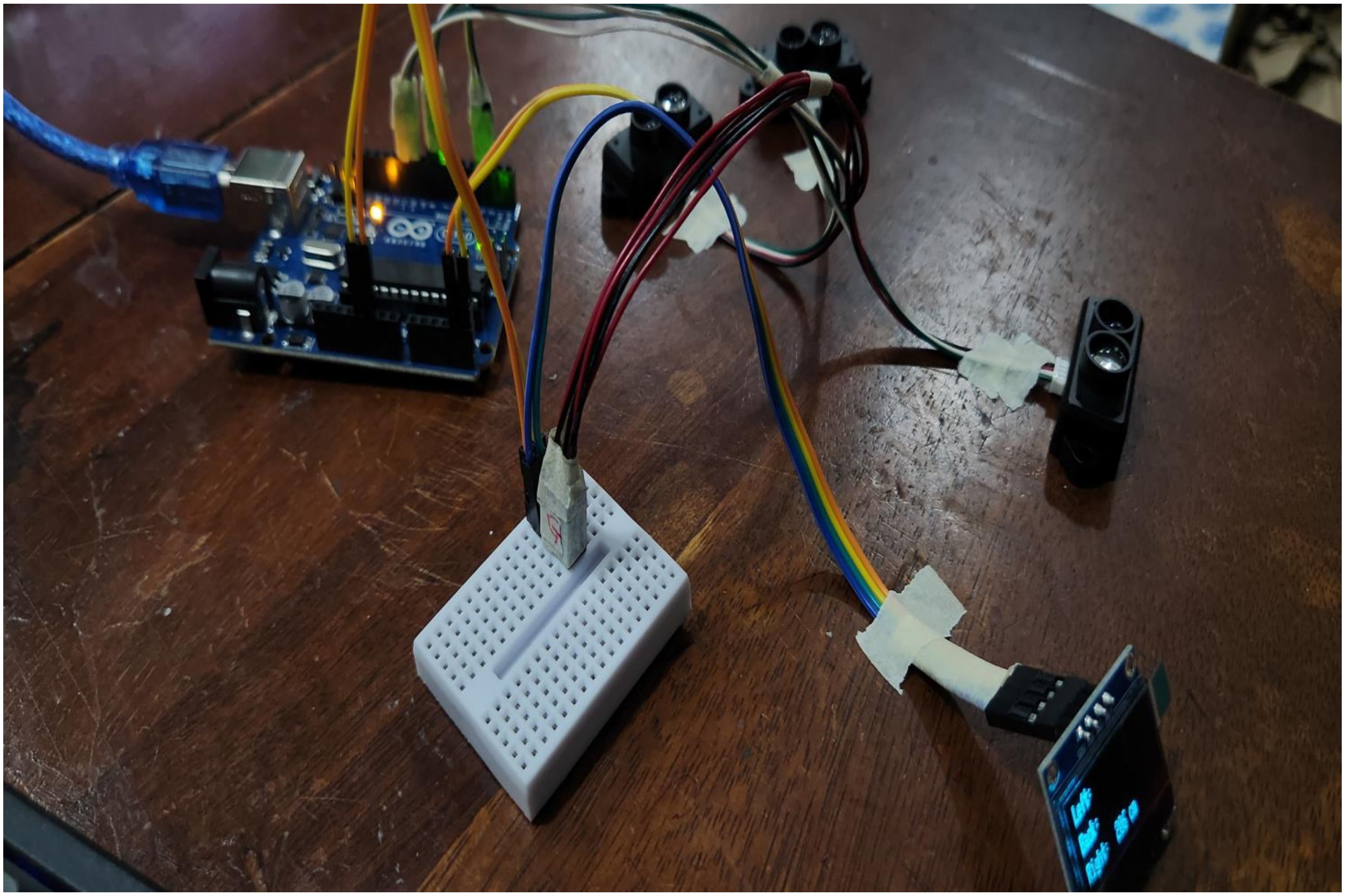


Fig.4.2 - Arduino Uno connected to all the three TF Mini-S Micro LiDAR Sensors and OLED Display

4.2 Prototypes

4.2.1 Single Sensor

In the initial implementation prototype, we focused on a fundamental setup, integrating the Arduino Microcontroller with a single TF Mini-S Micro LiDAR Sensor. This simplified configuration allowed us to establish a proof of concept, showcasing the basic interaction between the LiDAR sensor and the Arduino. Through this prototype, we laid the groundwork for the more complex Smart Helmet design, demonstrating the feasibility of real-time distance measurement and data acquisition. This minimalist approach provided valuable insights into the technical aspects and paved the way for the subsequent development stages involving multiple sensors and advanced functionalities.

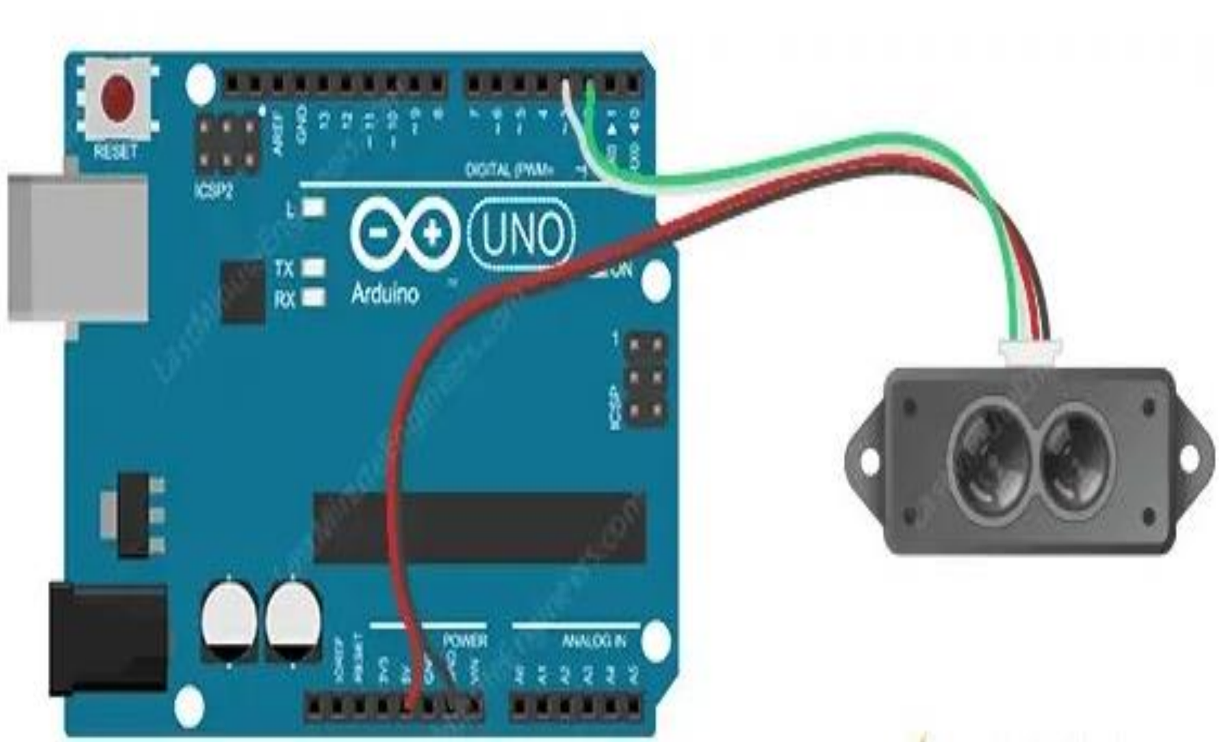


Fig.4.3 - Arduino Uno connected to a single TF Mini-S Micro LiDAR Sensor – Circuit Diagram

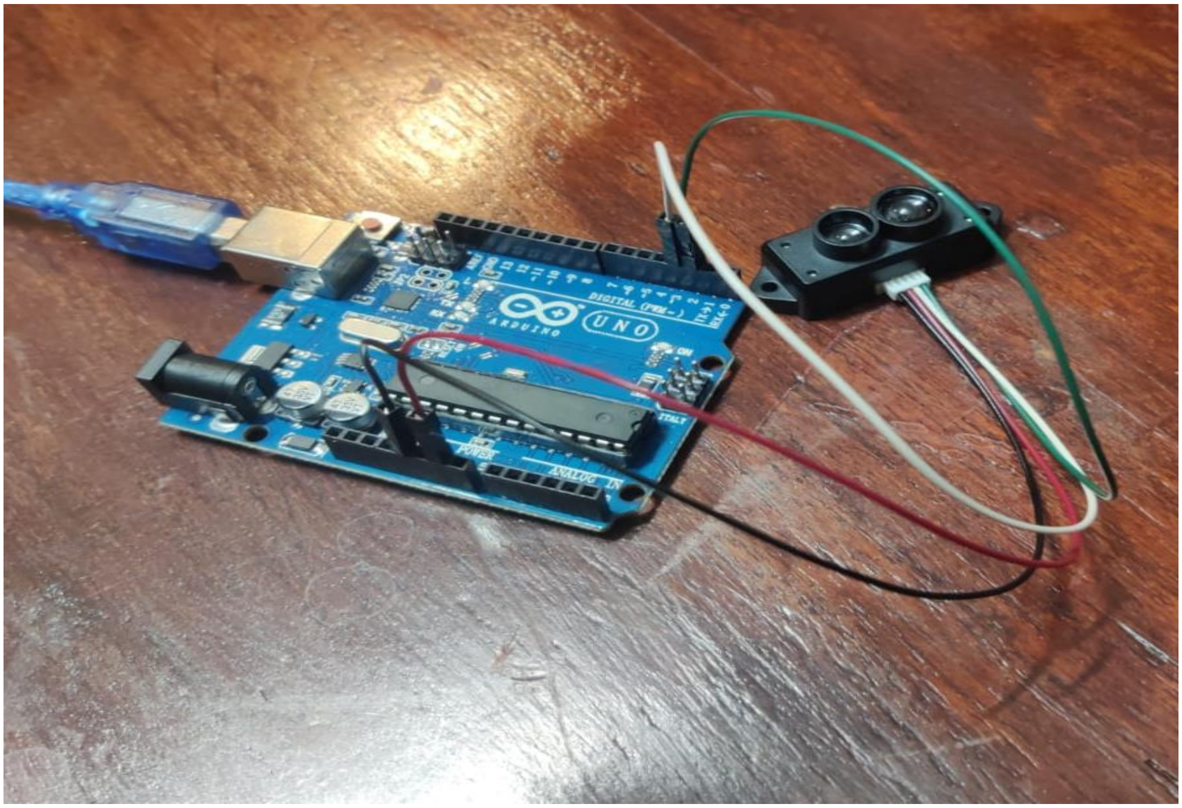


Fig.4.4 - Arduino Uno connected to a single TF Mini-S Micro LiDAR Sensor

4.2.2 Three Sensors

In the initial implementation prototype, we concentrated on a basic configuration by integrating the Arduino Uno Microcontroller with three TF Mini-S Micro LiDAR Sensors. This prototype aimed to validate the feasibility of utilizing multiple sensors in tandem with the Arduino platform. Through this setup, we sought to demonstrate the capability of the Arduino to collect data from multiple sources simultaneously and process them effectively. Despite encountering integration challenges during this phase, such as synchronization and data handling complexities, this prototype served as a crucial stepping stone in understanding the intricacies of managing multiple sensor inputs within the Smart Helmet framework. These insights guided us in refining our approach for subsequent iterations, leading to a more optimized and robust sensor integration solution.

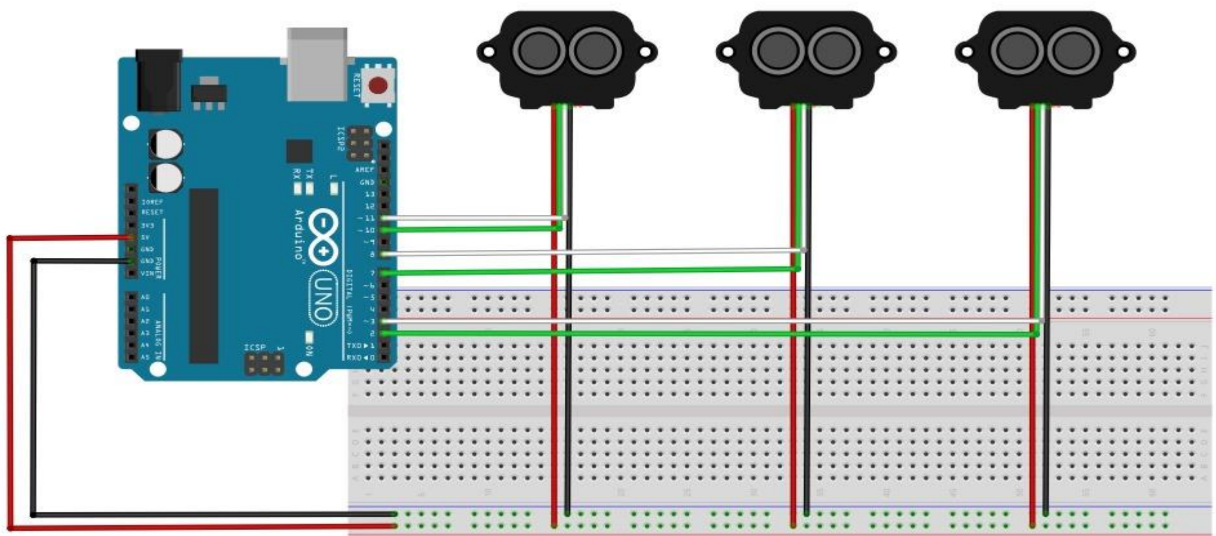


Fig.4.5 - Arduino Uno connected to three TF Mini-S Micro LiDAR Sensors - Circuit Diagram

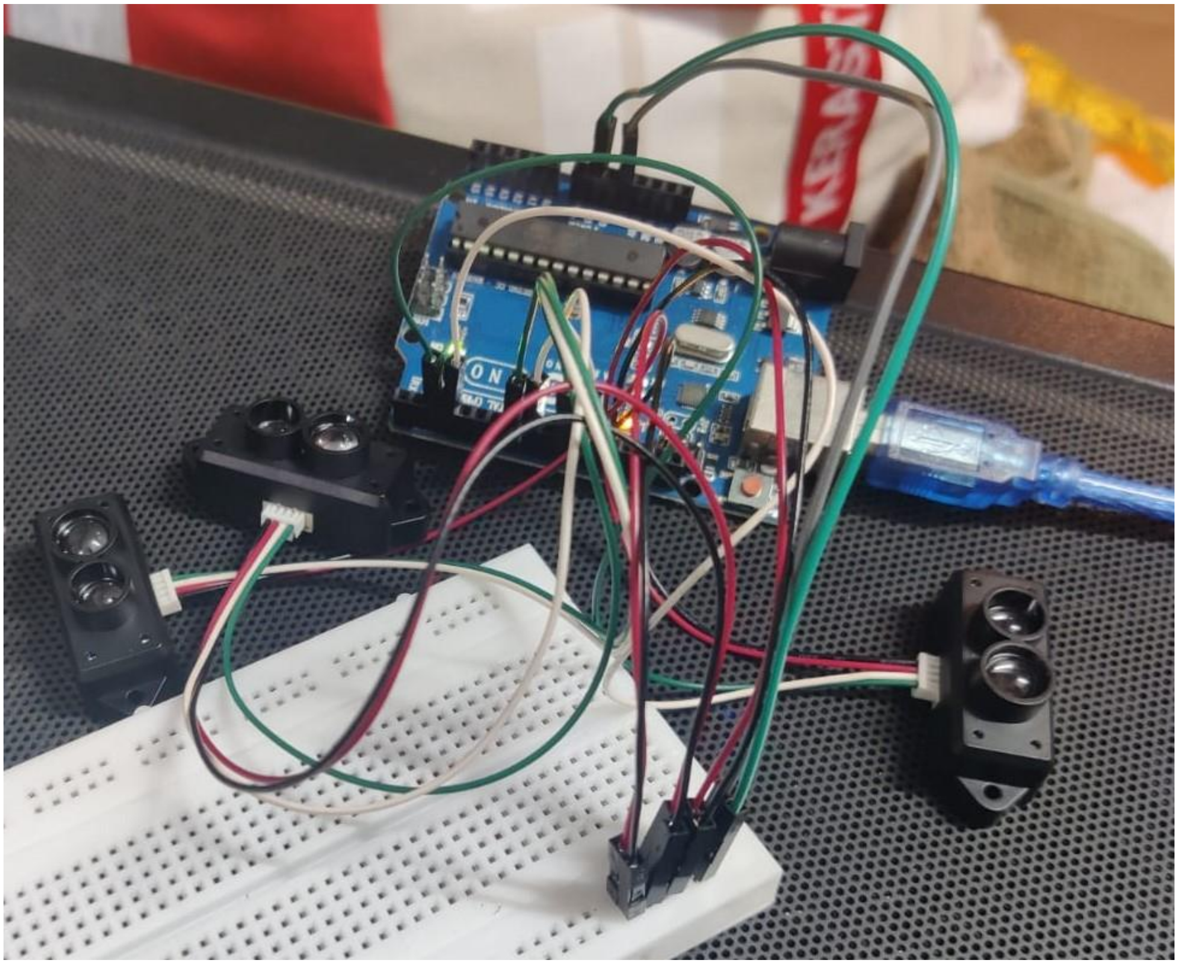


Fig.4.6 - Arduino Uno connected to three TF Mini-S Micro LiDAR Sensors

4.2.3 OLED Display

In another prototype endeavor, we explored a more streamlined setup by integrating the Arduino Uno Microcontroller with an OLED display. This prototype aimed to showcase a simplified yet effective solution for real-time distance measurement and data visualization. By combining the Arduino Uno and an OLED display, we aimed to demonstrate the compactness and versatility of the Smart Helmet design. Despite facing challenges related to limited processing power and display integration complexities, this prototype provided valuable insights into optimizing hardware resources and maximizing functionality within constrained environments. These learnings informed our design decisions for subsequent iterations, guiding us toward a more efficient and user-friendly Smart Helmet solution.

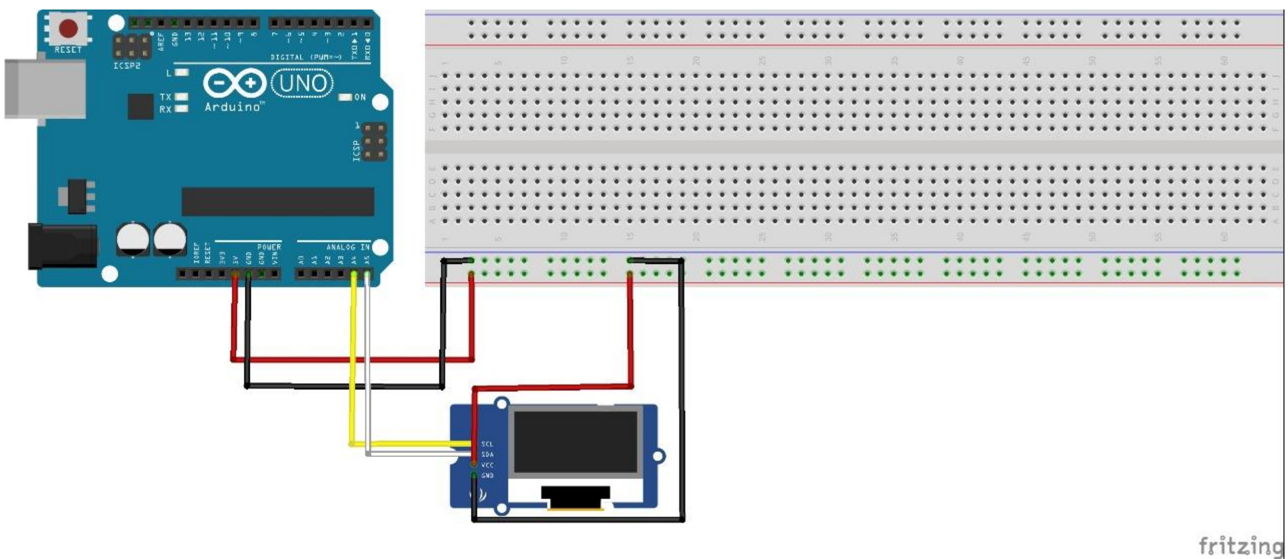


Fig.4.7 - Arduino Uno connected to OLED Display - Circuit Diagram

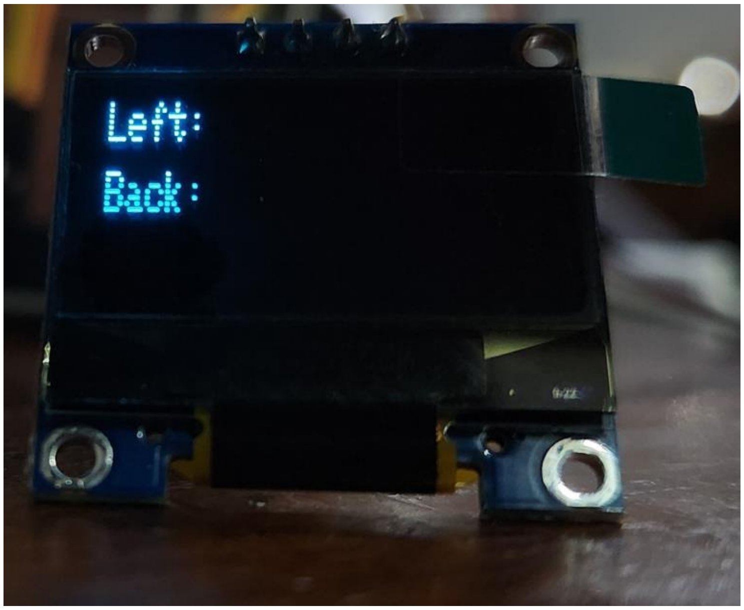


Fig.4.8 - Arduino Uno connected to OLED Display

4.3 3D Printed Parts

4.3.1 Arduino Uno Case

Top Part of Case:

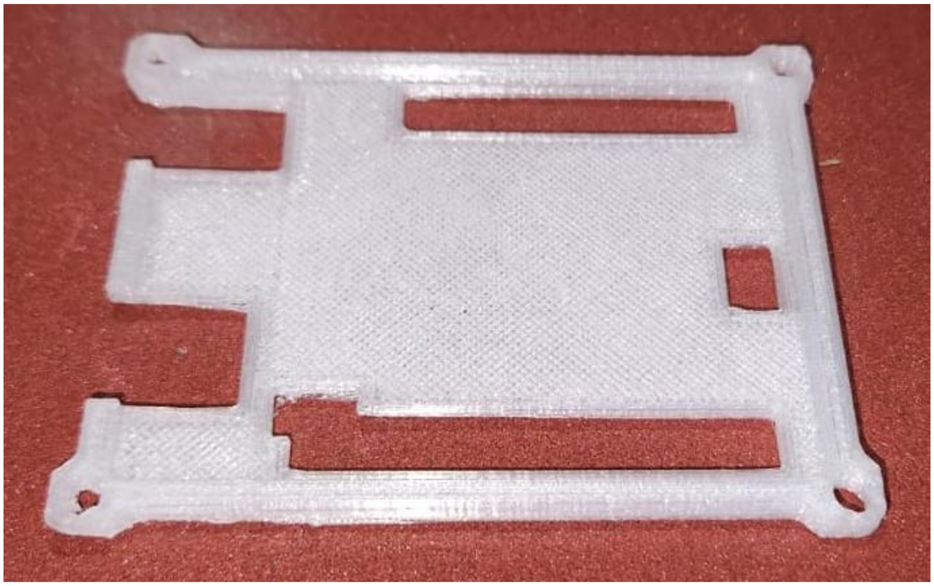


Fig.4.9 – Top Part of Arduino Uno Case

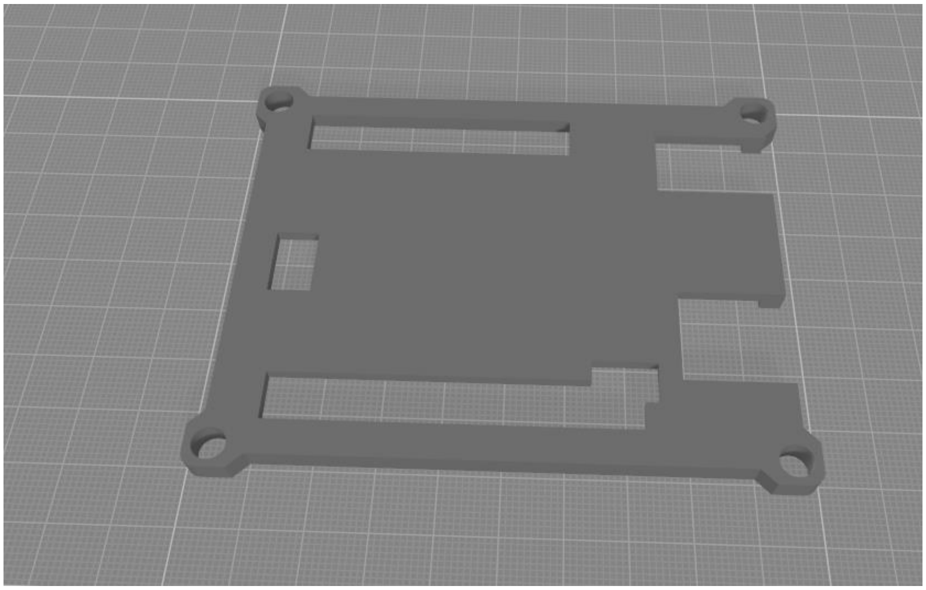


Fig.4.10 – Top Part of Arduino Uno Case – 3D Model

Bottom Part of Case:

Fig.4.11 – Bottom Part of Arduino Uno Case

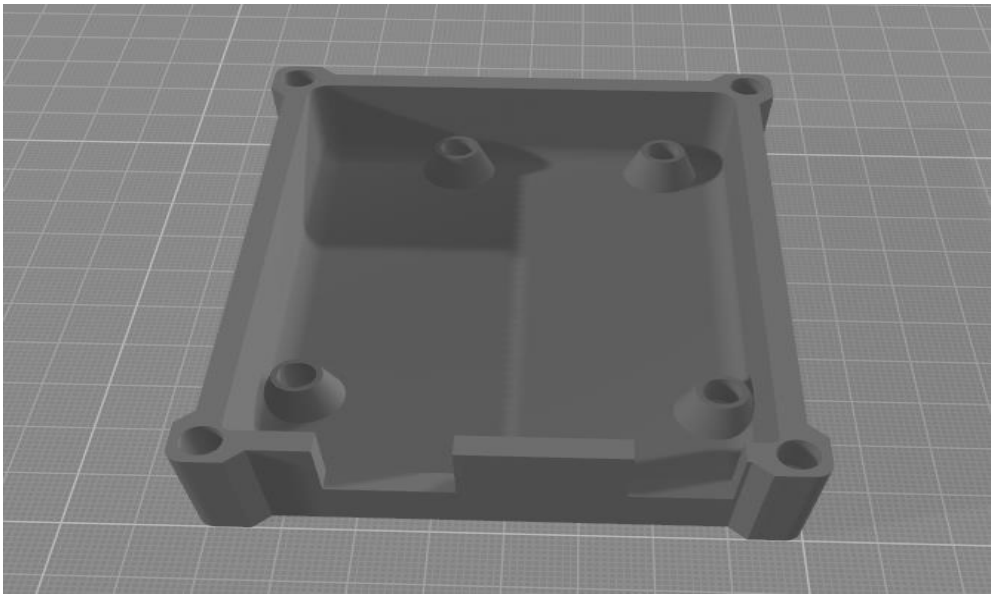


Fig.4.12 – Bottom Part of Arduino Uno Case – 3D Model

4.3.2 OLED Case

OLED Case Disassembled:

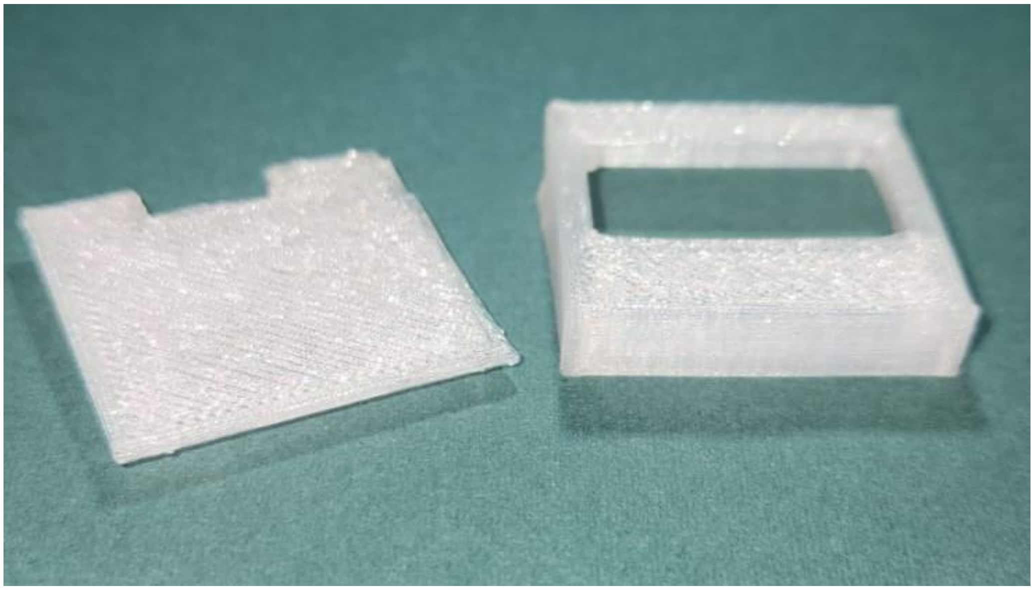


Fig.4.13 – OLED Case Top and Bottom Parts

OLED Case Assembled:

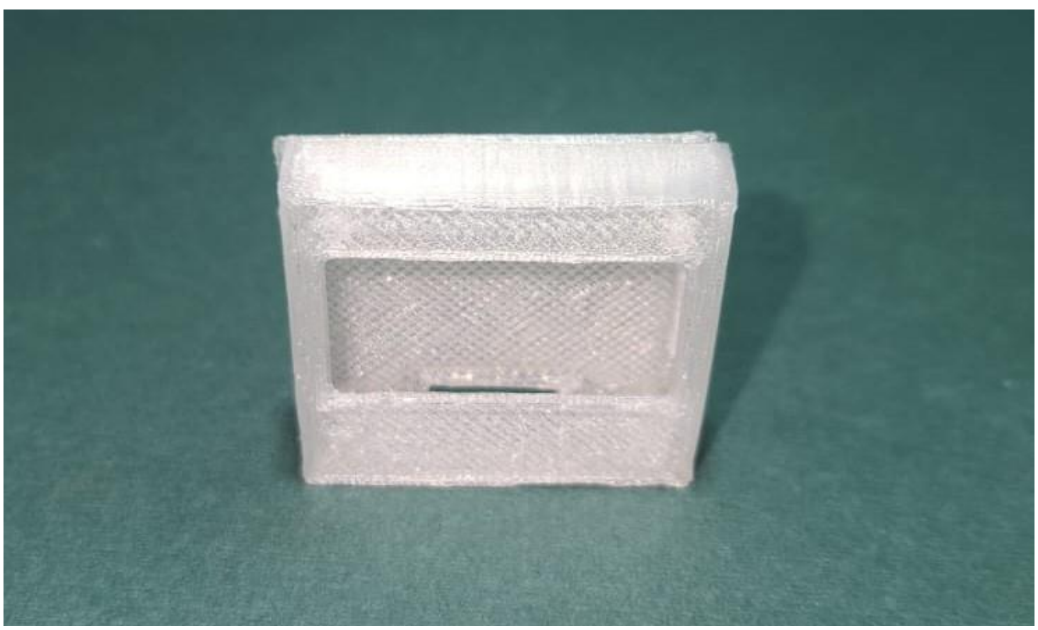


Fig.4.14 – OLED Case Assembled

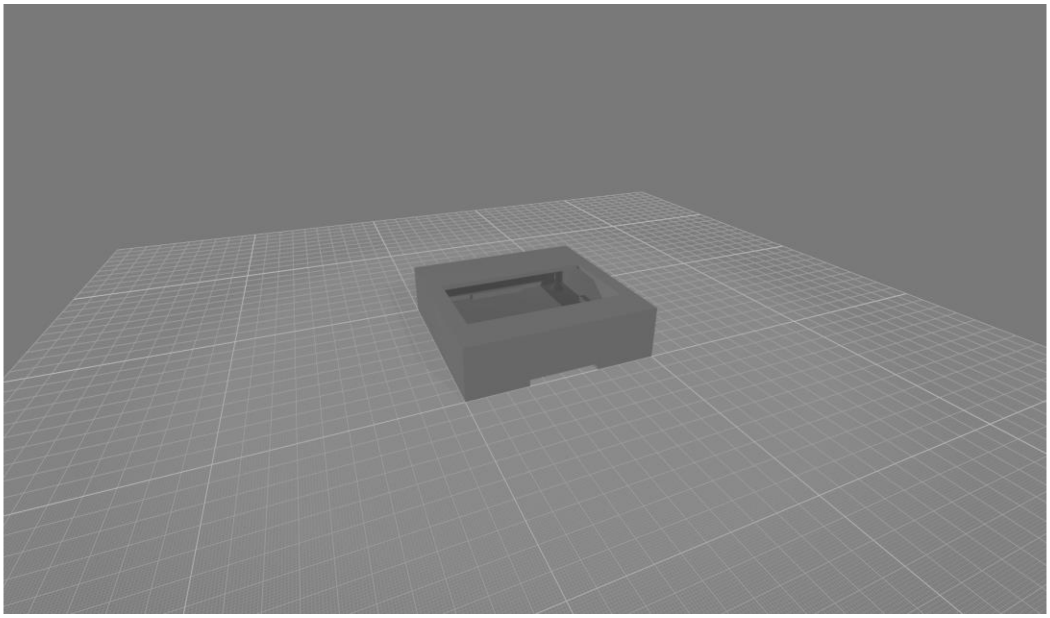


Fig.4.15 – OLED Case Assembled – 3D Model

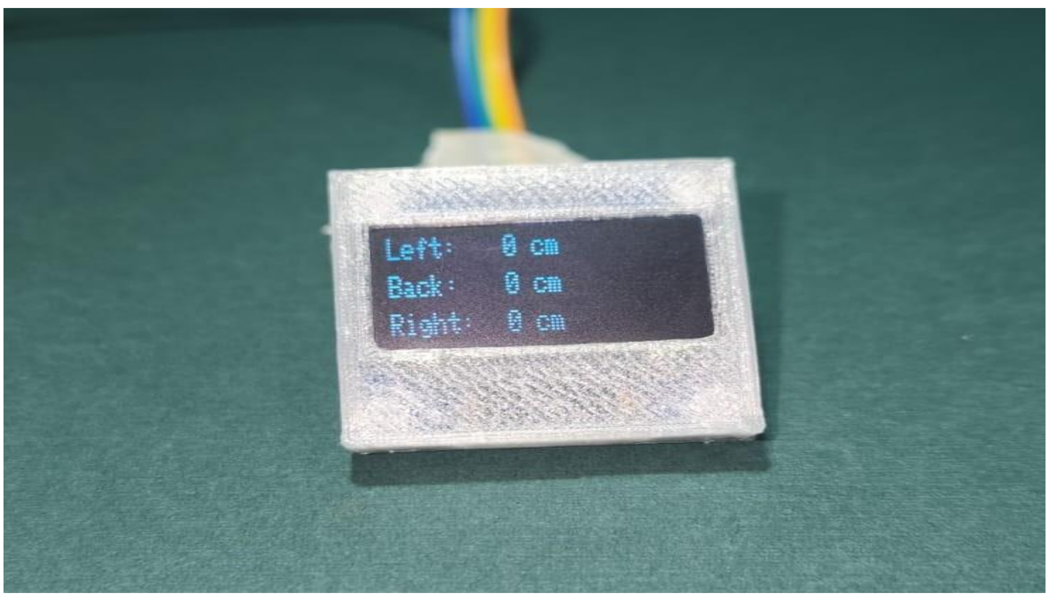


Fig.4.16 – OLED Case Assembled with OLED Inside

4.3.3 LiDAR Sensor Mount

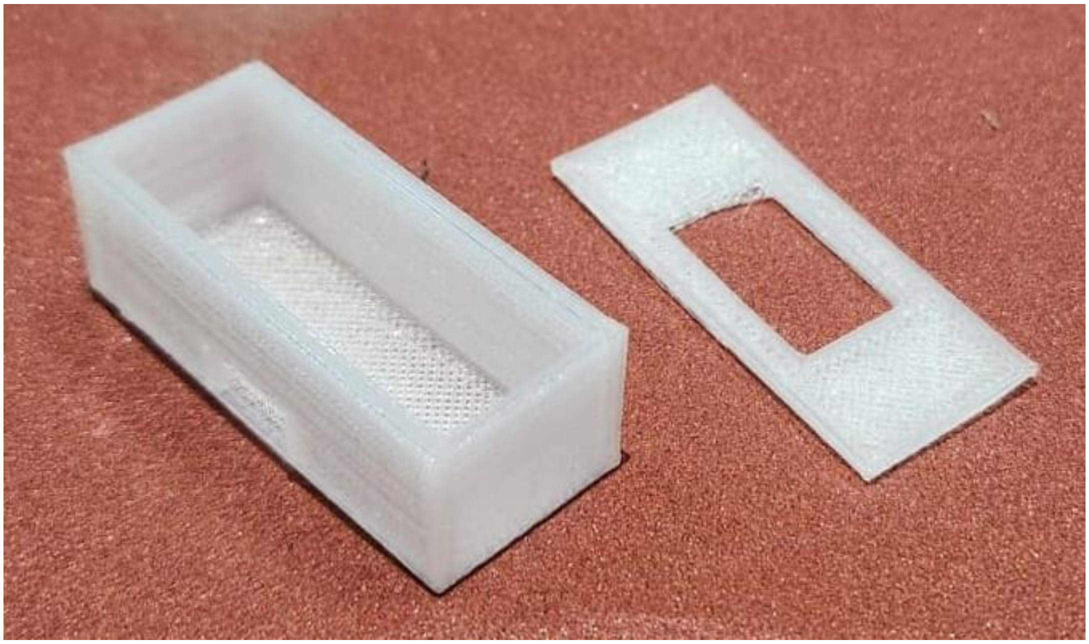


Fig.4.17 – LiDAR Sensor Mount

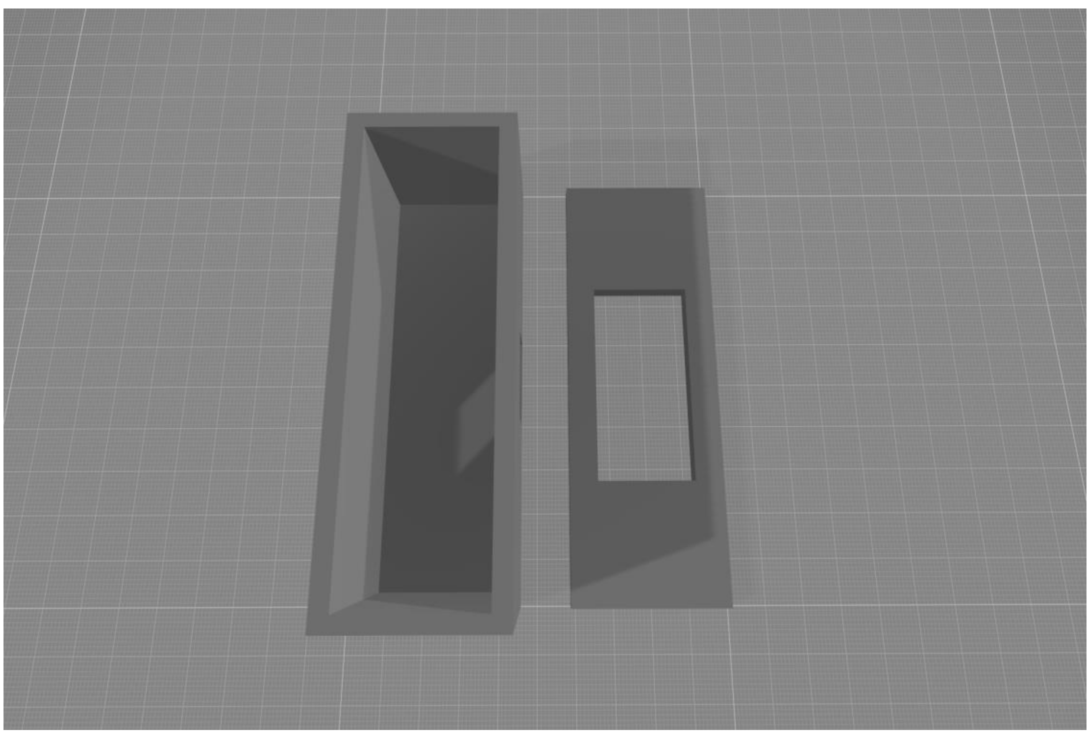


Fig.4.18 – LiDAR Sensor Mount – 3D Model

4.4 Discarded Ideas

4.4.1 Time of Flight Sensor

In one of the early prototypes, we considered utilizing the VL53L0X V2 Time of Flight Sensor as an alternative to the TF Mini-S Micro LiDAR Sensor. The primary motivation behind this consideration was the cost-effectiveness of the VL53L0X sensor. However, after thorough evaluation and experimentation, we opted to discard this idea. Despite its affordability, the VL53L0X sensor did not meet the precision and range requirements essential for our Smart Helmet project. The decision to stick with the TF Mini-S Micro LiDAR Sensor ensured a balance between cost efficiency and the necessary performance parameters for accurate obstacle detection in a real-world riding scenario.

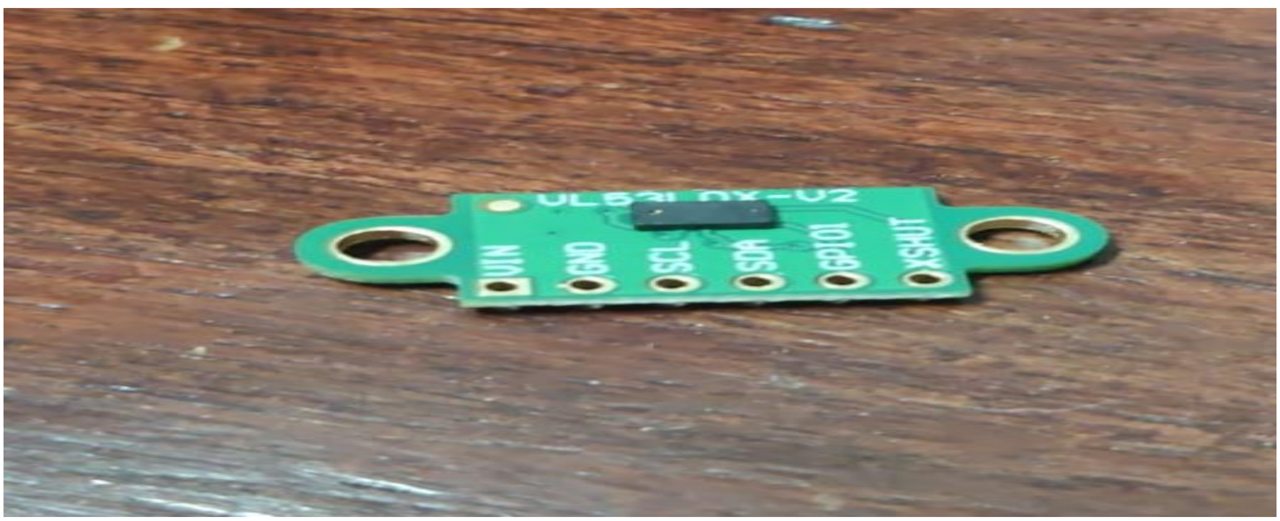


Fig.4.19 - VL53LOX – V2 Time of Flight Sensor

4.4.2 LCD Display

In another discarded idea, we attempted to integrate the Arduino Microcontroller with a 16x2 LCD Display to enhance our project's capabilities. This setup aimed to showcase real-time data presentation, with Arduino information directly displayed on the LCD screen. However, during testing, we encountered integration issues between the sensors and the LCD, which hampered the seamless functionality we envisioned. Despite this setback, this experiment provided valuable insights into the challenges of integrating different components within the Smart Helmet design. These findings informed our decision to explore alternative approaches for achieving clear and instant feedback to the user about surrounding obstacles, ultimately leading to the development of a more robust and effective solution.

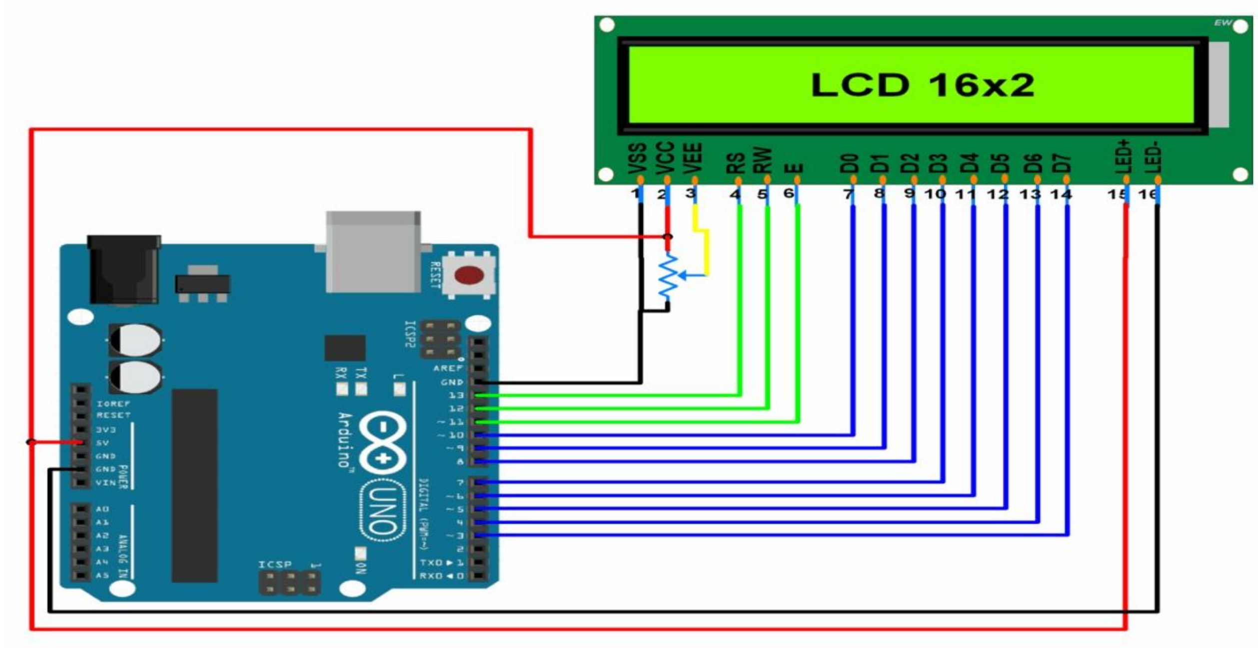


Fig.4.20 - Arduino Uno connected to a 16x2 LCD Display – Circuit Diagram

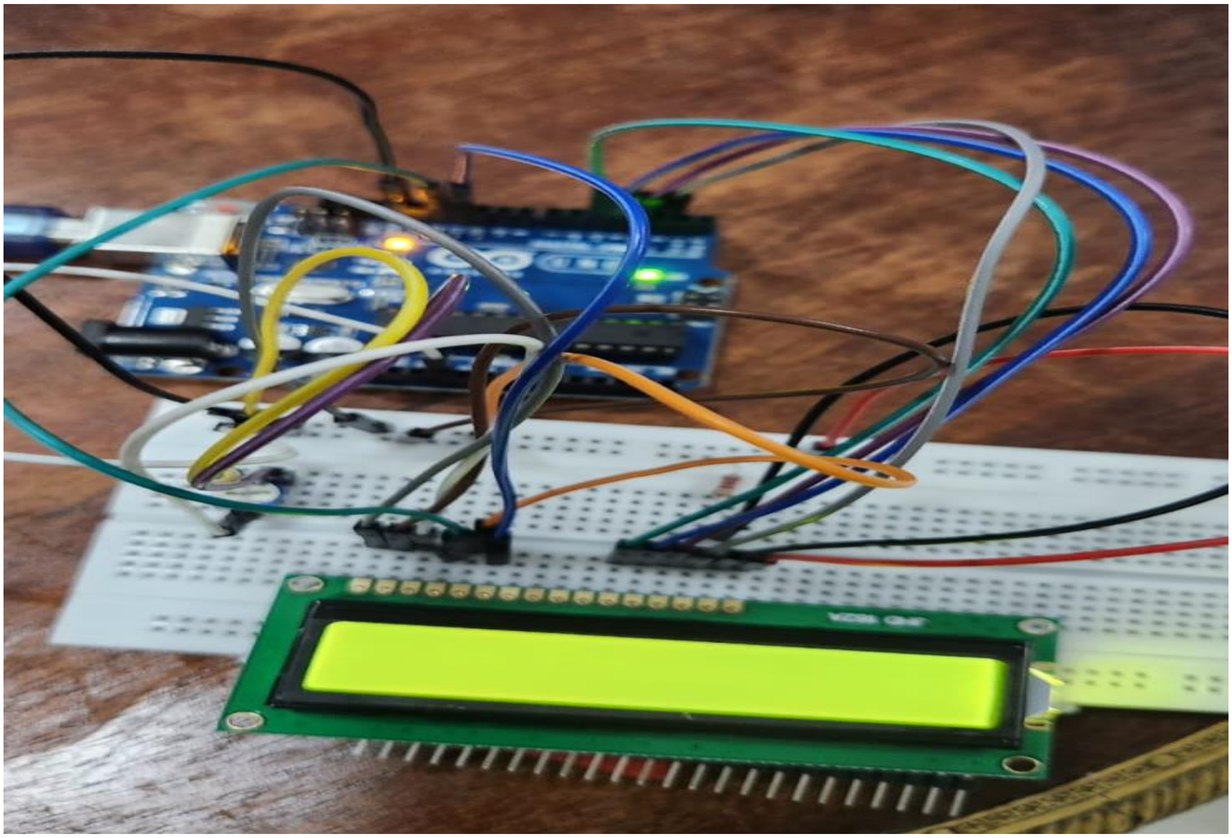


Fig.4.21 - Arduino Uno connected to a 16x2 LCD Display

4.4.3 Unused 3D Model Ideas

An open design for the sensor to be mounted on but was discarded due to the danger from direct sunlight, heat and dust to the sensor.

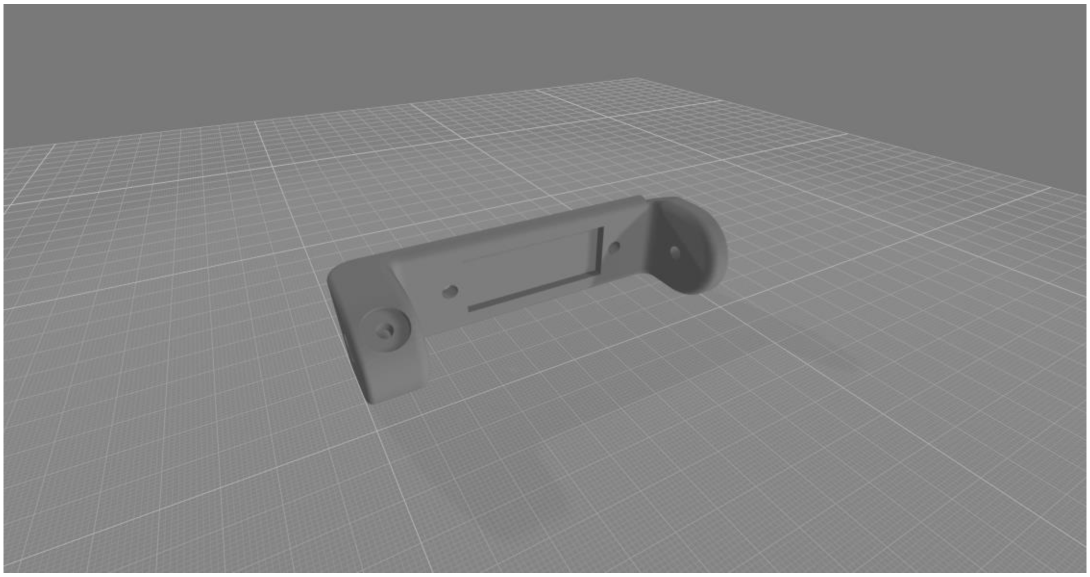


Fig.4.22 – Open Mount for LiDAR Sensor

This Design Was discarded as the hinges that were added for a closing mechanism in the mount couldn’t be printed in an effective manner.

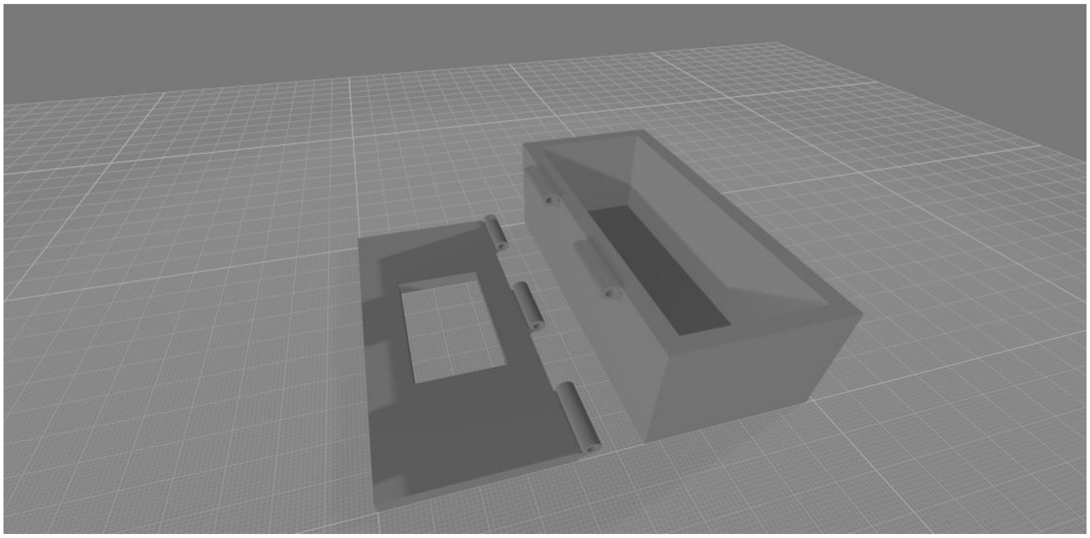


Fig.4.23 – Mount for LiDAR Sensor with Hinges

Chapter 5

Conclusions and Scope for further work

The conclusion and future scope section succinctly wraps up the project. It offers key takeaways, summarizing findings, and underscores the achieved objectives. Additionally, it outlines potential areas for future work, ensuring a seamless transition from the current project to further advancements and improvements.

5.1 Conclusions

Our unwavering commitment to advancing motorcycle safety through the development of the Smart Helmet equipped with LiDAR Sensors reflects our deep dedication to innovation and societal impact. By integrating cutting-edge technologies such as LiDAR sensors and Arduino microcontrollers, we address the pressing need for novel solutions to mitigate the rising incidence of motorcycle accidents, particularly in regions like India.

Central to our project's success are the Arduino IDE and the SoftwareSerial.h library, serving as invaluable tools for coding and fostering seamless collaboration. Our project's evolutionary journey, starting from simple prototypes featuring a single LiDAR sensor and OLED display, underscores the importance of iterative development. This approach enabled meticulous testing, refinement, and validation, paving the way for more complex configurations.

A crucial lesson learned is the significance of strategic technology selection. Opting for the TF Mini-S Micro LiDAR Sensor over the initially considered VL53L0X V2 Time of Flight Sensor demonstrates the delicate balance between cost-effectiveness and performance. Through diligent implementation and experimentation, we not only achieved real-time data presentation on a 128x64 OLED display but also laid the foundation for a comprehensive Smart Helmet design poised to revolutionize motorcycle safety.

The synthesis of technology and motorcycle safety has been at the heart of our project's success. The achieved objectives underscore our commitment to a systematic approach, integrating literature surveys, design considerations, and iterative prototype development. The strategic decision to discard the initial idea of a different LiDAR sensor serves as a poignant reminder of the paramount importance of thorough evaluation in the realization of project goals.

Looking ahead, our vision extends beyond the confines of this phase. The future scope envisions a continuous refinement of the Smart Helmet design, rigorous real-world testing to validate its efficacy, and a perpetual quest for avenues of improvement. Beyond being a mere technological venture, our journey has been about contributing to a safer and more informed riding experience for motorcycle enthusiasts. The lessons learned and insights accrued from this project lay the groundwork for further advancements, aligning with our broader vision for a future where technology stands as a pivotal force in ensuring road safety for all.

5.2 Scope for future work

The envisioned future scope for the Smart Helmet project includes a strategic transition from the Arduino Uno to the Arduino Mega. This upgrade is anticipated to enhance real-time processing capabilities, addressing the current delays in obtaining sensor data. The Arduino Mega's expanded memory and increased processing power are poised to significantly improve the helmet's responsiveness, providing more instantaneous results for heightened rider safety.

Another pivotal aspect of our future endeavors involves the development of 3D-printed models for mounting the LiDAR sensors, Arduino Mega, and OLED display. These customized mounts aim to optimize the placement of components on the helmet, ensuring not only structural integrity but also ergonomic comfort for the rider. The 3D-printed casings will add a layer of precision to the Smart Helmet's design, fostering a seamless integration of technology and safety.

Looking forward, our ambitions extend to incorporating a sensor that can assess whether the helmet is worn correctly. This addition is paramount for ensuring the effectiveness of the Smart Helmet in real-world scenarios. By implementing a sensor to monitor proper helmet usage, we aim to enhance user compliance and guarantee the optimal functionality of the safety features embedded in the Smart Helmet.

In the pursuit of these future objectives, our commitment remains steadfast in advancing the Smart Helmet's capabilities and ensuring its seamless integration into the daily lives of motorcycle riders. These proposed enhancements not only address the current limitations but also anticipate emerging challenges, positioning the Smart Helmet as an evolving and indispensable tool for motorcycle safety.

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Glossary

- LiDAR Sensor:

  Definition: LiDAR (Light Detection and Ranging) sensor is a remote sensing technology that measures distances by illuminating a target with laser light and analyzing the reflected light.

- LiDAR:

  Definition: LiDAR, an acronym for Light Detection and Ranging, is a technology that employs laser light to measure distances with high precision. It finds applications in various fields, including topography mapping, autonomous vehicles, and obstacle detection.

- Arduino:

  Definition: Arduino refers to an open-source electronics platform that utilizes a simple software interface and a versatile microcontroller to facilitate the development of interactive projects and prototypes.

- Microcontroller:

  Definition: A microcontroller is a compact integrated circuit that combines a processor core, memory, and programmable input/output peripherals. It is designed to execute specific tasks and is a fundamental component in various electronic applications.

- LCD:

  Definition: LCD (Liquid Crystal Display) is a flat-panel technology that uses liquid crystals to modulate light and create images. It is commonly used in electronic displays, including those in Smart Helmets, to convey information visually.

- OLED Display:

  Definition: OLED (Organic Light Emitting Diode) Display is a display technology that uses organic compounds that emit light when an electric current is applied. It offers high contrast ratios, wide viewing angles, and fast response times, making it suitable for applications where vibrant and power-efficient displays are needed, such as in wearable devices, smartphones, and the emerging field of augmented reality.

- 3D Printing:

  Definition: 3D printing, or additive manufacturing, is a process of creating three-dimensional objects by layering successive material deposits based on a digital model. It is widely employed in prototyping and custom manufacturing.

- Blind Spot:

  Definition: A blind spot refers to an area around a vehicle, typically not visible to the driver through standard mirrors. In the context of motorcycle safety, addressing blind spots is crucial to enhance situational awareness.

- Potentiometer:

  Definition: A potentiometer is a variable resistor that allows for manual adjustment of electrical resistance. It is often used in electronic circuits to control voltage levels.

- Time of Flight Sensor:

  Definition: A Time of Flight (ToF) sensor measures the time it takes for a signal, often a light pulse, to travel to a target and back. This technology is commonly employed in distance measurement and object detection.

- SPI (Serial Peripheral Interface):

  Definition: SPI (Serial Peripheral Interface) is a synchronous serial communication protocol used for connecting microcontrollers and peripheral devices. It enables full-duplex communication between a master device and one or more slave devices, with high data transfer rates and support for multiple devices on the same bus. SPI is commonly used in applications such as sensor interfacing, memory expansion, and display control.

- I2C (Inter-Integrated Circuit):

  Definition: I2C (Inter-Integrated Circuit) is a synchronous serial communication protocol used for interconnecting digital integrated circuits and peripheral devices. It facilitates communication between a master device and one or more slave devices over a two-wire serial bus, consisting of a data line (SDA) and a clock line (SCL). I2C is widely utilized in embedded systems, sensors, EEPROMs (Electrically Erasable Programmable Read-Only Memory), and other ICs requiring simple and efficient communication.

- UART (Universal Asynchronous Receiver-Transmitter):

  Definition: UART (Universal Asynchronous Receiver-Transmitter) is a hardware component or communication protocol commonly used in microcontrollers and peripheral devices to facilitate serial communication. It enables the transmission and reception of asynchronous serial data between devices by converting parallel data from the microcontroller into serial data streams for transmission and vice versa. UART communication typically involves two communication lines: TX (transmit) and RX (receive), and supports various baud rates, data formats, and parity settings.

- Arduino IDE (Integrated Development Environment):

  Definition: Arduino IDE (Integrated Development Environment) is a software application used for writing, compiling, and uploading code to Arduino microcontroller boards. It provides a user-friendly interface for creating Arduino sketches (programs) based on the C++ programming language, as well as libraries and tools for code editing, syntax highlighting, serial monitoring, and debugging. Arduino IDE simplifies the development process for hobbyists, students, and professionals by offering a platform for prototyping and deploying interactive electronic projects and IoT applications.

- Digital Input/Output (Digital I/O):

  Definition: Digital Input/Output (Digital I/O) refers to the ability of microcontrollers, like those found in Arduino boards, to interface with digital signals represented by binary states (high/low, on/off, 1/0). Digital inputs allow the microcontroller to detect the presence or absence of voltage or logic levels on external pins, while digital outputs enable the microcontroller to drive external devices by toggling pins between high and low states. Digital I/O functionality is fundamental for controlling switches, LEDs, relays, and other digital components in Arduino-based projects.

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