Rear End Collision Avoidance System in Motorcycle Using TF luna Micro Lidar And ESP8266

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Abstract

Purpose: of this paper to develop a system for Rear End Collision Avoidance System for motorcyclists . Motorcycles have very less Blind spot compared to 4 vehicles but rear end is one of the concern.Whenever Rider is taking turn if he/she forgets to look at rear view mirror ,this system alerts the rider .This system could also be included in making the motorcycle smart.

Design/Methodology/Approach:This System has 3 parts,First-collection of distance from Tf Luna micro lidar.Second-processing of data and calculation of Time to collision based upon Distance and Relative Speed. Here 3 Distinct threshold TTC are set low ,medium and high.Last part-In this part alert is generated by blinking of the led based on the Threshold TTC set.

Keywords—Time To Collision,Rear end collision

I. Introduction

Innovations in technology have led to a rise in vehicle safety features like Advanced Driving Assistance System (ADAS) [6] These,however, had no effect on lowering the number of accident deaths. Regretfully, according to the World Health Organization (WHO), 1.19 million humans lose their lives in traffic accidents (RTAs) each year. Pedestrians, riders, and motorcycle riders are among the most at-risk road users that account for over fifty percent of all traffic fatalities. Over 90% of fatalities from traffic accidents happen in low- and middle-income nations.The folks who require this safety feature are not able to afford these kinds of technologies.Because it requires multiple expensive sensors, ADAS is expensive; therefore, creating a cost-effective ADAS is key to promoting adoption.Effective development is growing rapidly in an effort to enhance safety measures across a number of sectors, including transportation. Collision avoidance systems are one of these innovations that has attracted a lot of interest because of their ability to reduce the risks related to car accidents. Specifically, rear-end crashes, which are common in situations with considerable traffic, are quite dangerous for motorcycle riders. The research presented here focuses on the development and application of a unique rear-end collision avoidance system made especially for motorcycles in order to address this problem.

The proposed system integrates components, including the TF-Luna LiDAR sensor, ESP8266 microcontroller, servo motor, and LED alert system, to create a comprehensive detection and warning mechanism. Through a combination of precise data handling, servo motor control, and real-time alerting, the system aims to provide motorcyclists with timely notifications of potential collision threats from vehicles approaching from behind.Further more, this system leverages the Arduino IDE, allowing for efficient firmware management and execution. Key tasks encompass data acquisition from the TF-Luna sensor, servo motor control for enhanced scanning capabilities, and the activation of the LED alert system based on calculated time-to-collision (TTC) metrics.

This research paper delves into the technical intricacies of the hardware setup, software architecture, and algorithm design of the proposed rear-end collision avoidance system. Moreover, it examines the effectiveness of the system in enhancing motorcycle safety by considering factors such as rider reaction time, motorcycle stopping distance, and traffic conditions. Ultimately, the findings aim to contribute to the ongoing efforts towards improving road safety through innovative technological solutions.

A. *Scope of Work*

The scope of work for the proposed rear-end collision avoidance system for motorcycles using sensors and ESP8266 encompasses the following key areas:

- Design and develop a proof of concept for the rear-end collision avoidance system.
- Utilize low-cost sensors, including TF-Luna LiDAR sensor and IMU, along with the ESP8266

microcontroller, to demonstrate the feasibility of the system.
- Implement a Time-to-collision (TTC) algorithm based on data collected from the TF-Luna LiDAR sensor

B. *Limitation*

While the Rear End Collision Avoidance System for motorcycles using sensors and ESP8266 offers significant potential in enhancing road safety, it also has certain limitations that should be considered

Accuracy of Sensor Data: The TF-Luna LiDAR sensor's sensor data, in particular, is critically important to the system's efficiency. Inconsistencies or challenges in the distance estimations could result in missed collision warnings or false alerts.

Dependent on Environmental Conditions: A system's performance could be affected by outside factors like ambient light levels and weather (such as rain or fog). Bad weather or dim lighting may interfere with the ability of the sensor to detect things with accuracy, hence affecting the efficacy of the system.

Variations in Rider Response Time: The system's efficacy is also based upon the riders' ability in reacting to the alerts that are issued. Variability in rider responses, which can be caused by distractions, tiredness, or experience level, may affect how well the system avoids collisions.

Limited Alerting Mechanism: The system's LED-based alerting mechanism could not be effective in every situation, especially if riders are traveling at a high pace or in heavy traffic and their attention might be split. The addition of more haptic or auditory feedback systems may improve the system's ability to hold the rider's interest.

Motorcycle vibration: The stability and accuracy of the readings from sensors may be impacted by vibrations generated by the motorcycle's engine and the condition of the road. In order to reduce the effects of the noise that these vibrations may inject into the data, additional filtering or testing techniques may be required.

C.Literature review

[1]This research describes a vehicle collision avoidance system that uses an ultrasonic sensor to detect vehicles.
To reduce the danger of accidents, the system makes use of embedded technological applications in automobiles. It is specifically concerned with creating a model for preventing rear-end collisions by identifying the separation between cars traveling in the same direction and lane. Based on the identified gap, a microcontroller notifies the driver when they approach a dangerous area. An ultrasonic sensor makes gap measurement easier and allows for early obstacle detection. By issuing timely warnings, this strategy seeks to improve driver awareness and prevent collisions.
[2]Using both longitudinal and lateral collision avoidance models, the collision avoidance switching system combines driver behavior analysis to improve road safety. The best collision avoidance tactic is chosen using a two-layer fuzzy controller taking into account the frequency of vehicle overlap. For better adaptation to a variety of driving conditions, intelligent switching is informed by parameters derived from the NGSIM dataset. The findings of the simulation show that collision avoidance is more successful. Subsequent investigations will try to verify the system using actual cars and investigate how well it functions in different traffic and road situations, which would improve road safety.[3]In this paper, wireless communication between vehicles on roads is used to simulate a vehicle accident. It talks about how to use ultrasonic sensors to gather data on the status of the vehicle, which makes it possible to foresee and reduce the risk of crashes by changing the speed of the vehicle. When there is a decrease in the predetermined safety distance between vehicles, the protocol sends out warning messages. Every car has an ultrasonic sensor installed to keep an eye out for impending hazards. When a barrier is spotted, the microcontroller measures how far it is from the sensor and applies the brakes if the distance gets smaller, signaling that the vehicle coming is too close. The study also explores different kinds of sensors and how collision avoidance systems use them.[4]An important advancement in the creation of rear-end anti-collision warning systems is the use of the IR distance sensor GP2D12. The technology warns drivers of possible hazards by sensing objects within a range of 10 to 80 cm and translates this into voltage output. Nevertheless, factors like sensor precision and longer-range detection capabilities need to be taken into account in order to improve practical application. The system's performance is encouraging despite difficulties, suggesting room for improvement and integration into cars. In order to achieve widespread adoption in automobile safety, future research may concentrate on refining sensor technology and enhancing system reliability.[5]The implementation of a collision avoidance system, controlled by the ATMEGA32 microcontroller, represents a significant advancement in automotive safety technology. Utilizing two Sharp distance sensors for front and rear object detection within the danger range enhances the system's capability to prevent collisions effectively. However, reliance on crystal oscillators for generating clock pulses may pose reliability concerns, necessitating thorough testing for robustness in real-world conditions. Integration of LCD and GLCD displays provides vital information about safe distances, enhancing driver awareness. The inclusion of a buzzer as an alarm and an actuator for automatic braking further strengthens the system's proactive approach to collision avoidance. While the use of "microC PRO for PIC" for coding and "Proteus Design Suite Version 8 Software" for simulation streamlines development, additional validation through real-world testing is crucial for ensuring the system's effectiveness and reliability in practical automotive applications.[7]These systems use different types of collision detection techniques with each one having some limitations, restricting the performance of the system. To find the effectiveness of collision warning system notifications, it is important to study the physiological response of drivers toward these systemsThe existing literature predominantly focuses on the physiological reactions of car drivers to collision warning systems, primarily using auditory cues. However, there is a noticeable gap in research concerning motorcyclists' responses to such systems, particularly with regard to their distinct maneuverability and sensory perceptions.By analyzing event-related potential components such as N100, N200, P300, and N400 extracted from

electroencephalography (EEG) data, we seek to understand the cognitive processing involved when motorcyclists receive and respond to auditory verbal alerts about potential rear-end collisions.[8]The purpose of this study was to determine the baseline motorcycle riders' perception–response times (PRTs) in an expected object braking task and to determine the significant difference between PRTs of older and younger riders.The results indicate that regardless of riders' age or gender, the average PRT for motorcyclists under baseline conditions is 0.44 seconds, with a standard deviation of 0.11 seconds. Interestingly, neither the age nor the gender of the riders emerged as significant factors influencing PRT.Drawback of this study is that it conducted on very less sample and age can affect the decision or response time.[9]This article introduces a novel Frontal Collision Warning system for motorcycles, which has been developed in the SAFERIDER project of the 7th EU FP. The Frontal Collision Warning function (FCW) described here is based on a holistic approach, which localizes the motorcycle in the road geometry, estimates the motorcycle dynamics state and rider input and senses obstacles in the motorcycle lane.The proposed warning strategy aims to enhance motorcycle safety by continuously computing the optimal trajectory based on the current vehicle state and surrounding conditions. This involves dynamic optimization considering factors such as motorcycle dynamics, road geometry, obstacle positions, and rider preferences. By prioritizing safety, comfort, and style, the system adjusts the trajectory to minimize riding risks while maintaining an optimal riding experience. This approach ensures proactive collision avoidance and enhances overall safety for motorcyclists on the road.[10]. To increase the safety of motorcyclists and minimize their road fatalities, this paper introduces a vision-based rear-end collision detection system. The binary road detection scheme contributes significantly to reduce the negative false detections and helps to achieve reliable results even though shadows and different lane markers are present on the road.[11]There are no specific safe distances suggested for motorcycle especially in emergency braking situation. This study proposed a model based on piecewise linear model of motorcycle braking deceleration profile and kinematic equations for calculating the stopping distances in a worst case scenario.This study proposes safe following distances for motorcycles in worst-case scenarios using a piecewise linear model of acceleration profiles. These calculated distances serve as recommendations to prevent rear-end collisions when following other vehicles. While comparing these distances to test results from this study and existing literature, it's noted that due to varying testing conditions, a comprehensive evaluation couldn't be achieved .[12]employed the Fuzzy Inference System Tool in MATLAB to examine the various accident contributing factor categories. In the NetLogo simulation model, the VOMAS agent is used to validate fuzzy findings. When there is a larger likelihood of an accident, the suggested system can alert the car's autonomous system, allowing the car to take over from the driver. The suggested study is very beneficial in addressing different types of accident-related issues.The proposed research is extremely helpful in handling various kinds of factors involved in accidents. The results of the experiments demonstrated that multi-factor-enabled vehicles could better avoid collision as compared to other vehicles.The Society of Automotive Engineers (SAE) defines six levels of autonomy, from Level 0 where the driver performs all tasks, to Level 5 which is fully autonomous. Levels 1 and 2 involve driver assistance systems, while Levels 3 to 5 rely on autonomous systems, with the driver still required in Levels 3 and 4. Legislative and technological constraints mandate human drivers in autonomous vehicles (AVs), making the proposed architecture relevant for semi-autonomous vehicles where control can be shifted between human and vehicle based on accident likelihood, as depicted in Figure 2, with factors assessed at a fuzzy level in Figure 3.

Design and Experimental Study of an Ultrasonic Sensor System for Lateral Collision Avoidance at Low Speeds research introduces a novel ultrasonic sensor system designed to prevent lateral collisions in low-speed automobiles. In order to successfully eliminate blind spots found in traditional rear-view mirrors, the system is designed to identify automobiles, motorbikes, bicycles, and people passing by the lateral sides of a vehicle. At low speeds, the system provides lateral object detection capabilities by utilizing ultrasonic sensors, which are often used for rear object identification during parking. To validate the system's performance, particularly its resistance to wind interference, extensive experimental research is carried out. The findings show that the suggested system, with a maximum range of 6 meters, is capable of detecting cars moving at up to 40 km/h. Furthermore, an investigation into how wind affects sensor readings reveals that the system maintains satisfactory accuracy at up to 35 km/h in gusty situations.[13]The World Health Organization's findings highlight the critical need for enhanced traffic safety regulations, especially with regard to motorbikes, which have been disproportionately responsible for road fatalities. In order to deal with this urgent problem, the study's design and implementation will focus on creating active safety features that will stop motorcyclists from colliding head-on. When an accident is about to happen, the proposed Detection and Warning System for Motorcycle Vehicular accident Avoidance aims to promptly alert the rider and any detected objects with auditory alerts. The presence of an object within the stopping distance limit, the object's trajectory toward the motorcycle's center, and the relative velocity that could cause a frontal collision are the three main requirements that the device is meant to meet in order to accomplish so. As an addition to the current Blind Spot Detection Systems (BSDS) the goal of DEWAMCA is to drastically lower motorcycle-related collisions. The research carefully describes the stages of the algorithm and specifications for design, highlighting the least amount of extra hardware needed for system integration. The goal of developing and testing a DEWAMCA prototype is to improve motorcycle rider safety by implementing early detection and warning systems. The system's potential to improve road safety is further highlighted by its ability to notify drivers of passenger cars when motorbikes are approaching. In order to ensure user satisfaction and efficiency, the study recommends fine-tuning the algorithm in the future to strike a balance between warning sensitivity and driver acceptability. Further research directions include placing the sensor optimally, improving the information processing technique, and evaluating the system's effectiveness in a variety of situations and temperatures.[14] In an effort to improve road safety, there have been an increase in interest in vision-based vehicle detection methods. Nevertheless, these methods encounter difficulties because there are many forms of automobiles, especially motorcyclists, and external elements including congested areas, uneven lighting, and unpredictable driving patterns. In order to better support collision avoidance systems (CASs), this paper provides a comprehensive overview of the most recent on-road vision-based vehicle identification and tracking systems. The study is organized around the vehicle detection process and carefully examines and evaluates methods at every turn, through sensor choice to tracking. Two noteworthy contributions are a comparison study of sensors based on criteria such as expense and range, and a targeted investigation on motorbike detection techniques. Notably, active detectors exhibit effectiveness across various climates but experience interfering issues, whereas passive sensors, especially cameras, emerge as the best option due to their affordable price, high resolution, and simple installation. The study also emphasizes the significance of distinct motorcycle detection schemes, particularly in areas like ASEAN where current technology is insufficient for bike detection and classification. The research offers a thorough strategy that combines optical sensors, appearance-based cueing techniques, and classifier-based verification to close these gaps and provide a CAS design that is both dependable and reasonably priced for the automobile sector. This comprehensive review underlines the ongoing improvements and challenges in CAS technology, setting the path toward subsequent development and research in the realm of road safety[15]

Intelligent Transportation Systems (ITS) designed specifically with motorcycle safety in mind, emphasizing new and developing trends and technology that improve vehicle safety. Although automobiles and other vehicles have historically been the focus of ITS applications, motorcycle security may now be enhanced by ITS. Since the majority of ITS systems are now intended for in-vehicle use, there hasn't been much development of ITS specifically for motorcycles. The study lists a number of intelligent transportation systems (ITS) that have the potential to improve motorcycle safety directly or indirectly. These technologies include advanced driver support systems, intelligent speed adaption, collision warning systems, and visibility improving devices. It highlights how crucial it is to set standards when creating ITS systems for motorbikes because of the particular difficulties in implementing new technology.The study also emphasizes the requirement for greater investigation to assess the usability, adaptability, and cost-benefit analysis of current ITS systems. This paper adds to the ongoing attempts to increase motorcycle safety through technology developments by offering insights into the current state of ITS for bikes and highlighting potential research directions.[16]

II. HARDWARE AND COMPONENTS

NodeMCU Board: The ESP8266 is a widely used option for Internet of Things applications since it is a very feature-rich and adaptable Wi-Fi module. The Tensilica L106 32-bit microprocessor, operating at 80 MHz, powers the device and allows it to interact with other microcontrollers or operate independently. With its many functions (including digital I/O, PWM, I2C, and SPI) supported by its GPIO pins, the module can be easily integrated with sensors and electrical gear. A wide range of development tools are available with the ESP8266, which includes an ADC for converting analog signals, onboard Flash memory for storing programs, and support for SPI, I2C, and UART connectivity. Internet communication is facilitated by its integrated TCP/IP stack, and energy-efficient applications can benefit from its low power consumption. The inexpensive cost and simplicity of programming of the ESP8266, along with a vibrant community offering a wealth of documentation and tutorials

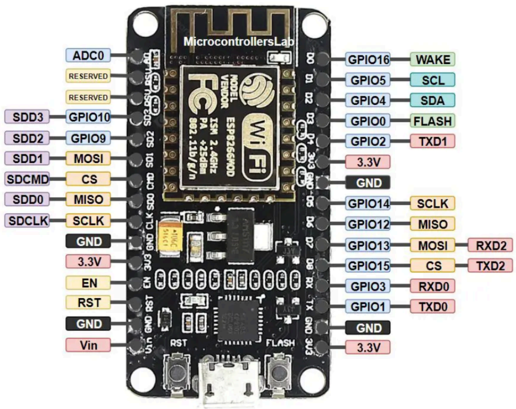


fig1..ESP8266 NodeMCU Board

The ToF-based TF-Luna is a single-point ranging LiDAR. primarily employed for high-frame rate range detection that is steady and accurate. In order to provide exceptional distance measuring performances in challenging application areas and scenarios, the product is constructed with algorithms that are tailored to a variety of application contexts and adopts different customizable configurations and parameters. Principal characteristics tiny dimensions Lightweight minimal power use inexpensive.principal scenario for application supplementary emphasis Elevator projection, detection of intrusions, and measuring of levels

fig2.TF luna micro lidar

An easy-to-use software package called the Integrated Development Environment (IDE) makes programming Arduino boards simple. With its rich toolbox, writing, compiling, and uploading code to Arduino microcontrollers is considerably easy. The integrated development environment's (IDE) user-friendly text editor, with its extensive highlighting of syntax and auto-completion capabilities, may help both seasoned developers and beginners work more efficiently. With the integrated serial monitor included in the Arduino Development Environment (IDE), users may work with their projects utilizing the Arduino in real-time for code testing and debugging. Thanks to the Arduino IDE's user-friendly interface, extensive library of tutorials, and sample code, users can quickly realize their electronic creations and unleash their creativity.

fig3. Arduino Logo

One kind of rotary actuator that enables exact control over angular position, acceleration, and velocity is a servo motor. It is made of a control circuit, a feedback mechanism (such an encoder or potentiometer), and a motor. Servo motors are widely employed in many different applications, including robotics, automation, remote control systems, and CNC machines, where precise movement control is necessary.The capacity of a servo motor to precisely retain a given position or follow a predetermined path is one of its essential characteristics.The motor's speed and direction are then modified by the control circuit to reduce the discrepancy between the intended and actual positions, producing smooth and accurate motion.

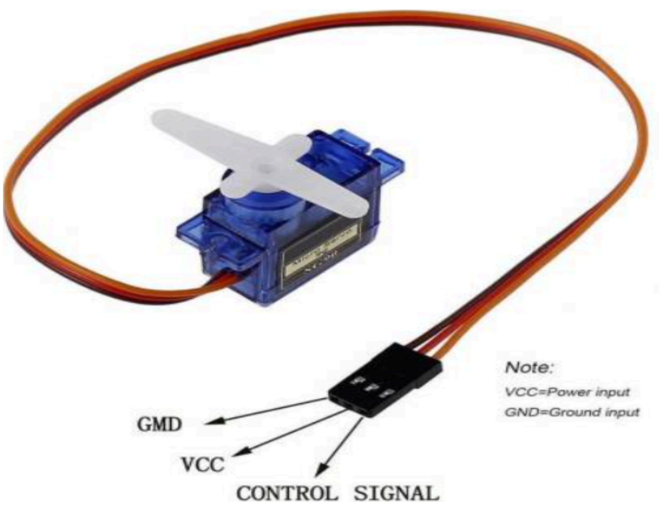
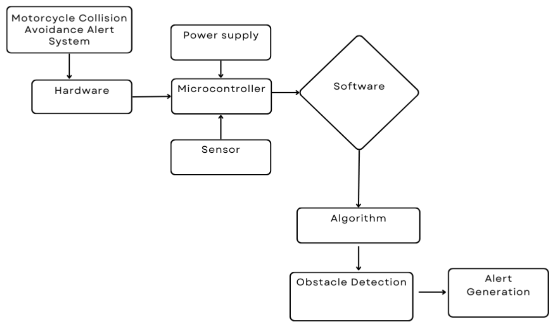


fig4..Servo motor

III. Methodology

Fig5. Flow Chart



Power Supply: This block provides the necessary power to the entire system.
Hardware: This block represents the physical components of the system, including the microcontroller, sensors, and other peripherals.
Sensor: This block is responsible for detecting obstacles or potential collisions. It sends the detected data to the microcontroller.
Microcontroller: This block runs the software that processes the sensor data and executes the algorithm for obstacle detection.
Algorithm: This block represents the software algorithm that analyzes the sensor data and determines whether a collision is likely to occur.
Obstacle Detection: This block is a part of the algorithm that identifies potential obstacles and calculates the risk of collision.
Alert Generation: If the algorithm detects a potential collision, this block generates an alert signal to warn the motorcycle rider.
Software : This block represents the software component that integrates with the microcontroller and provides the necessary functionality for the collision avoidance system.
The flow of the system is as follows:

1. The power supply provides power to the system.
2. The sensor detects obstacles and sends data to the microcontroller.
3. The microcontroller runs the software algorithm to analyze the sensor data.
4. The algorithm detects potential obstacles and calculates the risk of collision.
5. If a collision is likely, the alert generation block sends a warning signal to the motorcycle rider.

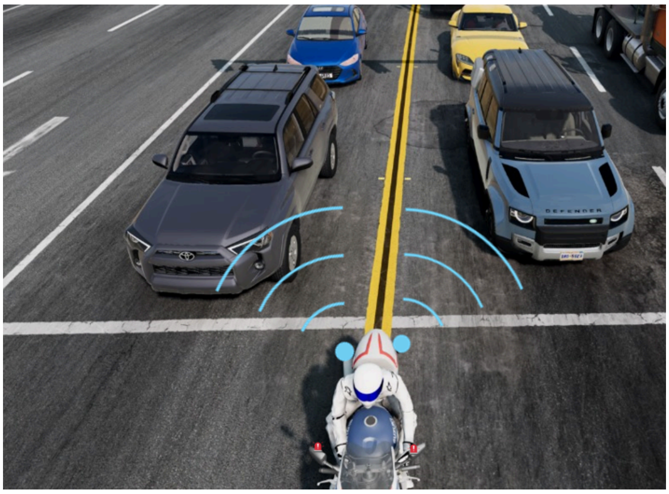


Fig 6.3D Image Motorcycle with Rear End Collision Avoidance System

A. Hardware setup

The power supply is derived from the motorcycle's battery, which is connected to the input pin of an L78M05CV voltage regulator. The 5V pin of the TF-Luna LiDAR sensor is connected to the Vin of the ESP8266 to maintain consistent voltage levels across the system.The output pin of the L78M05CV is connected to the Vin of the ESP8266 microcontroller, for a stable 5V supply. .UART establish communication between Tf luna and Esp8266, where the RX pin of the ESP8266 is connected to the TX pin of the TF-Luna, and vice versa, enabling data transfer.The TF-Luna sensor is mounted on a servo motor which allow for rotational movement, increasing the sensor's field of view. The servo motor is powered directly from the ESP8266, with connections made to the power supply, control, and ground pins of the motor. An LED is integrated into the system as an alert system.. It is connected to a digital pin on the ESP8266 and its ground is connected to the ground of the voltage regulator, making circuit complete.This configuration forms the base of the rear-end collision avoidance system.

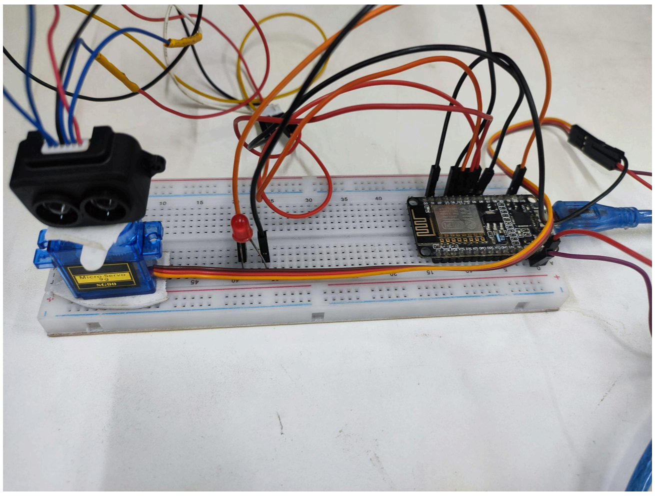


Fig 7.Hardware Setup

B. Software Setup

The Firmware used to developed this system is Arduino IDE.The key Task for the Firmware are-a)Data Handling from TF luna:here ESP8266 Continuously takes reading through software Serial library from RX and TX pins. b)Servo Motor Control:The motor scan the area from rear end of the bike maximize scanning.Here servo.h library is used.c)Alert System:LED act as alert system activated when any vehicle is approaching in the pre defined region.

Algorithm Design: Algorithm focuses on alerting the rider based on Time-to-collision. Here Rider Get 3 Distinct alert . TTC measure time remaining until a collision occurs by using relative speed of vehicles and distance of the object.First Tf luna continuously detect distance of the object at every 100 milliseconds.Secondly,Relative Speed is calculated from Two consecutive Distance D1 and D2 taken at times t1 and t2.Relative Speed=(D2-D1)/(T2-T1). At last TTC is calculated using the formula =D/Relative Speed. Decision making: Here 3 threshold TTC set at 5sec where normal alert sends that vehicle is at potential collision. TTC=3 sec (Medium Alert) where aggressive LED blinking is done which alerts the rider to take necessary action. TT=1.5 sec (High Alert) urgent reaction is needed. These TTC Thresholds have been decided considering Rider Reaction Time,Motorcycle Stopping Distance and Traffic Conditions:.

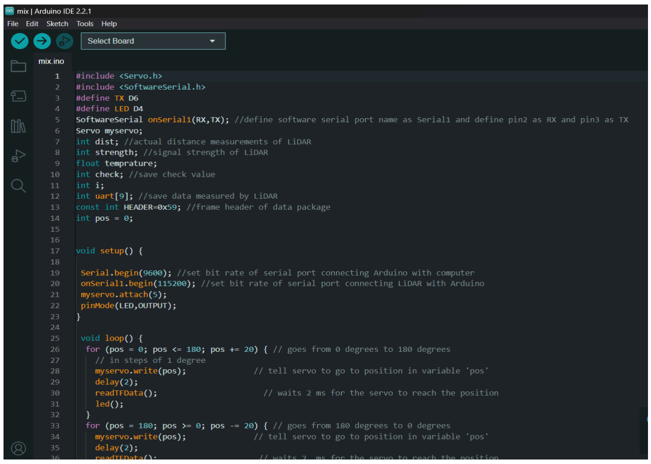


Fig8 Software Setup in Arduino IDE

V. Comparison With Existing Market Product

ASPECT	OUR PROJECT	RIDE VISION
Technology and Components	TF-Luna LiDAR sensor, ESP8266 microcontroller- LED alert mechanism	Front and rear camerasAdvanced image processing algorithms- LED indicators integrated into mirrors
Detection and Alert Mechanisms	LiDAR sensor-based obstacle detection- LED alerts	Camera-based obstacle detection- LED indicators in mirrors

User Experience and Integration	Retrofit solution, cost-effective	Comprehensive solution with advanced features- Seamless integration into motorcycle design
Cost and Accessibility	Low-cost option Cost=Rs3000 below	Premium Product cost=$700 or Rs58000

VI.Result And Analysis

Simulation Accuracy and Reliability-The simulated TF-Luna LiDAR sensor provided accurate distance measurements within the specified range, as validated against known distances in the simulation environment.Repeated simulations demonstrated consistent and reliable performance of the sensor model, indicating its potential suitability for real-world applications.

Analysis of the model's response time from simulated obstacle detection to alert activation revealed a small latency.While the latency is minimal, further optimization may be necessary to reduce response time and enhance system reactivity.While the current latency is within acceptable limits, reducing response time could enhance the system's ability to provide timely warnings to riders and mitigate collision risks effectively.

Future research and development efforts should focus on identifying and addressing factors contributing to latency, such as algorithm efficiency and hardware limitations. By optimizing system components and fine-tuning parameters, the system's responsiveness can be enhanced, thereby maximizing its effectiveness in enhancing motorcycle safety.This approach acknowledges the limitations of not having installed the system on an actual motorcycle but emphasizes the value of the simulation-based evaluation in informing further development and optimization efforts.

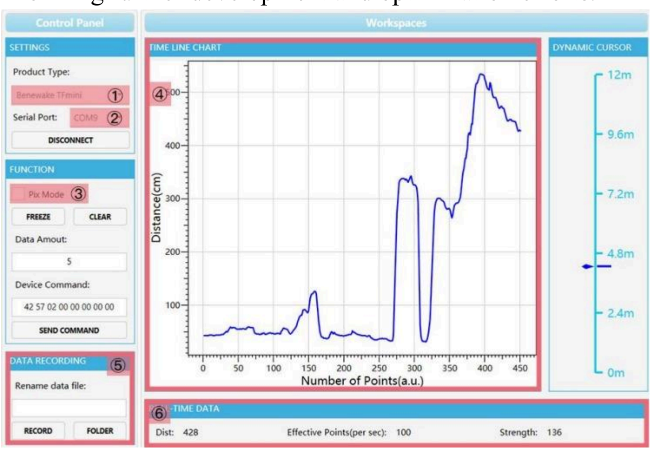


fig 9.Shows the object distance measurement

VII. CONCLUSION

The Primary Goal of this paper is to develop an effective and low cost rear end collision avoidance system in motorcycle. which ensure rider safety.This system can be deployed Independently on motorcycle.The system generate alert efficiently based upon the Set TTC threshold.The low cost of development makes this an attractive choice for enhancing motorcycle safety. The System is working fine but there is a scope of work in installation and weather resistance.TTC calculations could be more dynamic if we can have access to speed of the motorcycle.This approach acknowledges the limitations of not having installed the system on an actual motorcycle but emphasizes the value of the simulation-based evaluation in informing further development and optimization efforts.At last Rear end collision Avoidance System could be significant step in field of motorcycle safety where safety features are less introduced compare to cars.

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