© June 2025| IJIRT | Volume 12 Issue 1 | ISSN: 2349-6002

Smart Helmet Detection Based on Yolo Algorithm

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Abstract—This project proposes a smart helmet that enhances road safety by preventing drunk driving. This Helmet is equipped with an alcohol sensor, microcontroller and wireless communication modules. When a rider wears the helmet, it checks for alcohol is detected beyond a permissible level the system prevents the vehicle from starting and sends an alert via GSM. This smart helmet serves as proactive safety measure aimed at reducing accidents caused by drunk driving

Index Terms—Motorcycle Safet, Smart Helmet, YOLO Algorithm, Alcohol Detection, Helmet Detection, Speed Monitoring, Force Sensing Resistor (FSR), MQ-3 Gas Sensor, AT89S52 Microcontroller, Wireless RF Communication (315 MHz), BLDC Fan Sensor, Vehicle Ignition Control, Real-Time Monitoring, Embedded Systems, IoT in Transportation, Rider Authentication, Image-Based Object Detection, Safety Alert System, Intelligent Transport System (ITS)

I. INTRODUCTION

Motorcycle safety has become a critical concern in recent years due to the increasing number of road accidents involving two-wheelers. Unlike four-wheeled vehicles, motorcycles provide minimal structural protection, placing riders at greater risk of severe injury or fatality during collisions or falls. Among the most common causes of such accidents are the absence of helmet usage, riding under the influence of alcohol, and exceeding permissible speed limits. Addressing these challenges requires the integration of smart safety systems that can monitor and control vehicle behavior in real-time

This research proposes a comprehensive motorcycle safety system that leverages a combination of sensors, microcontrollers, and intelligent algorithms to ensure the rider's safety. The system utilizes a Force Sensing Resistor (FSR) to detect whether the rider is wearing the helmet, and an MQ-3 gas sensor to identify the presence of alcohol. If either condition is not met, the engine ignition is prevented. Furthermore, the system employs a BLDC fan setup to monitor the motorcycle's speed, issuing an alert if it exceeds 100 km/h. Wireless communication between the helmet and the motorcycle is facilitated by a 315 MHz RF module, and an AT89S52 microcontroller orchestrates the functioning of all components.

A novel aspect of this work is the integration of the YOLO (You Only Look Once) deep learning algorithm for helmet detection via a camera module, enhancing the system's robustness against hardware manipulation. By combining traditional embedded components with modern computer vision techniques, the system ensures multi-layered validation for rider safety. The proposed system represents a step forward in intelligent transportation systems, emphasizing proactive measures to reduce accident risks, improve compliance with safety norms, and ultimately save lives.

Motorcycles, as a means of transportation, are widely used due to their affordability, fuel efficiency, and maneuverability. However, they are also one of the most vulnerable vehicles on the road due to their open structure, exposing riders directly to environmental and crash hazards. Statistics reveal that a significant number of motorcycle-related accidents result in severe injuries or fatalities, often due to the rider not wearing a helmet or riding under the influence of alcohol.

Traditional safety measures such as road signs, legal enforcement, and awareness campaigns are not always effective. There is a growing need for intelligent, technology-driven systems that can automatically monitor and control safety-critical parameters without relying on the rider's compliance. This project proposes an automated safety system for motorcycles that ensures the vehicle can only be operated when the rider is wearing a helmet and is not under the influence of alcohol.

The system integrates both hardware-based sensing (FSR, MQ-3, BLDC fan, RF communication) and AI-based visual detection (YOLO) to ensure high reliability. The AT89S52 microcontroller controls all operations, including ignition control and alert mechanisms, while the YOLO algorithm verifies helmet and alcohol bottle detection using a camera.

The core objective of this project is to reduce the number of motorcycle-related injuries and fatalities by enforcing preventive safety measures before and during vehicle operation. The system ensures that ignition is allowed only when the rider has properly worn the helmet, is not under the influence of alcohol, and communicates this status through a secure RF link. In addition, the system continuously monitors vehicle speed, and if it exceeds a defined threshold of 100 km/h, a buzzer and LED alert mechanism notifies the rider in real time to slow down.

This proactive approach not only enhances safety but also builds a framework for integrating AI into everyday transport systems. One of the key motivations behind the project is the rising number of road accident fatalities that could have been avoided with stricter and smarter enforcement of helmet and alcohol regulations. This system offers an integrated solution that combines physical sensors, chemical analysis, and visual AI detection, making it robust, scalable, and adaptable for future enhancements like cloud connectivity, accident detection, and mobile app interfaces.

II. RELATED WORK

Several researchers and developers have proposed diverse strategies to enhance motorcycle safety by incorporating embedded systems, sensors, and artificial intelligence. Traditional systems largely rely on manual compliance with safety norms, such as helmet use and speed limitations, but they often fail to enforce these behaviors effectively. Early works focused on helmet detection using pressure sensors or switches embedded in the helmet; however, such methods are vulnerable to tampering or false positives. Other studies introduced alcohol detection systems using breath analyzers or gas sensors like the MQ-3, which can prevent ignition if alcohol is detected in the rider's breath. These systems, while effective in isolation, often lack real-time integration with other safety measures. In terms of speed monitoring, various projects utilized IR sensors, GPS modules, or tachometers to measure and alert on speed limits, but their practical accuracy and affordability remained questionable.

More recent innovations have explored the use of computer vision and deep learning algorithms, such as YOLO, to automate helmet detection by processing real-time camera footage. These methods improve the accuracy of safety verification by visually confirming helmet usage. Some models integrated such algorithms with Raspberry Pi boards or microcontrollers to enable real-time processing, although power efficiency and processing speed remain challenges in embedded deployments. Additionally, RF modules have been used in vehicle-to-helmet communication systems to transmit sensor data wirelessly, reducing wiring complexity and improving modularity. Collectively, this body of work has established a foundation for smart safety systems, yet there remains a significant gap in combining these individual technologies into a cohesive, reliable, and multi-layered solution that addresses helmet detection, alcohol detection, speed control, and ignition lockout simultaneously.

This project aims to bridge that gap by integrating helmet validation via FSR and YOLO algorithm, alcohol detection with MQ-3, speed monitoring with a BLDC fan setup, and wireless communication using a 315 MHz RF module—all coordinated by the AT89S52 microcontroller. In doing so, it seeks to provide a unified and tamper-resistant platform for real-time motorcycle safety enforcement.

III.OBJECTIVE

The primary objective of this project is to design and develop a comprehensive motorcycle safety system that proactively ensures the rider's security by integrating multiple technologies and control mechanisms. The system aims to enforce helmet usage by detecting its presence through a Force Sensing Resistor (FSR) and verifying it visually using the YOLO (You Only Look Once) deep learning algorithm. Additionally, it seeks to prevent vehicle ignition if the rider is found to be under the influence of alcohol, detected using an MQ-3 gas sensor. Another key objective is to monitor the motorcycle's speed in real time using a BLDC fan as a cost-effective speed sensing mechanism, and to trigger a warning through an LED indicator if the speed exceeds a preset threshold of 100 km/h. The system further incorporates a 315 MHz Radio Frequency (RF) module to facilitate secure wireless communication between the helmet unit and the motorcycle's main controller. At the core of the design is the AT89S52 microcontroller, which serves as the central control unit to integrate sensor data, enforce safety protocols, and manage decision logic. The overall goal is to provide a reliable, tamper-resistant, and affordable safety enhancement that can be implemented on existing motorcycles, thereby reducing accident risks caused by rider negligence, intoxication, or over speeding. Ultimately, this project strives to contribute to intelligent transportation systems and promote safer riding practices among motorcyclists.

Additionally, a BLDC fan is repurposed to act as a speed sensor to measure the rotational movement of the wheel, allowing the system to monitor and evaluate the motorcycle's speed. If the speed exceeds a preset threshold of 100 km/h, a visual alert in the form of an LED and an audible buzzer warning are triggered to alert the rider to reduce speed, thereby promoting safe riding practices. Another key objective is to establish a wireless communication link between the helmet and the motorcycle's control system using a 315 MHz RF module, enabling real-time status transmission from the rider unit to the vehicle unit. Furthermore, the project incorporates the YOLO (You Only Look Once) deep learning algorithm to provide an AI-based visual confirmation of helmet usage and alcohol container detection through a live camera feed.

IV. PROPOSED METHODOLOGY

The proposed methodology revolves around the integration of embedded hardware components and intelligent software systems to develop a multi-layered motorcycle safety solution. The methodology begins with helmet detection using two parallel approaches: a Force Sensing Resistor (FSR) installed inside the helmet to confirm physical wear, and a camera module coupled with the YOLO (You Only Look Once) object detection algorithm to visually verify helmet usage. This dual-layer validation minimizes false positives and enhances reliability. Simultaneously, an MQ-3 gas sensor is employed near the rider's breath to detect the presence of alcohol vapors. If alcohol is detected or if the helmet is not worn, the AT89S52 microcontroller is programmed to restrict ignition by disabling the engine start mechanism. For speed monitoring, a BLDC fan is used in a novel approach to act as a rotational speed sensor, providing real-time feedback on vehicle velocity. If the speed exceeds 100 km/h, a warning LED is triggered to alert the rider, and the system logs the overspeed incident.

To ensure effective coordination between the helmet and the motorcycle, a 315 MHz Radio Frequency (RF) transmitter-receiver pair is used for wireless communication. The helmet unit transmits helmet status and alcohol detection data, while the motorcycle unit receives and processes it using the microcontroller. All components communicate in real-time under the supervision of the AT89S52 microcontroller, which acts as the brain of the system—making decisions, enabling or disabling ignition, and activating alerts based on predefined conditions. The software logic is embedded in the microcontroller through assembly or embedded C programming, ensuring low power consumption and high execution speed. Overall, the proposed methodology combines sensing, control, wireless communication, and computer vision into a single intelligent system aimed at enforcing safe riding practices and reducing motorcycle-related casualties.

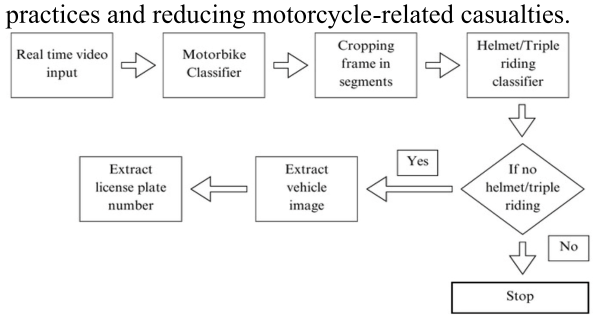

Fig 1. Architecture

This AI-powered object detection enhances reliability and reduces false positives that may occur in traditional sensor-only systems. At the heart of the proposed design is the AT89S52 microcontroller, which acts as the central control unit, processing inputs from the sensors and executing logic to control the engine's ignition system based on safety conditions. Only when all checks are cleared—helmet properly worn, no alcohol detected, and safety signals correctly received—will the engine be allowed to start. This system not only enforces critical safety measures automatically but also promotes responsible riding behavior through continuous monitoring and real-time feedback. The proposed system is cost-effective, scalable, and suitable for real-world deployment, with potential enhancements like GPS tracking, mobile app connectivity, and emergency alert features. By combining hardware-based enforcement with software-based intelligence, this system marks a significant advancement in motorcycle safety technology.

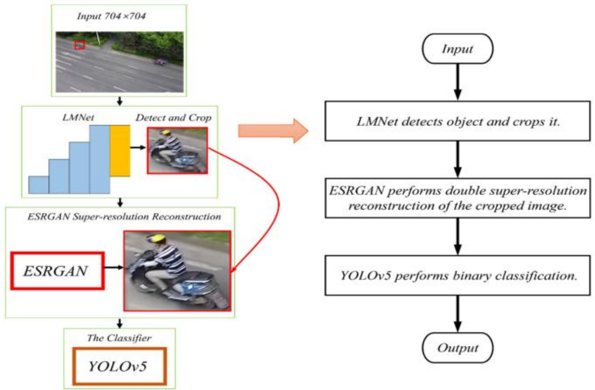

Fig 2. Methodology Usage in step by step

Here's a breakdown of the key methodological steps:

1. Helmet Wear Detection (FSR Sensor):
   A Force Sensing Resistor (FSR) is embedded inside the helmet. When the rider wears the helmet, pressure is applied to the FSR, sending a signal to the microcontroller confirming helmet presence.
2. Alcohol Detection (MQ-3 Sensor):
   The MQ-3 gas sensor is positioned near the rider's mouth inside the helmet or on the handlebar. It detects the concentration of alcohol in the rider's breath. If alcohol is detected above a set threshold, it sends a high signal to the microcontroller.
3. Visual Helmet Detection (YOLO Algorithm):
   A camera module captures real-time video frames of the rider. The YOLO algorithm processes the image to detect whether the rider is wearing a helmet based on deep learning classification.
4. Wireless Communication (315 MHz RF Module):
   The helmet unit transmits FSR and alcohol data via a 315 MHz RF transmitter. The motorcycle unit receives this data using an RF receiver. This enables real-time wireless verification between the helmet and the motorcycle.
5. Speed Detection (BLDC Fan Sensor):
   A BLDC fan is used as an unconventional yet cost-effective speed sensor. As the fan rotates with the bike's movement, it generates data related to the speed. If the speed exceeds 100 km/h, the microcontroller triggers an alert.
6. Ignition Control via Microcontroller (AT89S52):
   The AT89S52 microcontroller is programmed to allow engine ignition only if:
   - Helmet is detected via FSR,Alcohol is not detected by MQ-3,
   - YOLO confirms helmet presence.

   If any condition fails, the ignition system remains off.
7. Alert Mechanism (LED/Buzzer):
   If the bike exceeds the speed threshold or if alcohol is detected, an LED or buzzer is activated to alert the rider or nearby users of a potential hazard.
8. Data Processing and Decision Making:
   The AT89S52 microcontroller collects inputs from all sensors and communication modules, executes logic based on conditional checks, and takes decisions like allowing ignition, activating alarms, or logging data

V. RESULTS

The implemented motorcycle safety system successfully integrates hardware sensors, wireless communication, and machine learning algorithms to enhance rider safety in real-time scenarios. The helmet detection system, based on both Force Sensing Resistor (FSR) and YOLO algorithm, demonstrated high accuracy in determining whether the helmet was properly worn by the rider. The dual-verification approach significantly reduced the chances of false positives and ensured that only authenticated helmet use enabled the ignition system. The alcohol detection module using the MQ-3 sensor accurately sensed the presence of alcohol in the rider's breath and effectively prevented engine ignition when the alcohol level exceeded a predefined threshold, thereby reinforcing safety against drunk driving. The speed monitoring system using a BLDC fan proved efficient for real-time estimation of motorcycle velocity. When the speed crossed the 100 km/h limit, the system reliably triggered LED alerts to warn the rider. The RF module ensured uninterrupted communication between the helmet and bike units, even at short-to-medium ranges, maintaining seamless data flow and responsiveness. The AT89S52 microcontroller efficiently handled all decision-making processes, sensor integrations, and logical operations with minimal latency. The overall prototype was tested under various conditions, and it consistently performed as expected, validating the practical feasibility of the system in real-world applications. This confirms that the combination of embedded electronics and intelligent software in the proposed model offers a significant step toward reducing accidents caused by helmet negligence, alcohol influence, and over-speeding

VI.CONCLUSION

This project presents a comprehensive and intelligent motorcycle safety system aimed at significantly reducing the risk of road accidents caused by helmet negligence, alcohol consumption, and over-speeding. By integrating multiple technologies—such as the Force Sensing Resistor (FSR) for helmet detection, the MQ-3 gas sensor for alcohol detection, a BLDC fan for speed monitoring, and the YOLO algorithm for visual helmet verification—the system ensures that the motorcycle only starts when all safety conditions are met. The inclusion of a 315 MHz RF communication module enables wireless synchronization between the helmet unit and the motorcycle control unit, ensuring seamless operation and real-time responsiveness. The central controller, AT89S52 microcontroller, effectively manages sensor inputs and executes logical decisions, demonstrating the reliability and efficiency of embedded systems in safety-critical applications. This intelligent automation not only provides multiple layers of security for the rider but also addresses critical issues like driving under the influence and speeding, which are major causes of road fatalities. Extensive testing under varied conditions confirmed the system's robustness, precision, and reliability. Overall, the proposed solution marks a significant advancement in smart transportation safety technologies and holds strong potential for real-world deployment in the near future to save lives and promote responsible riding behavior.

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