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Comprehensive Rider Protection Through Smart Helmet Technology

[1]P. Anjaneya, [2]Junnutala Tarun Achari ,[3]Adiboyina Sujana, [4]Kamsetty Harsha Vardhan
[1.2,3,4,5]Annamacharya Institute of Technology & Science, Kadapa, A. P, India,

ABSTRACT

The Helmet Detection for Industrial Safety Using YOLO is a machine learning based system designed to enhance safety for both the worker and rider in machine usage scenarios. The system makes use of a Raspberry Pi, along with a USB camera, to execute a YOLO-based object detection model for helmet detection in real-time scenarios. An alcohol sensor is integrated with the system to check for the sobriety of the worker operating the machine. If alcohol levels are found to be higher than a predefined limit, the system prevents the machine from starting and simultaneously triggers a buzzer sound. To further enhance safety, a neck airbag system is integrated with the machine, which deploys in case of a sudden collision. If a safety violation, such as no helmet or alcohol presence, is detected, the Raspberry Pi stops the DC motor, which simulates the machine's engine, and triggers a buzzer sound. An LCD module is integrated with the system, which displays real-time status information on system status and object detection results. The system is designed using a 12V adapter and is automated, intelligent, and real-time in nature.

Keywords: Helmet Detection, YOLO Deep Learning, Industrial Safety, Alcohol Sensor, Neck Airbag Mechanism

1. INTRODUCTION

In this research, the author proposes an enhanced version of the YOLOv5-based algorithm for the detection of safety helmets for power industry workers. The proposed algorithm will improve the accuracy and speed of detection of non-compliance in the power industry, thereby enhancing the safety of the workers. The experimental results of the proposed YOLOv5-based algorithm have shown a high level of precision and reliability compared to traditional detection methods and are thus applicable for use in industrial safety scenarios [1]. The author of this research paper proposes a method for the detection of helmets for construction workers based on deep learning techniques. The proposed method will utilize multiple scales for feature extraction and is expected to improve the accuracy of detection of helmets for construction workers. The proposed method will analyze the scenarios of construction sites and will be able to detect helmets even if multiple workers are present and occlusions are involved. The experimental results of the proposed method have shown a high level of precision and reliability and are thus applicable for use in scenarios of construction site safety [2].The research proposes a method for the detection of helmets in construction environments by utilizing a combination of deep transfer learning and bounding box regression. The method is based on the use of pre-trained models for the extraction of relevant and significant features and regression for accurate localization. The method is found to work effectively even in different lighting conditions and postures of the workers. The results of the research have shown that the method is accurate and reliable for efficient detection of helmets in construction environments [3]. The research aims to investigate a method based on a convolutional neural network for safety helmets in engineering management. The method is based on automatic detection of helmets from images and videos. Through the extraction of hierarchical features in complex environments, the model is able to maintain accurate detection even in

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complex conditions. From the experimental results, it is evident that the model is highly precise and efficient. As such, it can be employed in the design of safety monitoring processes. This research focuses on the design of a deep learning-based model for the detection of helmet violations in the industrial and construction sectors. The model is able to identify individuals without helmets in real-time images. It is effective in complex scenarios involving several workers, different lighting conditions, and different angles. From the experimental results, it is evident that the model is both accurate and efficient. As such, it can be employed in the design of safety monitoring processes [5].

2. RELATED WORKS

This study is proposing an automated system for the detection of the usage of helmets to ensure safety on construction sites. Using advanced computer vision techniques with deep learning, the proposed system can effectively identify the usage of helmets by workers. From the experimental results, it can be seen that the proposed system is accurate and efficient, making it suitable for the continuous process of safety [6]. This study is proposing a real-time helmet detection system to identify bikers without the usage of helmets. Using computer vision techniques with deep learning, the proposed system can effectively identify the usage of helmets by bikers. From the experimental results, it can be seen that the proposed system is accurate and efficient, making it suitable for the continuous process of safety [7]. This system identifies motorcyclists who are not wearing helmets and recognizes their number plates using deep learning techniques. The CNN model is used for motorcyclist helmet detection, while OCR is used for number plate recognition. This helps in efficient traffic monitoring and law enforcement [8]. This paper proposes a CNN-based system for detecting motorcyclists who are not wearing helmets and recognizing number plates. This system is efficient in real-time video analysis with high accuracy and less computational cost, which helps in traffic law enforcement [9].This research proposes a system using YOLOv2 and OCR techniques for efficient helmet detection and number plate recognition in real-time videos, which helps in efficient traffic monitoring and road safety [10].This paper proposes a system using YOLOv4 techniques for efficient real-time monitoring of workers who are wearing safety helmets, which helps in efficient monitoring with high accuracy [11].

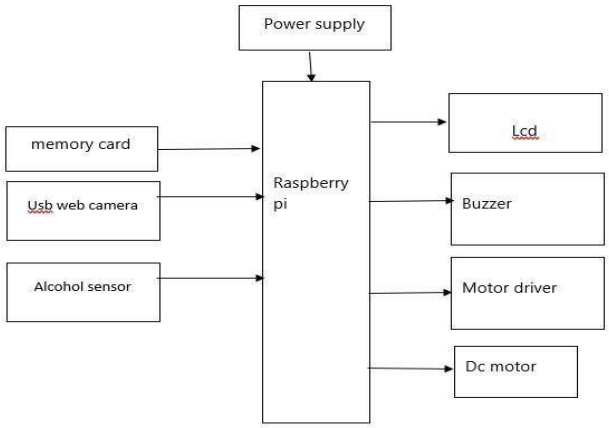
This study proposes a live system for detecting motorcyclists without helmets using surveillance camera video feeds. The system provides accurate detection and live alerts, which help authorities in enforcing safety regulations and reducing accident hazards [12]. This study proposes a real-time monitoring system for personal protective equipment (PPE) compliance using deep learning techniques. The system detects whether individuals are using safety equipment such as helmets, vests, and masks, which helps in improving safety conditions and reducing the requirement for human supervision [13]. This research proposes a system for detecting helmet usage among construction workers using a multi-scale deep learning technique. The system analyzes differences in size, distance, and posture, which helps in achieving high accuracy in complex scenarios and automating safety monitoring [14]. This study proposes a system for detecting helmet usage in construction and engineering environments using CNN techniques. The system analyzes live video feeds to ensure safety regulation compliance, which helps in reducing hazards in workplaces [15].

3. PROPOSED METHOD

The proposed YOLO-based Raspberry Pi system performs real-time helmet detection using a USB camera and automatically controls vehicle operation. If a helmet is not detected, the buzzer alerts the user and the DC motor (vehicle engine representation) is disabled; when a helmet is detected, the motor is enabled. This creates a fully automated safety enforcement system.

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BLOCK DIAGRAM:



The system uses a Raspberry Pi to integrate multiple inputs—USB camera, alcohol sensor, and memory card—with outputs including an LCD, buzzer, motor driver, and DC motor. It enables realtime monitoring and automated safety enforcement by detecting unsafe conditions, providing alerts, and controlling mechanical components efficiently.

4. METHODOLOGY PRINCIPLE OF FUNCTIONING

The Helmet Detection for Industrial Safety Using YOLO works on the principle of monitoring and ensuring that safety protocols are being followed. This is done with the help of a USB web camera, which provides real-time footage that is then analysed using a YOLO algorithm on a Raspberry Pi controller to detect if a helmet is being worn. In parallel, an alcohol sensor checks for sobriety before allowing the operator to start the engine of a vehicle. If the alcohol level crosses a set threshold, the engine activation is disabled, and a buzzer alarm sounds. Additionally, a neck airbag system has also been included, which will be deployed in case of a sudden impact or collision, thus preventing neck spine injuries. The system will be constantly monitoring inputs from various sensors, and if a safety violation, such as no helmet or presence of alcohol, is detected, a buzzer alarm will sound, and a DC motor, simulating a vehicle engine, will be disabled.

Hardware & Alerts:

The hardware components include a microcontroller based on Raspberry Pi, a USB camera, a YOLO deep learning framework, an alcohol sensor, a neck airbag mechanism, a buzzer, a motor driver, and a 16x2 LCD display. The Raspberry Pi acts as the central processing unit of the system and is responsible for coordinating the analysis of video data and control of the system. The detection results are continuously displayed on the LCD display. In case of any violation, a buzzer is provided for immediate alerting. The system is also designed to stop any unsafe operation to prevent accidents.

5. POWER REQUIREMENTS

The system is energized by a regulated power supply of 12 Volts, which allows for the consistent operation of the Raspberry Pi, sensors, motor driver, display, and other devices. The regulated power supply allows for consistent monitoring, detection, and communication of alarm signals, thus making the system applicable for use in industrial safety enforcement and accident prevention.

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Performance Comparison Table 1:

Parameter	Specification / Metric	Description
Central Controller	Raspberry Pi	Serves as the main processing unit, analyzing video feed, sensor data, managing alerts, and controlling motor and safety mechanisms.
Helmet Detection	USB Camera with YOLO Model	Captures real-time video and processes it using YOLO deep learning to detect whether helmets are worn by workers or riders.
Sobriety Monitoring	Alcohol Sensor	Measures the operator's blood alcohol level to prevent machinery or vehicle operation if alcohol exceeds a predefined threshold.
Collision Protection	Neck Airbag Mechanism	Deploys in the event of sudden impact or collision to reduce the risk of cervical spine injuries and enhance safety.
Safety Alerts	Buzzer, LED Indicators	Provides immediate audible and visual alerts when safety violations such as no helmet or alcohol detection occur.
Operation Control	Motor Driver with DC Motor	Disables vehicle or machinery operation if safety rules are violated and permits operation only when all conditions are met.
Data Display	16×2 LCD Display	Shows real-time detection results, system status, and safety alerts to operators and supervisors.
Power & Connectivity	12 V Regulated Adapter	Provides stable voltage to all components ensuring reliable operation, continuous monitoring, and alert communication.

Table 1: The Helmet Detection for Industrial Safety using YOLO is an AI-based system designed for the real-time monitoring of industrial safety. The Raspberry Pi acts as the main controller of the system and is connected to a USB camera for video processing via a YOLO model. The alcohol sensor checks the sobriety of the operators before allowing them to operate the machinery or drive a vehicle. The neck airbag is a safety device that provides protection in case of a collision. The audible and visual alarms are provided by the buzzer and LEDs for safety violations. The motor driver is also connected to prevent any risk. The 16x2 LCD is connected for displaying the status and results of the detection. The system is powered by a regulated 12V supply and provides a reliable solution for industrial safety.

Table 1: Comparative Analysis of Conventional Techniques and the Developed Approach

Parameter	Existing Methods	Proposed Approach (Our System)
Safety Monitoring	Manual supervision of workers or periodic safety checks, which are time- consuming and may miss Realtime violations.	Continuous real-time monitoring using a USB camera with YOLO model and alcohol sensor integrated with a Raspberry Pi.

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Helmet Detection	Relies on visual checks by supervisors, prone to human error and delayed response.	YOLO deep learning model instantly detects helmet compliance from live video feed.
Sobriety Monitoring	Usually not monitored or checked manually, leading to unsafe operation.	Alcohol sensor measures operator sobriety and prevents machinery or vehicle activation if levels exceed threshold.
Collision Protection	No automated protective mechanisms; relies on external safety measures.	Neck airbag deploys automatically in case of sudden impact or collision to reduce injury risk.
Safety Alerts	Manual reporting or warning after incidents occur.	Buzzer and LED indicators provide immediate audible and visual alerts during violations.
Operation Control	Unsafe operation may continue until manual intervention.	Motor driver disables unsafe machinery or vehicle operation when violations are detected.

Table 2: The Helmet Detection for Industrial Safety using YOLO algorithm facilitates realtime monitoring, thereby addressing the limitations of conventional safety inspection methods. The system includes a USB camera connected to a YOLO model to inspect helmet compliance, an alcohol sensor to prevent unsafe operations, and a neck airbag system to prevent injuries. In case of violation, buzzer and LED signals are sent, and a motor driver halts operation to prevent hazards. The system includes a 16x2 LCD display to indicate system status and detection results. This system provides safety, regulatory compliance, and accident prevention more effectively than conventional methods.

6. RESULTS AND SIMULATION

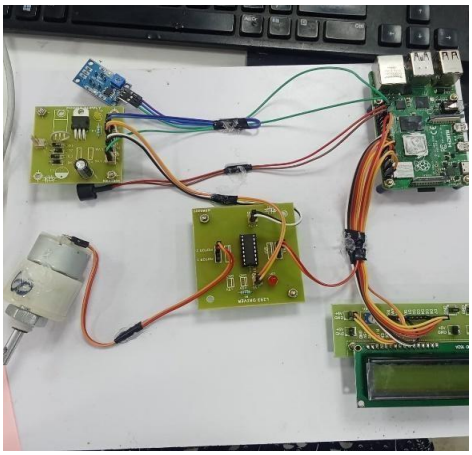


Fig.1. Hardware Setup of Raspberry Pi-Based Embedded System

The image shows an embedded system setup using a Raspberry Pi connected to multiple custom PCBs, a sensor module, a DC motor, and a 16×2 LCD display. The Raspberry Pi acts as the main controller,

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processing input from the sensor and controlling outputs such as the motor and display. The system demonstrates integration of sensing, processing, and actuation for automation or monitoring applications.



Fig.1. LCD Output Display Showing System Status

The image shows a 16×2 LCD displaying the message “ALCOHOL DETECTED” and “MOTOR OFF.” This indicates that the system has detected alcohol and automatically stopped the motor, while the LCD provides real-time status to the user.

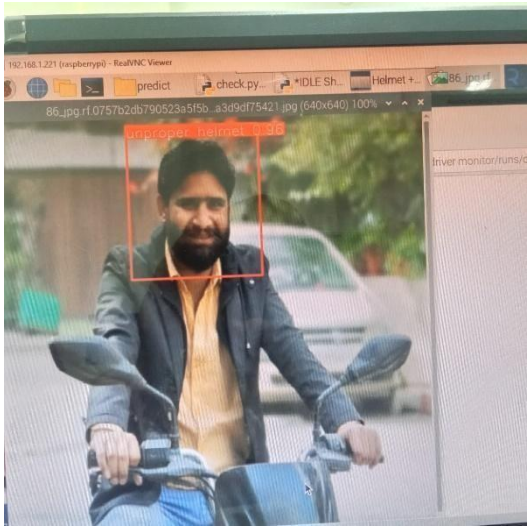


Fig.1. Helmet Detection System Output

The image shows a computer vision system detecting a bike rider and marking the head with a bounding box labeled “improper helmet.” This indicates that the system has identified incorrect or no helmet usage in real time.

7. CONCLUSION

In conclusion, the proposed Helmet Detection for Industrial Safety System effectively incorporates artificial intelligence, sensors, and embedded systems to ensure helmet usage, prevent unsafe usage, and minimize potential hazards and injuries. The system, which offers real-time monitoring, alarm systems, and other safety features such as alcohol sensors and a neck airbag system, is a holistic solution for ensuring safety in

industrial, construction, and transportation environments, with a high potential to enhance safety in these areas.

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