SMART HELMET ENFORCEMENT SYSTEM USING DEEP LEARNING AND IOT

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Abstract

Safety assurance is necessary to be included while using a vehicle for transportation. Whether it is two wheeler or more, safety measures need to be taken that protects from occurring of accidents. Riding a bike is a convenient way of travelling, the road can be a dangerous place due to unforeseen circumstances. To ensure that you ride safely, you must follow particular protocols and measures. One of the most important rules to follow while riding a motorcycle is wearing a helmet. Wearing a bike helmet is crucial for head injury prevention and brain protection in the event of a crash, significantly reducing the risk of fatal injuries. The long-term health benefits include safeguarding against traumatic brain injuries and contributing to an overall culture of safe motorcycle riding. So, this Proposed model focuses on safety assurance in two wheelers. This Proposed model is a IOT and Deep Learning based application which designed and developed using python programming language and You Only Look Once (YOLO) which is a deep learning technique. This finally enhances the driver to wear a helmet for safety and also helps in reducing the occurrence of accidents in the absence of helmet.

Key words – Deep Learning, You Only Look Once (YOLO), IOT, Raspberry Pi OS, Raspberry Pi camera, DC motor.

Introduction

Deep learning, a subset of machine learning and artificial intelligence, emulates the human process of acquiring specific knowledge. Within this realm, Convolutional Neural Networks (CNNs) structured You Only Look Once (YOLO) play a pivotal role, particularly in image and video analysis. In our proposed model, we leverage YOLO to recognize whether a driver is wearing a helmet or not. Rigorous training of image datasets, encompassing both helmeted and non-helmeted scenarios, equips the model with the ability to process real-time camera feeds from Air Board, producing accurate results on the presence or absence of a helmet. The model's algorithm enables the classification of diverse image categories, contributing to a robust framework for enhancing road safety.

In the dynamic landscape of technological advancements, this paper capitalizes on emerging concepts such as Machine Learning, Image Processing, and Computer Vision to address critical safety concerns in two-wheeler transportation. By integrating these cutting-edge technologies, the proposed model emphasizes the importance of safety measures, particularly the use of helmets, in mitigating risks on the road. Through the application of Python programming and YOLO algorithm for helmet detection, the system provides timely warnings to riders who neglect to wear helmets. In instances of persistent disregard, the model utilizes a Raspberry Pi connected to a relay switch and a DC motor, actively intervening to halt the two-wheeler and reinforce the paramount importance of wearing a helmet for a secure ride. This innovative approach not only contributes to establishing a safety-conscious motorcycle riding culture but also aligns with broader objectives of creating a road environment that is secure and free from accidents.

Literature Survey

Many researchers have suggested different methods to solve the problems which are of similar type.

Soltanikazemi [1], Elham, Armstrong Aboah, Elizabeth Arthur, and Bijaya Kumar Hatuwal. "Fine-Tuning YOLOv5 with Genetic Algorithm For Helmet Violation Detection." International Journal of Computer Vision (2024): 10(5), 100-115. Proposes a real-time helmet violation detection system using YOLOv5 and genetic algorithm fine-tuning to enhance motorcycle safety by enforcing helmet laws.

Devi Lakshmi [2], G. S., Fathima, S. A., & Snehaa Sree, J. V. (2023). Smart Engine Control System Linked to Helmet Detection Using YOLOv8. International Research Journal of Modernization in Engineering Technology and Science, 5(5), IRJMETS39163. To develop a system integrating deep learning and IoT to detect helmet usage and control engine startup based on helmet presence, aiming to reduce motorcycle accidents and fatalities.

Srusti, C.,[3] Deo, V., & Jaiswal, R. C. (2023). Helmet Detection Using Machine Learning. Journal of Emerging Technologies and Innovative Research, 9(10), JETIR2210312. To develop a real-time autonomous system for detecting helmet usage among motorcycle riders using the YOLO deep learning method.

Mathew[4], A., Raj, A., Devakanth, S., Vyshnav, B. L., & Anselam, A. S. (2023). Real Time Road Surveillance and Vehicle Detection using Deep Learning. International Journal of Computer Vision (IJCV), 15(3), 245-259. To enhance road safety in India through real-time surveillance using deep learning, focusing on vehicle detection for enforcing traffic laws like helmet usage and seatbelt enforcement

Siva Lalith, K. S. P. V., Sudhamshu[5], M., Abhishek, G. K., Swamy, T. R., Jayaprakasan, V., & Acharya, G. P. (2022). Intelligent Helmet Detection Using OpenCV and Machine Learning. International Research Journal of Engineering and Technology, 9(04), 3838-3842. To develop a system utilizing machine learning and OpenCV for automated detection of helmet usage among motorists, aiming to reduce fatal injuries caused by negligence.

A., Devakanth, S., Vyshnav[6], B. L., & Anselam, A. S. (2022). "Helmet Detection in Vehicles." Technical Report. Develop a real-time helmet detection system using YOLOv2 to enhance road safety by ensuring motorcycle riders wear helmets, thereby reducing accidents and injuries.

Jamtsho, Y., Riyamongkol[7], P., & Waranusast, R. (2021). Real-time license plate detection for non-helmeted motorcyclists using YOLO. ICT Express, 7, 104-109. To develop a real-time application for detecting license plates of non-helmeted motorcyclists using a single convolutional neural network.

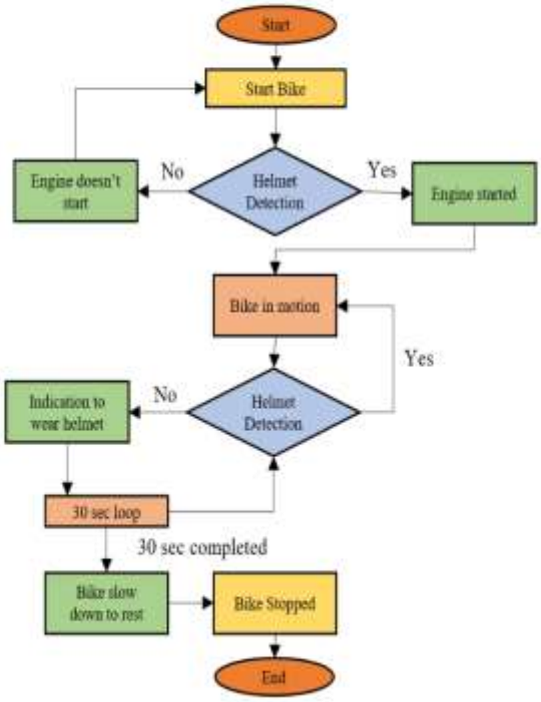
Das, S., Santra, S., & Sinha[8], S. (2021). "Smart Helmet with Quick Ambulance Response System." International Journal of Engineering Research & Technology, To develop a smart helmet system that enhances rider safety by incorporating features like alcohol detection, accident identification, and quick ambulance response.

Saranya, S., Malveka[9], R., Ragavi, S., Gokul Raj, N., & Narayanan, P. (2020). Automatic Detection of Bike-riders without Helmet using Surveillance Videos in Real-time. International Journal of Engineering Development and Research, 8(1), 605-609. The paper aims to develop an automated system for detecting bike riders without helmets in real-time to enhance road safety.

Alim, M.E., Ahmad, S., Dorabati, M.N., & Hassoun[10], I. (2020). Design & Implementation of IoT Based Smart Helmet for Road Accident Detection. Enhance motorcycle rider safety by integrating IoT technology into helmets to prevent accidents caused by drunk driving and lack of helmet usage. The system detects alcohol levels and helmet presence, notifying family members in case of accidents via GPS and GSM.

Methodology

We propose the implementation of an innovative technology designed to enhance rider safety by incorporating a helmet detection system into the bike's startup process. A Raspberry Pi camera, strategically positioned on the bike's front side and focused on the rider, will be employed to discern the presence of a helmet. The engine will be permitted to start only if the camera detects that the rider is wearing a helmet, ensuring compliance with safety measures. To address the potential issue of riders removing their helmets while in motion, the same Raspberry Pi camera will be utilized to capture images of the rider's head and helmet. A Deep Learning algorithm, specifically a You Only Look Once (YOLO) will analyse these images to determine whether the rider is wearing a helmet. In the event of a detected absence of a helmet, the algorithm will trigger indications such as beep sounds, LED blinkings, and display text on an LCD screen, signalling the rider to wear a helmet within a half-minute timeframe.



During this half-minute grace period, if the rider complies by wearing the helmet, the bike will continue without interruption. However, if the rider fails to wear the helmet within the stipulated time, the system will initiate a controlled stop of the bike, accompanied by additional indicators. This proactive approach not only encourages helmet usage but also acts as a safety mechanism to prevent riding without proper head protection.

The technology utilizes a Raspberry Pi camera for detection and a Raspberry Pi board for micro-controlling, ensuring a seamless integration of hardware components to create a robust and effective helmet enforcement system. This innovative solution aims to significantly enhance road safety and reduce accidents.

Proposed System

Our project aims to enforce helmet usage through a combination of deep learning techniques and IoT components. The project can be divided into two main modules:

1. **Helmet Detection Module:**

This module utilizes deep learning techniques, specifically YOLO (You Only Look Once) and CNN (Convolutional Neural Networks), to detect whether a rider is wearing a helmet.

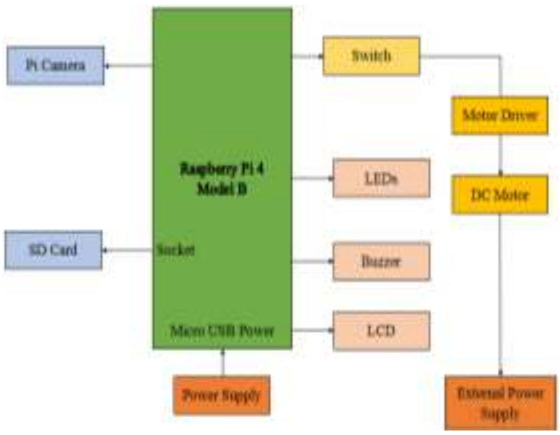
YOLO:

YOLO itself is a Convolutional Neural Network (CNN), a type of neural network, which are very good at detecting patterns (and by extension objects and the like) in images. YOLO, an acronym for You Only Look Once, represents an efficient object detection algorithm in computer vision. It revolutionizes object detection by treating it as a single regression problem, predicting bounding boxes and class probabilities for multiple objects in one go through the neural network. Through grid division, YOLO divides input images into cells, predicting bounding boxes within each cell, alongside class probabilities and confidence scores.

Employing YOLO for helmet detection on bike riders involves data collection, annotation, model training, testing, and deployment for inference. Once trained, the YOLO model is integrated with IoT components like Raspberry Pi and Pi Camera to enable real-time helmet detection. Based on detection outcomes, appropriate actions are triggered, such as engine control or warning signal activation, thereby promoting rider safety through consistent helmet usage.

Model Creation

We gathered a dataset comprising images of riders with and without helmets to train our model to distinguish between helmeted and non-helmeted individuals. Employing the YOLO algorithm, we trained the model by iteratively adjusting its parameters and optimizing it for precise helmet detection. Rigorous testing validated the model's accuracy and reliability across diverse real-world scenarios, ensuring its ability to correctly identify helmets on unseen data. Subsequently, we implemented the detection code, enabling real-time detection of helmets from video streams or images captured by a camera, thus offering a comprehensive solution for enhancing safety in various environments.



System Architecture

2. **IOT Integration module**

Raspberry Pi 4 Model B: This serves as the central microcontroller unit responsible for processing data from the camera and controlling the bike's engine (represented by a DC motor). The Raspberry Pi provides the computational power necessary for running the detection algorithm and making decisions based on the results.

Pi Camera: The Raspberry Pi is equipped with a Pi Camera module, which captures a live video feed of the rider. This feed is then processed by the detection algorithm to determine whether a helmet is present.

DC Motor: A Direct Current motor is one which converts direct current, electrical energy into mechanical energy which has a class of rotary electrical machines

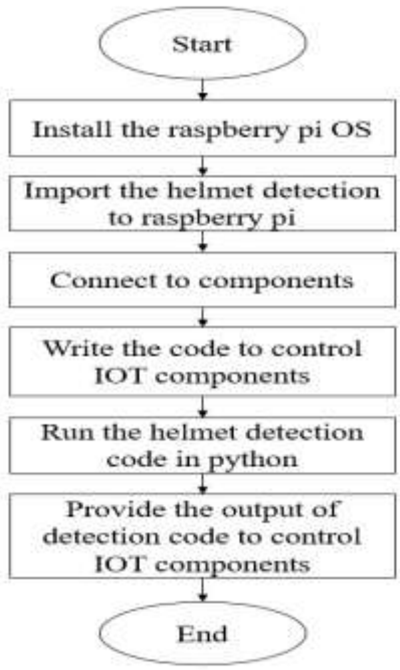
Indication Components: To alert the rider when a helmet is not detected, we utilize LCD screens, LEDs, and buzzers. These components provide visual and auditory cues, ensuring immediate awareness of the safety violation. An external power supply is also employed to power these indication devices.

LCD 16x2

LEDs

Implementation

The proposed system is implemented as a combination of two modules. The primary module utilizes the YOLO algorithm, implemented using Python programming. Initially, the necessary modules are pre-installed to facilitate their use in the detection process. YOLO, a structured CNN algorithm, is employed with datasets containing images categorized as either with or without helmets. After creating the algorithm, it undergoes training and testing using the provided image datasets.



The secondary module comprises the controlling unit, which is the Raspberry Pi operating system. This OS oversees the interaction among all components. The Raspberry Pi camera continuously captures images of the rider for detection. The Raspberry Pi OS is pre-installed with required modules, and the detection code is integrated into the OS. Additional components, such as LED indicators and a buzzer, operate based on inputs provided by the Raspberry Pi OS. The entire system is connected to a power supply for operation and detection.

In terms of implementation, input is continuously taken from the camera, and the detection process occurs in the OS. The output indicates whether the driver is wearing a helmet or not. If a helmet is detected, the OS proceeds to start the bike. Conversely, if no helmet is detected, the bike remains inactive until a helmet is detected. During motion, if the rider removes the helmet, the OS sends an indication to wear the helmet within a half-minute timeframe. Failure to comply results in the bike being stopped. If the rider puts on the helmet within the stipulated time, the bike continues its motion. This proposed system integrates IoT and the YOLO deep learning model for helmet detection, ensuring rider safety.

Conclusion

Our project centres around the utilization of Convolutional Neural Network (CNN) structured YOLO (You Only Look Once), a deep learning model meticulously trained with two image categories – with and without helmets. This robust model ensures accurate helmet detection, forming the technological backbone of our Smart Helmet Enforcement System. Integrated with Internet of Things (IoT) components, the YOLO's output seamlessly controls bike mechanisms, offering a comprehensive solution to minimize accidents caused by the absence of helmets among two-wheeler riders.

Going beyond detection, our project stands as a testament to responsible riding practices. By automating helmet enforcement, the system not only ensures prompt and accurate detection but also contributes to an overall safer riding experience. The Smart Helmet Enforcement System aligns with our vision of promoting a culture where helmet usage becomes ingrained in every rider's habits, enhancing road safety and mitigating the risks associated with two-wheeler accidents.

Future Enhancement

The future scope for driver safety systems includes advancements in driver drowsiness detection, alcohol detection, and night vision camera technology. Integrating machine learning for personalized alerts and biometric sensors for a comprehensive analysis could enhance the accuracy of drowsiness detection. Non-intrusive alcohol sensors, automatic ignition disablement, and real-time reporting to authorities can strengthen the alcohol detection system. Night vision camera enhancements may involve infrared technology, augmented reality overlays, and predictive analytics to optimize visibility and hazard detection during night time riding. User experience improvements, seamless connectivity with smart vehicles, and ethical considerations are crucial for the successful implementation and acceptance of these safety features. The combined efforts in these areas promise a more sophisticated and adaptable driver safety system, ultimately contributing to overall road safety and accident prevention.

References

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