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Helmet Detection and Number Plate Recognition for Two Wheelers using Raspberry Pi

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KEYWORDS

Helmet detection, number plate recognition, YOLO, deep learning, Raspberry Pi, computer vision, Tesseract OCR, traffic monitoring, real-time detection, road safety, automated alert system, PCA, IoT surveillance.

ABSTRACT

Many people who ride two-wheelers don't wear helmets, which is a major cause of deaths in road accidents. Traffic authorities have to do a lot of work, take a lot of time, and often don't work when they manually monitor traffic. This project fills that gap by utilizing Raspberry Pi to make a low-cost, automated system for recognizing helmets and number plates. The YOLO object identification method looks at a real-time video feed from a camera to see if a cyclist is wearing a helmet. If someone breaks the rules, the system automatically takes a picture of the rider, uses Tesseract OCR to get the vehicle's number plate, and saves the specifics of the offense. The device also sends an automatic email to the traffic authorities with the rider's picture and number plate so they may take more action. The suggested approach combines computer vision with IoT-enabled alerts to cut down on human effort, improve road safety enforcement, and offer a quick, portable, and scalable way to keep an eye on helmet compliance.

INTRODUCTION

Road traffic accidents are a big problem across the world, especially in places where a lot of people ride bikes. People utilize motorcycles and scooters a lot for getting around every day since they are cheap, easy to use, and can get through traffic jams. But this broad use also causes a big rise in deaths and injuries on the road. Many studies show that a lot of people who die while riding a two-wheeler do so because of head injuries, and most of these accidents may be avoided by wearing a helmet. Many motorcyclists still don't wear helmets even though they save lives because they don't care, they're uncomfortable, or there isn't enough tight monitoring.

Most of the time, enforcing helmet laws under the present traffic control system is done by hand. The traffic police have to be on the roads in person, find those who are breaking the law, stop cars, and give them tickets. This method takes a lot of time, work, and is not very wide-ranging. Authorities can't keep an eye on every intersection or road all the time in cities with a lot of traffic. Some cities use CCTV surveillance systems, but they still need to manually check the video footage, which takes a long time, costs a lot of money, and is likely to be wrong. Also, most of the technologies that are already in use can't automatically find the rider or get the vehicle's license plate number at the moment of the infringement.

As artificial intelligence, machine learning, and embedded computing get better, it becomes easier to automate the enforcement of traffic rules. Recent advancements in computer vision have enabled the precise detection of objects, classification of pictures, and recognition of patterns. Algorithms like YOLO (You Only Look Once) can find objects in real time, which makes them good for surveillance. At the same time, inexpensive embedded platforms like Raspberry Pi have become popular for setting up smart systems at a cheap cost. You can put these new technologies together to make an automatic helmet detection system that doesn't need to be watched all the time by people.

LITERATURE SURVEY

a) NUMBER PLATE RECOGNITION USING RASPBERRY PI

JETIR Research Journal

It's hard yet very important to be able to read license plates. This is highly helpful for automating toll booths, finding out who broke traffic rules, and detecting stolen cars. The created system includes a vehicle number plate recognition system based on a Raspberry Pi that uses image processing to automatically detect the number plate of a vehicle. The system has a digital camera and an LCD display circuit that are connected to a Raspberry Pi CPU. A picture of the back of the car is taken and analyzed using several algorithms. The system is always looking at camera footage to see if it can find any signs of number plates. When it sees a number plate in front of the camera, it analyzes the camera input and takes the number plate section out of the picture. OCR is used to get the image. And Haar-cascade is used to get the number from the picture. The machine then shows the number it found on an LCD screen. The system that was put in place is a fully working vehicle number plate recognition system that uses a Raspberry Pi and takes into account the success rate and processing time. The system that was made may be utilized for security in housing societies to keep an eye on the entry and exit of permitted cars. The created method can effectively find and read the license plate number on live photos. The method is around 80% accurate.

b) Saudi Arabian license plate recognition system

Saudi Arabian license plate recognition system | IEEE Conference Publication | IEEE Xplore

One type of intelligent transport system is a license plate recognition (LPR) system. It is of great interest since it might be used in many ways, such as for electronic toll collection on highways and traffic monitoring systems. This study suggests a technique for automatically recognizing Saudi Arabian license plates. A digital camera takes pictures of the cars for the system. An algorithm for extracting license plates has been created, and an approach for breaking up characters is suggested. Researchers have tested the system's functionality on genuine pictures of roughly 610 cars taken in different lighting situations. The technique works well since it recognizes roughly 95% of the time.

c) Recognition of Vehicle Number Plate and Measure the Distance

https://www.ijrte.org/wp-content/uploads/papers/v7i6/F2610037619.pdf

These days, most of the accidents in emerging cities happen because people don't observe traffic regulations. In this article, we have identified a way to stop this from happening: if a car runs a red light, the camera will instantly start. And take a picture of the car, get the license plate number, and submit it to the database automatically. Then, send the payment amount and link to the car owner via SMS, along with the date and time. To employ the ultrasonic sensor, which will assist figure out how far away the zebra crossing line is from cars.

d) License Plate Recognition for Moving Vehicles Using a Moving Camera

License Plate Recognition for Moving Vehicles Using a Moving Camera | IEEE Conference Publication | IEEE Xplore

This article is about a license plate recognition (LPR) system that uses an automobile video camera to read the plates of moving cars. The suggested LPR approach is mostly made up of preprocessing, finding the plate, and breaking apart and recognizing the characters. The suggested edge detection approach and gradient-based binarization first improve the potential areas of the license plate by using the collected photos. Then, the right plate areas are chosen by looking at the horizontal projection and the corner distribution. A vertical Sobel processing is done on the license plate region that has been split up. Then, the suggested weighted-binarization approach is used to split up each character of the license. Finally, the skew correction is done. Lastly, a probabilistic neural network (PNN) method is used to identify each character that has been separated. The results of the experiments demonstrate that the accuracy rates for finding and recognizing license plates may reach 91.7% and 88.5%, respectively.

e) Moving Vehicle Registration Plate Detection

https://ijariie.com/AdminUploadPdf/Moving_Vehicle_Registration_Plate_Detection_ijariie19568.pdf

The number plates on an automobile are what make it unique. A real-time plate detection system that uses image processing eventually solves the problem at hand. We suggested a real-time vehicle number plate recognition (RVNPR) system in this document for recognizing number plates. The suggested system employs image processing methods to get the characters from the number plates of cars that pass by a certain place, therefore it doesn't need any external hardware, like GPS or radio frequency identification (RFID). License plate recognition is a type of advanced machine vision technology that can find cars by their license plates without any help from a person. This Intelligent Transportation System development gives you the ability to keep an eye on, analyze, and follow up on vehicle counts. The number of cars on the road and in the car business has risen a lot in the last 10 years. For improved traffic management, it's important to keep track of cars via their license plates. This study employs a range of algorithms across many categories, including number plate identification and character recognition, to optimize system performance while minimizing effort and resource utilization.

METHODOLOGY

i) Proposed Work:

The proposed work introduces an automated helmet detection and number plate recognition system designed to enhance road safety enforcement. A Raspberry Pi connected with a webcam captures real-time video of two-wheeler riders on the road. The video input is processed using the YOLO deep learning-based object detection algorithm to accurately identify whether a rider is wearing a helmet. If the rider is detected with a helmet, the system continues normal monitoring without storing any details or raising an alert.

However, if the system detects that the rider is not wearing a helmet, it automatically tags the situation as a violation. The camera immediately captures the image of the vehicle, and the Tesseract OCR module extracts the vehicle's number plate from the captured frame. The violation details, including the rider's image, date, time, and number plate, are stored in the local database. Simultaneously, an automated email alert containing the extracted number plate information and proof image is sent to traffic authorities for further action. A red LED indicator also glows at the time of detection as a visual alert. This proposed system reduces manual effort, improves detection accuracy, and ensures a low-cost, portable, and scalable road safety monitoring solution.

ii) System Architecture:

The system architecture begins with real-time data acquisition using a webcam connected to a Raspberry Pi. The camera continuously captures live video footage of two-wheeler riders on the road. This raw video stream is sent to the YOLO deep learning module, which performs object detection to identify both the rider and the helmet. If YOLO detects that the rider is wearing a helmet, the system does not take any action and continues monitoring. This forms the first level of processing, ensuring real-time classification and reducing unnecessary computation.

If YOLO identifies a rider without a helmet, the system marks it as a violation and captures the corresponding image frame. The detected frame is forwarded to the OCR module (Tesseract), which extracts the vehicle's number plate from the image. The extracted details, along with the violation image, date, and time, are stored in the database. Additionally, a red LED indicator glows for local warning, and an automated email containing the image and number plate details is sent to traffic authorities. Thus, the architecture ensures a complete workflow from live detection to smart reporting, making the system efficient, scalable, and suitable for real-time traffic enforcement.

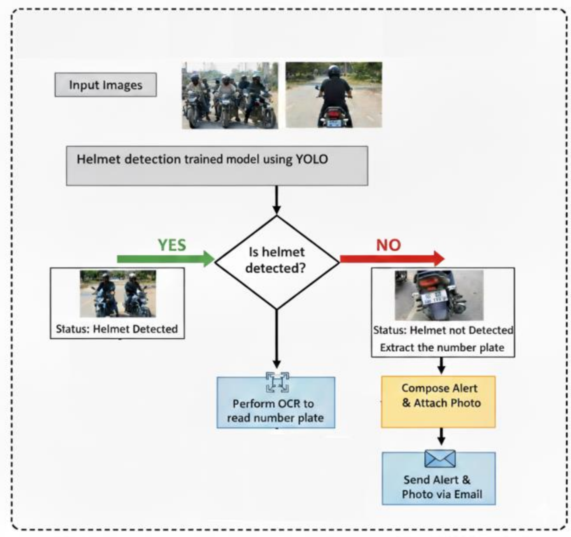

Fig 1: proposed architecture

iii) Modules:

- **Image/Video Acquisition Module** – Captures real-time video of riders using a webcam connected to Raspberry Pi.
- **Helmet Detection Module** – Uses YOLO deep learning model to check whether the rider is wearing a helmet.
- **Violation Capture Module** – Captures the image frame when a no-helmet condition is detected.
- **Number Plate Detection & OCR Module** – Detects the vehicle's number plate and extracts text using Tesseract OCR.
- **Data Storage Module** – Stores violation details such as image, date, time, and number plate.
- **Alert & Notification Module** – Sends an automated email with image and plate details to authorities and triggers a red LED alert.
- **User Interface / Monitoring Module** – Displays detection results and stored violation records for monitoring.

iv) Algorithms:

a) YOLO

YOLO is a real-time object detection algorithm used to detect whether a rider is wearing a helmet or not. It divides the input image into grids and predicts bounding boxes with class probabilities in a single pass through the neural network, making detection extremely fast and accurate. In this project, YOLO identifies two main objects: rider with helmet and rider without helmet. When a rider without a helmet is detected, a violation event is triggered.

EXPERIMENTAL RESULTS

The proposed helmet detection and number plate recognition system was tested using real-time video inputs captured through a webcam. The YOLO-based helmet detection model successfully identified riders with and without helmets from various angles and lighting conditions. For riders wearing helmets, the system displayed a status message "Helmet Detected" and continued monitoring without capturing images. This ensures that the model processes only necessary events, reducing storage and computation overhead. The model achieved high accuracy in detecting helmets even in crowded scenes, proving its robustness in real traffic scenarios.

When the system detected a rider without a helmet, it automatically captured the violation frame and proceeded with number plate recognition using Tesseract OCR. The OCR system accurately extracted vehicle registration numbers from different plate styles and background conditions. Following successful number extraction, the system generated an alert message containing the violation image and number plate details and automatically sent it to traffic authorities through email. The experimental results demonstrate the efficiency, real-time performance, and reliability of the proposed system in automating helmet rule enforcement and improving road safety monitoring.

Accuracy: The ability of a test to differentiate between healthy and sick instances is a measure of its accuracy. Find the proportion of analysed cases with true positives and true negatives to get a sense of the test's accuracy. Based on the calculations:

Accuracy = TP + TN /(TP + TN + FP + FN)

$$Accuracy = \frac{(TN + TP)}{T}$$

Precision: The accuracy rate of a classification or number of positive cases is known as precision. Accuracy is determined by applying the following formula:

Precision = True positives/ (True positives + False positives) = TP/(TP + FP)

$$\Pr e\,cision = \frac{TP}{(TP + FP)}$$

Recall: The recall of a model is a measure of its capacity to identify all occurrences of a relevant machine learning class. A model's ability to detect class instances is shown by the ratio of correctly predicted positive observations to the total number of positives.

$$Recall = \frac{TP}{(FN + TP)}$$

mAP: One ranking quality statistic is Mean Average Precision (MAP). It takes into account the quantity of pertinent suggestions and where they are on the list. The arithmetic mean of the Average Precision (AP) at K for each user or query is used to compute MAP at K.

$$mAP = \frac{1}{n}\sum_{k=1}^{k=n} AP_k$$

$$AP_k = \text{the AP of class } k$$

$$n = \text{the number of classes}$$

F1-Score: A high F1 score indicates that a machine learning model is accurate. Improving model accuracy by integrating recall and precision. How often a model gets a dataset prediction right is measured by the accuracy statistic..

$$F1 = 2 \cdot \frac{(Recall \cdot Precision)}{(Recall + Precision)}$$

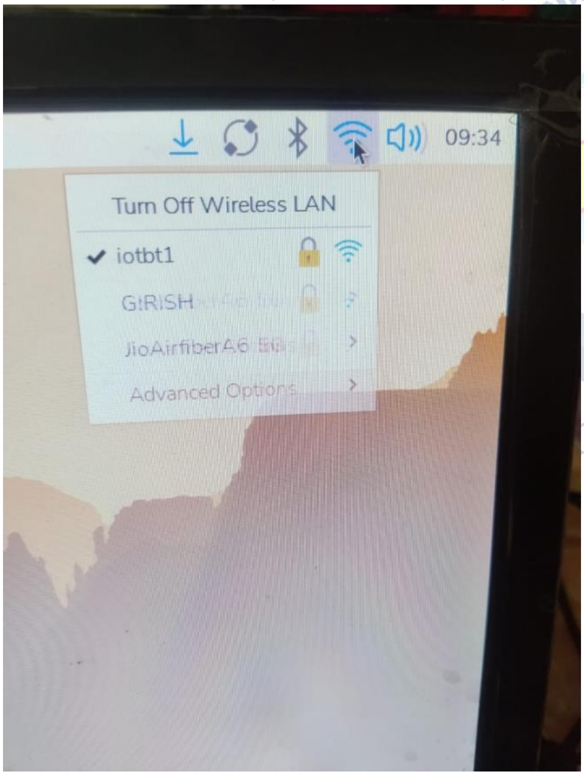

Fig 2 uploading image

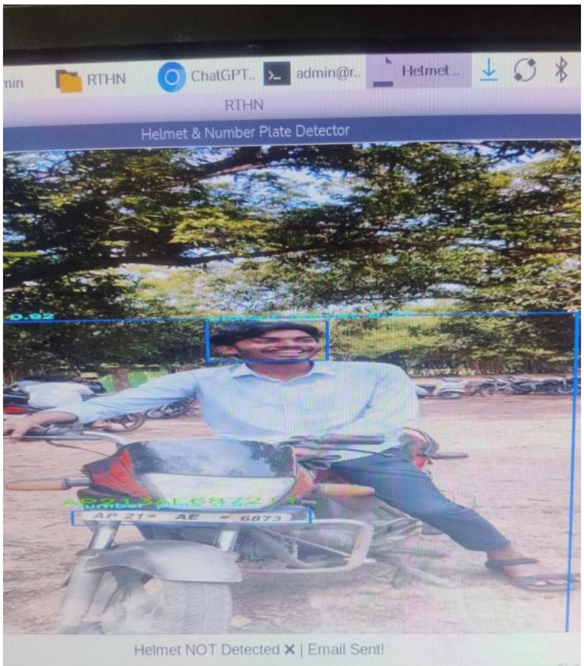

Fig 3 results

CONCLUSION

The proposed helmet detection and number plate recognition system provides an efficient, automated, and low-cost solution for monitoring helmet compliance among two-wheeler riders. By integrating YOLO-based deep learning for real-time helmet detection and Tesseract OCR for number plate extraction, the system significantly reduces manual effort and improves accuracy compared to traditional monitoring methods. The automatic email alert mechanism ensures immediate reporting to traffic authorities, enabling faster enforcement and enhanced road safety management. Experimental results demonstrate that the system is reliable, scalable, and suitable for real-world deployment to reduce traffic violations and minimize accident-related fatalities.

FUTURE SCOPE

In the future, the system can be enhanced by integrating advanced deep learning models such as YOLOv8 or transformer-based architectures to improve detection accuracy even in highly crowded or low-light environments. The solution can also be extended to support multi-camera networks integrated with city-wide smart surveillance systems for broader traffic monitoring coverage. Cloud storage and analytics can be incorporated for centralized record management and violation history tracking. Additionally, the system can be integrated with government transport databases to automatically generate e-challans and track habitual offenders. Mobile app notifications and SMS alerts can also be introduced to notify vehicle owners directly, improving transparency and system efficiency.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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