Enhanced Road Safety and Traffic Regulation System

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Abstract - Violations in traffic laws are very common in a highly populated country like India. The accidents associated with these violations cause a huge loss to life and property. Since utilization of bikes is high, mishaps associated with bikes are additionally high contrasted with different vehicles. One of the main causes of these is not using motorcycle helmets. So we propose an approach called "Enhanced road safety and traffic regulation System" using deep learning which automatically sends challan or send an SMS for individuals in case of identification of bicycle riders without headgear and who are triple riding utilizing surveillance videos in real-time. The proposed approach initially recognizes motorcycle riders utilizing background subtraction and object segmentation.At that point we utilize object classifier to classify violators. Since wearing helmet is critical while driving, our main aim is to decrease the danger of injuries in case of accident. By detecting the motorcyclists without helmets, triple riding or other violations we can therefore increase their safety while on road. Hence by automating we reduce the workload on the traffic control team and will be able to share the evidence with the team efficiently to impose fines on violators

***Key Words*:** CNN-Convolutional Neural Network, R-CNN-Region based CNN, YOLO-You Only Look Once, SVM-Support Vector Machine, IDE-Integrated Development Environment, CCTV-Closed Circuit Television

1.INTRODUCTION

1.1 Motivation and Objectives

All over the world around 1.35 million lives are lost each year, 50 million people are getting injured due to road accidents, according to a report titled " The Global status Revised Manuscript Received on December 05, 2019 report on road safety 2018" released by world health organization. It is very hard to imagine that this burden is unevenly borne by motorcyclists, cyclists, and pedestrians. This report noted that a comprehensive action plan must be set up in order to save lives. Two-wheeler is a very popular mode of transportation in almost every country. However, there is a high risk involved because of less protection. When a two-wheeler meets with an accident, due of sudden deceleration, the rider is thrown away from the vehicle. If head strikes any object, motion of the head becomes zero, but with its own mass brain continues to be in motion until the object hits inner part of the skull. Sometimes this type of head injury may be fatal in nature. In such times helmet acts as life saviour. Helmet reduces the chances of skull getting decelerated, hence sets the motion of the head to almost zero. Cushion inside the helmet absorbs the impact of collision and as time passes head comes to a halt. It also spreads the impact to a larger area, thus safeguarding the head from severe injuries. More importantly it acts as a mechanical barrier between head and object to which the rider came into contact. Injuries can be minimized if a good quality full helmet is used. Traffic rules are there to bring a sense of discipline, so that the risk of deaths and injuries can be minimized significantly. However strict adherence to these laws is absent. Hence efficient and feasible techniques must be created to overcome these problems. To reduce the involved risk, it is highly desirable for bike-riders to use helmet. Worrying fact is that India ranks in top as far as road crash deaths are considered. Rapid urbanization, avoiding helmets, seat belts and other safety measures while driving are some of the reasons behind this trend according to analysis done by experts. In 2015 India signed Brasilia Declaration on Road Safety, where India committed to reduce road crash deaths to 50 percent by 2020. Observing the usefulness of helmet, Governments have made it a punishable offense to ride a bike without helmet and have adopted manual strategies to catch the violators. However, the existing video surveillance-based methods are passive and require significant human assistance. In general, such systems are infeasible due to involvement of humans, whose efficiency decreases over long duration. Automation of this process is highly desirable for reliable and robust monitoring of these violations as well as it also significantly reduces the amount of human resources needed. Recent research has successfully done this work based on CNN, R-CNN, LBP, HOG, HAAR features, etc. But these works are limited with respect to efficiency, accuracy or the speed with which object detection and classification is done

1.2 Problem Statement

The helmet detection project is a significant initiative aimed at improving motorcycle safety through technology. Here are detailed insights into the various aspects of this project and the broader context of motorcycle .

Rising Motorcycle Accidents: Motorcycle accidents are on the rise globally, with various factors contributing to this trend. The differences in social and economic conditions across regions lead to varying levels of safety awareness and adherence to traffic laws. Motorcycles are a favored mode of transport for many, particularly in middle-class communities, which correlates with increased accident rates due to higher usage . **Importance of Helmet Usage**: Helmets are critical safety gear for motorcyclists. However, many riders fail to wear them, which significantly increases the risk of severe injuries during accidents. The lack of proper safety measures, such as wearing helmets, is a major concern, as it can lead to life-threatening situations even when riders take other precautions, like avoiding speeding.

Triple Riding Dangers: The practice of triple riding, where three individuals ride on a single motorcycle, is prevalent in many areas. This behavior not only violates traffic regulations but also poses serious safety risks. Overloading a motorcycle can lead to instability, making it difficult for the rider to control the vehicle.

Signs of Unsafe Riding: Law enforcement and concerned citizens can identify unsafe riding practices, such as triple riding, by observing specific signs. These include overloaded motorcycles, where the rear suspension is compressed, and the front wheel is lifted off the ground. Recognizing these signs is crucial for preventing accidents and ensuring compliance with safety regulations .

1.3 Contributions

The helmet detection project makes several important contributions to motorcycle safety and technology. Here are the key contributions outlined in the project:

- **Promotion of Helmet Usage**: The primary goal of the project is to encourage riders to wear helmets consistently. By utilizing a computer vision-based system, the project aims to raise awareness about the importance of helmet safety among motorcyclists, thereby potentially reducing accident rates.
- **Implementation of Advanced Technology**: The project employs cutting-edge technology, including a Raspberry Pi and a webcam, integrated with the YOLOv3 deep learning model. This combination allows for real-time detection of helmet usage, showcasing how technology can be harnessed to address public safety issues.
- **Real-Time Monitoring and Enforcement**: The system is designed to monitor helmet usage in

real-time, which can help in enforcing helmet laws more effectively. By sending notifications to riders who are not wearing helmets, the project aims to create a deterrent against non-compliance, thus promoting safer riding practices.

- **Data Collection and Analysis**: The project involves the collection of a dataset containing labeled images of individuals wearing and not wearing helmets. This data is crucial for training the YOLOv3 model, enhancing its accuracy in detecting helmet usage in various conditions. The use of OpenCV for annotating images further demonstrates the project's commitment to utilizing robust data processing techniques.

The helmet detection project contributes significantly to motorcycle safety through technology implementation, real-time monitoring, data analysis, and public awareness initiatives. These efforts collectively aim to reduce accidents and promote safer riding practices among motorcyclists.

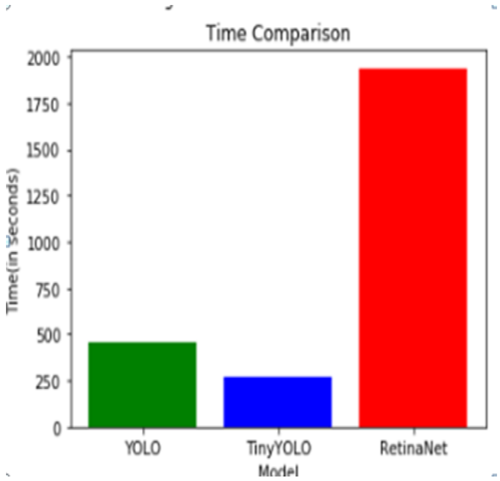
2. Related Work

2.1 Lliterature Review

Recently, studies on automatic detection of safety helmets are mostly based on data from still images or video sequences using computer vision and image processing techniques. Some of these studies are automatic vehicle classification systems based on the assumption that a motorcyclist usually wears a helmet in order to classify and track motorcycles in traffic scenes. Chiu proposed algorithms to detect occluded motorcycles using the visual length, visual width, and Pixel Ratio. They assume that motorcycle riders usually wear helmets to detect motorcycles in the scene. However these studies do not explicitly focus on detecting a helmet for safety reasons but use a helmet as a cue to identify a motorcycle. For the studies focusing on helmets detection, Liu, Liao, Chen, and Chen presented a technique to find a full-face helmet in a scene using circle fitting on its Canny edge image. Similar techniques were introduced by Wen and his colleagues to detect helmets based on Circle Hough Transform. They developed this method to be used in surveillance systems in banks or at ATM machines. These techniques work well on full-face helmets with easily extractable circles or circular arcs. More recently, Chiverton proposed a system for the automatic classification and tracking of motorcycle riders with and without helmets. In this system, the motorcycle riders are automatically segmented from video data using background subtraction, and support vector machines (SVM) are used to train histograms derived from head region image data of motorcycle riders to classify whether or not the riders are wearing helmets. However, this technique is not designed to distinguish each rider or count people on a motorcycle.

2.2 YOLOV3

Yolov3 is a real-time object detection algorithm that identifies specific objects in videos, live feeds, or images. Versions 1-3 of Yolo were created by Joseph Redmon and Ali Farhadi. The first version of Yolo was created in 2016, and version 3, which is discussed extensively in this article, was made two years later in 2018. Yolo is implemented using the Keras or OpenCV deep learning libraries.



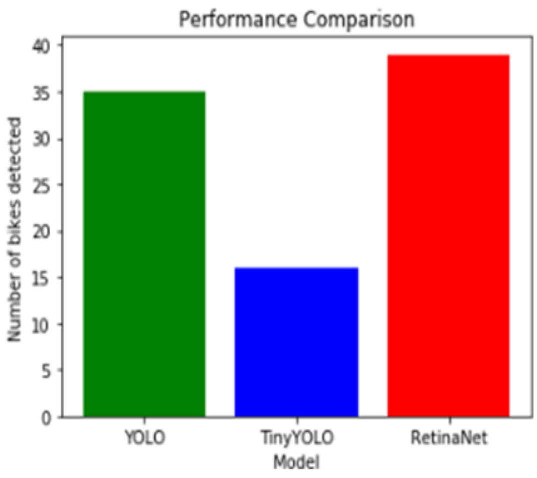


Fig 1.1 Yolov3

We compare the time and performance of the yolo , tiny yolo and retinanet in Fig.1.1 Yolo v3 algorithm consists of fully CNN and an algorithm for post-processing outputs from neural network. CNNs are special architecture of neural networks suitable for processing grid-like data topology. The distinctive feature of CNNs which bears importance in object detection is parameter sharing. Unlike feed forward neural networks, where each weight parameter is used once, in CNN architecture each member of the kernel is used at every position of the input, which means learning one set of parameters for every location instead a separate set of parameters. This feature plays important role in capturing whole scene.

This algorithm starts with extraction single image from video stream, in a next step extracted image is resized and that represent input to Yolo network. YOLO v3 neural network consist of 106 layers. Besides using convolutional layers, its architecture also contains residual layers, up sampling layers, and skip (shortcut) connections. Coordinates and positions of predicted bounding boxes which should contain objects, A probability that each bounding box contains object, Probabilities that each object inside its bounding box belongs to a specific class.

The detection is done on the three separate layers. Object detection done at 3 different scales addresses the issue of older YOLO neural network architectures, the detection of the small objects. Output tensors from those detection layers have the same widths and heights as their inputs, but depth is defined as: the number of bounding box properties such as width (bw), height (bh), x and y position of the box (bx, by) inside the image, 1 is the probability that box contains the detectable object (pc) and class probabilities for each of the classes (c1, c2, ..., c5).That sum is multiplied by 3, because each of the cells inside the grid can predict 3 bounding boxes. As the output from the network, we get 10 647 bounding box predictions.

This network has an ability to simultaneously detect multiple objects on the single input image. Features are learned during the network training process when the network analyses the whole input image and does the predictions. In that way, the network has knowledge about the whole scenery and objects environment, which helps the network to perform better and achieve higher precision results comparing to the methods which use the sliding window approach. The concept of breaking down the images to grid cells is unique in YOLO, as compared to other object detection solutions. Predictions whose pc is lower than 0.5 are ignored and that way, most of the false predictions are filtered out. Remaining bounding boxes are usually prediction of the same object inside the image. They are filtered out using the non max suppression algorithm.

3. Proposed System

3.1 Helmet Detection

Helmet Detection-In this research, YOLOv3 computes an attempt to do image grouping to analyse the information dataset regarding motorcyclists wearing helmets or not. Furthermore, a deep learning strategy for picture identification to attempt to find a rider by not having helmet detection from the video picture.

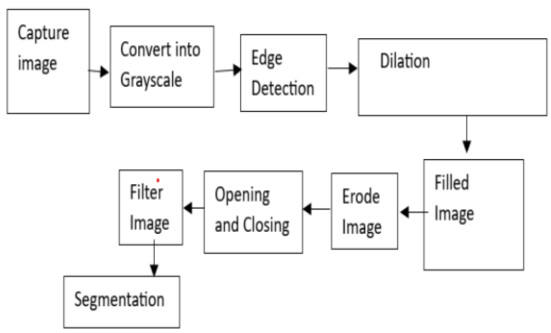


Fig 2.1 Helmet Detection

3.2 Moveing Object Detection

The first part of the system is the moving object detection. In this paper, after applying a low-pass filter to all the input images to reduce noise, we firstly construct a background image using the mixture model algorithm and doing background subtraction as described in and . This algorithm provides good results with decent performance and works well for shadow removal. After background subtraction, images were binarized so that moving parts were marked white and stationary parts were marked black. Morphological closing is performed on the obtained binary images to reduce noise. Fig. 2 shows the results of this algorithm, which (a) and (b) are extracted moving objects and their corresponding results after applying closing operation, respectively.

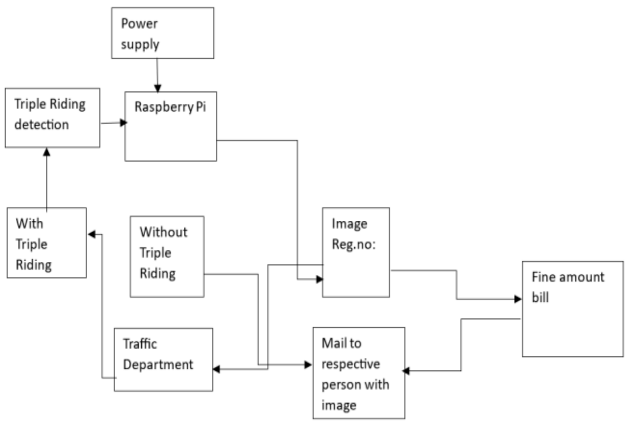


Fig 3.1 Overview of the system

Whenever any white pixels which belong to a moving object touch this line, the rest of the process is executed; otherwise the system is still in idle state. The detection line also serves another purpose. It is used to determine the direction of a moving object. When a white pixel touches the line, a connected component labeling algorithm based on contour analysis is performed on the binary image. A moving direction can be found from the spatial relationship between the position of the detection line and the centroid $(\bar{x}, \bar{y})$ of the region that touches the line. For example, if the centroid $(\bar{x}, \bar{y})$ of the region is on the right side of the detection line, says $\bar{x} > xline$, then the object is identified as moving from right to left. Fig 2 (b) illustrates the detection line and the centroid of an object. The acquired direction can be used to identify the driving lane of a moving vehicle. As Thailand uses left-hand traffic, in which traffic keeps to the left side of the road, so that an object that moves from right to left is considered to be an object in the near (closer to the camera) lane, while an object that moves from left to right is considered to be in the far lane.

4. Triples Detection

4.1 Motorcycle Regognition

The purpose of this system is to detect safety helmets worn by people riding on motorcycles in a traffic scene. Hence, firstly, a motorcycle must be distinguished from other moving objects. To achieve this goal, we extract 3 features from the moving *blob* (connected region) that touches the detection line.

Feature 1: Area of bounding rectangle

The first feature extracted from the blob of interest is the area of its bounding rectangle. This feature is used based on the fact that a motorcycle is usually smaller than other forms of vehicle on the road. This feature is normalized to make it range within 0.0 to 1.0 by dividing the rectangle area by the area of the whole frame.

Feature 2: Aspect ratio of bounding rectangle

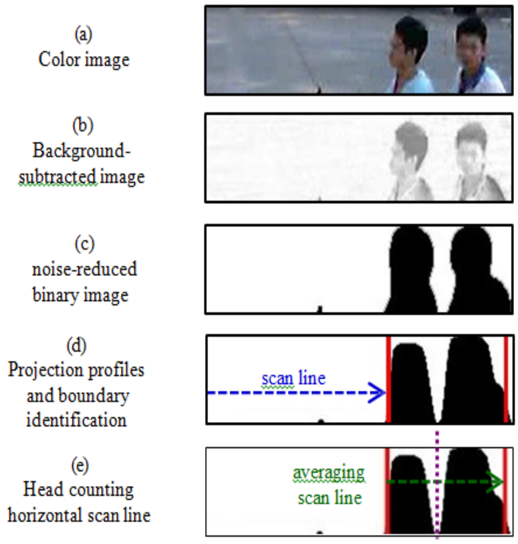
The aspect ratio of bounding rectangle is defined as the ratio of the length of the shorter side of the bounding rectangle to the length of its longer side. This feature is used because from our observation, we noticed that the aspect ratio of the bounding box of a motorcycle is closer to 1.0 (closer to a square) than other moving objects e.g. cars, buses, trucks, and pedestrians.

Feature 3: Standard deviation of hue around blob center

The third feature is the standard deviation (S.D.) of hue (H in the HSV color model) in a small rectangular area around the blob's centroid. This feature is used based on the observations that an image part at the center of each motorcycle region has more variation of colors due to the motorcycle parts, riders' legs, and shadows compared to the same area of cars as shown in Fig. 3.

The areas used in S.D. computations are marked by red rectangles in Fig. 3 (a) and Fig. 3 (b).

After all 3 features are extracted from the moving blob, the K-Nearest Neighbor (KNN) [16] classifier is applied on these features to classify either the blob is a motorcycle or other moving object.



4.2 Rider count and HeadExtraction

The heads of motorcycle riders are usually in the upper part of a motorcycle blob. Thus, the top 25% of the height of a motorcycle blob is defined as the region of interest (ROI) for counting and extracting motorcycle riders' heads. Fig. 4 (a) depicts the *top ROI* of Fig. 3 (a), while Fig. 4 (b) shows the background-subtracted image of the top ROI in Fig. 3a. From this top ROI, heads in the region can be counted and extracted as follows:

1) Vertical projection

After background of the image is subtracted, small holes and small isolate regions in binary image of ROI are eliminated using morphological closing. The top ROI is vertically projected to construct vertical projection profiles. A projection profile is a frequency distribution of the projected head pixels onto the projection line. The projection

5. Implementation & Experimental Results

5.1 Datasets Used

The dataset used in the helmet detection project is crucial for training the YOLOv3 model to accurately identify whether motorcyclists are wearing helmets. Here are the key details regarding the dataset:

- **Labelled Images**: The dataset consists of labelled images that include both individuals wearing helmets and those not wearing helmets
- **Data Collection**: The images were collected to create a diverse dataset that reflects various scenarios and conditions under which helmet usage can be observed.
- **Annotation Process**: The collected images were annotated using OpenCV, where bounding boxes were created around the heads and helmets of the individuals.

5.2 Performance Evaluation

- **Helmet Detection Accuracy:** 91.0%
- **Triples Detection:** 89.2%
- **Average Latency (WebRTC Integration):** 120ms

These results indicate that Helmet and Triples Detection achieves high accuracy in real-time communication scenarios, with minimal latency.

6. Conclusion

We proposed a real-time motorcycle safety helmet detection system. The system used a moving object detection method and classified heads using the proposed techniques which consists mainly of head extraction and classification. The extraction method is based on vertical and horizontal projection profiling methods, while the classification method is based on features derived from head regions. The experimental results show that our methods accurately detected helmet wearing at the rate of 74% for both lane.

7. Future Work

While the current implementation of Helmet and Triples detection demonstrates significant advancements,further improvements and expansions are needed to enhance its effectiveness and usability. Future work will focus on:

The proposed system is expected to achieve high detection accuracy for both images and videos.It achieves to allow the system or mobile to detect the real or fake image or video. If real it allows the image or video to use by the user. When the image or video is fake it automatically deletes it from the system or mobile.

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