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Automatic Helmet Detection System on Motorcyclists Using YOLOv3

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Abstract: Safety, it is the most important thing to keep in mind when travelling. But it is often neglected by most people, especially by motorcyclists who are often caught riding without a helmet. The objective of this project is to help better enforce traffic rules with motorcyclists by automating the process, as it is quite tedious for traffic police to catch every offender by themselves. In the proposed approach we implement a methodology for automatic helmet detection for motorcyclists riding without a helmet, using a video of traffic on public roads as input. The first step is to detect and classify the different vehicles on the road applying a vehicle classifier for each frame using OpenCV and Python, after which we extract the image of the motorcycle and apply YOLOV3 algorithm, a deep learning algorithm on the extracted image to check if the rider is wearing a helmet or not. If the output is negative, i.e. not wearing a helmet the licence plate is then noted down by the respective officials.
Keywords: Helmet Detection, Motorcycle, Vehicle classification, Image processing, YOLOv3

I. INTRODUCTION

In a developing country like India people prefer two-wheelers or popularly known as motorcycles to cars or other means of transport as they are easily affordable and holds low maintenance charges. According to the Data Intelligence Unit (DIU) in the year 2017 there were more than 48,746 motorcyclists died in road mishaps, of this 73.8 per cent of them were found not wearing a helmet hence around 35,974 people died from not wearing a helmet. This means that every hour, four motorcyclist riders died in a road accident which could've easily been avoided if they had worn a helmet. On September 1, 2019 the government of India introduced the Motor Vehicle Act 2019 in which the fine for not wearing a helmet for both the rider and pavilion rider increased from Rs.100 to Rs.1000. But even with all these rules enforced people still manage to escape the traffic police and continue to break the rules, making issuing tickets a very tedious job for the traffic police. Automating this process would lessen the workload on the traffic police and significantly catch more traffic offenders as compared to before. This would hopefully force people to take traffic rules and regulations more seriously and help administration in issuing helmet violation tickets more efficiently. We have proposed a helmet detection system that uses vehicle classification to detect motorcyclists and apply the YOLOv3 algorithm to detect if the persons wearing a helmet or not. YOLOv3 is fast, has at par accuracy with the best two stage detectors, making this a very powerful object detection model, hence a very useful algorithm for our system. We take our video footage from roadside CCTV cameras making this system very cost effective.

II. EXISTING WORK

In the last decade various types of algorithms have been used to automatically detect helmets. In [1], the proposed system used LBP (Local Binary Patterns) a cascade classifier as opposed to the Haar classifier to detect helmets on motorcyclists as it was found to be comparatively faster to train the algorithm as opposed to Haar. But even this approach is quite time consuming. [3] system was built to detect if workers were wearing their construction helmet in worksites, it uses a ViBe background modelling algorithm to detect motion in the surveillance video, a patented algorithm which is proven to be an excellent algorithm for motion detection, as for the helmet detection it uses C4 algorithm which is based on differentiating the colour of the hardhat from a face, this could not be applicable to detecting helmets on motorcyclists as helmets come in various different colours, designs and footage from roadside CCTV cameras aren't very clear especially if the footage being tested was recorded at night. In paper [4] they used adaptive background subtraction on video frames to detect moving objects after which they applied CNN (Convolution Neural Networks) to detect motorcycles and to check if the rider was wearing a helmet. [5] Tested various machine learning algorithms, including random forest, Gradient Boosted Trees, Support Vector Machine and Deep neural networks to check which algorithm was more efficient for their system and settles on random forest as it required less training data and time. This paper, however, is not able to detect multiple vehicles on the road. Paper [2] proposes a system that can identify multiple vehicles on road and put them in our categories it uses GMM (Gaussian Matrix Method) to account for lighting defects and camera vibrations.

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It trained its algorithm using the SVM (Support Vector Machine) algorithm, this system is limited to just detecting various vehicles. [8] Talks about a system that addresses one more issue with motorcyclists, Triple riding which is very dangerous yet a very common site. The approach here initially recognizes motorcyclists utilizing background subtraction and object segmentation. HOG is then used to classify violators. The vertical projection of binary image is used for counting number of riders.

III. PROPOSED WORK

The proposed system consists of the following modules: Acquiring image, Pre-processing, Motorcycle and Helmet Detection.

A video stream i.e camera footage is captured and is analysed frame by frame. Background subtraction is used to detect moving objects and separate them from static objects in the scene, where a static camera is used. Simple thresholding is then applied to create a binary image, removing shadows in the process. Next, morphological operations like opening, closing, erosion, and dilation are used to reduce noise. The next step is to draw contours and bounding boxes across the moving objects. Two reference lines are used to detect the relative movement of a vehicle across the screen, and when a moving object crosses them, they are classified. The aspect ratios of bounding boxes are considered and used to determine if the moving object is a motorcycle, car or a different heavy vehicle. Implementation of the helmet detection system used the YOLOv3 network. Thousands of images are used to train this YOLOv3 network, which uses Darknet-53, a CNN which analyses the ROI (Region of interest) to determine if the rider of the motorcycle is wearing a helmet or not.

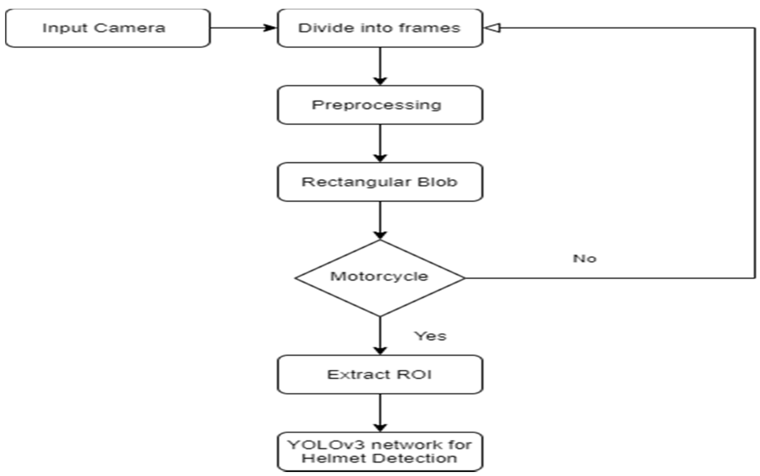

Fig 1: Simplified flow chart for the proposed system

IV. METHODOLOGY

A. Footage

Camera footage is required to be processed and analysed. The camera must be placed at an intersection to get view of maximum number of vehicles. Camera must be placed at a slightly elevated angle so that one vehicle is not hidden behind another. It must also be placed in a shaded region to prevent being affected by heavy rain or sunlight. A wide-angle camera can be used, and it must be steady. Streetlights can be used to account for the systems use during night-time. The footage is then analysed frame by frame. We use two reference lines to detect if a vehicle is moving or not. If the centre of the vehicle crosses both lines, it will be detected. Once the second line of reference is crossed, the vehicle will not be detected further.

Fig. 2: Examples of useful camera footage

B. Pre-processing

1) *Background Subtraction:* This is the first step in order to isolate the moving parts of the frame, by dividing it into background and foreground.

Fig. 3: Camera Footage (Right); After Background subtraction (Left)

2) *Thresholding:* Thresholding is then performed to create a binary (black and white) image based on a threshold value. Pixels below the specified threshold value are converted to 0 value (black) and those above the threshold value are converted to 1 value(white).

3) *Morphological Operations:* These non-linear operations are applied to configure the shape of the image, with the use of a structing element, processing each pixel individually. The opening and closing operations are performed to remove noise. Opening erodes an image and then dilates the eroded image. Closing is done by first dilating the image and then eroding it.

Opening ($X \circ Y=(X \ominus Y) \oplus Y$)

Closing ($X \bullet Y=(X \oplus Y) \ominus Y$)

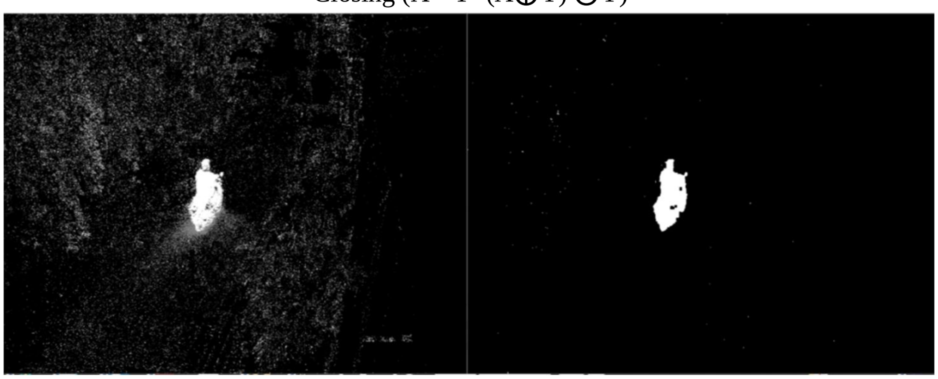

Fig. 4: Background subtracted image (Left); After thresholding and morphological operations (Right)

4) *Motorcycle and Helmet Detection:* The aspect ratio of the detected blob has been used to classify the vehicle type. The aspect ratio is the ratio of the height of the object to its width. Motorcycles are considered to have aspect ratio > 1.25, while other vehicles have a value <1.25. Only moving objects that satisfy this criterion will be treated as a motorcycle and ROI (region of interest) will be extracted. The region of interest is selected to be the top 50% of the rectangular blob.

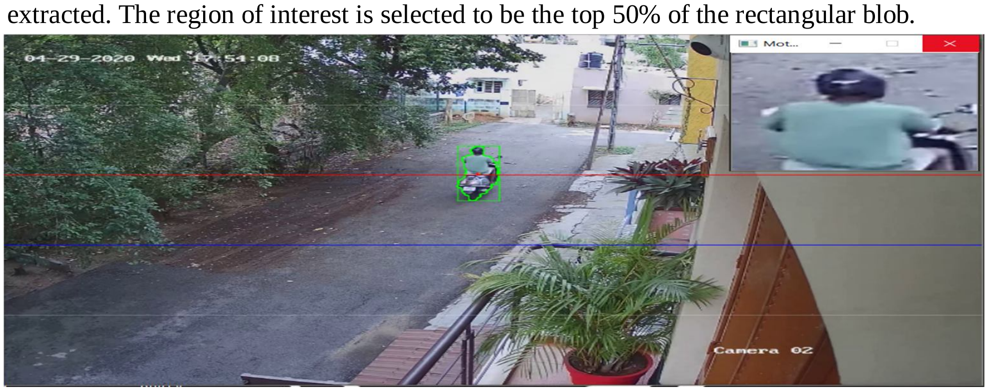

Fig. 5: Detected motorcycle and extracted ROI (top right)

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The helmet detection module has been implemented using a YOLOv3 network. In YOLOv3, only one neural network is applied to the whole of the ROI. The image is then divided into regions and bounding boxes for each region is predicted. The boxes are then weighted based on the probability. A few thousand images were used to train the model. Sum of squared errors loss is used during training.

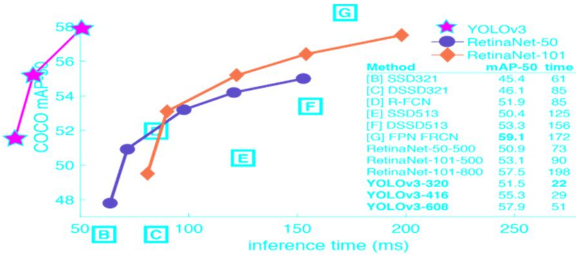

Fig. 6: YOLOv3 as compared to some other object detection models as described in [10] YOLOv3 runs faster than most models.

The extracted ROI's for each detected motorcycle rider divided into a 416x416 size image and is fed to the YOLOv3 network and the probabilities of a detection are generated (using logistic regression). The confidence threshold in this case has been set to 0.7 or higher. Any bounding boxes with probability > 0.7 are classified as wearing a helmet, while others are not.

Fig: Detected helmets with their predicted probabilities

V. CONCLUSION

The system proposes a system for helmet detection on motorcyclists for safety and surveillance using the deep learning YOLOv3 network. OpenCV was used to process the video as well as detect the motorcyclists based on aspect ratio and reference lines. The tests on a large set of helmet positive images showed the system to detect about 80% of all vehicles correctly. The system can be further integrated with a license plate detection system to allow law offenders to be tracked and then penalised. Further improvements can be made to the accuracy of the system by using a more extensive database.

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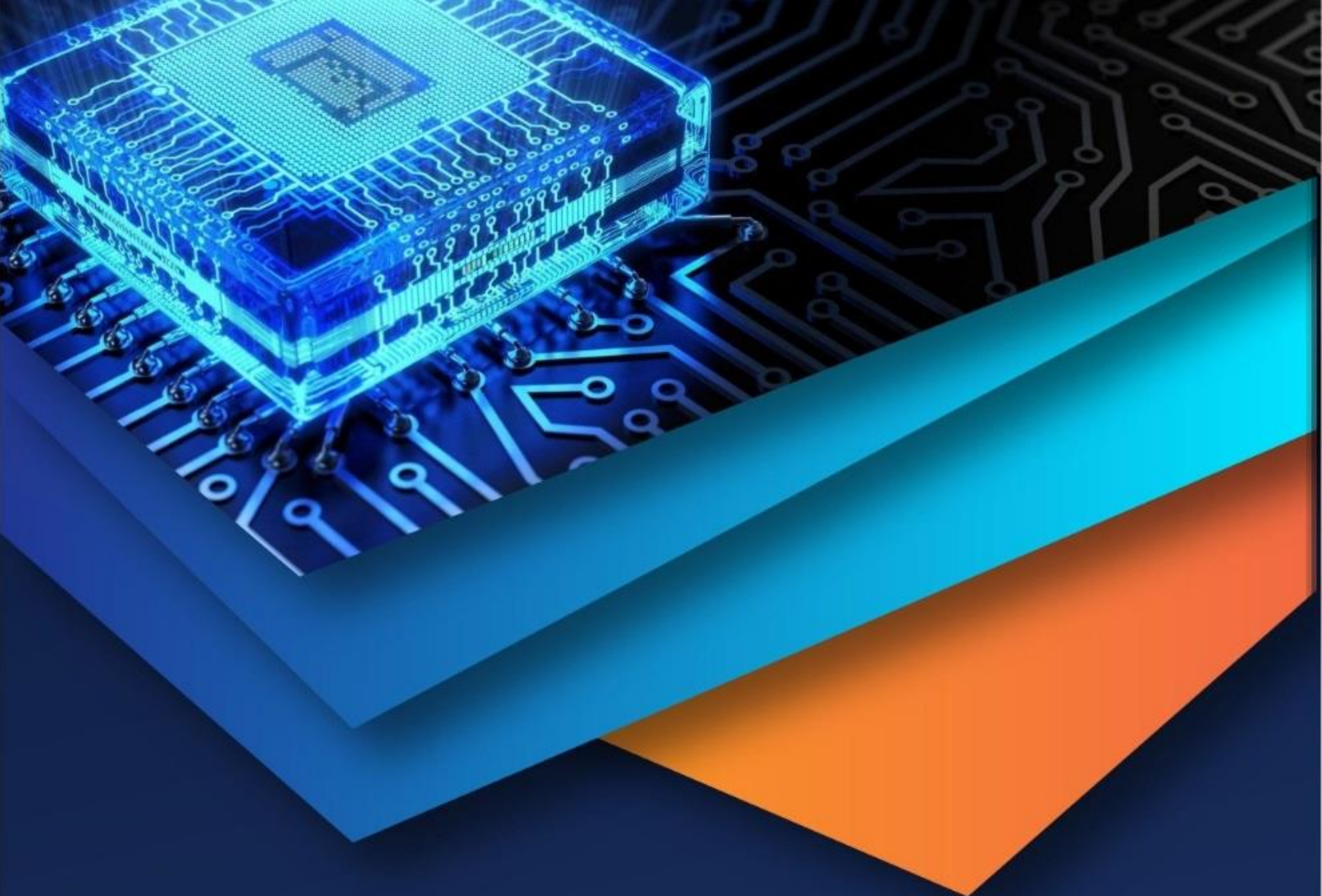

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