Improved Helmet Detection Model Using YOLOv5

Premanand Ghadekar, Shreyas Mendhekar, Vallabh Niturkar, Sanika Salunke, Abhinav Shambharkar, and Kshitij Taley

Abstract This report is about detecting motorbike riders without a helmet and also the pillion rider with the use of YOLO object detection algorithm. We introduced the updated approach for helmet detection. This approach is an upgradation of YOLO object detection algorithm which detects not only the rider's helmet but also the helmet of the pillion rider. Primary objective is Detection of helmet of rider and pillion rider in that targeted image and Increase the accuracy of the YOLOv5 algorithm by adding one layer for detection of small details in an image. In this proposed model a new layer has been added for detection of smaller objects having smaller features. This has been done by changing the configuration of YOLOv5 architecture. The helmet detection using this proposed model has been carried out for a dataset containing images with maximum 3 people, with no helmets, 1 helmet each or 2 wearing it.

Keywords YOLO · Helmet · YOLOv5 · Darknet · PyTorch · CSP · PA-Net · YAML · Head · Backbone · Feature maps · Anchor box · Bounding box · GPU · Custom data

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1 Introduction

In India, two-wheeler is one of the mostly used mode of transport for shorter or sometime longer distance travelling. The reason behind this is two-wheeler have comparatively low maintenance, easy handling and less price. But, there is one concern about the this vehicle is the physical security issue [1]. If we compare the damage due to two-wheeler accidents and the other vehicle accidents then we will get that damage in two-wheeler is more insane and deadliest. In last 15 years accidents were increased extensively, in that specifically two-Wheeler accidents are comparatively more than other transport vehicles such as bus, car and also the majority about 90% of the rider didn't wear the helmet so that they were seriously injured or at some serious cases death occurred [2], so that use of helmet for the rider and also the pillion rider is must.

The new innovation for helmet detection and road safety is the smart helmet i.e. if a rider doesn't wear the helmet then that bike or two-wheeler won't start, but this implementation in real world is not that cost effective and the optimum solution [3]. The special feature of smart helmet is it can call contacts from emergency contact list whenever that helmet senses the considerable impact at the time of unfortunate accident. The system nowadays used to detect the helmet is manual; it means the traffic police need to capture the image for proof, but this the age of AI, machine learning and deep learning so that, in India some major metropolitan cities the high resolution cctv cameras are used to detect illegal activities, speed violations and also helmet detection purpose [4, 5]. The algorithm available for specifically helmet detection are not that much optimized and not able to detect the helmet of pillion rider [6]. The proposed model in report is focused on YOLOv4 (object detection model), other version of YOLO are good but not accurate as YOLOv4 [7]. This YOLO is actually a deep learning algorithm in which there are many convolution layers, addition of some more layer to detect the smaller details [8, 9].

2 Literature Survey

Wen et al. [10] proposed a model in that they used the technique like Image Descriptors and Classifiers for helmet detection purpose. Specifically For vehicle classification, wavelet transform. The HOG 9 i.e. Histogram of oriented gradient and CHT i.e. Circular Hough Transform is mainly used for feature extraction of input images.

The accuracy is high i.e. 97.66% for the vehicle classification and for helmet detection it is about 91% [11].

Hu et al. [12] proposed a model, which mainly focuses on the detection of mask, helmet and number plate detection and this paper is published in 2021. They used the YOLO algorithm Version 3 and canny edge detection technique.

Now, the accuracy of the model is a very important constraint. Their accuracy through YOLOv3 [13] is about 95% for the vehicle classification which is decent, but the accuracy is 90% for the helmet detection which is less as we compare to other models and the mask detection accuracy is about 99% [14]. But, one more concern is that it requires large datasets for training and testing purposes, it is very much time consuming. The detection of helmet and mask of pillion rider is not done in this paper [15].

Hu and Li [16] proposed a model which uses Yolov4's deep neural network architecture for the helmet recognition and also the accuracy is pretty much good i.e. 95%, this paper mainly focuses on the helmet detection of construction site workers.

They used a data set for the practically visible light which is sensitive to the human eye. For this they commit some changes in the properties of the images like noise, intensity, brightness to understand situations in real time data. They used different image enhancement techniques like first the input image undergoes some process like (scaled, flipped and clipped) to increase the accuracy of the proposed model. They also mentioned that when dealing with image occlusion, target overlap etc. [17]. They are using random erase and grid mask and other techniques which are the same as the avoidance of unnecessary ROI in the process of feature extraction and then selection of most appropriate rational part in the image area [18].

Raju et al. [18] proposed the model of object detection using YOLO v1. In which they modified the yolov1 algorithm. They mainly focused on improvement in 3 areas like loss function, inception structure and spatial pyramid pooling layer [19].

For the analysis of modified models, they prefer pascal VOC dataset [20], but the average accuracy was about 65% which is better than the basic model of yolov1.

Krishna and Reddy [21] proposed the model for automatic detection of helmets on a real time video [22]. They approached the problem in the simplest manner i.e. they converted the image to grayscale, then subtracting the background data and targeted on ROI (region of interest). For classification purpose they prefer the SVM because of the robustness of that classification algorithm. The accuracy they got was about 93% which was impressive with the basic model.

3 Architecture of YOLOv5

The crucial and very useful contribution of YOLOv5 is to translate the analysis done by Darknet [23] (which is the most important architectural part of the framework as it contains configuration files) to the PyTorch framework. The darknet framework is developed entirely in C and provides first-class fine-grained control over the network's activities. YOLOv5 composes the model configuration in .yaml, as contradictory to .cfg files in Darknet. The main difference between these two formats is that the .yaml file is built to enumerate the varied layers that the network comprises and then multiply those by the total number of layers in each block [24]. This updated yaml format sense like the following:

YOLO architecture is based on 3 items:

Backbone—It is CNN (Convolutional Neural Network) that gathers and generates image options at numerous granularities.

Neck—This is a sequence of layers to combine and mix image options to pass them forward to prediction.

Head—Collects the options from the neck and takes bounding boxes and sophistication predicting steps.

4 Proposed System

As we have mentioned the architecture for the YOLOv5l above, In the proposed model for adding a new layer, the head and the backbone parameters in the Yaml configuration file for YOLOv5l are changed. Previously the head consisted of three feature maps 52 * 52 * 255, 26 * 26 * 255, 13 * 13 * 255. In the proposed technique a 104 * 104 * 255 feature maps have been added for the detection of extra small features. After experimenting with the proposed model this model can also detect whether the pillion rider is wearing a helmet or not with the help of an extra added layer. So the model also works for 3 people sitting on the vehicle and detects whether they are wearing helmets or not. The proposed model is efficient and convenient for any OpenCv developer for specific reasons. Figure 1 shows improved architecture of YOLOv5.

5 Results and Discussion

5.1 Experimental Environment

Experimental environment used for this project: Intel(R) Core i5-9300H CPU 8 GB RAM, GPU NVIDIA GeForce GTX 1650, 64 bit operating system.

5.2 Dataset

Experimental dataset contains images of riders wearing helmets and riders who don't wear helmets and their annotations into YOLOV5 format. This proposed model used data which was gathered from Kaggle, Google and used some random images for the experimentation part. Experimental dataset contains 555 images for training and their annotations and 63 validation images and their annotations. Training and testing data is given in Table 1.

As there is no sufficient data available for bike rider helmet detection, this proposed model uses some images for bicycle riders also for more accuracy and as there is so much similarity between bike helmets and bicycle helmets. Figure 2 shows training dataset.

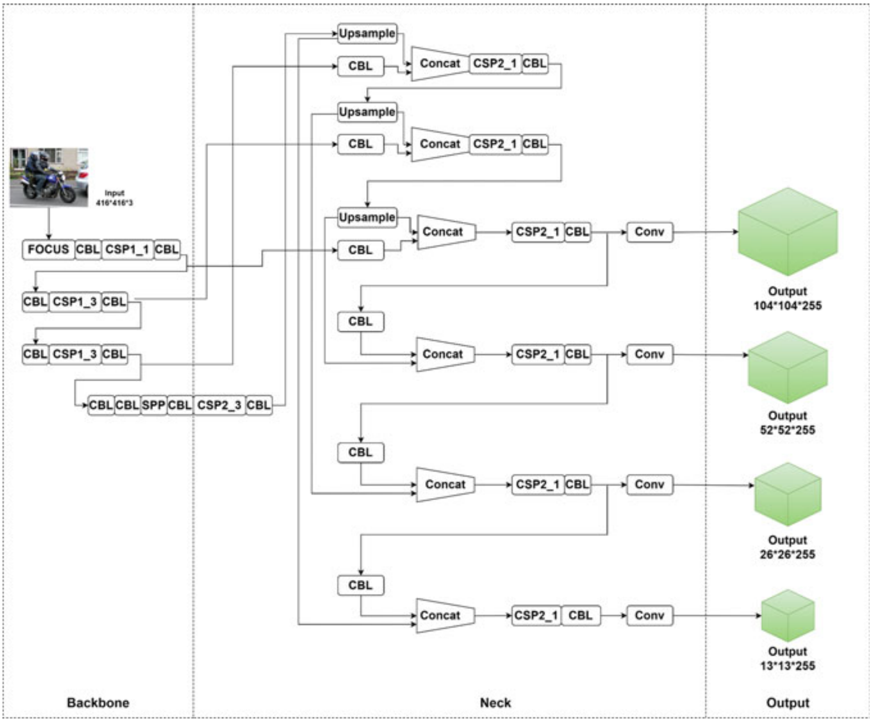

Fig. 1 Improved architecture of YOLOV5

Table 1 Training and testing data

Number of training images	555
Number of testing images	63

5.3 Results

This proposed model mainly focuses on detection of rear person helmets. For detection of the rear person's helmet one detection head is added to the architecture of YOLOV5 and it gives results as follows. This proposed model gives better results for helmet detection and non-helmet detection also. Detection of helmet results are given in Fig. 3.

This proposed model gives precision and recall graphs as shown in Fig. 4. These results/graphs show precision and recall values for 100 epochs. After each epoch it will calculate value and Fig. 4 is a graph for that precision and recall values. In the Fig. 5, the accuracy and mAP values are shown. The proposed model gives accuracy about 89% for helmet detection as mAP value is about 0.89. This proposed model has given 100 epochs for training. Precision and recall values are also taken under consideration. Figure 4 shows precision and recall graph over 100 epochs.

Fig. 2 Training dataset

mAP value which gives accuracy measure shown in Fig. 5. In Fig. 6 Box loss and Object loss are shown. It helps much in the proposed model for YOLOV5. Results are based on detection of the pillion rider helmet. Accuracy for helmet detection is about 89% and accuracy for non helmet detection is about 75% as this model contains two classes helmet and non-helmet.

6 Conclusion

The proposed technique focuses on producing a ROI region of interest detector model. The output that we get by using YOLOv5 modified algorithm is better as compared with different object detection techniques [19, 25]. Pytorch procedure for the training is extensively useful for the enhancement in the performance of YOLOv5, at the same time the yolov5 and yolov4 are similar architecture wise. Proposed model gives accuracy about 89% for helmet detection of rider and pillion riders as mAP value is about 0.89 and for non-helmet rider detection is about 75% for riders as well as pillion riders.

The helmet is a very important safety guard for the workers, two-wheeler drivers and also for cyclist. Due to the lack of awareness and not taking seriously about wearing the helmet become the reason of many accidents. To help the traffic department by digitally monitoring the helmet we proposed this improved model YOLOv5.

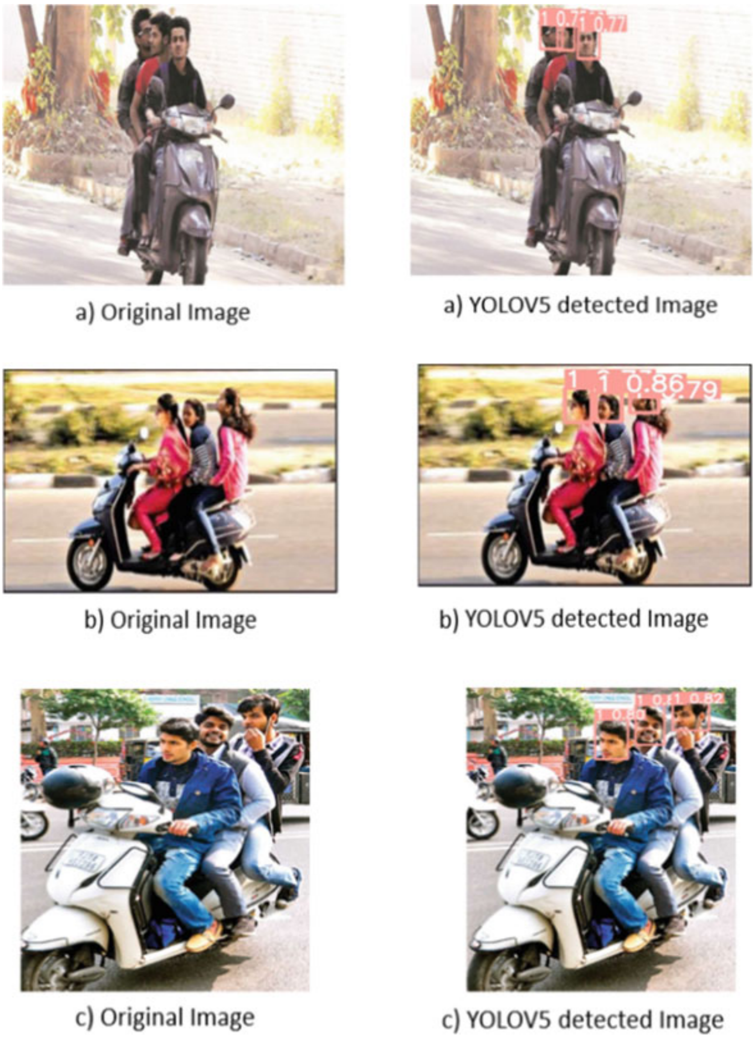

Fig. 3 Detection of helmet results

After that the gathered data set was annotated and the YOLOv5 model was trained and tested using different parameters. The experiment result displays that yolo v5 have better detection speed which is about 110 FPS for the real time helmet detection [26].

The YOLOv5 is currently a new and evolving technology in object detection techniques. There is scope for improvement in accuracy and some minor modification in the architecture part of YOLOv4 which is similar to YOLOv5 architecture wise [27]. We are planning to use optimized and updated dataset for more accurate

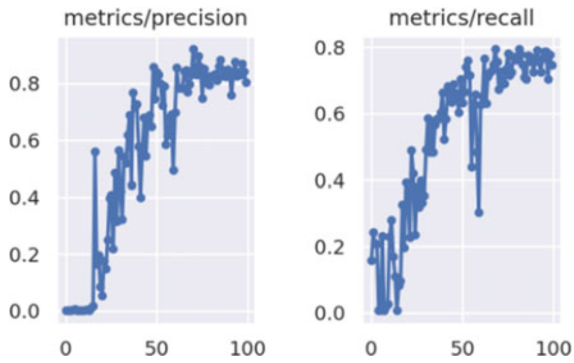

Fig. 4 Precision and recall graphs over 100 epochs

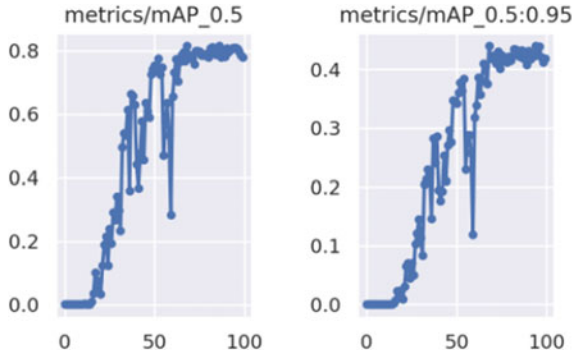

Fig. 5 mAP value which gives accuracy measure

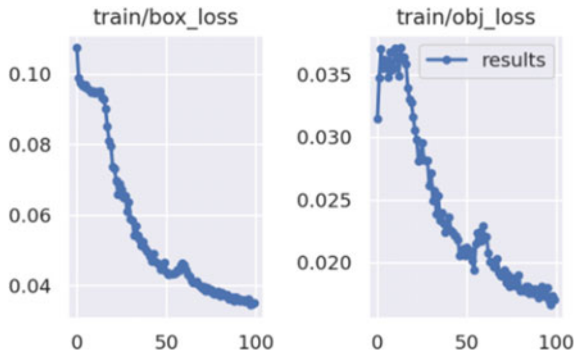

Fig. 6 Box loss and obj loss

detection. This algorithm can be optimized to use in complex object detection. Optimized version of YOLOv5 [28] is very useful in CCTV cameras (upto 60 fps camera resolution) for precise detection of riders with or without helmet.

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