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Helmet Violation Detection Application for Road Safety

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Abstract - *Two-wheelers are a convenient mode of transportation for any general travel in India. Almost 70% of Indians are using this type of transportation. There is less protection in this mode of transportation hence there is a high risk involved. To reduce this risk involved and for personal safety, it is sensible for bike riders to wear a helmet while driving two-wheelers. Not wearing helmets resulted in the death of around forty-four thousand people in India in the year 2019. When the government observed the usefulness of helmet, they have made it an offence to drive a bike without helmet and they are using some manual techniques to find the violators who are not following this rule. The process of automating detecting bike riders without a helmet is necessary for robust monitoring of breaching rules by the riders. It also reduces human resource wastage which could have been used elsewhere. Manual administration of this can lead to errors and also requires a lot of human effort. To overcome this, we propose an approach for real-time automatic detection of bike riders without helmets using road CCTV footage to impose fines to defaulters as a part of law enforcement. This approach first detects bike riders from footage video using YOLO (You Only Look Once) V3(Version 3) and then determines whether the rider is using a helmet or not. Through this approach, we can create a system that is reliable and robust for monitoring the violators and also reduce the number of human resources needed.*

Key Words: bike-rider, helmet, YOLO V3, CCTV footages.

1. INTRODUCTION

Bike transportation is increasing day by day in most countries. Motorbikes are used by citizens belonging to different classes of society because of their economic value. However, there is a high risk involved in bike transportation. Helmets should be compulsorily used by riders to reduce the risk involved in this type of transportation. To strictly implement the use of helmets, the government has made it compulsory and is using some manual strategies to catch violators. Keeping this in mind, Government has made riding a bikes without using helmet a punishable offense and used some manual techniques to punish the violators. But, these systems are not practical as human efficiency decreases over a long duration. Automation of this process is required for reliable monitoring of these violators and to reduce the number of human beings required. Also, this method is cost-effective. The algorithm used here for detecting bike riders is YOLO(You Only Look Once) Version-3 that uses Darknet-53 Architecture which consists of 106 Convolutional Layers. In this system, CCTV footage is converted into frames and Bike riders are detected from the frames. The frames detected will be sent to the next modules and we get rid of the other frames. The rider's face without a helmet is extracted and is stored in the database. If the rider uses the helmet, the frame is ignored.

2. LITERATURE SURVEY

The current emerging technologies can help in detecting helmet in motor cycle riders. Meenu R [1] proposed a solution using Deep Learning and Image Processing technology. Footage from CCTV is used to detect if a rider is wearing a helmet or not. Faster RCNN is used here because it increases motor cycle's detection rate. The system includes features such as motorcycle detection, head detection, helmet detection and number plate detection. The vehicle's registration number is captured using open-ALPR and the nearby police station receives an alerting message.

Yange Li [2] in his solution based on Convolutional neural network-based SSD algorithm model is used. In this system time required for training has been reduced and resources required for computing has been minimized by analyzing the characteristics of Safety Helmet. In this method different depths of CNN are used to predict the Helmets. In this model number of anchors has been increased and to make detection more accurate. The results of this experiment shows that the dispensed deep learning-based model using the SSD algorithm is capable of detecting not wearing helmets in construction sites and other relevant places in an accurate and efficient manner.

Kunal Dahiya [3] used Vector machine classifier to detect the bike riders without helmet. This model uses Circle arc detection to detect the objects. This model takes 11.58 milliseconds to process a single frame. Bike-riders are detected in first step. Bike rider's head is located in the second step and based on existence of the helmet bike rider is classified. The results are collected from consecutive frames for final prediction. A limitation of this method is that it tries to locate helmet in the entire frame which is processing power intensive and also it may confuse any other similar shaped objects as helmets. Dedicated hardware is required to set this up so it is not as efficient as the other models.

In solution proposed by Shravan Maliye [4] YOLO and Canny Edge Detection is used. Quantity of available dataset and training time of the model are the factors that affects the model's accuracy in this system.Traffic video is converted as frames and bike-riders are detected from each of the given frames. The frames have images of two wheelers as well as other vehicles. This is done using YOLOv3. After detecting bike riders, the system classifies the bike-rider based on existence of helmet and mask. This is also done using YOLO. This system crops the number plates who are not using helmet or face mask or both and saves those number plates in the given folder.

Kavyashree Devadiga [5] using the COCO model created a database of all the bike riders driving without a helmet along with an image for verification. A video camera would be installed facing the roads which would be the input to the system. The frames undergo background subtraction in which only the moving objects are retained and other factors are eliminated. Under fair lighting conditions this system was tested to give fool proof results. The frames undergo background subtraction where pedestrians and other entities except the moving objects will be eliminated. Then the moving object will be classified and labelled by a trained model. Commodity objects will be classified using the coco model.

Wonghabut P [6] in his paper, HAAR algorithm is used and the system includes detection of motor cyclist, detection of helmet and detection result verification. Output of this process are frames having motorcyclists in them. These frames have ratios in the range 0 to 80 pixels width and 0 to 120 pixels height. Detection performance of the program dripped during rush hours due to dense traffic which causes overlapping of motorcycles image on video frames. This hinders the ability to capture motorcyclists within frames.

K C Dharma Raj [7] proposed a system which is based on the study of Image Processing and Deep Learning. Image processing is used here to detect motor cyclists without helmet. Then the bike-riders are classified as with or without helmet for license plate recognition. A series of experiments is held to find the best model for the task by changing the hyper parameters and number of training examples as well as applying data augmentation techniques. The algorithm used here for identifying bike riders and the helmet is Support Vector Machine (SVM). Depth of the Convolutional Neural Network is more important than its width and small models are more effective even without a lot of processing power.

H. Lin [11] used three steps to detect the bike rider without helmet. In first step they used pre trained RetinaNet model for detecting active motor cycles in the frame. In the second step, motor cycle is tracked using adjacent frames. In the third step, when motor cycle leaves the CCTV camera's view the number, bike-rider's position and existence of Helmet are identified. So, the rider can be classified as violator or he is wearing the Helmet.

Muhammad Fachrie [12] used two modules to counting the vehicles those are passing through the camera. First module is for detecting objects and second one is for counting the vehicles. In his research, the car has the highest accuracy and truck has the least accuracy. Bikes and bus got second and third positions in accuracy. In his system, 4GB of VRAM with 1.5 GHz is used for training.

Miao Yon [13] used YOLO V3 for detecting vehicles from night time images. In their system, two modules have been used to perform these detections. In first module night time images are processed using optimal MSR algorithm to improve brightness and information. A pretrained YOLO V3 model has been fine-tuned using images enhanced by the MSR algorithm to improve the accuracy. Finally, the enhanced YOLO V3 model is used for detecting vehicles from night time images.

Fichman [14] used YOLO V3 model for detecting safety helmets in mining areas. Safety helmets are mandatory for employees working in mines. So, as per the government norms it is necessary to take care of employee's safety in the working areas. The accuracy has been increased from 58% to 73% by using YOLO V3 model instead of existing systems.

3. YOLO V3 ARCHITECHTURE

YOLO V2 used Darnet-19 which consists of 19-Convolutional Layers supplemented with 11 more layers. Totally YOLO V2 used 30-layer network. So, YOLO cannot be used for detecting tiny objects. YOLO V3 uses Darknet-53 Architecture which consists of 53 layers and for detection task 53 more layers are added. Totally 106-layer fully convolutional architecture is used in YOLO for detection. In Figure, we can see the Architecture of YOLO (You Only Look Once) algorithm.

	Type	Filters	Size	Output
	Convolutional	32	3 × 3	256 × 256
	Convolutional	64	3 × 3 / 2	128 × 128
1×	Convolutional	32	1 × 1	
	Convolutional	64	3 × 3	
	Residual			128 × 128
	Convolutional	128	3 × 3 / 2	64 × 64
2×	Convolutional	64	1 × 1	
	Convolutional	128	3 × 3	
	Residual			64 × 64
	Convolutional	256	3 × 3 / 2	32 × 32
8×	Convolutional	128	1 × 1	
	Convolutional	256	3 × 3	
	Residual			32 × 32
	Convolutional	512	3 × 3 / 2	16 × 16
8×	Convolutional	256	1 × 1	
	Convolutional	512	3 × 3	
	Residual			16 × 16
	Convolutional	1024	3 × 3 / 2	8 × 8
4×	Convolutional	512	1 × 1	
	Convolutional	1024	3 × 3	
	Residual			8 × 8
	Avgpool		Global	
	Connected		1000	
	Softmax			

Fig-1: YOLO V3 Architecture

4. PROPOSED SOLUTION

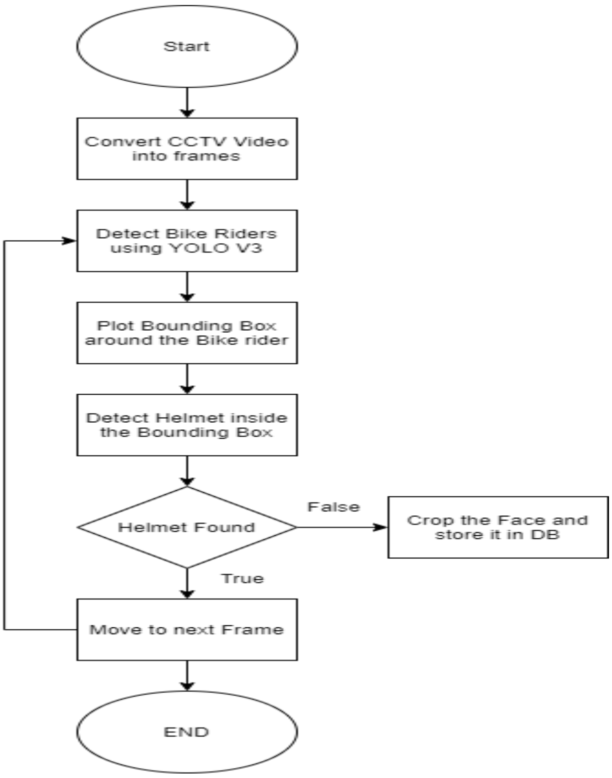

Fig-2: Proposed solution

Proposed Solution Consists of 2 Modules

i. Detection of Bike Rider

ii. Detection of Helmet

Fig-2 shows detailed approach for detecting Bike Rider without Helmet.

4.1. Detection of Bike Rider

CCTV Video is converted as frames and sent as input to the first model which gives confidence and bounding box as output.

4.2. Detection of Helmet

Bike rider image from the model is cropped and sent as input to the second model. This gives the confidence and bounding box of the Helmet as output. Bike rider is classified using following algorithm.

$If(Helmet\ not\ detected):$
  $Classify\ as\ violator$
$Else:$
  $If(Bounding\ box\ helemet\ is\ in\ top\ 40\%\ of\ bikerider):$
    $Move\ to\ next\ Frame$
  $Else:$
    $Classify\ as\ violatore$

Fig-3: Algorithm for classification

4.3. Non-max Suppression

Sometimes YOLO predicts multiple Bounding Boxes for same object. But only one bounding box should be predicted for each object. We can achieve this using non-max suppression technique.

The non-max suppression takes two things into account

1. The objectiveness score given by the YOLO v3 model

2. The Intersection Over Union (IOU) or overlap of the bounding boxes

Process of selecting the best bounding box using NMS

Step 1: Select the box with highest objectiveness score given by the model YOLO v3.

Step 2: Then, compare the overlap (IOU) of this box with other boxes.

Step 3: Remove the bounding boxes with overlap (IOU) > threshold.

Step 4: Then, move to the next highest objectiveness score and continue the process.

Step 5: Finally, repeat steps 2-4 until we get best bounding box for each object.

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5. EXPERIMENTAL SETUP

This experiment is performed in Google Colab Notebook with 16GB Nvidia T4 GPU which has clock speed of 1.59GHz.

5.1. Datasets

We Collected Bike riders and Helmets images from various open-source websites. Dataset consists of 1000 Bike Rider images and 1121 Helmet images. Images are stored inside darknet's obj folder for training. Figure 3 shows the sample bike rider and Helmet image.

Fig-4: Sample Bike Rider image

5.2. Preprocessing

In preprocessing phase some augmented images are produced from collected images to expand the dataset. Now the new images are annotated to represent the bike-rider and helmet using open-source software. Annotation consists of object id, center point of the object, width and height. Annotations are stored in text file which has the same name of the image for training.

6. RESULTS

Figure 5 shows loss graph of Bike rider detection training. In loss graph, we can see that after 200 epochs the Loss reduces drastically after that it reduces very slowly.

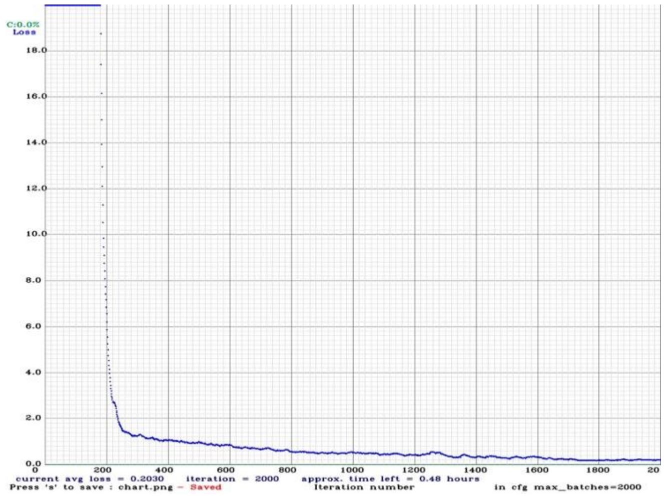

Fig-5: Loss Graph of Bike Rider Prediction Model

Figure 6 Shows Prediction Result of Bike Rider detection model.

Fig-6: Prediction Result of Bike Riders

Figure 6 shows detected object after applying Non-max Suppression. So, Single bounding box is detected for each object.

Table-1: Accuracy of Bike Rider Detection

Algorithm	Accuracy (%)
YOLO V3 (Proposed)	91.19
SSD300 [11]	74.30
Caffe Model [8]	76.00

Table 1 shows the Accuracies of various Algorithm. In that our proposed system using YOLO V3 has high Accuracy. Even though, YOLO has high accuracy, it is difficult to predict smaller objects using YOLO. But, Bike-Rider and Helmets can be predicted using YOLO.

Figure 7 shows Loss graph of Helmet Detection Training Process. In this Loss graph also, we can see that after 200 epochs the loss value reduces drastically once after that it reduces slowly.

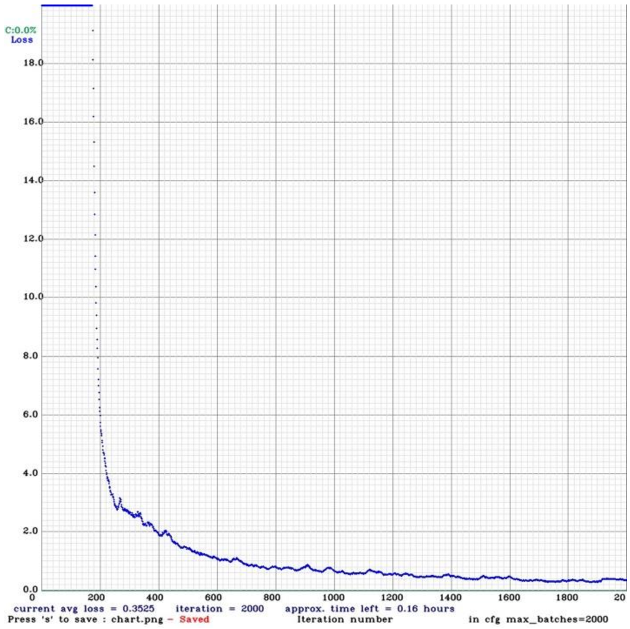

Fig-7: Loss Graph of Helmet Detection Model

Tab-2: Accuracy of Helmet Detection

Algorithm	Accuracy (%)
YOLO V3 (Proposed)	90.13
CNN [2]	85.00
YOLO V1 [4]	81.00

From Table 2 We can see that YOLO V3 has the high Accuracy than other two models. Addition to that YOLO has the high processing speed and it can evaluate 65 Frames per Second.

Fig-8: Detection Result of Helmets

Figure 8 also shows the result after applying non-max suppression. So, we can see only one bounding box over each Helmet.

We can see the final result from Figure 9 and Figure 10. Figure 9 shows the Bike rider without helmet and the bike rider is plotted with red bounding box. Similarly, Figure 10 shows the Bike riders with helmets and they are classified with Green bounding boxes.

Fig-9: Bike Riders Without Helmet

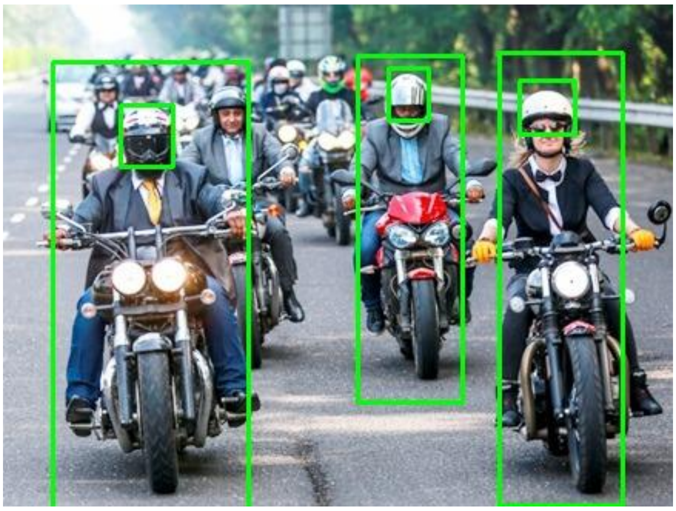

Fig-10: Bike Riders with Helmet

7. CONCLUSION

This project aims to decrease the accidents caused due to not wearing the helmet. It also ensures whether the law is violated or not. It stores the image of the violating people. This work is a helmet violation detection application for road safety. A YOLO v3 framework, which is custom trained is used for helmet detection on motorcyclists in the Region of Interest inside the frame. This system mainly consists of three parts – Bike Rider Detection, Helmet Detection, scanning face images of those bike riders who doesn't wear helmet. The model is trained on a custom data set, and the newly trained layer is added to the existing model. The detection model gives an array of values which can be used to draw bounding boxes over detected motor cycles, the values are centroid coordinates information, height and width.

Since the given approach needs ROI for its operation, in future the work can be improved for different indoor and outdoor environments. AI based ROI selection can be developed to allow the system to select the ROI points without manual intervention. The performance of this system can be improved with help of multithreading for monitoring different ROIs of video frames that are captured by Traffic cameras. Performance can also be improved by increasing dataset training and training algorithm for a longer period of time.

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