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HELMET PRESENCE DETECTION ON MOTORCYCLISTS USING IMAGE PROCESSING AND MACHINE VISION TECHNIQUES

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ABSTRACT

High number in usage of Motorcycles has led to increase in road related accidents and injuries. The major reasons for accidents is the motorcyclist not wearing a helmet. One of the method is by traffic police manually monitoring motorcyclists at road junctions for not wearing helmet or through the CCTV footage video, which requires human efforts to detect motorcyclists without helmet. This paper presents an automated machine system for detecting motorcyclists not wearing helmet from video. The system extracts moving objects by background subtraction and classifies them as a motorcycle or other moving objects based on features extracted. Then for classified motorcyclist, head portion is located and it is classified as helmet or non-helmet. The system uses Convolutional Neural Networks trained using transfer learning on top of pre-trained model and combined with computer vision for classification which has helped in achieving greater accuracy. Our results on traffic videos show an accuracy of 98.56% on detection of motorcyclists without helmet.

Keywords— Helmet detection; Motorcycle, Convolutional Neural Network, Computer Vision, Transfer learning.

INTRODUCTION

Motorcycle helmets are essential for human safety. Unfortunately their use is not always easily enforced, particularly where the culture is not accustomed to such practices. The goal of this work is to provide an automated system approach to the detection of motorcycle riders not wearing a helmet.

According to the survey [1] The death percentage for two-wheeler riders not wearing a helmet was the highest in Jharkhand - 52.33 per cent. This means that in one out of every two road accidents, a two-wheeler rider not wearing a helmet died in Jharkhand. Jharkhand is followed by Rajasthan (40.84 per cent), Punjab (40.67 per cent), Uttar Pradesh (38.89 per cent), Maharashtra (36.81 per cent) and West Bengal (36.27 per cent).In the states of Arunachal Pradesh (6.45 per cent), Nagaland (6.25 per cent), Kerala (5.55 per cent), Delhi (5.41 per cent), Tripura (4.17 per cent), Sikkim (4.17 per cent) and Jammu & Kashmir (1.01 per cent), the death rate was below 10 per cent. The death rate of non-helmet two-wheeler riders in Meghalaya and Mizoram was zero. This means that every hour, two-wheeler users who died in a road accident did not wear a helmet. The number of two-wheeler users who died in road accidents was 48,746, which was 33 per cent of the total deaths in road accidents. Two-wheeler users were followed by car/jeep/taxi users whose death toll was 26,869.

To increase the use of helmet ,Government of India has proposed Various Penalties under Motor Vehicles (Amendment) Bill – 2019.According to section 194D a person without helmet will be fined rupees 1000 with disqualification of licence for 3 months [2].

Currently, Traffic Police are entrusted with the task of ensuring that motorcycle riders wear helmet or not. But, this method of monitoring motorcyclists is time-consuming as well as there are limitations of human interventions. Also, in all major cities CCTV surveillance based methods are not automated and require human to manually identify person not wearing helmet.

The increasing amount of motorcycles and accidents caused due to not wearing helmet, there has been a growing amount of research in the domain of road surveillance department. The system proposed in this paper automates detection of motorcyclists wearing helmet or not. The system proposed makes use of Image Processing and Computer Vision techniques. The System combines Pre-trained Model (MobileNet-SingleShotDetector trained on Common Objects in Context dataset) and fine-tuned for helmet detection. MobileNet is the neural network which is used for classification and recognition and SSD is the framework to realize multibox detector.

RELATED WORK

From many years, different algorithms are being presented to automatically detect helmet. The first automated system for detection of motorcycle riders not wearing helmet was done by Chiverton [3]. The system uses SVM classifier trained, derived from image data near head region of motorcyclists. The features selected capture the shape and reflective property of helmets. It also uses circular arc detection technique based on Hough transform. The disadvantage of this approach is that it leads to a lot of misclassification. Another drawback is that it does not firstly identify motorcyclists in the frames, it directly identifies helmet in some cases.

To overcome the problem, Waranusast et al, [4] developed a system that uses K-Nearest Neighbors (KNN) classifier on features extracted from an image. For KNN classifier for motorcycle classification, the features considered an area of bounding rectangle and aspect ratio of the bounding rectangle. For KNN classifier for helmet classification, features like arc circularity (similarity between a circle and an arc) and average intensity of pixel are considered. But, the images captured in the system did not involve any occlusion as the images were perpendicular to camera. So, occlusion was not considered in this system.

In parallel Silva et al, [5] developed a system which first identifies motorcyclists in the frame using SVM classifier. After that, helmet classification is done using SVM on features extracted by a hybrid descriptor, combining Local binary pattern, Circular Hough transform and Histogram of Oriented Gradients descriptors.

In [6], K. Dahiya et al, proposed a system with helmet detection from surveillance videos and used an SVM classifier for classifying between motorcyclist and non-motorcyclist and another SVM classifier for classifying between helmet and without helmet. For both classifiers, HOG, SIFT and LBP were implemented and the performance of each was compared. They concluded that HOG descriptor helped them to achieve greater accuracy.

In [7], Dhwani et al, proposed the technique by which motorcyclists without helmet are detected. In this technique moving vehicles are detected by thresholding and then classified into motorcyclist & non-motorcyclist by area and aspect ratio. To detect helmet first ROI is determined and by cascade classifier without helmet are detected.

In [8], Jie Li et al, proposed a system for safety helmet detection for pedestrians at power substations. This system first does background subtraction to find region of interest. After that, HOG features are extracted and SVM classifier is used to classify pedestrians. Finally, for the identified pedestrian, safety helmet classification is done by using color feature recognition.

In [9], C. Vishnu et al, proposed an approach using Convolutional Neural Networks (CNNs) for classification. They used their own prepared dataset of videos from the surveillance network at IIT Hyderabad campus and achieved good performance and accuracy.

PROPOSED WORK

Most of the existing systems for this proposed work use classifiers built on handcrafted features on the images/frames in video. Coming up with really good handcrafted features is a invincible task. This is why, deep Convolutional Neural Networks (CNNs) [10] have become popular in recent years for the job of image classification. CNNs learn rich feature representations from a broad range of images which often outperform handcrafted features and lead to more accurate and efficient image classification. Thus, implementation of the proposed system for this problem statement is done using CNN classifiers. One CNN classifier is used to classify between motorcyclist and non-motorcyclist and another CNN classifier is used to classify between non-helmet and helmet.

Building a CNN classifier from scratch requires huge amount of data good hardware resources. Also, having both of these, the built CNN model may not perform really well due to problems in its architecture or small amount of data, may overfit or underfit the data based on the given type of learning. So, transfer learning [11], is used on top of one of the most popular CNN model, MobileNet-SSD [12], that is pre-trained on the Common Objects in Context (COCO) [13] dataset. This has facilitated in obtaining high accuracy in classification.

Our proposed work system is divided into several steps which can be seen in Fig. 1.

Background subtraction and Object segmentation

Background subtraction [14] detects all the foreground moving objects like vehicles, pedestrians and discards all the stationary objects in the background like trees, road, etc. Background subtraction is done on the input footage video by calculating absolute difference between consecutive two frames of video. The output of background subtraction of two consecutive frames is a single binary image containing moving objects.

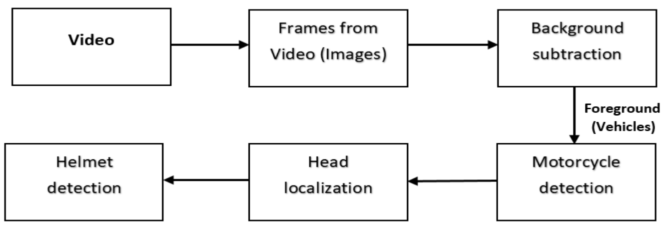

Fig. 1. Block diagram of proposed method

To obtain appropriately segmented moving objects, Canny edge detection algorithm [15] is applied on each frame before calculating absolute difference between two consecutive frames. Canny edge detection algorithm detects wide range of edges in an image which help in object segmentation. Also, morphological operations are applied on the calculated absolute difference between two frames to remove noise and fill the gaps inside the white areas of the binary image to extract complete moving objects. After this, contours in the image are found out and individual moving objects are obtained. To prevent the same vehicle getting detected more than once, the vehicles are extracted only when they reach a specific horizontal line. The lower boundary for the bounding contours is considered for this.These individual moving objects are then fed to Motorcyclist vs Non-motorcyclist classifier. Segmented moving objects using result of background subtraction.

This method used for background subtraction does not require image of background as input, making it independent of the video and it is independent of various factors like quality of video and illumination.

Motorcyclist vs Non-motorcyclist classifier

This classifier was built using transfer learning on our training dataset of motorcyclists and non-motorcyclists on top of MobileNet-SSD. MobileNet is a convolutional neural network that is trained on more than a million images from the ImageNet database. The network is 54 layers deep and can classify images into 1000 object categories. MobileNet is a neural network that is used for classification and recognition whereas the SSD is a framework that is used to realize the multibox detector. Both of them are combined for object detection. SSD's architecture was build on the venerable MobileNet architecture, but discards the fully connected layers. The reason MobileNet was used as the base network is because of its strong performance in high quality image classification tasks and its popularity for problems where transfer learning helps in improving results. Instead of the original MobileNet fully connected layers, a set of auxiliary convolutional layers (from conv6 onwards) were added, thus enabling to extract features at multiple scales and progressively decrease the size of the input to each subsequent layer.

For the classifier MobileNet-SSD was fine-tuned to detect motorcycle, person on the motorcycle and finally the helmet. Transfer learning via Fine-tuning is used. The convolutional layers were kept as it is and only the added layers were trained on our training dataset. When moving object is fed to this classifier, it classifies it as a motorcyclist or non-motorcyclist, then it is forwarded for head localization. Fig. 2 shows detected motorcyclist with helmet.

Fig. 2. Detected Motorcyclist with helmet

Head localization for detected motorcyclist

Once a moving object is classified as motorcyclist, image of the head portion is extracted by taking upper one-forth portion of the original image. The extracted head portion is then fed to helmet vs non-helmet classifier.

Helmet vs Non-helmet classifier

This classifier was built similar to the Motorcyclist vs Non-Motorcyclist classifier. The layers added to MobileNet-SSD were trained on our dataset of helmets and non-helmet objects using fine-tuning.

Input motorcyclist image is first converted to grayscale. Then, it is thresholded. After this, the binary image obtained is inverted. Now, the contours are found out. Minimum area rectangles are generated around the contours, but there might be few other parts of motorcycle detected too. These are filtered out based on their orientation, height, width, aspect ratio. After this step, many of the candidates get filtered out.The Region of

Interest i.e the Helmet-Head area is cropped and then the classifier checks whether the person is with helmet or without helmet and returns the results obtained.

EXPERIMENT AND RESULTS

Platform and Tools Used

The experiments are performed on a machine with 64 bit Windows 10 Pro Operating System. The specifications of the system are 16 GB RAM (DDR4), Core i5 (8^{th} gen) 2.3 GHz processors and NVIDIA Geforce GTX 1050Ti GPU. The system is developed in Python-3.8.1 using libraries such as OpenCV-3.4.1 for computer vision and image processing, Keras-2.3.0 with Tensorflow-1.15 backend for building CNN, numpy-1.19 for multi-dimensional arrays and scikit-learn-0.22.2 for machine learning.

Dataset Used

Since the pre-train Model MobileNet is already trained on COCO dataset, it is combined with SSD for object detection. Later it is fine-tuned by removing fully connected layers and replacing it with new fully connected layers, with new labels. Total sample images were 3000 images, where 2100 images were given in training and 900 images in testing i.e 70% data in training and 30% data in testing.

RESULTS

The accuracy of motorcycle vs non-motorcycle classifier gave an accuracy of 99.47%, precision of 99.30% and recall of 99.30% on dataset (test) and helmet vs non-helmet classifier gave 99.09% accuracy, 99.25% precision and 98.85% recall on dataset (test). Therefore, the overall accuracy for detection of motorcyclist is 99.47% * 99.09% = 98.56%. Table I shows performance of each classifier on the data (test) respectively. Accuracy is calculated between, Number of samples correctly classified to the Total number of samples given. Precision is calculated between, Number of positive samples classified as positive to the given Total number of samples classified as positive. Recall is calculated between, Number of positive samples classified as positive to the given Total number of positive samples.

TABLE I. PERFORMANCE OF EACH CLASSIFIER ON TEST DATA

Classifier	**Performance (%)**		
	Accuracy	***Precision***	***Recall***
Motorcycle vs nonmotorcycle classifier	99.47	99.30	99.30
Helmet vs non-helmet classifier	99.09	99.25	98.85

CONCLUSION

In this work, the described framework system detects motorcyclists riding with and without helmet with accuracy of 98.56% from the video. The Pre-trained model and fine-tuning it for particular class has helped to get good accuracy. The extraction method is based on vertical and horizontal projection methods, while the classification method is based on features derived from head regions. But, only detection of such motorcyclists is not sufficient for taking action against them. This framework can be extended and combined with automated license plate recognition system, to detect license plate automatically and store it in the database of the person riding motorcycle without helmet and to automatically send penalty fine to the respective person. The system can also be improved by using different framework and test the results on data for improving accuracy and by using different algorithms, combination of different algorithms may help to improve accuracy.

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