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Helmet Detection and Number Plate Extraction System for Automated Traffic Violation Monitoring

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1. **ABSTRACT**

Two-wheelers are the most common modes of transportation in India. Traffic accidents are the major cause of death globally, particularly in India. Although two-wheeled motorcycles are a natural alternative for a practical mode of transportation, they also significantly increase the number of fatalities and injuries in traffic accidents. Despite government regulations, many people opt not to wear helmets while driving. According to government data, more than 10,000 people die in motorcycle accidents in India each year, and a considerable fraction of these deaths might be avoided if riders wore helmets. The most popular method for ensuring that motorcyclists wear helmets is for traffic officers to manually check motorcyclists at traffic junctions or through CCTV video and penalize those who do not wear a helmet. However, it needs human interaction and effort. The goal of this study is to create a robust system for helmet recognition and number plate extraction from motorcycle photos and videos utilizing the YOLO (You Only Look Once) object detection method and OpenCV-based Optical Character Recognition (OCR) technology. The method is intended to address the growing number of accidents caused by riders who do not wear helmets, as well as the necessity for improved automobile traffic management. To detect the presence of helmets on motorcyclists, the YOLO algorithm is trained on a huge dataset of motorcycle photos. This method provides an automated approach for recognizing non-helmeted motorcyclists and a system for collecting motorcycle license plates from CCTV camera footage. To begin, the system categorizes moving objects as either motorcycling or non-motorcycling using YOLO and then it detects and localize the presence of helmet whether the rider is wearing or not. Finally, the rider who was not wearing a helmet is recognized. If the quality of footage is low, we will use Laplacian filtration method to filter the video and minimise the excess noise from it. Then the number plate characters are extracted using OCR technology. The system is tested on a large set of real-world images and videos, and the results demonstrate high accuracy in detecting helmets and extracting number plate information.

Keywords: - YOLO, Convolutional Neural Network, OCR, Pytesseract, Laplacian filter.

2. INTRODUCTION

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 report on road safety 2019" released by world health organization. It is very hard to imagine that this burden is unevenly borne by motorcyclists, cyclists and pedestrians. Worrying fact is that India ranks number one as far as road crash deaths are considered. The use of helmets while riding a motorcycle is a critical factor in preventing fatal head injuries in the event of an accident. Despite laws mandating helmet use in many countries, including India, a significant number of motorcycle riders still choose not to wear helmets, putting themselves and others at risk. The need for effective enforcement of helmet use laws and road safety measures is therefore crucial. In order to address this issue, this research focuses on developing a system for helmet detection and number plate extraction from images and videos of motorcycles in India, using cutting-edge computer vision and machine learning techniques. The system utilizes the YOLO (You Only Look Once) object detection algorithm and

Optical Character Recognition (OCR) technology based on OpenCV to accurately detect the presence of helmets on riders and extract number plate information from each frame. YOLO is a fast and efficient deep learning algorithm for object detection, which has been widely used in various applications including traffic monitoring, vehicle tracking, and security systems. In this study, YOLO is trained on a large dataset of motorcycle images to detect the presence of helmets on riders. By using the OCR technology, the characters are extracted from license plate and it can be useful in various applications in real life. This system consists of two main components: helmet detection and number plate extraction. The helmet detection component utilizes the YOLO algorithm to detect the presence of helmets on riders in real-time. YOLO is a deep learning algorithm that uses convolutional neural networks (CNNs) to perform object detection. The algorithm is trained on a large dataset of motorcycle images, which includes both images with riders wearing helmets and images with riders not wearing helmets. The OCR technology is based on pattern recognition and machine learning algorithms, which are trained on a large dataset of number plates to accurately recognize the characters and digits on the number plates. It provides several benefits over traditional physical human intervention for enforcing helmet use. Firstly, the system operates in real-time and can process large amounts of data efficiently, making it possible to monitor a large number of motorcycles simultaneously. Secondly, the system objective is to eliminate the possibility of human error or bias, leading to more reliable enforcement of helmet use. Lastly, the system can be used for various purposes, such as tracking vehicles involved in accidents, and investigating crimes. Thus, by combining the power of computer vision, machine learning, and CCTV cameras and providing valuable information for traffic management and crime investigation, the system has the potential to significantly improve road safety and security in India and also making it a promising solution for countries facing similar challenges.

3. RELATED WORK

The object detection domain has been more frequent due to the evolving Object detection algorithms, which detect objects quickly and with higher accuracy. While working in the same domain, it is important to analyse the previous research work to comprehend how logic is constructed, how algorithms have evolved, and what are the limitations and drawbacks of their work so that we can improve it. This review of the previous literature will focus on the discussed aspects of each algorithm and the reason for choosing a specific algorithm for this project will be justified.

3.1 HELMET DETECTION

For the helmet detection Aditya Mandeep Vakani et al. [1] employs YOLO with pre-trained weights on the dataset to identify motorcyclist and person. Furthermore, the upper one-fourth region is divided into helmet and non-helmet categories. YOLO's advantages include speed and real-time processing. The limitation of this system is, for better performance good illumination and clear weather is a required. Rachmad Jibril et al. [2] applied Histogram of Oriented Gradient (HOG) and Circular Hough Transform (CHT) for object detection purpose. For circular object detection CHT is utilized. In this HOG feature extraction process involves Pre-processing of the recorded frames, computing the gradient and then calculating the HOG value in each cell, normalizing each block, and calculating the feature. In pre-processing, all frames in the footage are transformed to greyscale. For each cell, the HOG is calculated by matching the Gradient Direction and Magnitude But this model fails to detect and extract the licence plate. F.Wu et al.[3] proposed an innovative and practical safety helmet wearing detection method based on image processing and machine learning. At first, the Vibe background modelling algorithm is exploited to detect motion object under a view of fix surveillant camera, after obtaining the motion region of interest, the Histogram of Oriented Gradient (HOG) feature is extracted and finally, the safety helmet detection will be implemented by colour feature recognition. Parasa Teja Sree et al. [4] has discussed a machine learning-based approach to identify helmet is used by motorcyclists. Video is taken as input from surveillance footage. The object detection-based algorithm is trained to detect motorcycles and their helmet through various methods corresponding to Open CV and SVM classifier. This system has an accuracy of 87%. The advantage is system has Greater accuracy in classification and recognition algorithms which is more beneficial. The only downside is data processing time is more for training the model. Silva et al. [5] have talked about image descriptors and classifiers to identify riders without helmet. Three steps involve in this process of identifying such riders i.e., Segmenting moving objects, classifying moving objects, and detecting helmets. Because the geometry of the head and the helmet is comparable, a technique just considers geometric features, but this feature is not enough to detect the helmet because many times the head can be mistaken with the helmet and does not produce satisfactory results.

3.2 NUMBER PLATE DETECTION

Hendry et al.[6] proposed a system where the sliding window detects each digit of the license plate, and each window is then detected by a single YOLO framework. The system has more accuracy in detection of speed and objects. The challenges they faced were Real-time Implementation, Occlusion, Direction of Motion, variations in Conditions, and Quality of Video Feed. Rajkumar et al.[7] discussed the effective approach for helmet recognition and Licence plate detection is restricted to the recognition of those objects and does not include alphanumeric character recognition from the licence plate. In [8] H.Li et al. proposed method to detect and recognize vehicle plates. In this method, features are first extracted from the input image using CNNs. Plate regions are then identified. After that, the number plate characters are recognized using CNN. But the downside is that the model is unable to detect and recognize the number plate from the video. Gao et al. [9] proposed a method where the images are fed as an input and then number plate is detected by making

bounding classes around them. and the cropped image of a number plate is provided as output. Shen et al. [10] discussed a plate recognition method that is a combination based on deep neural networks. In this method, recurrent neural networks (RNN) were used for plate feature extraction. The extracted features in this part are given to a CNN for character detection. The advantage of this method is that there is no need for plate segmentation. But the accuracy and processing time is too much. Wang et al.[11] in their study used YOLOv3 and CNN algorithm for detection of motorcyclists without helmets, the picture of the number plate is recorded as an image but the limitations to this work is the no characters can be recognized from the number plate. It is not possible to digitally save the pictures of the licence plate and utilise them for future research.
These are the drawbacks we have found by doing a literature survey of existing systems, and to automate the process, we need to resolve them. To overcome the issue which is mentioned in [8], [9], and [10] where the models are able to detect the objects and extract the number plates only from the images. So, we are using YOLO, which will detect moving objects, helmets, and number plates from the real-time video footage as well. Due to the low quality of the video, [2] [3] [6] reported a problem in the detection of the objects, so we are using the Laplacian filtration method to filter the video, reduce excess noise, and detect the objects with more accuracy.Again, the problem of high processing time mentioned in [10] and [12] will be minimized, as YOLO will scan the entire frame only once and detect the objects with more accuracy. As we are using Transfer learning technique, model will quickly detect the required objects like Bike, Helmet and Number plate. We are using Pytesseract for easy implementation of the OCR with Python code, which will extract the license plate quickly and efficiently.

4. METHODOLOGY

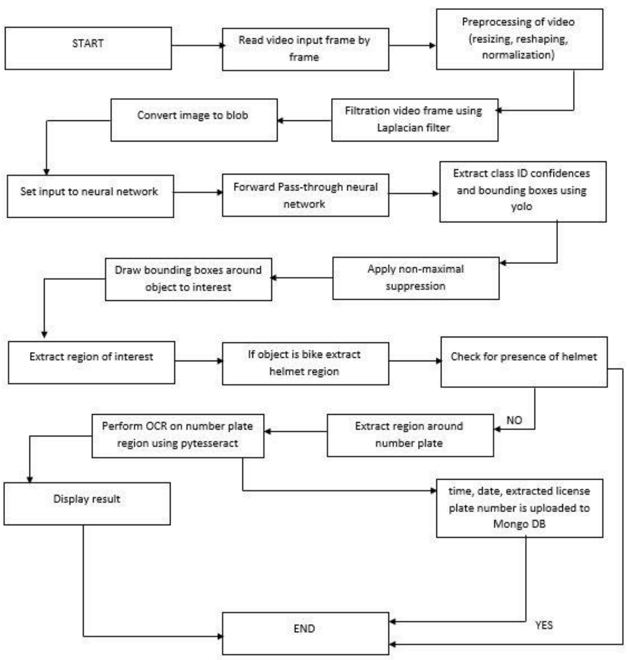

Fig-1 Data Flow Diagram

1. **PRE-PROCESSING:**

This step consists of following sub-steps: -

- Import Libraries:
  The necessary libraries for this project are imported at the beginning of the code. These libraries include OpenCV, numpy, os, imutils, pytesseract, and keras,etc
- Load the Model:
  Two pre-trained models are loaded in this code. The first is a YOLOv3 object detection model used to detect motorcycles, helmets, and number plates. The second is a convolutional neural network (CNN) used to determine whether or not a person is wearing a helmet.
- Video Capture:
  A video file is captured using the OpenCV function cv2.VideoCapture(). The video file is read frame by frame and processed.
- Filtration of each video frame-
  Contrast enhancement, Canny edge detection and Laplacian filter are used in our system to improve the quality of video so as to increase the accuracy.

I. Contrast enhancement-

Increase the contrast of the image to enhance the edges and make the objects more prominent. It uses the cv2.equalizeHist function to apply a contrast enhancement filter to the image. The code snippet you provided performs contrast enhancement on a given video frame using the cv2.convertScaleAbs() function.

II.Canny edge detection:

Canny edge detection is an image processing technique used to detect edges in an image. It is widely used due to its accuracy and effectiveness. The algorithm works by identifying the changes in intensity (or colour) between adjacent pixels in an image, and then highlighting the areas of the image where these changes occur.
This operation is performed using the cv2.Canny() function, which applies the Canny edge detection algorithm on the input frame to detect edges. It takes three arguments.

II.Laplacian filter:

The Laplacian filter is a type of edge detector used in image processing and computer vision. The filter is applied to the image to enhance edges and features by highlighting the areas of rapid intensity changes. The Laplacian filter can be applied to an image using convolution. In image processing, convolution is a process where a kernel (or filter) is passed over an image and each pixel are replaced by a weighted sum of its neighbours. The Laplacian filter kernel is usually a 3x3 matrix

The Laplacian filter is a popular edge detection technique and is used in various applications such as object detection, image segmentation, and feature extraction.

This operation is performed using the cv2.Laplacian() function, which applies the Laplacian filter on the input frame to detect edges. It takes two arguments.

2. **DETECTION**: - This step consists of following sub-steps: - In the detection stage, we first resize the input image to a height of 500 using the imutils.resize() method. Next, we convert the image into a blob, which is an optimized format for object detection using deep neural networks. We then feed the blob into the YOLOv3 custom object detection model and forward the data through the network to obtain the output. We extract the bounding boxes, class IDs, and confidence scores of the detected objects and perform Non-maximum Suppression (NMS) to eliminate overlapping boxes and retain only the most confident detections.

The YOLOv3 model is used to detect motorcycles, helmets, and number plates in each frame of the video. The model uses deep neural networks to detect objects in real-time. The model is pre-trained on a large dataset of images and can recognize objects with high accuracy.

Non-Maximum Suppression:

The output of the YOLOv3 model is a list of bounding boxes and corresponding confidence scores for each detected object. To eliminate overlapping bounding boxes and keep only the most confident detection, the Non-Maximum Suppression (NMS) algorithm is used.

Helmet Detection:

If a motorcycle is detected, the system extracts the region of interest (ROI) where the rider's head would be located. This ROI is passed through the pre-trained CNN model to determine whether or not the rider is wearing a helmet. The CNN model is trained on a dataset of helmet and non-helmet images and can classify the ROI with high accuracy.

Once it is known that rider is not wearing the helmet, the frame with all the information like ROI etc is then sent to the next function for the extraction of the number plate. Otherwise, the frame is discarded and system chooses new frame.

3. **EXTRACTION**: - This step consists of following sub-steps: -

- Number Plate Extraction:

  Once a number plate is detected, the system extracts the region of interest (ROI) where the number plate is located. This ROI is processed using OpenCV functions and then passed through the pytesseract library to extract the text from the image.

- Display Results:

  Finally, the system displays the results of the object detection and helmet detection on the video stream. Bounding boxes are drawn around the detected objects

- Save Output:

  The License Plate Number along with the current date and local time is sent to the cloud database in Mongo DB Atlas in real time where it is stored securely and only people with credentials can access the database.

  This information can then further be used for appropriate procedures.

5.CONCLUSION

In this the model has shown the potential to significantly enhance road safety by ensuring that riders are wearing helmets. The project has successfully identified and recognized the presence of helmets and number plates on motorcycles. The implementation of this technology can help reduce the number of accidents caused by riders which are common issues in many regions. Furthermore, the project can be integrated into existing traffic management systems, providing a cost-effective solution for enforcing traffic laws and regulations. Overall, the helmet and number plate detection project can greatly benefit society by improving road safety and reducing the number of traffic accidents. Further improvements in the technology can lead to wider adoption and implementation, making our roads safer for everyone.

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