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A Framework for Automatic Detection of Traffic Violations

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***Abstract*— Automatic detection of violations is a well-studied area of research. Detection of traffic regulations violations and recognition of the violating vehicles using automated techniques can efficiently replace the requirement of traffic police with virtual traffic police. Detection of violations includes detecting motorcyclists without helmets and triple riding. Also, the automated number plate recognition system plays a crucial role in identifying defaulters and simplifying traffic jams. This paper proposes automated techniques for the detection and classification of vehicles violating traffic rules and also for tracking stolen vehicles or uncertified vehicles.**

Keywords – Traffic violations, Vehicle number plate detection, Machine Learning

I. Introduction

The growing number of cars in cities might result in heavy traffic, which suggests that traffic offenses are becoming more serious in India and elsewhere in the world today. Due to the significant property damage and subsequent mishaps, people's lives are put in danger[1]. To address this challenging problem automated Traffic Infraction systems are required. A real-time traffic infraction detection system is necessary since it has to be done in real time and must be able to replace the law enforcement officers who constantly monitor for some violations. Because the traffic monitoring system finds transgressions more rapidly, traffic enforcers will have no issue enforcing safe roadways precisely and effectively.

A steady rise in the overall number of traffic offenses on the roads was typically caused by the daily growth in the number of vehicles. The traffic violations largely include incidents like speeding, Jumping the red signals, not following the rules of lane driving, driving without helmets or seat belts, etc. The traffic police must constantly be on watch for such incidents and must keep track of the vehicles that are disobeying the law [1]. All modern cities have already put in place a network of video surveillance to track such offenses. Utilizing this type of pre-existing security system is a financially wise choice, but as it relies heavily on human performance, it is not an effective long-term solution. Recent research has revealed that the amount of mistakes drivers make and the time taken to watch surveillance videos and identify the offenders both decrease the effectiveness of the system. Variations in the signboard formats, also have made the task very challenging. This paper identifies some of the challenges and proposes an automated system for efficient traffic infractions. The rest of the paper is organized as follows. Section 2 reviews a few recent developments done in this field which is followed by the major features of the proposed system in section 3. Experimental evaluation along with the results and discussions are provided in section 4 and section 5 concludes the paper.

II. Related Work

Several automated traffic infraction systems are proposed in the literature and this section reviews a few recent works done in this field. Authors in [2] propose a video-based traffic violation detection system implemented using OpenCV. Using the features of wavelet transforms and dynamic background updates their system is able to do efficient detection of various traffic violations. In [3] authors propose a system to assist the traffic police officers to detect a transit infraction and capture complete information about the infraction like the photo, vehicle number plate, date and time etc. System uses Tesseract, an Optical Character Recognition (OCR) library to recognize the characters of plate numbers. For detecting if the motorcyclist is wearing a helmet, 'imfindcircles' module in MATLAB is used. It uses Hough circular transformation to detect circles in the analysed images and the technique could achieve 85.5% accuracy in the detection. Authors in [4] propose a method for identifying motorcycle defaulters who triple ride and do not wear helmets. They use a method based on object segmentation and backdrop subtraction to identify the violators. The violations are later classified into different categories using an object classifier. In [5] an automatic traffic violation detection system is proposed on Deep learning. The system focuses on automatic detection of number plates of traffic rules violating vehicles. They could achieve an accuracy rate of 98.8% for speed violation detection and 99.3% for license plate number identification. In [6] an AI based traffic offence and booking system is proposed which detects and recognises the traffic defaulters and issue penalty against them. Though there are several methods for detecting and classifying the defaulting vehicles it is a very challenging problem as there are several factors which results in reducing the accuracy of the system. Identifying the vehicle using the number plate recognition or identifying whether the driver is wearing a helmet in case of two wheelers is really challenging because of the visibility issues of the number plates and difficult in identifying the Region of Interest (ROI). In this paper we focus of accurate identification of ROI so that the automated system can improve on its accuracy on identifying the vehicles.

III. PROPOSED METHODOLOGY

In our paper, we propose a traffic violation tracking system based on Darknet-53 features proposed in [7]. The model has two main phases, vehicle detection being the first. Vehicle detection is considered as an object detection issue and using the high-level Darknet-53 features moving vehicle objects are identified from the road. Once the vehicles are identified a review of the infraction circumstances are performed. The proposed system consists of the following modules:

- Vehicle detection module.
- A graphical user interface (GUI).
- Speed detection.
- In and Out Traffic of City.

In the first step the system receives the video footages from the surveillance cameras and monitors the movements on the roads and scans for any incidents of traffic rule violation. The user can interact with the system through an efficient GUI . The violation is identified using the vehicle bounding box of the system. When a violation is identified the system provides a warning and allows the user to analyse the situation and take the necessary action. The user can also monitor the speed of a moving car and take appropriate action to warn and control the vehicle to reduce the speed. One feature that is primarily used for traffic control in the city is in and out traffic. This function allows users to control the city's general traffic and take further actions as necessary. The workflow of the system is shown in Figure 1 and the different steps involved in our system is discussed below.

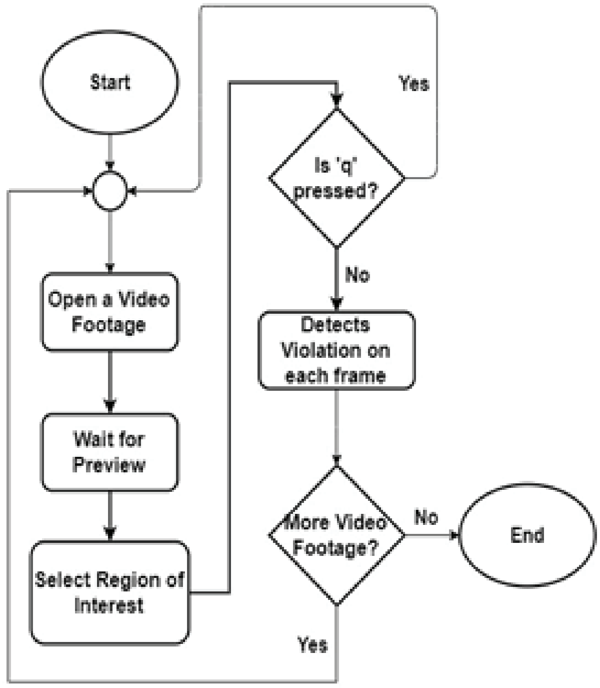

Fig. 1. Workflow of the system

A. *Vehicle Detection*

The first step in any traffic infraction system is to identify the vehicles that are defaulters of the law. In our model we have used the YOLOv3 model [8][9] for identifying the vehicles that are violating the traffic rules. Once the vehicles are identified the violation instance is carefully investigated.

Vehicle detection is done as follows: The traffic lanes are initially created across the road aligned to the user's preview and the lanes will be color coded with red color. If a vehicle crosses the center line when the light is red, it is tagged as a defaulter for violating the traffic law. A bounding box will be surrounding all identified vehicles and by default the box will be color coded green. The vehicles are detected first and is marked by a green bounding box. Whenever a bounded vehicle causes any kind of violation the bounding box turns red indicating a traffic rule violation.

B. *Vehicle Classification*

The object detection model *YOLOv3* is used for the detection of the vehicles. For classification of the objects the Darknet-53 architecture is used. It extracts CNN based features from the input image. Darknet-53 architecture model is shown in Table 1.

C. *Features*

1) *Bound Box prediction :*

Since it is a single network, it is necessary to calculate the loss for objectivity and classification separately from one another using the same network [10]. It uses logistic regression to predict the objectiveness score, where '1' denotes a bounding box prior that completely overlaps the ground truth object. For each ground truth item, it will only forecast bonding box prior, and any error here will result in both classification and detection loss. Other bounding box priors with objectiveness scores higher than cutoff but lower than the optimal one would also exist as shown in Figure 2.

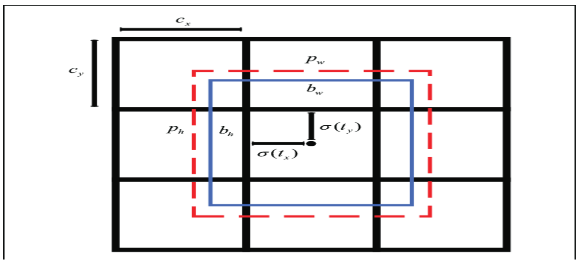

Fig. 2. Bound Box Prediction

2) *Class prediction :*

Instead of a typical softmax layer, it uses independent logistic classifiers for each class. The purpose of this is to create a multi-label classification. With the use of multilabel categorization, each box forecasts the classes that the bounding box might include [11].

3) *Prediction across tables:*

Using a strategy like feature pyramid networks, features are taken from each scale. Using the aforementioned approach, it becomes more adept at making predictions at various scales. The dimension clusters used to construct the bounding box priors are separated into three scales, each of which has three bounding box priors, for a total of nine bounding box priors.

4) Feature Extractor:

The new Darknet-53 [2] network is used by YOLOv3. Darknet-53 is deeper than YOLOv2 and features 53 convolutional layers in addition to residuals or shortcut connections. It is more effective than ResNet-101 or ResNet-152 and more potent than Darknet-19.

IV. EXPERIMENTAL EVALUATION

In this work, image processing is done using the open-source computer vision and machine learning software package known as OpenCV. The car classifier with darknet-53 is implemented using TensorFlow. All the options required by the software are available on the graphical user interface [12]. The initial interface view is shown in Figure 3. The program is used for administration and other types of debugging. We don't need to alter any management-related code. For instance, with the Open item, we may access any video as shown in Figure 4.

TABLE I. DARKNET-53

	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			

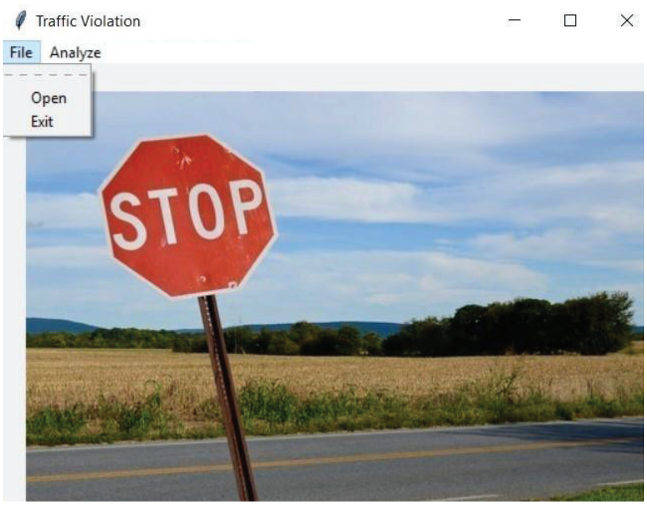

Fig. 3. Initial user interface view

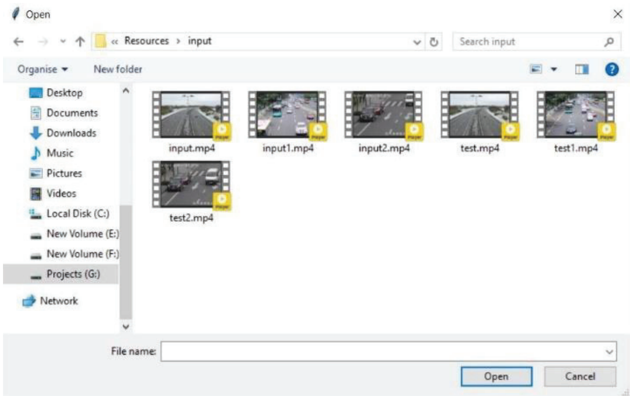

Fig. 4. Opening a video footage from storage

The administrator must first open a video clip using the 'Open' item under 'File' as shown in Figure 3 in order to begin using the project. The administrator is able to access any video content stored in the files as shown in Figure 4.

The system will obtain a preview of the video after opening it from storage. A frame from the video clip provided is included in the preview. Roads are identified and a traffic line is drawn over them using the preview. The administrator's designed traffic line will serve as a traffic signal line. The 'Region of interest' item under the 'Analyze' option as shown in Figure 5, must be selected in order to activate the line drawing capability. The administrator will next need to choose two places from which to construct a line defining the traffic signal.

Fig. 5. Region of interest (drawing signal line)

The violation detection system will begin after you choose the area of interest. On the console, the line's coordinates will be displayed as shown in Figure 6. The moment the line is drawn, the violation detecting system will activate. The weights will initially be loaded. The system will then look for violations after detecting items. The output from the GUI will be displayed frame by frame.

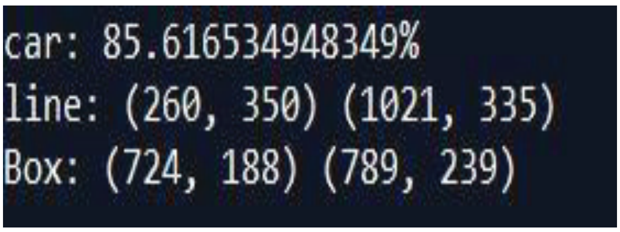

Fig. 6. Line coordinates (from Console)

Up to the very last frame of the video, the system will display output. 'output.mp4' will be generated in the background as shown in Figure 7. The file will be located in the Resources' "output" folder. By pressing "q," the process will be ended right away.

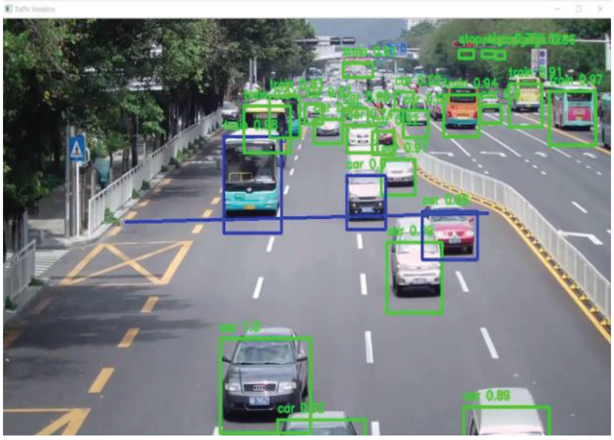

Fig. 7. Final Output (on each frame)

The administrator can add more video footage from the original file manager after processing one video footage. When all work is finished, the administrator can exit by selecting the 'Exit' option from the File menu (Figure 1).

The system offers numerous data regarding the quantity of cars and vehicle speed. Speed is one of the major factors in traffic collisions. You can utilize video frames to compare the speed between two points [13] in order to establish whether or not the car is moving.

On the Screen there will be two options i.e., the speed of the car and the In and Out traffic of the city as shown in Figure 8. This is done by using car counting [14][15] using OpenCV.

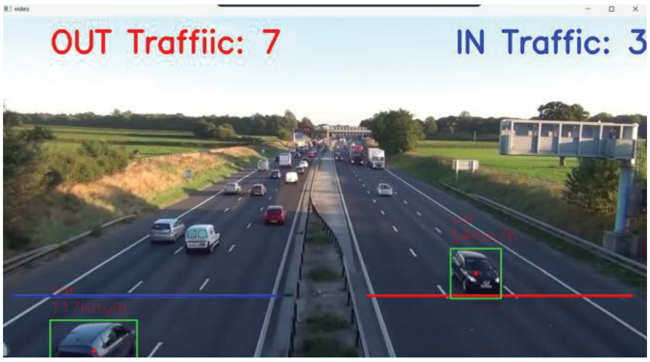

Fig. 8. In and Out Traffic and speed of vehicles.

You don't need anything more to figure out the speed if you know the distance [16][17], framerate, and total amount of frames the car occupies in the scene.

You must generate an ID for each car you find, and you must increase a counter each time that ID appears in the scene. This implies that in order to continue counting, you must match every car detection between frames.

Consider a scene where the road is 200 meters long, the car moves from beginning to end in 120 frames, and the frame rate is 30 frames per second. The duration of the car in the video was 120/30, or 4 seconds. A 200-meter distance was covered in 4 seconds by the automobile [18][19]. That indicates a speed of 50 m/s, which you may translate to 180 km/h.

Major contributions of the work are:

- Helps Traffic police

  The traffic police may benefit from a vehicle detection and counting system because everything can be tracked from a single location, including how many vehicles have passed this toll and whose vehicle.

- Maintaining Records

  Some people find it difficult to capture all the automobiles in their vicinity because they are passing by in real time. In order to get around this restriction, this application can be very well-versed to achieve the time-saving quality and be automated. It's not like one is viewing the video and they can pause it and take a note of it.

- Traffic surveillance record

  Since this application can be installed anywhere and only needs a camera or a few wires (to establish connectivity with the central system), if traffic is heavy somewhere, an officer can keep an eye on it there and send the information to the next toll officer so that they can be ready when it happens.

V. Conclusion

The developed algorithm successfully identified the project-specified type of infringement, which is disobeying traffic signals. The indicated traffic infraction has a varied threshold condition, which makes the convergence of detection different. The system offers traffic signal infraction detection. The system can also process one piece of data at a time. A computer with a high-speed processor or GPU can speed up the program runtime, which is also a bit slow. Future investigation on the use of the created algorithm for additional sophisticated image processing methods. As a result, by skipping over other needless actions carried out by a background difference technique, this may enhance the program runtime of the system. Instead, a computer vision algorithm might be implemented to give the system greater intelligence. In order to strengthen this system, we intend to incorporate number plate detection with OCR assistance in the future.

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