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Detection of Traffic Rule Violations Using Machine Learning: An Analytical Review

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ABSTRACT

This research paper focuses on current and previous efforts to detect traffic rule violations. So far, some remarkable works have been discovered, and many approaches for detecting traffic rule violations have been introduced from the current situation. Hence, machine learning has been the main target to detect traffic rule violations. A summary of the frameworks and methods that have been used to solve this problem so far is also provided in this study. This study has been divided into two parts. In the first part, the recent works on traffic rule violations have been portrayed. Moreover, the algorithms and frameworks that have been used so far and major works on violation detection using machine learning can be found in this section. In the second part, this study summarizes a brief discussion based on the image quality, camera resolution, device performance, and accuracy level of the works, as well as the algorithms and frameworks that have been used to conduct the detection of traffic rule violation problems using machine learning.

1. INTRODUCTION

Everyone nowadays wants to make things easier. This is the era of digitalization. The modern world is all about technology. And it is true that every technology has a good side and a bad side. Nowadays, there are a lot of vehicles running on the roads. It is a necessary thing for everyone to move from one place to another. It saves time and energy, too. But managing these things is a bigger challenge now. There are lots of traffic rules established worldwide. According to a news report, there are 107 traffic police boxes with hundreds of traffic police officers always working to manage the traffic control system in Dhaka, the capital of Bangladesh [1]. But after all this, according to another report, an average of 17 people die every day in Bangladesh due to road accidents [2]. The main reason for all of these is violating the traffic rules. Most of the people are not aware of traffic rules. And those who are aware also break the rules willingly by hiding. So, there is a considerable safety issue for others.

To resolve this problem, computer science could help maintain traffic rules. An automated system can prevent this issue. To build a system that can work like a traffic police, that can manage the whole traffic violation system, that can detect traffic rule violations, and that can penalize people according to how they break the traffic rules, it is necessary to make an automated decision-making system.

2. BACKGROUND STUDY

Today, traffic infractions are a major issue. Nowadays, both people's safety and the safety of vehicles are top concerns. The majority of traffic accidents are caused by people's ignorance. According to a report, there were approximately 1.45 billion vehicles on the road in the previous year [3]. The number of registered vehicles was approximately 450 thousand in Bangladesh [4]. However, the majority of its drivers were inexperienced. The vast majority of local bus drivers in Bangladesh are also underage. They were unaware of the road policies, which resulted in accidents and deaths. In 2021, there were 5629 road accidents in Bangladesh, leading to 7809 fatalities and 9039 injuries, according to the Bangladesh Passengers' Welfare Association [5]. To reduce this problem,

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traffic police are always trying to manage the traffic system. However, as the world becomes more automated, this manual check cannot always take action against violations. Nowadays, machines are everywhere. So, using an automated system for controlling traffic situations can be a huge chance to reduce traffic violations. It will be a revolutionary idea to save people's lives, to ensure their safe travel, and to ensure their security. So, this research will introduce an automatic system that can detect traffic offenses in real time, prosecute the offender, let them know, and also alert the local police station with pertinent information.

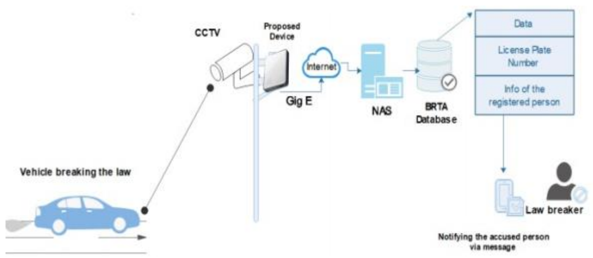
3. Review Based on Methods

3.1 Detecting Vehicles

The inventors of the paper [6] introduced a new technology called Autoscope for detecting vehicles. Autoscope is used to detect vehicles by comparing frames by frames. This system compares each pixel with a pre-defined threshold, detects the presence of any obstacles, and comes to a decision. I. Pavlidis et al. have suggested a novel system for detecting vehicles using infrared imaging signals. [7] The authors used a fuzzy neural network (FNN) classifier to manage this system. The system detects infrared imaging signals nearby and detects vehicle presence. After processing the image, they used a neural network to count the vehicle numbers. Again, the authors of [8] presented an intelligent monitoring system used for the management of road vehicles based on the Intelligent Visual Internet of Things (IVIoT). This method is an image haze removal method that deals with hazy weather conditions. The intelligent visual sensors of the IVIoT have the ability to extract the visual labels of vehicles on urban roads. In this case, the authors have processed hundreds of haze images and compared the algorithm with other algorithms.

3.2 Lane Detections

There can be seen some remarkable works in Lane Detection. M. Fuad et al. have recently attempted to solve the Lane Based Rule Violation Detection problem. [9] To elaborate on the findings, they have used the Raspberry Pi 4. They wanted to develop a prototype device as well to show the result. They have used high-resolution cameras, embedded processors, GPS, network adapters, etc. to elaborate on the



result.

Fig. 1. Working Flow of Traffic Violation Detection [9]

The authors of the paper [10] build a system that can detect traffic rule violations, to be specific, the detection of the lane for a road. They also implemented a message system that is linked to a central data system and aids in identifying and notifying the person who violates the rule. By using the Raspberry Pi 3 Model B with a camera, they were capturing real-time data from various traffic points. H. Aly et al. has introduced a new system named Lane Quest. [11] This system collects a car's current location from the user's mobile sensors, and it senses the surroundings of that car. It can sense a car's angular velocity as well. It basically uses the user's mobile sensors to detect car lanes and sense the surrounding cars. Detection of lane and street type classification is being a popular field of research nowadays [12]. For this, they have used a range of images generated by a laser mounted at the front of a car. The dynamic object modeling framework is used in this case. The laser range finder over the cars helps to detect the object in a lane. J. Sparbert et al. have researched lane detection systems from the perspective of a self-driving car [13]. A similar paper has introduced some algorithms for this kind of situation for the toll road of a particular place. To take the images, an action camera needs to be mounted over the cars. While solving the problem, they found that they needed to read the objects according to daylight, as constant parameters can only be used in the same lighting. Z. Fang et al. have introduced the methods of preprocessing and ROI (Regions of Interest) selection. [14] They performed edge detection twice to improve the lane detection rate. In addition, the concept of lane detection based on structural analysis and CNNs (Convolutional Neural Networks) can be found in the study [15]. The authors of this paper propose an algorithm based on these two methods. In the pre-processing stage, they extracted the pavement. After that, they used the waveforms from the images to analyze if it was considered under the road marking or not. The study [16], has presented a new system for detecting road lanes. They have used various classifiers for processing images. After detecting lane markings, this system can create a group of lane boundaries. Finally, this system will automatically detect if any vehicle violates the lane base rules.

3.3 Speed Detections

K. Sridharamurthy et al. proposed a traffic violation detection system for vehicular ad hoc networks to detect vehicles crossing speed limits. [17] To analyze the behavior of vehicles, they used V2I communication and divided the network into clusters, each having an infrastructure node. A control center gets data on all infrastructure. Whenever a violation occurs, the infrastructure node sends an alert to the control center. The authors of the paper [18] proposed a method for vehicle speed detection using motion-blurred images. The process is based on the concept of a pinhole camera. The car's speed is calculated from a single moving image, which was extracted using an image deblurring program. The Sum Modified Laplacian (SML) focus measure is computed to determine the most focused image in this study. Detection of vehicle speed can be measured by comparing the frame by frame of the camera, using some algorithms. [19]

In this system, a camera was used to take real-time data. The authors also used Cor2Duo computers and MATLAB software to build this system. In a study, the authors have proposed a speed measurement method to estimate vehicle speeds. [20] The proposed method measures the speed from the previous step and determines whether the playback speed of the video is altered. The authors used dashcam videos recorded in various road environments and analysed them by comparing them to ground-level youth. The authors determined the real playback speed using optical character recognition (OCR). Using R-CNN network architecture for the recognition of vehicles from any image or video, the authors of the paper [21] introduced a new prototype application to detect and calculate vehicle speed. They used the Google Collab platform to train the neural network. They also used Simple Online and Real-time Tracking (SORT) as a video tracking algorithm that helps detect objects from recorded video.

According to the study of D.C. Luvizon et al. introduced a video-based system for vehicle speed measurement. [22] The system uses an optimized motion detector and a novel text detector. For license plate detection, the authors used the T-HOG text descriptor, which is a texture classifier specialized for capturing the gradient distribution characteristic of occidental-like scripts. An analytical model for measuring moving vehicle speed has been presented in the paper [23]. To estimate the density function of a vehicle's speed, they used the sampling rate of the camera and intrusion lines. This model is verified by comparing its PDF with the simulation result of vehicle movement. In addition, the author proposed this model for video-based vehicle speed measurement. First, a simulation model is initialized with the camera sampling time and distance of the instruction line. Then vehicle speed is measured using analytical and simulation models. The output of the analytical and simulation models was identical.

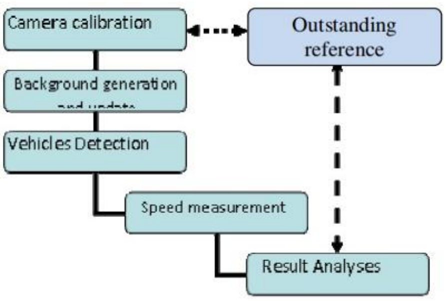


Fig. 2. System architecture of speed violation detection [19]

3.4 Blocking Pedestrian Lane

The study [24] presented an algorithm to detect traffic violations. With the help of this algorithm, they can detect the blockage of a pedestrian lane. The authors used an image and subtracted it from a reference image, then applied a genetic algorithm to that subtracted image. They also used a fitness function to analyse the white and black dots of an image. The authors of that paper used a CCTV camera to take the images. Many works in the field of traffic violations, particularly detecting the pedestrian lane, can be seen. The authors of that work [25] introduced a system that is able to detect traffic violations at pedestrian crossings. To detect pedestrian crossings, the authors also used a segmentation method depending on user marks. To detect objects like humans and vehicles, neural network algorithms have been used in this study. Moreover, to identify traffic violations, the authors propose a new method that works by tracking vehicle speed and detecting collisions between pedestrians and vehicles.

3.5 License Plate Detection

By detecting the license plates, the people who are violating the traffic rules can be caught and brought under the law. The authors of the paper [26] proposed a new method called ALPR, which stands for Automatic License Plate Recognition. ALPR is used to track traffic violations in enclosed spaces like institutions. They used the thinning function, the Optical Character Recognition (OCR) module as a character segmentation, and the Erosion function to analyze the image of the number plate. They used a camera to take pictures of the vehicle's number plate and apply some algorithm to detect the vehicle's author from the pre-stored database. In a study, the authors have introduced a new algorithm for license plate recognition of vehicles. [27] The authors developed a new binary method for image processing and character recognition with the help of some algorithms. In this paper, they claimed that a binary method with a global threshold couldn't produce a satisfactory result. To solve this issue, they combined Bernsen and Otsu. They also used a character database to compare and detect four types of different language characters. Though, because of some camera resolution issues, they have underrated their system.

Besides this specific traffic violation problem, some papers have talked about the violations regarding the signal of a road, the auto police system, and tracking driver activity to ensure the reduction of traffic rule violations. The authors of the paper [28] introduced a new system that is able to detect traffic signal violations by using AI and deep learning. The authors used the YOLO V3 algorithm to detect objects. This system can only detect speed violations and count the number of vehicles in a certain area. As a sample dataset, they used an MSCOCO datasheet. In a study, the author proposed an automatic policing (AUTOPOLIS) system to guide the detection of traffic violations. [29] In this system, continuous monitoring of vehicles must be ensured. Since it relies on computer simulation, the AUTOPOLIC system is simple. In this system, a camera detector arrangement is used, vehicles have electronic tags, and a central computer is assigned for local processing using a sensor. The primary data structure of this system is the identification of the vehicle, speed, lane position, warnings, and violations. The system records it when a car fails to pass a road within a predetermined amount of time, and the accident procedure then begins.

S. Roy et al. in his study has proposed a novel decision-support system called a Fog-based intelligent decision support system (DSS) for reducing traffic violations. [30] This model detected rule violations based on the Internet Of Things (IoT). They used Global Camera Sensor (GCS) in order to detect vehicle numbers, and they also used a Local Camera Sensor (LCS) to track the activities of drivers. By analysing the data that came from GCS and LCS this model can take decisions about the violations of traffic rules and send warnings to the driver according to the violations. A new framework-based model to build an Advanced Driver Assistant System (ADAS) has proposed by the authors of the paper [31]. ADAS was able to detect traffic violations and store the data in a local database system. The authors also introduced a visual model based on real-time scenes. A module called Traffic Sign Detection and Recognition (TSDR) is used here to alert users in dangerous situations. Another module named Traffic Violations Recorder (TVR) was used here to detect several traffic violations by processing images. An embedded system that was built using a Mini-ITX board with some external and internal devices has been used in this case.

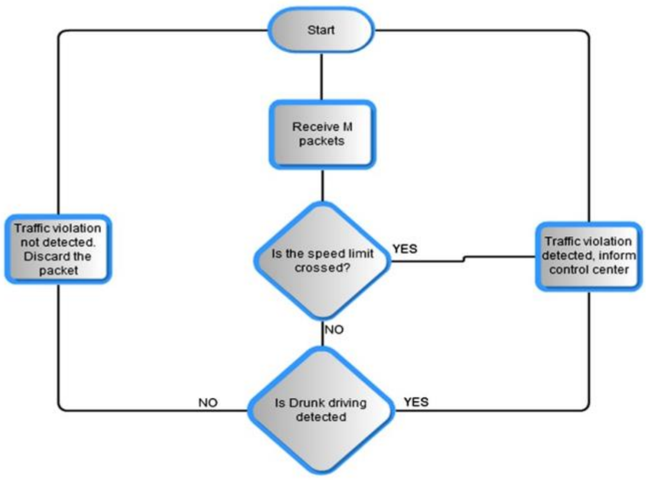


Fig. 3. Flow Chart for detecting vehicle speed violation [17]

Table 1. Summary of different problem's solution, to solve traffic rule violations problem.

Paper	Vehicle	License plate	Lane	Speed	Pedestrian lane
[6]	✓			✓	
[7]	✓				
[8]	✓				
[9]			✓		
[10]		✓	✓		
[11]			✓		
[12]			✓		
[13]			✓		
[14]			✓		
[15]			✓		
[16]			✓		
[17]				✓	
[18]				✓	
[19]				✓	
[20]				✓	
[21]				✓	
[22]				✓	
[23]				✓	
[24]					✓
[25]					✓
[26]		✓			
[27]		✓			
[29]			✓	✓	
[31]				✓	

4. Review Based on Algorithm

4.1 Hough Line Transform

Hough Line Transformation is a method for detecting any shape and uses a polar coordinate system to detect lines from an image. According to the study in [9], the Hough Line Transform algorithm is used for straight-line detection. To gather proof of lines, the Hough line transformation produces a 2D array called an accumulator. In order to find traffic lane violations from recorded videos, F. A. Arnob et al. have used the Hough Line Transformation technique in their study. [10] This method takes a snapshot at that precise moment and transmits it to another system if it is unable to recognize a straight line. In another study [13], the authors apply the Hough Transform for lane identification. The Hough Line is a line extraction technique used in image analysis. For analysing intelligent autonomous vehicles, the authors of [14] applied the Hough Transform method. The Hough Transform extracts the lane profile and performs a clustering algorithm to find the lane line. Hough transform is utilized by many related algorithms to find straight lines in images. In the Hough Transform algorithm, straight lines are found from statistical likelihood by analysing a pick point in Hough space. A lane detection technique built on lane structure analysis is described by the authors in [15].

4.2 K -Nearest Neighbors Algorithm (KNN)

The K-nearest neighbors (KNN) algorithm is used for classification and does not depend on any assumption. The Lane Based Rule Violation Detection problem is resolved using the proposed methods in the paper [9]. The K-nearest neighbors (KNN) algorithm reads characters on a license plate and chooses a specific sample to produce the most precise label. The K-nearest neighbors (KNN) technique is employed in a particular way to identify the character match that is closest and longest with the characters on the plate. The K-nearest neighbors (KNN) approach was employed by F. A. Arnob et al. to identify license plates from moving automobiles using OpenCV functionalities. [10]

4.3 Convolutional Neural Network (CNN)

A subset of neural networks called convolutional neural networks (CNNs) are particularly helpful for processing input and producing well-behaved output [28]. This method uses a digital image as its input to find a certain object inside of a box. To remove non-lane region, Convolutional Neural Networks (CNN) and structural analysis-based lane recognition is utilized [15]. Small patches in an image as well as dashed line endings can both be recognized by the CNN algorithm.

4.4 Fuzzy Neural Network (FNN)

A novel system for detecting vehicles using infrared imaging signals is used by the creators of that paper [7]. The authors used a fuzzy neural network (FNN) classifier to manage this system. The system detects infrared imaging signals nearby and detects vehicle presence. After processing the image, they used a neural network to count the vehicle numbers.

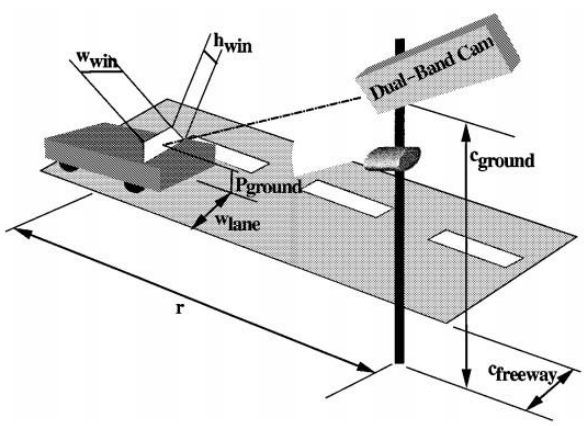


Fig. 4. Camera position for detect vehicle [7]

4.5 CANNY Edge Detection

The Canny Algorithm is used by the author of [9] to identify a variety of edges in photos. The 2D array of collected data called the accumulator has edges that are examined by the Canny edge detection algorithm. The Canny edge detection technique for self-driving cars is employed in [13]. This algorithm minimizes the amount of data while extracting structural information that is useful. The Canny edge operator is one of the commonly employed algorithms for visual analysis of smart cars [14]. By entering any image frame, the Canny Edge Operator generates an edge image that helps in lane line edge detection.

4.6 You Only Look Once (YOLO) Version3

The object detection algorithm known as YOLOv3 primarily uses video input to identify vehicles and detect traffic violations. By implementing YOLO v3 algorithm, R. J. Franklin et al. have detected traffic violations on roads. [28] This algorithm divides digital images into a number of grids that makes the object detection process easier. For automatic traffic violation detection, the neural network YOLOv3 is applied in the paper [25]. YOLOv3 algorithm is faster than other algorithms and the output has three layers that detect the object of different sizes.

4.7 Other Algorithms

The OCR algorithm recognizes playback speed and extracts time information from videos for measuring vehicle speed. The authors of [20] used OCR to extract temporal data from video input in order to determine vehicle speed.

Genetic Algorithm is a search algorithm that adapts its behavior from natural process of evaluation. By converting the image to grayscale, it can then detect the violation by analyzing the chromosomes of that image [24]. The authors also used a fitness function to analyze the white and black dots of an image.

Automatic License Plate Recognition (ALPR), also known as Automatic Number Plate Recognition (ANPR), is a technology that provides picture solutions and enhances them using various image processing methods. In a paper, ALPR is described as a tool for detecting traffic violations [26]. The ALPR technique is used in MATLAB to process the image of the vehicle's license plate that was taken.

In the paper [30], to reduce traffic violations, the authors have applied Fog-based intelligent decision support system (DSS). This algorithm monitors system for rule violation and makes better location awareness. Using the DSS algorithm the authors created a smart processing system over the WSN that can automatically control driver safety and support decision-making for the appropriate authority.

With the help of CVS algorithm, the vehicle speed detection is measured by authors of that paper [19] The authors used an algorithm called a Combination of Saturation and Value (CVS) to detect vehicle movement by comparing frames by frame. This algorithm then analyzes the data from real-time image and generates the speed result for that vehicle.

To estimate vehicle speeds, in [20] a speed measurement method VESM is applied. The proposed method measures the speed from the previous step and determines whether the playback speed of the video is altered. The authors adopted a statistical approach, Pearson’s correlation coefficient analysis, to verify the proposed vehicle speed estimation method (VSEM).

The shadow reduction technique known as the Gaussian Filter employs the gaussian function. To eliminate shadow and recognize the characters on a license plate, the Bernsen method with a Gaussian filter is utilized [27]. A technique for motion tracing from images that remove shadows and reduces noise is the use of a Gaussian filter. Gaussian filters are used to blur images and lessen noise in motion tracing on paper [14] for smart device analysis. Erosion is a method for enhancing any acquired photographs and condensing the image regions. It is used to blur the tiny bright spot in photos and remove irrelevant elements from image erosion by analyzing the image of the number plate [26]. To find any violations on the highways in real-time situations the author [31] employed the Traffic Sign Detection and Recognition subsystem. Here, the Traffic Sign Detection and Recognition (TSDR) system is employed to warn users of the risk. For the purpose of detecting vertical signs on the road, this system is operational both during the day and at night. For vehicle speed measurement the paper [22] proposed a video-based system KLT. The authors used the Kanade–Lucas–Tomasi (KLT) algorithm for license plate detection, the authors used the T-HOG text descriptor, which is a texture classifier specialized for capturing the gradient distribution characteristic of occidental-like scripts. SIFT is a technique for identifying, characterizing, and illuminating variance in images. In paper [22], the SIFT (Scale Invariant Feature Transform) approach is proposed. The primary use of this technique is image-based license plate recognition. An algorithm based on these two techniques was suggested by the authors of this publication [15]. In this instance, line markings are tracked using the Hough Transformation and Kalman Filter. The Kalman filter helps in the creation of a non-linear tracking model that tracks two side lane markings. In this paper [27], to solve this issue binary method with a global threshold they combined Bernsen and Otsu. The authors used a character database to compare and detect four types of different language characters. For illumination of obstacle and shadow images, Otsu is a traditional binary method. The Bernsen algorithm is used for license plate detection to get rid of complex backgrounds and different lighting conditions. For the removal of shadows and uneven lighting, the authors suggested the Bernsen algorithm [27]. The authors developed a new binary method for image processing and a character recognition algorithm (CRA) for detecting vehicle numbers [27]. In the paper [16], Artificial Neural Networks (ANN) is used to compare hidden nodes. In [21], to detect and calculate vehicle speed the authors of this paper employed R-CNN algorithm. The authors used the R-CNN network architecture for the recognition of vehicles from any image or video. The Intensity-bump detection algorithm is one of the commonly used lane detection approaches [16].

Table 2. Summary of different algorithms for detecting traffic rule violations.

Paper	Algorithm
[6]	Vehicle Detection Algorithm
[7]	FNN
[9]	KNN, Hough Line Transform, Canny
[10]	KNN, Hough Line Transform, Canny
[11]	LEA
[13]	Hough transform, canny
[14]	Gaussian filter, Hough, Canny
[15]	CNN, Kalman filter, Houge
[16]	ANN, NBC, intensity-bump detection algorithm
[19]	CVS
[20]	OCR, VSEM
[21]	R-CNN, SORT
[22]	KLT, T-HOG, SIFT
[23]	Horn–Schunck optical flow
[24]	GA
[25]	YOLO v3
[26]	OCR, ANPR, Erosion
[27]	Otsu, Bernsen, Gaussian filter, CRA
[28]	YOLO v3, CNN
[30]	DSS
[31]	TSDR

5. REVIEW BASED ON FRAMEWORK

To record the vehicle and its internal condition, N. Aliane et al. introduced the Test-Bed framework [31]. The whole system is an embedded system that was built with the help of a Mini-ITX board with a GPS unit and two types of supported memory. A memory is used to save the vehicle's internal information, and another can be used to store the captured images and videos. The Test-Bed framework with embossed hardware can also function properly in low-light conditions. This system can activate and detect near-infrared automatically in night vision, which can help detect objects nearby. To better interact with users, this system can also contain a graphical user interface. By detecting traffic signs, this framework can also identify traffic violations. A traffic violations recording unit was also introduced to set the policies for traffic violations.

H. Aly et al. employ a different unified probabilistic Markov framework to determine the vehicle's current lane [11]. This system was constructed using four modules and the framework. This framework initially handles the sensor and location data. Then, using driving patterns, this system can identify events like lane changes, U-turns, etc. The Markov Localization method was then applied to this system to increase accuracy. With the use of a digital map, this technology can also estimate the number of lanes on various roadways.

Another framework named KITTI was developed by Z. Fang et al. to address the lane detection issue by utilizing HSV color transformation [14]. Applying HSV color transformation, KITTI was able to detect the white feature and select the region of interest. In further steps, KITTI used some popular algorithms to reduce the noise of images, and then the image was obtained using a binary threshold. Finally, this system is able to detect the road lane in real time by using Hough transformation and Canny detection.

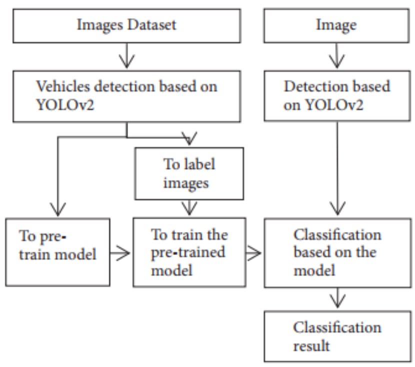


Fig.6. Proposed Working process in [14]

6. Review Based on Dataset

All the work in the field of traffic violation detection basically uses various kinds of datasets according to their requirements. Some of them used video, some of them used pictures, and so on. But the main motive of their dataset was to measure a different kind of characteristic to solve the traffic violation problem. Listed below are the datasets used by the authors in their works:

6.1 Process with Image

N. Aliane et al. have implemented an ADAS system that uses cameras with a 1322 x 1040 resolution and a 12 mm focal length to detect all traffic offenses [31]. In addition to this, they have employed two distinct types of cameras: daytime cameras and IR-supported nighttime cameras with IR support. A similar study can be found in [24], where A.C.P. Uy et al. have also used the CCTV camera to record images of the vehicles. The resolution of the camera is 480x850. They have converted the cropped image and optimized the pictures for 116x161 resolution. To track traffic violations in enclosed spaces like institutions, the authors of [26] have used a camera of their own to take a picture of the vehicle's license plate. The authors of [7] used both upper-band and lower-band cameras in their study. A near-IR camera with a depth length of 0.7-2.4 micrometers has been employed. In order to identify the number plate on the automobiles, Y. Wen et al. [27] utilized some low-resolution (640x480) cameras to take pictures of the vehicles. 52,000 objects were found in 750 photos that were utilized as training data in the research [21] to determine vehicle speed. Laser-range images are also being used in different cases, especially in detecting objects on the lane [12]. A 256x256 pixel low-resolution camera is used in the paper [14]. The authors of that paper used images for their further processing. The authors of the paper [15] also used a camera with a resolution of 400x500 pixels.

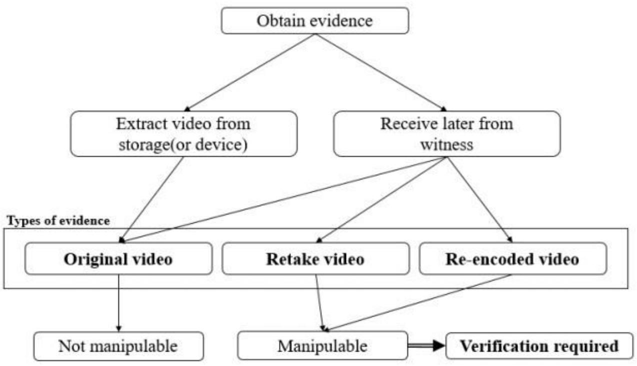


Fig. 5. Types of dataset processing [20]

6.2 Process with Video

In the approach of the paper [9], M. Fuad et al. have utilized high-resolution CCTV cameras, embedded processors, Wi-Fi networks, etc. They used the snapshots taken from the videos of the CCTV. In this project, the Raspberry Pi-4 was utilized. To produce a satisfactory result, the authors of the research [28] acquired footage from CCTV videos at a frame rate of 22–23 fps and used it with the Yolo V3 algorithm. P.G. Michalopoulos [6] used a camera to record videos at 30 frames per second in order to compare frames with frames. It has been recorded that the camera can capture 512-pixel pictures. In the paper [18], H.Y. Lin et al. processed the recorded images for determining vehicle speed using a video camera with 30 frames per second, a Pentium 1.6 GHz processor, and 512 MB of RAM. Global Camera Sensors (GCS) and Local Camera Sensors (LCS) are being used in various cases to detect vehicle number plates with the help of video cameras [30]. In the detection of humans and vehicles, the authors of [25] have used video cameras with high frame rates. They have also worked with pedestrian crossings with these cameras. Another video-based study [10] can be found where F.A. Arnob et al. attempt to use the Raspberry Pi 3 Model B and dual-band, high-resolution cameras to tackle the lane detecting violation problem. From the videos, images can be captured and used in the case of some naturally unstable moments, like hazy weather. By using the images from the videos and processing them appropriately in terms of managing road traffic, the authors of the research [8] have attempted to solve the issue. A similar paper [6] has tried to detect vehicle speed by comparing frames, and it can detect speeds up to 50 km/h with a 120-pixel camera video record capacity. [19] Similar properties are present in the study [20] once again, but in this instance, it can identify a speed of 80 km/h with a 24-fps video camera record. Some systems needed high-quality processing units and equipment. The researchers that wrote the paper [22] employed a Core i7 processor, 12 GB of Memory, and 20 video recordings to develop a novel video-based system. A video camera with a resolution of 1280x720 pixels that can record at a maximal speed of 10 km/h and is positioned on the top of the vehicles was utilized in another paper [13] to detect speed infractions. In the paper [16], Z. Kim used a video camera with 352 x 240 pixels. Another paper [23] used a high-resolution camera with 960 x 540 pixels to record the video. This camera has 50 frames per second of video quality.

Table 3. Summary of different camera/data quality for processing images/videos.

Paper	Pixels x Pixels	Image	Video	Frame per seconds
[6]	512 X 512		✓	
[7]		✓		
[8]		✓	✓	
[9]		✓	✓	
[10]			✓	
[12]		✓		
[13]	1280 X 720		✓	
[14]	256 X 256	✓		
[15]	400 X 150	✓		
[16]	352 X 240		✓	

[18]			✓	30
[19]	120 X 120		✓	
[20]			✓	24
[21]		✓		
[22]	1920 X 1080		✓	30.15
[23]	960 X 540		✓	50
[24]	480 X 850	✓		
[25]			✓	
[26]		✓		
[27]	640 X 480	✓		
[28]			✓	22-23
[30]			✓	
[31]	1392 X 1040	✓		

7. REVIEW BASED ON RESULT

7.1 Detecting Vehicles

A vehicle detection technique was employed by P. Agarwal et al. of the research [6] to identify the cars. They also have introduced a new technology called Autoscope to detect vehicles. The accuracy percentage for this study's conclusion is 97%. Another study on detecting vehicles using machine learning has used the FNN algorithm to detect the vehicles using infrared imaging signals on road [7]. The authors of the paper have reclaimed that for the threshold images, this study was 100% successful. Q. Li et al. [8] have tried to propose a method to detect vehicles on road. This study was based on the Intelligent Visual Internet of Things (IVIoT). For removing the hazy weather, they have used it as a haze removal method. In different weather conditions, it can give an accuracy rate between 82.21%-85.80%.

Table 4. Summary of different algorithms, frameworks, sensors, systems, applications for detecting vehicle.

Paper	Algorithm	Framework	Others	Accuracy
[6]	Vehicle Detection Algorithm		Autoscope, EDCLA	97%
[7]	FNN		HOV system	<50%
[8]			IVIoT	85.80%

7.2 Detecting Lane

M. Fuad et al. of the publication [9] have made an attempt to resolve the problem of lane detection. The authors have used Raspberry-pi 4, additionally, python has been used as a basic Framework. According to the study, this model is 27% faster than the previously existing models. Though it has ensured an accuracy rate of 80%. In the study of [10], F.A. Arnob et al. have used OpenCV functions to detect number plates from vehicles. They also proposed an algorithm to set the video dimension and format. Hence, this model has an accuracy rate of 78.83%. Lane detection is one of the major criteria for solving traffic rule violations. Many works have been done so far in this field. According to the paper [11], the authors have tried to make a new system LaneQuest, with the help of a novel probabilistic lane estimation algorithm (LEA), a unified probabilistic framework (UPF). Using the user's mobile sensors, it can be operated and have an accuracy rate of 89%-90%. M.V.G. Aziz et al. of the research have taken into consideration the enormously worrying problem of lane detection for the self-driving automobile [13]. As a programming language, Python 3 has been used in this case. While solving the problem they found that they need to read the objects according to daylight as constant parameters can be used only in the same lighting. Though it has an accuracy rate of above 90% in constant daylight. The ROI selection approach has been introduced by Z. Fang et al. of the study [14]. They've applied KITTI's framework. In this paper, two scenarios can be found. When CNNs is available without pre-training originally it has an accuracy rate of 86.89% and Sheared 91.42%. Again, when CNNs is available with pre-training originally it has an accuracy rate of 88.29% and Sheared 93.5%. In the study [15], lane detection based on structural analysis has been introduced by the authors. It has given the accuracy rate depending on the experiment venue and the accuracy rate was as follows: 99.35%, 98.09%, 98.12%, 98.37%, and the false for these areas was 1.26%, 5.17%, 1.52%, and 1.78% in different conditions. The study of the paper [16] also refers to the lane detection problem using machine learning. The authors have tried to present a new system to elaborate the problem of lane detection. Through this system, the accuracy rate is 50% with a misalignment of 11% and a misdirection of 37%.

Table 5. Summary of different algorithms, frameworks, sensors, systems, applications for detecting road lane.

Paper	Algorithm	Framework	Others	Accuracy
[9]	KNN, Hough Line Transform, Canny			80%
[10]	KNN, Hough Line Transform, Canny			78.83%
[11]	LEA	UPF		80%
[12]			Dynamic object modeling	Not yet tested

[13]	Hough transform, canny			>90%
[14]	Gaussian filter, Hough, Canny	KITTI		93.50%
[15]	CNN, Kalman filter, Houge			<99.35%
[16]	ANN, NBC, intensity-bump detection algorithm		SVM	52%

7.3 Detecting Speed

Detecting speed problems could be found in the paper [17], where K. Sridharamurthy et al. have proposed a system for vehicular ad hoc networks. But the cons of the study are that it was fully based on simulation and couldn't find any practical results from it. Again, in the detection of speed limit motion-blurred images are being used. [18] In this case, a single moving image has been used, and to determine the focused image, SML is computed. The findings from this study show that the accuracy rate of the suggested approach is 95%, which is quite encouraging. Vehicle speed can be determined by comparing frames by frames with an algorithm known as Combination of Saturation and Value (CVS) [19]. This algorithm can be efficient, as it can be seen that it has a 93% accuracy rate in order to detect the speed of a vehicle. According to the study [20], K.S. Shim et al. have given some ideas about how to measure the speed from the previous step and determine whether the playback speed of the video is altered. This is possible with dashcam videos. The proposed vehicle speed estimation method was validated by the authors using a statistical method called Pearson's correlation coefficient analysis (VSEM). The accuracy rate of the proposed method was 99.99%. A new prototype application to detect and calculate vehicle speed has been introduced by A. Grents et al. in the sector of speed detection in the paper [21]. They have achieved a 78% accuracy rate using the OpenCV libraries (Ghoneim 2020), the Google Collab platform, and the SORT video tracking method. A video-based system for vehicle speed measurement has been proposed by D.C. Luvizon et al. of the paper [22]. They achieved a 99.2% accuracy rate by combining the SIFT (Scale Invariant Feature Transform) method and the Kanade-Lucas-Tomasi (KLT) algorithm. They also mentioned that the processing time of the system is 49.8 sec/frame. In the study [23], an analytical model for measuring moving vehicle speed is presented by the authors. They measured the intrusion lines using camera footage and classified them as intrusion lines. The accuracy percentage for two intrusion line configurations was 98.08%, three intrusion line configurations were 98.72% accurate, and four intrusion line configurations were 98.3% accurate.

7.4 Detecting License Plate

In this area, a new method called ALPR is proposed by P. Agarwal et al. [26] to track traffic violations in enclosed spaces. Because of the geographical area problem, this system is lagging behind, even though it has a 93% accuracy rate according to the tested area. Using Otsu, Bernsen, Gaussian filter, and CRA algorithms Y. Wen et al. [27] tried to solve the number plate detection of the vehicle in different conditions. From the theory, it can be concluded that in segmentation and locating the number plate, the system can give up to 97.16% accuracy, and in different conditions, the number is 98.34%. The percentages for character recognition are 99.5%, 98.6%, and 97.8%. Even in complex situations, the study's total results can provide an accuracy rate of 93.54%.

Table 6. Summary of different algorithms, frameworks, sensors, systems, applications for detecting vehicle speed.

Paper	Algorithm	Framework	Others	Accuracy
[17]			Vehicular ad hoc network applications	100% (Tested by simulation)
[18]			SML, Pinhole camera model	95%
[19]	CVS			93%
[20]	OCR, VSEM			99.99%
[21]	R-CNN, SORT		Ghoneim 2020, Google Collab	78%
[22]	KLT, T-HOG, SIFT			99.2%
[23]	Horn–Schunck optical flow			98.08%

Table 7. Summary of different algorithms, frameworks, sensors, systems, applications for detecting license plate detection.

Paper	Algorithm	Framework	Others	Accuracy
[24]	GA			Not yet tested
[25]	YOLO v3		Segmentation method	Not yet tested
[26]	OCR, ANPR, Erosion			93%
[27]	Otsu, Bernsen, Gaussian filter, CRA		SVM	93.5%

Both speed detection and vehicle detection can be found in the study of the paper [28], where R.J. Franklin has used the YOLO V3 algorithm to detect objects and the CNN system for data processing. Moreover, in vehicle detection, this study can ensure an accuracy rate of 97.67%, whereas for speed detection, it drops down to 89.24%. A new model of ADAS was discovered by N. Aliane et al. [31] to detect traffic violations and, from there, store the data in a local database. As an existing algorithm, TSDR is used here. This experiment is best carried out during the day. However, it can provide an overall accuracy of 92%. To be accurate, in daytime and clear weather, the numbers for true positive, true negative, and false positive are, respectively, 89.2%, 9.2%, and 1.6%. During the day and in cloudy weather, the accuracy rates for true positive, true negative, and false positive are gradually 90.7%, 7.9%, and 1.4%, respectively, whereas at night, the accuracy rates are gradually 91.5%, 7.5%, and 1.0%.

Table 8. Summary of different algorithms, frameworks, sensors, systems, applications for detecting different type of traffic rule violations detection

Paper	Algorithm	Framework	Others	Accuracy
[28]	YOLO v3, CNN			89.24%
[29]			AUTOPOLIS system	Not yet tested
[30]	DSS		GCS, LCS	Not yet tested
[31]	TSDR	Test-bed		90.7%

8. Discussion

Traffic rule violation is an alarming news of recent days. In this paper, we may have a clear vision of the current and past works till now on the detection of traffic rule violations. Many algorithms and frameworks also have been introduced by many authors till now. Though it has been studied for more than 10 years there is still some lack in detecting the traffic rules violation. Here are some categories which should be taken under consideration:

- Lack of image processing: Till now, according to the research, many algorithms have been proposed for image processing. Some of them have tried out the pre-processing method to detect the lanes. But the lack of technical abilities leads the methods to be inaccurate way of solving the problem. Moreover, as the roads' structure is changing every day, the image processing needs to be very accurate to make the changes according to the road, which is not met by the date.

- High-performing computer: A massive dataset is measuring the roads, and as a result, there may be a gathered dataset to be processed. But it will be a little time-consuming if we use a normal computer processor. This processor will take a huge amount of time to process the images and make a decision. For this kind of image processing, we will need a high-performance system, aka a computer.

- High-resolution camera: From the following studies, it is clear that in some of the cases, we will need a camera that will directly take pictures or videos to make a road map decision. But all of them are CCTV surveillance cameras, which are basically low-resolution cameras, and as a result, sometimes they may give some unexpected errors or noises to the image processing.

- Unauthenticated data reliability: If we consider traffic lane detection, which is also a massive key point in traffic rule violations, we need to fully rely on the cameras. So, if the cameras are not meeting the desired angle, we will get the wrong data. So, the reliability of trustworthy data is being hampered here. Most importantly, because the cameras are the only solution in this situation, we cannot guarantee that the data we receive is completely accurate and reliable.

- Cost assumption: The huge obstacle is the cost of the equipment used in the system. Developing countries like Bangladesh, Sri Lanka, etc. are struggling with their daily lives. In these circumstances, the cost of the system and the equipment used in this method can be a huge burden. Moreover, as the surveillance cameras are not meeting all the needs, we need to establish some high-resolution cameras, which cost more than 1 lakh BDT. If we want to put them in all of Bangladesh's round squares, we estimate that we will need at least 100 crore BDT, which is a large sum.

9. Conclusion

According to an article, 7809 fatalities have been recorded in the year 2021 due to road accidents alone [5]. In the near future, this number is going to increase, and we can become victims of these horrible incidents. To minimize the predicament, we need to be aware and careful about using the system. With a view to reducing this calamity, many authors have introduced many algorithms and frameworks to make a safe AI-based system.

Some algorithms, such as KNN, Hough transformation, and Canny detection, provide a good accuracy rate in solving this kind of image processing-based road lane mapping system. Convolutional neural networks (CNNs) and YOLO v3 are also well-known algorithms in this case. Using CNNs along with the Kalman filter can give 99.35% accuracy in the detection of traffic rule violations. OCR and VSEM, on the other hand, can provide a system or method with a 99.99% accuracy rate, the highest rate so far according to this study.

In this whole study, we can find 3 major frameworks, which are Test-Bed, UPF, and KITTI. Using these frameworks can be helpful in detecting lane-based traffic violation problems, speed violation problems, etc.

After much deliberation, it has been determined that cost efficiency is a high priority when making decisions. We will propose a system with a low cost and a high-performing device to collect more precise data. For specific data to be extracted from video footage, it will be ensured that the camera resolution is high enough. Furthermore, a computer with sufficient processing power to process all traffic-related data and run algorithms in a short period of time must be provided. The quality of the images will be good enough to detect vehicles, license plates, and lanes.

So, in conclusion, we can say that road accidents cannot be removed from their roots. But the number of fatalities and injuries due to road accidents can be reduced by introducing some new systems using these algorithms and frameworks, so that the terrifying situation may be reduced.

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