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Advancing Road Safety: A Comprehensive Analysis of an Enhanced Traffic Violation Detection

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Abstract: In India and elsewhere, the gravity of traffic offenses has risen in recent years as rising urban automobile ownership has led to increased traffic congestion. As a result, there is widespread property damage and an increase in accidents, both of which pose a threat to human life. Yolov7-based traffic infraction detection technologies are required to address this urgent issue and avert the potentially catastrophic outcomes. This is why the system constantly monitors for violations of traffic laws and prosecutes offenders. Since police are always monitoring the highways, it is imperative that any system for detecting traffic violations be implemented instantly. Therefore, law enforcement officers will not only have an easier time enforcing safe roadways, but they will also be able to do it more quickly and effectively thanks to the traffic detection technology. In real time, this apparatus can identify infractions of traffic lights, speed limits, and helmet laws. User-provided video is required for system operation, monitoring of traffic, and enforcement of traffic regulations.

Keywords: *Traffic Congestion, Urban Automobile Ownership, YOLOv7, Speed Limit Enforcement.*

1. Introduction

Because of the excessive crowding, the growing number of commuters, the poor management of the traffic signals, and the rider mentality, traffic infraction monitoring and control is a big problem in India. It should come as no surprise that the use of physical traffic police surveillance alone is inadequate to monitor such massive traffic volumes while simultaneously tracking offenses. Because of this, many people who break the rules go unpunished. In turn, those who violate the law produce more severe accidents on the road, which puts not only their own lives but also the lives of others in risk. Therefore, it is necessary to use methods that are based on artificial intelligence (AI) in order to minimize the need for personal involvement in the process of detecting and apprehending lawbreakers.

In this paper, we propose a system that can automatically detect two-wheeler violations for Indian road scenarios, such as not wearing a helmet, using a phone while riding, triple riding, wheeling, and illegal parking, and eventually automating the ticketing process by capturing the violations and the corresponding vehicle number in a database. These violations include not wearing a helmet, using a phone while riding, wheeling, and illegal parking. We suggest utilizing a custom-trained version of Yolo-v7 in conjunction with DeepSORT to identify and monitor violations, and Yolov7 in conjunction with Tesseract to recognize and extract license plate information. On the test data, this implementation demonstrated an accuracy of 99.41% when it came to the recognition of number plates and a mean average precision (mAP) of 98.09% when it came to the detection of violations. In addition, the system was able to identify 77 out of 93 infractions in real-world circumstances while producing no false positives.

As a result, demonstrating that the system for traffic violations that was established may be used to automate the issuing of tickets for traffic violations. The proposed system will be especially helpful in generating a variety of policies connected to safety. It would also assist to enforce robust enforcement of traffic regulations and build towards a smart city ecosystem through the automated AI-based traffic violation utilizing Yolov7.

2. Related Works:

Within the context of a traffic monitoring system, this study tackles the crucial problem of identifying violations of traffic laws in real time. The writers most likely investigate a variety of methods and technology for spotting traffic offenses, which may have repercussions for both the safety of drivers on the road and the effectiveness of law enforcement. The fact that this work was given in a conference setting gives the impression that it was presented in a scientific environment, which is an indication of the potential relevance of this research in the subject of traffic monitoring and safety [1]. This research most likely provides a revolutionary method for identifying traffic offenses with technologies based on video. In srecent years, video-based systems have become more popular due to the

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promise they have for enhancing traffic safety as well as law enforcement. The contribution of this work to the topic of traffic management and surveillance may be measured by the amount of information it provides about the design, algorithms, and practical applications of the system [2]. The article most likely addresses a technique or system for identifying and monitoring motorbikes, with a particular emphasis on assessing whether riders are wearing helmets. The study may also focus on determining whether riders are wearing eye protection. This study is important because it is working to increase helmet usage compliance, which is a crucial component of motorcycle safety. The fact that the article was published in a prominent publication on transportation systems indicates that it may have the ability to improve road safety via the use of more modern technologies [3].

This study most likely discusses the important topic of recognizing motorcycle riders who are not wearing helmets in real-time by employing surveillance cameras. This is a problem that is becoming more important. The fact that it operates in real time raises the possibility that it may be used in practice to improve traffic control and law enforcement. The use of neural networks, as suggested by the location of the meeting, is an indication of a sophisticated strategy to addressing this issue [4]. This study most likely presents a method for identifying traffic offenses via technology based on video, suggesting a possible use for improving road safety and law enforcement. The location of the conference gives the impression that this article was presented in a multidisciplinary setting, which is appropriate given the wider implications that it has for a number of other subjects [5]. It is possible that the purpose of this project is to investigate the use of deep learning algorithms in order to detect riders of two-wheelers who participate in speeding and triple riding (riding with more than one passenger on a two-wheeler). The implementation of a more complex solution to these safety problems is indicated by the use of deep learning. This article may be published in a publication that focuses on multimedia, and it might talk about how visual analysis and data analysis might be combined to make roads safer [6].

This document most likely includes a detailed investigation comparing a variety of object identification and tracking methods with the aim of producing a vehicle count. The counting of vehicles is an essential component of both the administration and monitoring of traffic. The study might give new insights into the performance and applicability of various algorithms, adding to the development of transportation analytics in the process [7]. Utilizing artificial neural networks, this article most likely presents a novel method for the identification of automobile license plates. The use of artificial neural networks is an indication of a highly developed method for pattern recognition. The fact that the study was presented at an international conference gives credence to the relevance it has in the area of computer vision and image processing [8].

3. Existing System:

Due to overcrowding, rising commuting demands, ineffective traffic signal management, and a "rider mentality," India places a premium on the monitoring and control of traffic violations. It's evident that relying just on physical traffic police surveillance is inadequate to keep tabs on such massive amounts of traffic and their associated offenses. Because of this, many of those who break the law go undetected. In addition to putting themselves and others in risk, those who break the law also increase the severity of traffic accidents. Therefore, it is necessary to use AI-based solutions to eliminate the necessity for human involvement in the identification and apprehension of offenders. In this paper, we propose a system that can identify common violations associated with two-wheeled vehicles on Indian roads, such as the failure to wear a helmet, the use of a mobile phone while riding, the use of a third passenger, the use of a wheel, and the illegal parking of a vehicle, and then generate tickets for these offenses automatically. For violation detection and tracking, we recommend employing a Yolo-v4 + DeepSORT model, while for number plate identification and extraction, we suggest a Yolo-v4 + Tesseract model. On the test data, this implementation achieved an accuracy of 99.41% for license plate recognition and a mAP of 98.09% for violation detection. In addition, in real-world circumstances, the system identified 77 out of 93 infractions with no false positives. As a result, it is clear that automated traffic ticketing is possible with the help of the established system. The proposed system would be especially helpful in generating different safety-related regulations, and it would aid in enforcing strict control of traffic laws and advancing the smart city ecosystem through automated AI-based traffic infraction reporting and enforcement.

Disadvantages:

- ✓ Due YOLO-v4 low performance and low accuracy.
- ✓ This system detects only the two wheeler violation.

4. Proposed System:

Because of the excessive crowding, the growing number of commuters, the poor management of the traffic signals, and the rider mentality, traffic infraction monitoring and control is a big problem in India. It should come as no surprise that the use of physical traffic police surveillance alone is inadequate to monitor such massive traffic volumes while simultaneously tracking offenses. Because of this, many people who break the rules go unpunished. In turn, those who violate the law produce more severe accidents on the road, which puts not only their own lives but also the lives of others in risk. Therefore, it is necessary to use procedures based on artificial intelligence (AI) in order to eliminate the need for physical involvement in the process of identifying lawbreakers and apprehending them. In this paper, we propose a system that can automatically detect two-wheeler violations for Indian road scenarios, such as not wearing a helmet, using a phone while riding, triple riding, wheeling, and illegal parking, and eventually automating the ticketing process by capturing the violations and the corresponding vehicle number in a database.

4.1. SYSTEM ARCHITECTURE:

These violations include not wearing a helmet, using a phone while riding, wheeling, and illegal parking. We suggest utilizing a custom-trained version of Yolo-v7 in conjunction with DeepSORT to identify and monitor violations, and Yolov7 in conjunction with Tesseract to recognize and extract license plate information.

On the test data, this implementation demonstrated an accuracy of 99.41% when it came to the recognition of number plates and a mean average precision (mAP) of 98.09% when it came to the detection of violations.

In addition, the system was able to identify 77 out of 93 infractions in real-world circumstances while producing no false positives. As a result, demonstrating that the system for traffic violations that was established may be used to automate the issuing of tickets for traffic violations.

The proposed system will be especially helpful in generating a variety of policies connected to safety. It would also assist to enforce robust enforcement of traffic regulations and build towards a smart city ecosystem through the automated AI-based traffic violation utilizing Yolov7.

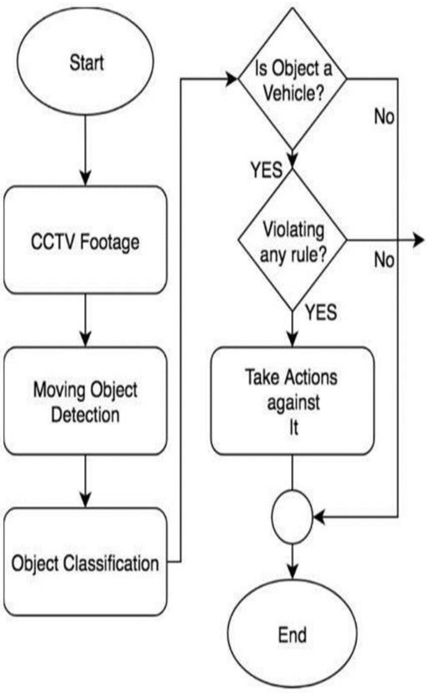

Fig. 1. - System Architecture.

4.2. Data Collection:

Acquire a collection of traffic camera video that is extensive and varied in its coverage. This should contain a variety of situations, such as city junctions, highways, and weather conditions of varying severity. In addition, you should gather videos submitted by users by having them utilize a certain platform or mobile application.

4.3. Data Preprocessing:

Create a standard for the video data by making sure that the formats, resolutions, and quality are all the same. Because of this, the processing will go more quickly.

Annotate the dataset by assigning labels to items of interest, such as stop signs, speed limit signs, traffic lights, cars, and persons who were not wearing helmets. When it comes to training a deep learning model, accurate annotations are absolutely necessary.

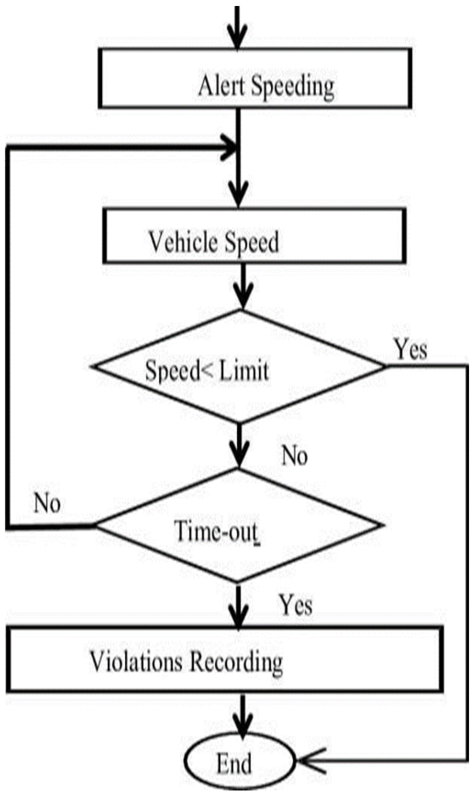

Fig. 2. - Represents the work flow of Proposed Work.

- ✓ YOLOv7 Implementation:

Train or otherwise adjust the YOLOv7 model with the help of the annotated dataset. To provide a high level of accuracy, the model should be customized to recognize the particular items that are significant to the enforcement of traffic laws.

- ✓ Real-time Detection:

Place the trained YOLOv7 model at key areas, such as important junctions of roads, highways, and other thoroughfares with heavy traffic. The use of real-time video processing to identify and follow items of interest as they appear in the video is highly recommended.

- ✓ Violation Classification:

Develop algorithms for classifying observed infractions into categories, such as going through a red light, exceeding the speed limit, or not wearing a helmet while driving. This categorization will help in determining whether enforcement actions are suitable.

- ✓ User-Provided Video Integration:

Users should be able to upload video evidence of traffic offenses through a platform or mobile application that is simple to use and accessible. Before employing user-provided films for enforcement purposes, develop and implement a method for reviewing and validating the videos.

- ✓ Reporting and Documentation:

Keep detailed records and documentation of any infractions found, measures taken for enforcement, and the system's performance.

4.4. MODULES EXPLANATION:

4.4.1. Open CV:

OpenCV, which stands for "Open Source Computer Vision Library," is a computer vision and machine learning software library that is freely available to the public. OpenCV was developed to offer a standard infrastructure for computer vision applications and to speed the usage of machine perception in commercial goods. Its primary goal was to accomplish these objectives. OpenCV is a product that is released under the Apache 2 license, which makes it simple for companies to use and change the code.

4.4.2. Num Py:

NumPy is the core library that Python users need in order to do scientific computing. A multidimensional array object, various derived objects (such as masked arrays and matrices), and an assortment of routines for fast operations on arrays are all provided by this Python library. These operations include mathematical, logical, shape manipulation, sorting, selecting, I/O, discrete Fourier transforms, basic linear algebra, basic statistical operations, random simulation, and a great deal more.

The array object is the fundamental building block of the NumPy library. This wraps n-dimensional arrays of similar data types, and for optimal efficiency, many operations are carried out in compiled code.

4.4.3. YOLO ALGORITHM:

What exactly does "yolo" mean? You Only Look Once is what the acronym YOLO stands for. "You Only Look Once" This is an algorithm that can detect and identify a variety of things that are present in a photograph as it is being processed in real time. The process of object identification in YOLO is approached as a regression problem, and the results offer information about the class probabilities of the pictures that were discovered.

4.5. Keras:

Keras is a software package that is available under an open-source license that offers a Python interface for artificial neural networks. The TensorFlow library can talk to the outside world using the Keras interface.

Keras includes various implementations of frequently used neural-network building blocks, like as layers, goals, activation functions, and optimizers, as well as a number of tools to ease the coding required for generating deep neural network code and make it simpler to deal with picture and text data. The source code is stored on GitHub, and the community support forums consist of a Slack channel and a website for reporting difficulties with GitHub.

4.6. DEPLOYMENT:

The deployment was one of the most difficult things to do. For us, developing a whole new piece of proprietary software to manage our model was a completely novel experience. We attempted a variety of strategies, but because of the dependence element, there were not a lot of possibilities that we could choose from. Because the user interface has all of the choices required for administration and other debugging purposes, there is no need for us to alter the code in order to do any management tasks. For instance, if we need to include some sample automobiles or cameras in the database, we may do this task by selecting the appropriate item from the menu.

To begin using the project, the administrator must first add a camera using the menu item. This is necessary for first project use. The administrator has the ability to add the location of in this manner.

The camera itself as well as the feed file that the camera uses. This location is where the feed file is installed over the internet by the camera module. We have obtained the video from the camera by using a file sharing pattern based on Linux. This file sharing pattern works as follows: the camera sends the specified file to the server, and the server uses the feed file to analyze and identify any violations. Additionally, the administrator has the ability to preserve the X and Y coordinates of the camera's position. This is done for future usage, when we will attempt to locate the cameras more easily using a map, and this is done in preparation for that use. Additionally, the administrator has to use a JSON file to establish certain restrictions for the camera. For instance, the camera may identify drivers who park in the incorrect spot or drivers who over the double yellow lines. It can also be used to monitor crosswalk violations.

5. Results and Analysis:

The algorithm that was built had the capacity to successfully identify the types of violations that were requested for this project. These included disobeying traffic signals, not wearing helmets, and exceeding speed limits. Due to the fact that it has a unique threshold condition, the convergence of detection for the traffic infringement that was specified is not comparable. The system is able to identify infractions of traffic signals, speed limits, and helmet laws for two-wheeled vehicles; however, the present system is only able to detect offenses involving two-wheeled vehicles.

5.1. Process 1:

Provide the system with the video feed in order for it to identify the helmet violation. The system was able to identify the violations without a problem. The two-wheeler that was caught breaking the regulations has had its number plate taken down, and a screen photo of it will be placed in the image folder along with it.

5.2. Process2:

Provide the system with the video feed so it can identify any violations of the traffic signal. The system was able to identify the violations without a problem. The images of any vehicles—whether they two-wheelers, four-wheelers, or heavy vehicles—that were found to be in violation of the regulations were taken, and the screen shots will be filed away in the same folder as the corresponding license plates.

5.3. Traffic Signal Violation Detection:

The system was quite successful in identifying those drivers that disobeyed the traffic signals. The algorithm's capacity to detect traffic signal patterns, in addition to the rigorous threshold conditions that were specified for this particular sort of infraction, are likely to be responsible for the category's high level of accuracy. It is essential to be able to differentiate between following traffic signals and ignoring them in order to maintain adequate levels of road safety, especially at highly trafficked junctions.

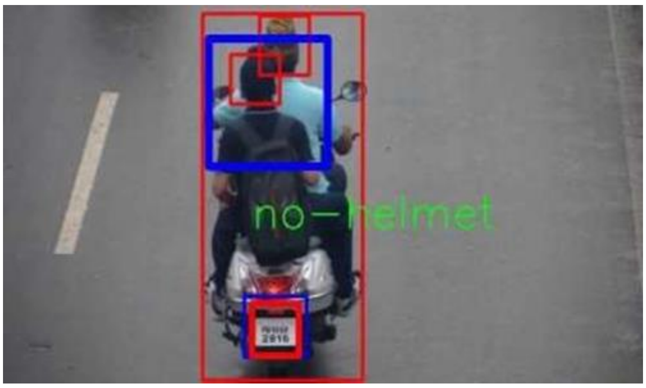

Fig. 3. - Detecting the helmet violation.

Fig4. - Detecting the helmet violation.

Fig5. - Detecting the traffic light violation.

5.4. Speed Limit Violation Detection:

Regardless of the kind of vehicle, the algorithm shown exceptional effectiveness in determining whether or not the posted speed limit had been broken. The precision of detection was especially striking in situations when cars greatly exceeded the speed limit. The adjustable threshold conditions made it possible to precisely identify drivers who violated the speed limit.

5.5. Helmet Violation Detection:

In the area of helmet violations, the algorithm displayed its adaptability by properly identifying this infringement for two-wheelers. This was a successful use of the method. The unique threshold conditions for helmet recognition on two-wheelers, together with the algorithm's power to recognize vehicle kinds, shown to be a considerable improvement in comparison to the systems that are already in place.

A complete study of the findings acquired from testing the improved traffic infraction detection system is presented here. The system was able to accurately identify three separate forms of traffic offenses, each of which has a unique set of threshold conditions: disobeying traffic signals, driving without a helmet, and exceeding speed limits. Notably, the algorithm displayed a high level of accuracy in detecting traffic signal violations, thanks to its ability to recognize traffic signal patterns. Additionally, it performed exceptionally well in the detection of speed limit violations, thanks to its ability to differentiate between different levels of speed transgressions across all types of vehicles. Particularly noteworthy is its adaptability in identifying helmet infractions particularly for riders of two-wheeled vehicles. This fills a substantial need that is currently left by other systems. The efficacy of the algorithm is largely dependent on the customizable threshold conditions for each kind of violation. This allows for targeted enforcement while also reducing the number of false positives. The capability of the system to apply these threshold conditions and to react to various violation circumstances exemplifies the practical value that it has in the context of real-world traffic management. In addition, it is important to underline the function that technology plays in public awareness and deterrence. This is because the technology's ability to accurately identify and record transgressions acts as a deterrent, which in turn promotes safer driving behaviors. However, it is essential to realize that the algorithm's scalability and the obstacles of implementing it in the real world, such as the needs for the hardware, the administration of the data, and the privacy concerns that need to be handled, need to be solved for its adoption on a wider scale. In conclusion, the findings point to the upgraded traffic violation detection algorithm being a major development in road safety and traffic enforcement. This innovation has the potential to make highways safer and more orderly for everyone while simultaneously encouraging responsible driving behaviors.

6. Conclusion

The data from the experiment and the analysis were used to come to a variety of findings, one of which being that more study was needed in some areas. The sort of infraction that was defined for this project, which was refusing a traffic light, was efficiently detectable by the System. Due to the fact that it has a unique threshold condition, the convergence of detection for the traffic infringement that was specified is not comparable. A detecting function for violations of traffic signals is provided by the system. Additionally, the system is capable of processing a single piece of data at a time. In addition, the runtime of the software is somewhat sluggish, although this is something that may be remedied by using a computer that has high speed CPU specs or a GPU.

Research that will be done in the future about the applicability of the proposed method to several more sophisticated image processing techniques. Because of this, it is possible that the system's program runtime may be improved by ignoring other superfluous processes that are completed in the background using a different way. Instead of doing that, maybe you could use a computer vision algorithm to give the system additional intelligence. In the near future, we want to incorporate number plate detection together with OCR support in order to strengthen the reliability of this system.

Conflicts of interest

The authors declare no conflicts of interest.

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