Traffic signal violation monitoring through video surveillance using CNN

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Abstract

Most of the traffic jams and accidents are occurred due to the bad traffic rule violation habits of the drivers or riders. This often leads to chaos and it may cause serious injuries, sometimes death also. This type of offenses can curb by identifying the offenders immediately and punish them with hefty fines. But many times due to over traffic and extreme weather conditions, traffic handling police personnel cannot do their duty up to their threshold. Availability of the artificial intelligence system which can do identify the offender and fine them immediately can bring the problem to considerable low level, this will lead to smooth traffic. Some methodologies are existed to identify the vehicles using Radio frequency identification tags (RF ID), this is again a costlier affair as all vehicles are not equipped with RF ID tags. So to better the process of traffic violation offender detection proposed model uses web cameras to identify the violated vehicle plate number through Convolution neural network, which uses the pattern matching technique for identification of numbers, thereby to fine the offender for the same and informing him through a text SMS.

Keywords: *CNN, Image Binarization, Region of interest, Number plate recognition.*

I. INTRODUCTION

But as is with everything, there are a few people that do not obey the rules and try to jump signals. Disobeying traffic rules is very dangerous and can seriously harm the person and others around him. But that was not a deterrent for many people that were breaking the rules and making the roads dangerous for everyone.

The rule breakers jump the signals and put other people'slives in jeopardy and that is a very wrong thing to do. Therefore, there is traffic policeman that make sure the rules are followed and catch the rule breakers to fine them so that they would not attempt to break the law again. But this is problematic as the number of signals and intersections keep growing there aren't many traffic policemen to man them all day. Therefore, an automated system is the need of the hour to catch the rule breakers and reprimand them by fining them.

Region of Interest is one of the most important characteristics in the realm of image processing. Region of Interest is defined as the area in an image or video, that is of greater importance than the rest of the image. Most applications of Region of Interest are based on the process of image processing, where various images are processed according to its fundamental data or an object in the picture.

As the Region of Interest is widely used in image processing techniques, it is actually one of the most basic and fundamental aspects of image processing. As the image that is required to be processed has to be segmented to enable faster and efficient use of the computational capabilities of the machine in use. The Region of Interest is useful for extracting the relevant parts of the image for processing. As the relevant parts are extracted from the image and utilised for the processing of the image, the computational complexity of the system is reduced as there are less areas in the image processing algorithm has to process in order to utilise it to its maximum potential. The Region of Interest technique has been in use predominantly in the medical sector for extracting the relevant segments of images.

The medical field uses this technique extensively to isolate tumours and other abnormal growths or defects in the medical images. as scanning through all the images manually for the signs of defect is cumbersome and could lead to some error in

diagnosing the disease which cannot be afforded at the medical level when there are lives at stake. Therefore, the Region of Interest is a substantial technique.

Convolutional Neural Networks are basically a sub-set of a broad category of computational networks known as Neural networks. These networks are basically inspired by the workings of the organic human brain. As the brain is one of the most complex organic calculators and has enabled us as a human race to advance forward to what we are now. All of these technological advancements and becoming the dominant species of the planet, capable of such immense feats has only been possible because of the brain.

The human brain is a complex machine that can enable us to think and analyse to react to a certain stimulus. It is the seat of our consciousness and the centre of all thought and intelligence of a human being. The brain is a very delicate organ housed in the cranium one of the most protective bones on the body. The brain itself is composed of neurons, billions of neurons interconnected.

The neurons are the most fundamental element of the brain, and it is responsible for all the activities a brain performs. The neurons are capable of producing an electrical current when excited. As the neurons are interconnected, firing of one neuron enables it to fire the adjacent neurons. As the electrical impulse spreads, it forms a unique pathway and these pathways are the brains ability to compute.

The neurons only fire when excited above its threshold point, what that means , is that if the stimulus intensity is more than the threshold of the particular neuron, it fires. This is very useful and a feature that has been adopted into various neural networks that work with a version of the neuron. The complex firing of neuron helps humans make memories and take logical thought out decisions.

This feature of the human brain is completely borrowed to form the Neural networks that also feature the neuron as the basic smallest computational element. There are a lot of neurons that are designed with specific thresholds. These thresholds enable a neural network to process the information like a human brain. This is useful in generating human like replies and interactions where they are necessary.

Convolutional Neural Networks are an extension of the Neural networks. In Convolutional Neural Networks, there are various layers of neurons, referred to as filters. These filters are trained with different thresholds. This enables the input to be filtered down through and come out on the other side as an output. This is very useful as adding more and more layers makes it extremely accurate and respond like a human would.

This type of behaviour is well suited for tasks involving Optical Character Recognition (OCR) and has been heavily used in applications involving image processing as it is very well suited for this job and can provide human-like assessment and evaluation of the images in question.

This research paper dedicates section 2 for analysis of past work as literature survey, section 3 deeply elaborates the proposed technique and whereas section 4 evaluates the performance of the system and finally section 5 concludes the paper with traces of future enhancement.

II. LITERATURE SURVEY

This section of the literature survey eventually reveals some facts based on thoughtful analysis of many authors work as follows.

V.Nagmode [1] Due to the increase in population there is growth in the city and simultaneously there is growth in vehicles as there is growth in vehicles the congestion in traffic. This congestion in traffic may cause a time delay problem in day to day life. To overcome this problem the author has developed a system by using the IoT platform to manage the traffic. To detect the traffic the ultrasonic sensors are used in lanes these sensors received the data throughthe controller and transmitto the web server through WI-FI. If any Lane receives the high traffic level it gives the high-level priority through a signal. This system is simple and low cost.

J.Lin [2] In recent years there isa major problem taking place in traffic violation field which disturbs routine. There are a few aims described by the author there are design a cost-effective fundamental contribution to communication network, use image processing techniques to develop a non-intrusive vehicle detector for monitoring traffic dynamics, utilize artificial intelligence to adapt traffic dynamics and to renew traffic control strategies, research and design a novel and multi-functional

traffic controller in a box, propose a specific concept for mobile intelligent traffic control center. This system is self-organized, self-coordinated and highly efficient.

E. Pfannerstill [3] To handle the traffic violation and monitoring the traffic. This paper is based on the network system in which the knowledge and the actual traffic condition the whole network id transferred automatically most reliably and the real-time by the authorities of the drivers.They have used the MAVE system which is used for the pattern recognition to measure the data related to traffic such as the journey speed and traffic density. This system does not require any additional sensor devices.

Yuebiao Li [4] On the large scale there isa problem faced in the domestic traffic signal controllers is observed to handle this problem there is need to develop atraffic monitoring system so this comes to the conclusion that the traffic controllers should be based on the web technology. The design of this monitoring system is divided into the four different layers each layer is accelerated in detailed. In this system,the B/S module is structured so that the maintenance and upgrade can be done easily.

M.Azer [5] Traffic Monitoring system is an important topic to be researched in these recent years and the coming years. As there is a boom in on social networking it is a significant part of the daily lives. As the Internet of Things and the networking communication model provides a great advantage to each and every person in their own life.In this proposed system social networking provides traffic monitoring from the individual person. As this paper provides real-time traffic monitoring and vehicle tracking for private and public transportation sector.

F. Filippi[6] This paper presents the case of the Perugia urban freeway. The Perugia urban freeway is a four-lane highway which an eleven-kilometer-long it consists the tunnels approximately 3000 vehicles passes in one direction in which 25 percent vehicle is heavy. The goal is to provide the higher safety and dealing with an emergency at a very high speed so it was requested to the Umbrian regional authorities requested the Department of Transport to find the way using the traffic monitoring system.

S.Mishra [7] Adaptive Traffic Monitoring and Controlling System (ATMC) is one of the cheapest and the automatic practical monitoring system. This system controls the traffic light controls, they also recognize the vehicle that breaks the signal it also analysis vehicle vehicles standing 20 meters near traffic light controls and on these views, they control the traffic light signal all these views are controlled by the IR receiver and they sent to the microcontroller. Using this information, the green and red light of the traffic in controlled.

N.Wu [8] This paper presents the recognition of the road interactions for traffic monitoring system using traffic light recognition method. The YUV space method is used to check the intersectionof the vehicleat the roadside if any rules are braked it is recorded in video and send to the E-police.The test video is recorded by the recorder of the E-Police system.Thus,the result of this experiment is better than previous researches.

F. Southworth[9] There is ongoing much development in the sector of the traffic monitoring system in which the real-time monitoring and analysis system takesplace. Due to the growthof vast population there is growth in the vehicles thus this due to this there is a violation of rules and alot of completes regarding traffic system occur. Thus, the real-time monitoring and analysis system is of the fastest growing and developing paper in coming years. It is one important element in ITS

N.Hung[10] Traffic Monitoring system is of the fastest growing technology in the Intelligent Transportations System. This methodology is using in of the growing countries where the flow of both vehicles is mixed such a motorcycle and car. Thus, traffic may vary from data to day time. Thus,the proposed system mounts the camera in where they can appear the moving vehicles and it also calculates the distance between the two vehicles. Thus,these videosgive the idea of the traffic and the traffic light monitoring is monitored from it.

QiuXinyun[11] Intelligent Transportation system is one of the fastest current topics which developing on a large scale mainly in the developing countries and they have already started using widely. Due to the development, the road is becoming more and more complex and vehicle are also increasing day by day so the control of the vehicle is an important thing. After the 90sthe Intelligent transportation system has grown rapidly. By using the ZigBee network, they can transfer the information fast related to traffic.

W.Jiao [12] In Traffic monitoring system there is a lot of exchange of data and the information is stored the vehicle information is sent by the monitoring center through GPRS and 3g network. This communication server exchanges data and stores the data according to the relationship if the monitoring.The number of information will be stored will be decided on the performance of the server.Thus to store this information IOCP mechanism is used this is one of the best mechanisms to store the information.

R.Lu [13] The Vehicular Ad Hoc Network (VANET), as a special mobile ad hoc network which has been widely developed in the coming years. In vanet each vehicle comes onboard unit (OBU) devices. Which enables a vehicle to communicate one and

then another in this the vehicle not only communicate with one and other but also the RSU i.e. the roadside communication regarding the traffic monitoring system vehicles can also access to the remote servers, such as a traffic monitoring server, on the road.

III PROPOSED METHODOLOGY

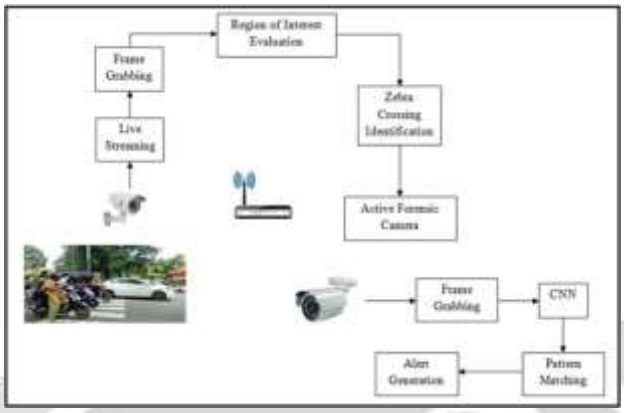

Figure 1: Overview of the proposed system

The overview of the proposed model for traffic signal violator detection can be depicted in the figure no 1. And the steps involved in the development of this model are broadly narrated as below.

Step 1: Setup and Video streaming - The proposed model is deployed using two laptops and two external web cameras. The both cameras were connected to the respective laptops. One camera is given a role to keep a vigil on the zebra crossing and on identifying any kind of signal violation, then it intimates to the other controller laptop of the other camera. Once the other camera is intimated then it will do the work number plate recognition and then this will result in vehicle registration number detection and fining the customer of that vehicle.

For the live streaming of the video frames proposed model uses the Java media Files (JMF) plug-in. Using this JMF a default player is created which will locate all the captured frames through the player continuously. This visible component of the players is converted into buffer objects to convert them into a proper image object of the Buffered images.

Step 2: Frame grabbing and Region of Interest evaluation - To grab a frame from the created video player through JMF a mechanism of Frame grabbing control is being used. By using the default factory method of frame grabbing control a frame is grabbed for the instance and stored as the image in the predefined location.

As the stored frame may not be in desired size for traffic signal analysis or number recognition. So the collected frames are needed to crop from the top, bottom, left and right to get the images with the proper region of interest. This decision of cropping is generally taken based on the setup plan of the model. To crop the image based on the region of interest a two dimensional graphics object is being used to refactor the frame according to the required size.

Step 3: Zebra crossing surveillance - The camera which is mounted to conduct a surveillance on the traffic single violator by capturing a frame in a given instance. This frame is subjected to find the region of interest then this is being converted into a binary image which contain only two kinds pixels like either white or black. To convert the image into binary the average RGB of the image pixel is estimated with the given threshold value.

Here in the proposed model the given threshold value is about 125. If the Average RGB of the pixel is more than that of the threshold value of 125 then that pixel is converted into white pixel as the values nearer to 255 adds more whiteness in the image. On the other hand, if it is less than the threshold value, the pixel is converted into black. This process is shown in the Algorithm 1.

ALGORITHM 1: Binary Conversion of the Image

// Input: Input Image IN_{IMG}
//Output: Binary Image B_{IMG}
// binaryConversion(IN_{IMG})
1: Start
2: B_{IMG} = Ø
3: ***for*** i = 0 to size of Width of IN_{IMG}
4: ***for*** j=0 to size of Height of IN_{IMG}
5: P_{SIGN} = $IN_{IMG\ (ij)}$ RGB
6: R= P_{SIGN} >> 16 & H_D
7: G= P_{SIGN} >> 8 & H_D
8: B= P_{SIGN} >> 0 & H_D
9: V=(R+G+B) / 3
10: ***IF*** V>125
11: SET $B_{IMG\ (i,j)}$ RGB → (255,255,255)
12: ***ELSE***
13: SET $B_{IMG\ (i,j)}$ RGB → (0,0,0)
14: ***End for***
15: ***End for***
16: **return** B_{IMG}

The original image is considered to estimate the status of the traffic signals by counting the number of the red colored pixels or green colored pixels. If the number of the red colored pixels is more, then it indicates the red signal of the traffic light. This initiates the checking for any violation on the zebra crossing by the vehicles in the converted binary image.

Once the image is converted into binary then the image is set to estimate the count of the black pixels on the opposite edge of the zebra crossing. If the count on the opposite edge is less than the threshold then it means some vehicle is being crossed with red light. Then the other controller laptop is being intimated to capture a frame for the number recognition process through a UDP protocol.

Step 4: Number Recognition Through CNN - As the number recognition controller system receives the signal from the zebra crossing vigilance system, it grabs a frame for that instance and then converts it into a binary image as mentioned in the algorithm 1.

Then the binary image is being searched for the number plate rectangular pattern identification through the first layer of the CNN. Here in this step all the four directional corners were estimated for the most number of white pixels in a considered row or a column. This is because in India the vehicle number plates are either yellow or white. Here for the sake of the experiment, it is considered as the white. If the more number of white pixels are found in the traversing axis then, that point is considered as the cropping points in all the directions as shown in algorithm 2.

ALGORITHM 2: Number plate Recognition

// Input: Input Image B_{IMG}
//Output: Number plate coordinates C_{SET}
// numberPlateRecognition(B_{IMG})
1: Start
2: Axis set A_{SET}= { N,S,E,W }
[North, South, East, WEST]
3: ***for*** k = 0 to size of A_{SET}
4: A_X=$A_{SET[K]}$
5: ***for*** i = 0 to size of Width of B_{IMG}
6: count=0
7: ***for*** j=0 to size of Height of B_{IMG}
8: P_{SIGN} = $B_{IMG\ (ij)}$ RGB
9: R= P_{SIGN} >> 16 & H_D
10: G= P_{SIGN} >> 8 & H_D
11: B= P_{SIGN} >> 0 & H_D

12: ***IF*** R=255 AND G=255 AND B=255
13: count++
14: ***End for***
15: ***IF*** count > T_H [T_H = Threshold]
16: $C_{SET[K]}$ = i || j
17: ***break***
18: ***End for***
19: ***End for***
20: **return** C_{SET}

After this by using a graphics object the image is being cropped for the number plates to recognize the proper vehicle number using the Tess OCR. This recognized number is searched in the database for the respective bank accounts through which the fine amount is automatically deducted in the simulated environment. Then a text message will be sent to the mobile number of the traffic offender for the same. If the offender is not having sufficient fund in his/ her account, then a text SMS will be sent to the next traffic signal traffic personnel to catch the offender and to register a case. The experimental result are shown in the figure 2.

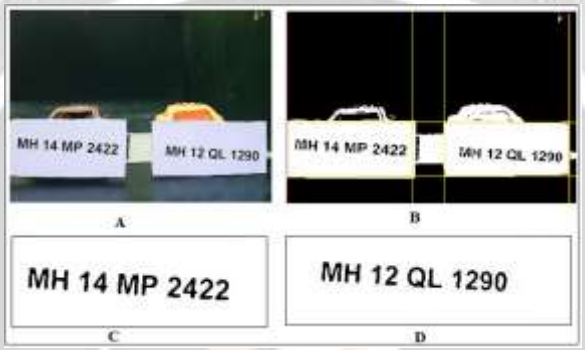

Figure 2: (A) Original Image (B) Number plate Detected through CNN (C,D) Number plates cropped.

IV RESULT AND DISCUSSIONS

The proposed methodology for the detection of the traffic rule violation and number plate recognition has been implemented successfully in Java Programming Language with the help of the NetBeans Integrated Development Environment. This technique has been deployed on a machine running on a Core i5 processor assisted by a 6 GB of Random-Access Memory. The database and storage capabilities were handled effectively by the MySQL Database Server.

The proposed techniques have been experimented on extensively to ascertain the performance and the efficiency of the system. This is essential to establish that the presented technique has been innovative and can be used to replace the traditional and conventional approaches. Therefore, to evaluate the robustness of this system, Precision and Recall have been used.

Precision and Recall are one of the most widely used techniques to determine the relevant accuracy of various different types of systems. They have been used in conjunction in the majority of the applications but Precision and Recall are very independent of one another and even though they seem to give the same information, but they are drastically different from each other, even though they share some similarities.

Precision is the percentage of the results obtained, that are relevant to our implementation of the proposed methodology. Whereas, Recall is defined as the percentage of total relevant results that are generated by the algorithm. The precision and Recall can be calculated and elaborated further in the Equation given below.

X = The number of relevant numbers identified
Y= The number of irrelevant numbers idenified
Z= The number of relevant numbers not identified.

So, precision can be given as

Precision = (X / (Y+ Z)) *100
Recall = (X / (X+ Z)) *100

There are very nuanced differences between both the approaches as evident by the equations for their calculation given above. Both the testing parameters have their own advantages and similar enough to compliment each other beautifully. Therefore, it is one of the best techniques to evaluate the performance of this system.

Testing Experiments with No of Trails	Relevant Numbers identified (A)	Irrelevant Numbers Identified (B)	Relevant Numbers not identified (C)	Precision in %	Recall in %
5	5	0	0	100	100
10	6	2	2	75	75
15	13	0	2	100	86.66666667
20	15	5	3	75	83.33333333
25	22	3	1	88	95.65217391
30	24	3	3	88.88888889	88.88888889
35	28	4	3	87.5	90.32258065
40	30	5	5	85.71428571	85.71428571

Table 1: Precision and Recall Experiment Details.

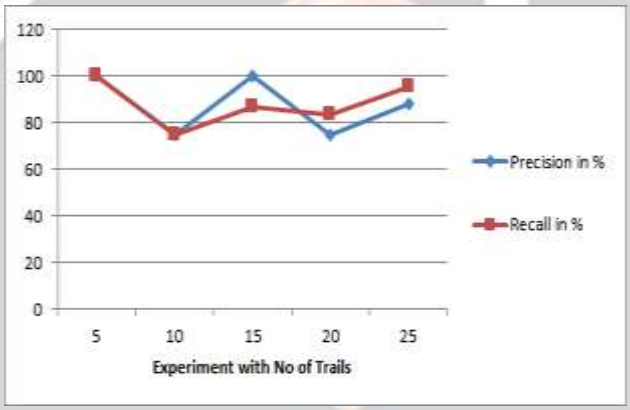

Figure 3: Precision and Recall Comparison

Table 1 above has the values evaluated for the Precision and Recall for the proposed methodology. The values given in the table are then plotted in the graph given in Figure 3 above. As it is evident from the graph, the proposed technique has an impressive score which indicates the efficiency of the proposed system.

V CONCLUSION ANF FUTURE SCOPE

The proposed methodology of traffic signal violator detection is deployed in a real time simulation environment. Where a proper road and traffic signals are created along with the zebra crossing. The toy cars are used as the vehicles with different number plates. The designed system accurately estimates the traffic signal violator using the threshold of the pixels on the opposite edge of the zebra crossing efficiently to alert the other camera of number capturing.

The vehicle number plates are properly identified using the first layer of the CNN. Thereafter the identified numbers are searched for the offender linked bank account in the simulated environment database. The Proposed model is evaluated for the precision and recall for the number of identified registration numbers of the vehicles. Where system found to achieve more than 80% of precision and recall that is eventually a good result in the very first trail of the proposed model.

In the future this idea can be enhanced to work in real time CC TV cameras to deal with all kinds of the number plates like fancy and with different fonts.

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