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Big Data solution forImproving TrafficManagement System Effectively for vehicular networks

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Abstract: Nowadays traffic congestion is a serious issue. Traffic congestion is most predominant in metro cities. There are different causes of traffic congestion such as increasing population, rising incomes leading to more vehicles on the road, insufficient capacity of roads to handle traffic etc. Therefore there is a need for optimizing the traffic management system of the city. This paper introduces a new technique using image processing and big data to build a better traffic management system. The system takes CCTV videos installed at various checkpoints as input and converts the video into image frames. Thereafter, background subtraction is performed on these image frames to obtain only objects of relevance. Haar-based cascade classifier is used to detect vehicles and finally vehicle count is performed using parallel computation power of Hadoop.

Keywords: Intelligent traffic system, Big data, transport system, smart city, reduce traffic congestion, vehicle count, video processing.

I. INTRODUCTION

It is predicted that, in few decades most of the world population will live in the urban regions. This may lead to many socio-economic challenges. In recent years the cities world over have grown by leaps and bounds. Smart citiesare essential for a sustainable urban development. It can remove many major problems faced by most of our cities for example traffic jams, thefts, environmental pollution, public transportation issues etc. [1].

One of the major problems faced by cities today is traffic congestion. Traffic jams causes a rise in the cost of transportation as well as it affects the routine lives of people. The problem of traffic congestion pervades everywhere, but mega cities are the ones that are most affected by it. The ever increasing nature of traffic makes it difficult to estimate the road traffic density in real time so as to make better traffic related decisions and manage the traffic more efficiently.

There are several reasons for this sudden surge in the traffic, in urban regions. The main reason can be attributed to rise in the population which in turn has caused rise in the number of vehicles on the road.Apart from this, congestion also occurs due to for congestion like insufficient capacity of roads, large red light delays, incomplete information regarding traffic, inefficient transport management, unrestrained demand etc. Insufficient capacity and unrestrained demand are interrelated but signal delays are hard coded and do not depend on the amount of traffic density. Therefore there is a need to optimize the traffic control systemand make it more dynamic so as to accommodate the varying traffic density.

In this paper we propose a dynamic traffic management system using video monitoring and traffic surveillance techniques. The proposed system uses CCTV cameras installed on traffic checkpoints as an input method to capture videos and converts them into image frames. Further image processing is performed on these image frames and total number of vehicles is calculated in each frame which is then added to get the total number of vehicles in every lane. Accordingly the traffic cycle for each lane will be increased or decreased based on the traffic density value.

II. RELATED WORK

A smart city framework for intelligent traffic system using VANET was proposed in [2]. VANETs provide communication between vehicles themselves and between vehicles and road side units. VANETs help improve the mobility of vehicles on the road and develop a safer and sophisticated city. Also easier communication facility between vehicles is provided using VANETs. But the limitation with VANET is that a specific hardware needs to be installed on every vehicle. Installation of such hardware on two-wheeler would be a difficult task.

An infrared based intelligent traffic system was proposed in [3]. In this IR based system, the IR transmitter first produces a 38 KHz carrier wave which is then modulated at a slower frequency to send data. At the receiver end, the processor converts this active-low signal into a standard TTL level signal. The IR based system proves to be cost-effective since all the microcontrollers used are cheap. The transmitter and receiver are powered by batteries and thus

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consume less power. Also the installation procedure is easy since the transmitter and receiver can be installed anywhere on the road. But the limitation with IR based system is that it requires the receivers and transmitters to be in direct line of sight of each other. This reduces the amount of flexibility in movement. Another drawback is that high intensity or fluorescent lights cause interference in the infrared signal. Also large areas require multiple emitter panels and quality of these emitter panels varies with company.

In [4] fuzzy logic is used to optimize the traffic light timing at a Diphasic's isolated intersection. Here two fuzzy logic controllers are used – one is to optimize the signal and other controller is used to extend the green phase of a lane in an intersection. The sensors used to collect input data are video cameras which are place at incoming and outgoing lines. The controller then utilizes the information collected through these sensors to make optimal decisions and minimize the goal function. This system showed great improvements in traffic control as compared to fixed time controllers using different traffic conditions such as certain, uncertain and random data. Although the paper states improvement in speed and high precision but use of fuzzy system proves transparent only for simple systems.

A heterogeneous network combining RFID and WSN is proposed in [5] to improve the efficiency of roads. In [6] paper focused on the basic framework of intelligent urban Traffic Management System Based on Cloud Computing and Internet of Things. The Internet of things (IOT) is a kind of computer network which is on the basis of the Internet. It uses Radio Frequency Identification (RFID) and wireless data communication technology to construct a network which covers everything. The problem with RFID systems is that they can be easily disrupted. Since RFID systems make use of the electromagnetic spectrum they are relatively easy to jam using energy at the right frequency. Also RFID has security, privacy and ethics problem. RFID tags can be read without the user's knowledge. There is a potential vulnerability of current RFID software if used together with a backend database.

In [7] an Intelligent cross road traffic management system is proposed using long range photoelectric sensors. The
traffic management department chooses appropriate distance to install these sensors, so that they can monitor the moving cars. This data is then sent to the traffic control cabinet where software is installed which will calculate the relative weight of each road. Based on the relative weight calculated the system will allow the overcrowded road to have larger duration of signal. Also this system is designed in such a way that it can handle emergency situations (such as passing of ambulance, ministries and other VIPs) by opening complete paths for these vehicles to pass first. In this way fluency of the traffic is guaranteed.

The system designed by Salama [7] faces limitation since it requires the deployment of photoelectric sensors. The cost of maintaining these sensors is huge since they are deployed in rugged external conditions and are prone to damage.

In [8] a vision based intelligent traffic management system is proposed. The proposed system uses image frames acquired through cameras installed on roads. The first step is to perform vehicle detection. Also background subtraction and other morphological operations have been used to increase the efficiency of vehicle detection. Region of Interest based method is used to obtain an accurate vehicle count. The proposed system shows good real time performance, however this system faces certain limitations such as occlusion and shadow overlapping.

III. SYSTEM DESIGN

The general system design is as shown in figure 1. First of all the videos are captured from the CCTV cameras installed at traffic junctions. We consider here a three-way intersection having signals S1, S2 and S. From every intersection the videos are captured and stored in the database of the traffic department. The system first acquires the traffic video data i.e. live traffic feed from the traffic department database. The videos are converted to image frames for further processing. These image frames are given as an input to the Image processing toolbox. This system uses Xuggler to convert video into image frames and Opencv to perform further image processing steps such as background subtraction and object detection.

After object detection, total vehicle count is determined usingparallel processing power of Hadoop. Accordingly the traffic signal is varied as follows:

If (total vehicle count at S1>total vehicle count at S2 && total vehicle count at S1>total vehicle count at S3)
    Then status for S1 = on;

Else if (total vehicle count at S2>total vehicle count at S1 &&total vehicle count at S2>total vehicle count at S3)
    Then status for S2 = on;
else
    status for S3 = on;

Here status is a Boolean value depicting the status of signal i.e. whether it will remain on or off. A higher vehicle count means the status will be on for that particular signal.

Apart from this hardware also includes connection of these cameras to the Traffic department server to receive live feed of traffic data from the server and a server capable enough to handle the huge processing requirements.

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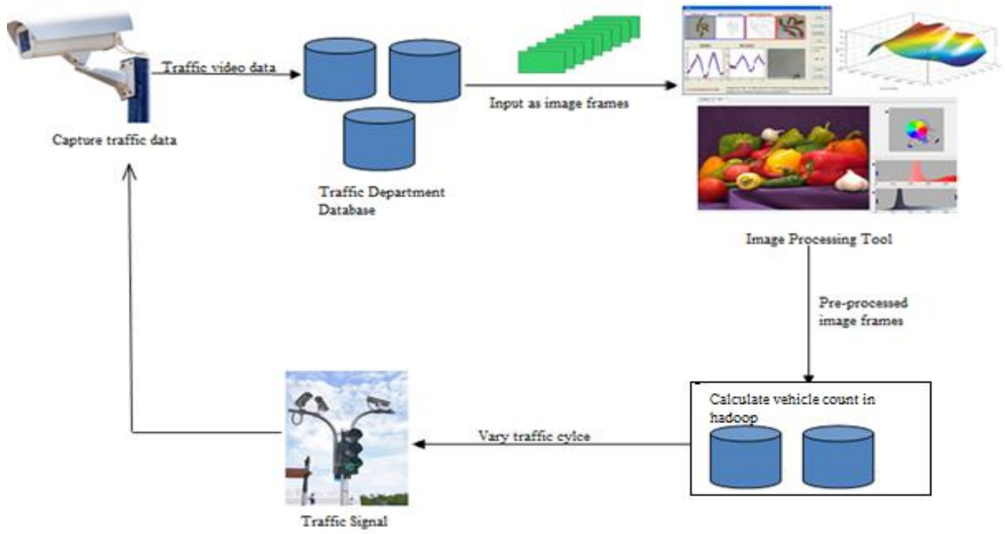

Fig.1: General system design

IV. METHODOLOGY

The first step is to convert the videos into image frames. This step is performed using Xuggler tool. First we create a Xuggler container object using make() method of IContainer class and store the video streams in it for further processing. Then we get the number of streams that are found after opening the container. We then need to iterate through all the video streams to find the first video stream. Decode this stream using the pre-configured decoder to get the codec information of this stream. The codec type of the first video stream is checked to see whether it matches the specified codec type. So let's consider there are n streams.

Now,
VideoCoder = null;
Fori=1:n
s = getStream (i);// Find the 1st stream object
Coder = getStreamCoder(); //Decode this stream

Then we check the codec type of the previously obtained stream:
If (StreamId = -1 &&codecType = CODEC_TYPE_VIDEO)
StreamId = i;
videoCoder = coder;
end
end

The video stream is checked for its pixel format which should be in BGR24 format and if not then it is converted into this format. Xuggler has a classVideoResampler containing make() method converts that for us.

BGR24 format uses 24 bits per pixel for its three primary channels Red, Green and Blue which provides upto 16 million colours for each image. Fig.2 shows the image frames obtained after applying the above steps.

Fig.2: Conversion from video into image frames

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These BGR24 format image frames are converted to grayscale images. A grayscale image is stored as an individual matrix. One image pixel in a grayscale image is stored in the form of elements of this matrix. To convert into grayscale image first we get the image height and width:

height = getHeight(image)
width = getWidth(image)

The RGB values of the image are extracted and added to get the decimal code for grayscale image.

```
For i=0:height
For j=0:width
C = getRGB(image)
red = getRed * 0.299
green = getGreen * 0.587
blue = getBlue * 0.114
Sum = red+green+blue
Color(sum,sum,sum)
End
End
```

Then background subtraction is performed to separate foreground objects from a relatively stationary background. There are several cues to differentiate a foreground object and a background image. Usually a smaller object in an image is considered as the foreground. Also convex shapes may be associated with foreground objects. The background is usually associated with one single colour whereas foreground objects have small local variations in colour, but again this may not be very indicative. Often, the foreground object can be thought of as a coherently moving object in a scene.

In pixel-based background subtraction technique a Bayesian decision is made whether the pixel belongs to foreground object or is a background image. A background model is estimated from a training set X which is denoted by $p(\vec{x}|X,BG)$[9]. But in reality there could be sudden or gradual illumination changes in the scene due to weather or daytime conditions.In order to update the training set to adapt to changes,new samples can be added and old ones can be discarded. For every new sample the training data set X_T(in the time period T) is updated and $p(\vec{x}|X_T,BG)$ is re-estimated. There could be some sample values from the recent history which belong to the foreground objects , so the model is re -estimated as $p(\vec{x}^{(t)}|X_T,BG+FG)$. Hereafter a GMM with M components can be created as shown in equation 1:

$$\hat{p}(\vec{x}|X_T, BG+FG) = \sum_{m=1}^{M} \hat{\pi}_m N(\vec{x}; \hat{\vec{\mu}}_m, \hat{\sigma}_m^2 I)$$

Where,

$\hat{\vec{\mu}}_1,\ldots,\hat{\vec{\mu}}_M$ are estimates of means.
$\hat{\sigma}_1,\ldots,\hat{\sigma}_M$ are estimate of variances that describe the Gaussian component.
$\hat{\pi}_m$ is the non-negative mixing weight that adds up to 1.

After detection of foreground image,object detection is performed on the resultant set of images by applying Haar-feature based cascade classifier [10]. The cascade classifier is given aninput file consisting of several positive and negative samples of vehicles. The classifier consists of several simpler classifiers (stages) that are applied subsequently to a region of interest until at some stage the candidate is rejected or all the stages are passed.For every vehicle detected, a rectangle is drawn around it as shown in fig.4. The first column of images are from video1 and depict the number of vehicles detected in the first frame and last frame of video1. Similar is the case for next column and last column which depicts number of vehicles detected in the first frame and last frame of video2 and video3 respectively.

Fig.3 Background subtraction

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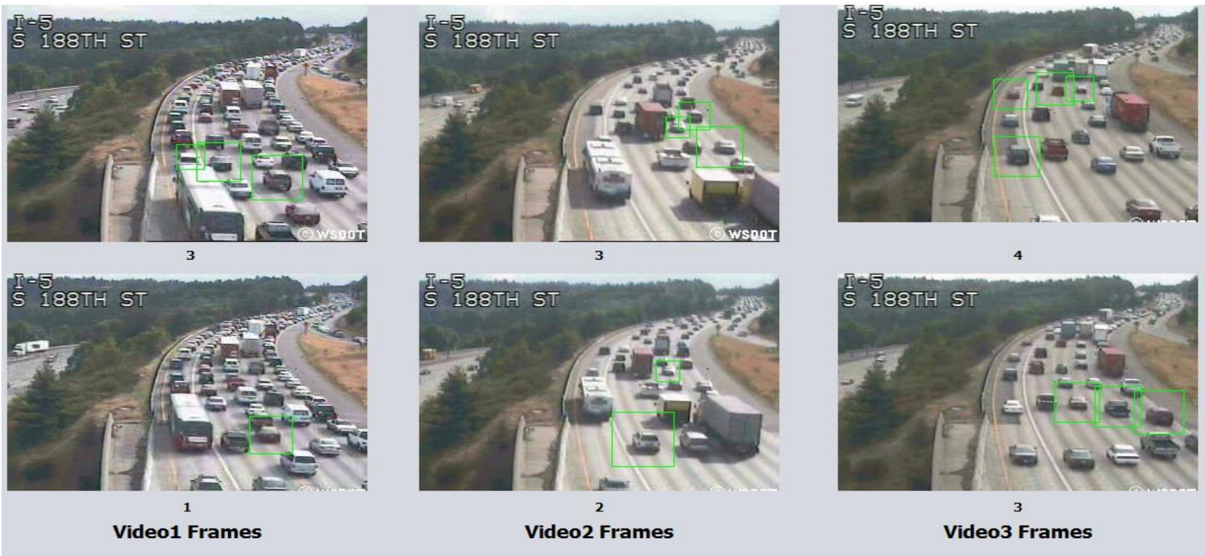

Fig.4 Object Detection

The proposed system also makes use of distributed computing power of Hadoop to determine the traffic density. The count ofrectangles in every video frame are added with the count of rectangles in the next video frame.

$$\text{Total vehicle count} = \sum_{i=0}^{n} \text{Count}$$

Here n is the number of frames, Count is the count of vehicles detected in one frame and Total vehicle count is the summation of all the vehicle countsin n frames.

The summation is performed in parallel for all video sequences in Hadoop.

V. RESULTS

This system uses three different scenarios of traffic: Heavy traffic, medium traffic and light traffic. For every scenario a video file is given as input to the system and the derivedtotal count of vehicles is as shown in fig. 5.

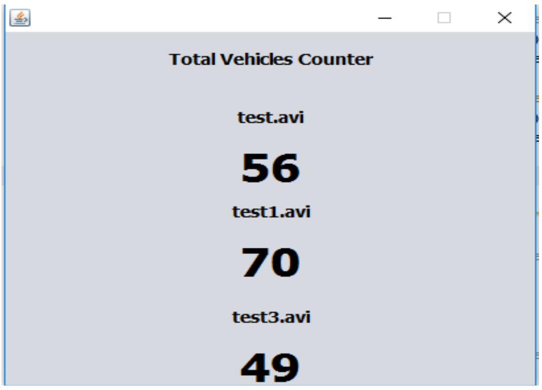

Fig.5: Total vehicle count for every video

The results are shown in the form of confusion matrix in the table 1, table 2 and table 3. Every confusion matrix table given below consists of two classes i.e. Vehicle_Detected = yes and Vehicle_Detected = no. Given these two classes we have determined the first attribute True Negative (TN) as the negative tuples that were correctly labelled by the system. The next attribute in the same row i.e. False Positives (FP) are the negative tuples that were incorrectly labelled. In the second row the attribute False Negative (FN) depicts the positive tuples that were incorrectly labelled and the attribute True Positive (TP) refers to the positive tuples that were correctly labelled. Five parameters are calculated:

- Accuracy : Overall how often is the classifier correct is termed as the accuracy
- Misclassification Rate: Overall how often the classifier is wrong is termed as the misclassification rate.
- Sensitivity: It is also referred to as the true positive rate i.e. the proportion of positive tuples that are correctly classified.
- Specificity: Specificity is the proportion of negative tuples that are correctly classified.
- Precision: Precision is the percentage of tuples labelled as Vehicle_Detected that are actually Vehicle_Detectedtuples.

A)For Test.avi

n = 71	Vehicle_ Detected =No	Vehicle_Detected = Yes
Vehicle_ Detected = No	TN = 12	FP = 0
Vehicle_ Detected = Yes	FN = 3	TP = 56

Table 1: Confusion matrix for video1

- Accuracy $= \frac{TP+TN}{\text{Positives } + \text{Negatives}} = \frac{56+12}{71} = 0.9576$
- Misclassification Rate = 1 – Accuracy = 1 - 0.95 = 0.05
- Sensitivity $= \frac{TP}{\text{Positives}} = \frac{56}{59} = 0.949$
- Specificity $= \frac{TN}{\text{Negatives}} = \frac{12}{12} = 1$
- Precision $= \frac{TP}{TP+FP} = \frac{56}{56+0} = 1.$

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B)For Test1.avi

n = 85	Vehicle_Detected = No	Vehicle_Detected = Yes
Vehicle_ Detected = No	TN = 12	FP = 0
Vehicle_Detected = Yes	FN = 3	TP = 70

Table 2: Confusion matrix for video2

- Accuracy = $\frac{TP+TN}{Positives\ +Negatives} = \frac{70+12}{85} = 0.964$
- Misclassification Rate = 1 – Accuracy = 1 - 0.964 = 0.036
- Sensitivity = $\frac{TP}{Positives} = \frac{70}{73} = 0.958$
- Specificity = $\frac{TN}{Negatives} = \frac{12}{12} = 1$
- Precision = $\frac{TP}{TP+FP} = \frac{70}{70+0} = 1.$

C)For Test2.avi

n = 69	Vehicle_Detected = No	Vehicle_Detected = Yes
Vehicle_Detected = No	TN = 17	FP = 0
Vehicle_Detected = Yes	FN = 3	TP = 49

Table 3: Confusion matrix for video3

- Accuracy =$\frac{TP+TN}{Positives\ +Negatives} = \frac{49+17}{69} = 0.956$
- Misclassification Rate = 1 – Accuracy = 1 - 0.956 = 0.044
- Sensitivity = $\frac{TP}{Positives} = \frac{49}{53} = 0.942$
- Specificity = $\frac{TN}{Negatives} = \frac{17}{17} = 1$
- Precision = $\frac{TP}{TP+FP} = \frac{49}{49+0} = 1.$

File name-e	Predi-cted Yes	Predi-cted No	Actual Yes	Actual No	Total	Accura-cy in %
Test.avi	56	15	59	12	71	95.76
Test1.avi	70	15	73	12	85	96.4
Test2.avi	49	20	52	17	69	95.6

Table 4: Table depicting accuracy obtained for every video

In table 4 the first column of the table depicts the file name given in the form of AVI extension. The second column depicts the predicted Yes values i.e. the count which is output by the system. The third column depicts the Predicted No i.e. the number of vehicles which the system did not count. The Actual Yes values depict the actual count of vehicles in the video. The last count shows the accuracy obtained for every video given as input to the system. As can be seen from the results above that the system on an average gives accuracy of 95.4%.

VI. CONCLUSION AND FUTURE SCOPE

This paper proposes a new design to improve the traffic issues in the city. By using big data techniques the traffic management system's response time can be improved to a great extent. Also this system is more cost-efficient as it requires only one time installation cost of the CCTV cameras and the maintenance cost is also negligible. Thus by making the traffic management system more dynamic this system tries to reduce the waiting time of vehicles, reduces traffic congestion and also controls air pollution.
The proposed system encounters only the traffic management problem. For future prospects this system can also be used for prediction of traffic by determining the vehicle count on all the days of the week. The data obtained can be given to a predictor to predict the vehicle count for the next week. This prediction could be forecast to the citizens for them to find alternate routes in case of emergencies.

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