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Application of Image Processing and Data Mining Techniques for Traffic Density Estimation and Prediction

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***Abstract*—** Most of the common problems encounter by the today's world is traffic congestion. As populations as well as number of vehicles are increasing in the cities and towns, traffic congestion has become a major problem for the time being. Delays, fuel consumption and air pollutions are some of the problems arise from traffic congestion. There are many reasons for traffic congestion like narrow roads, lack of alternate route, slow traffic speed, improper uses of traffic signals etc. In this paper, we proposed a system to overcome some these problems by providing an alternate route for the vehicles by predicting a possible congestion ahead of that road.

***Keywords*—** Traffic congestion, Traffic density, vehicle count, vehicle speed, background subtraction, frame, Artificial neural network (ANN), Epoch

I. INTRODUCTION

Traffic congestion is a critical problem which happens on roads and makes traffic busy. This is a very frustrating event that we encounter in our everyday life while travelling on roads. Traffic congestion cannot be eliminating only through build bridges, flyovers or increase road capacity. It is necessary to control traffic sequence with intelligent system for transportation management [10]. An intelligent transport management system can measure congestion using some measureable parameters so that this calculated congestion can be used to manage traffic for smooth traffic flow. Traffic speed and traffic density are commonly used parameters for measure congestion. Traffic speed is referring to the average speed of all the vehicles at an instance of time. Traffic density is known as total number of vehicle at a given length of the road [1].

In this paper, we propose a system for measure average speed and traffic density from camera in real time. Here we use computer vision techniques for measuring the parameters. We processed frame by frame [12] for counting vehicle and measure speed for each vehicle then we convert individual speed into average speed. We use background subtraction method for detection of individual vehicle. Artificial Neural Network (ANN) machine learning technique is used here for prediction and estimation of traffic density.

II. PROBLEM STATEMENT

The intelligent transportation system use by road traffic controller should aim to provide free flow of traffic without congestion and the movement should optimal and efficient in terms of time and money. But unfortunately traffic congestion is the biggest problem of the Indian cities. And major reasons for this are inadequate capacity of roads, incomplete information regarding traffic, inefficient transportation management. Rise in the population is also a reason for traffic congestion. According to the Quartz article (published 18th April 2018, travelers in India's biggest cities spend 1.5 hours more on their daily commuters than other Asian cities, causing them to lose up to $22 billion annually on accounts of delays and additional fuel consumption due to poor road condition and frequent halts [9]. According to the estimates, the cost of delays was $6.6 billion per year and the cost of additional fuel consumption due to delay was $14.7 billion per year.

By using complete information regarding traffic data such as total number vehicles and speed of vehicles, we can predict and estimate future state of a road segment and we also can provide an alternate route to the vehicles in that road segment if there will be possible traffic congestion in the near future.
For our work, we have collected dataset from National Roads Authority of Ireland official website (*https://web.nra.ie/CurrentTrafficCounterData/).* The collected data was from the Castleblaney Road in

Castleblaney town, Ireland from 1st January 2013 to 7th February 2013.

III. RELATED STUDY

The literature review covers some of the popular studies in the area of the traffic parameters calculation and prediction. First part of this review contains the studies of traffic parameters calculation using various types of methods. Second part covers the studies in the area of data mining and other means of methods for estimation and prediction traffic density.

S. Sri Harsha et al. [2] and Pejman Niksaz [3], discussed an image processing based solution for detection, counting and classification of vehicles from traffic video. Both of them used background subtraction technique for detection of vehicles and used threshold value for classification of vehicles. Alisha Janrao et al. [4], also used image based solution and background subtraction method for detection and counting of vehicles from traffic video. But they used Raspberry Pi as their control unit for control traffic signal. They synchronized traffic signals based on number of vehicles in an instance of time. Xi Yong et al. [6], they combine Haar features and Pairwise Geometrical Histogram (PGH) to detect vehicles. They use Haar features to detect the ROIs and then use an adaptive threshold to convert the ROIs into binary images. After that they use these binary images to make the PGH. In the next step they compute differences of the contours and if the average difference is below a pre-defined threshold value then the ROI is identifying as a vehicle. Kasmiran bin Jumari et al. [7], has proposed a technique to calculate speed of vehicles from traffic video. They have determined speed by detecting the front edge of a particular vehicle in two video frames of known interval. Speed is calculated by the distance travel between two frames and the time interval between two frames.

Till now we are see some methods for detecting, tracking and counting number of vehicles and speed of vehicles. Now we discuss how to estimate and predict traffic density using various methods (although we will be focused on data mining).

Jithin Raj et al. [1], proposed an ATIS system under Indian traffic condition. They addressed the problem of estimation or prediction of traffic density with the help of location based sensors. These sensors are capable of measuring parameters such as volume and TMS. After that they had analyzed the traffic parameters with ANN and KNN separately and at last combined both the machine learning techniques for estimation and prediction of traffic density. XuLuhang [5], analyzed how the data mining algorithms such as time series data mining algorithm and clustering algorithm applied to the problem of dealing with traffic flow. Sachin Kumar et al. [8], proposed a framework that used K-modes clustering algorithm for segmenting road accident dataset of road network and association rule mining algorithm to identify the various circumstances that are associated with the occurrence of a road accident for both the entire dataset and the clusters identified by K-modes clustering algorithm. Then the result of cluster based analysis and entire data set analysis are compared. After that a trend analysis is also done on monthly and hourly datasets.

IV. PROPOSED SOLUTION

To simplify the problem, we divide the problem into three distinct categories. In the first phase, image processing task is done such as detection and tracking of vehicles, vehicle counting and speed of vehicle. In the second phase, Artificial Neural Network (ANN) machine learning algorithm is use to estimate or predict the traffic volume or density. This calculated or predicted traffic density is use to find the state of a road segment. In the third phase, validation of the system is check.

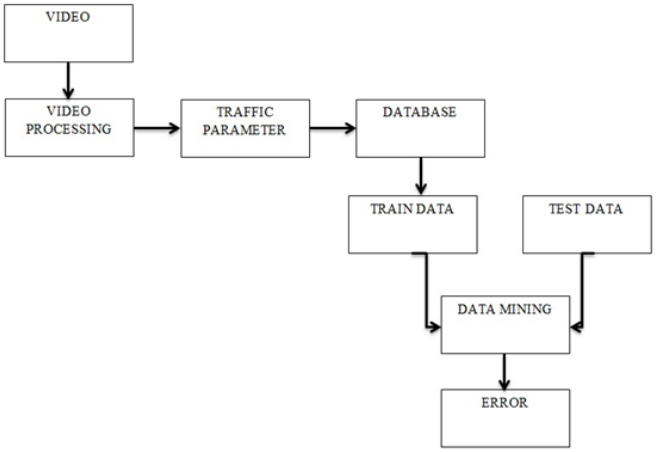

Figure 1. *System Architecture.*

First Phase:

In this phase main concern is to find individual vehicle speed and total number of vehicle passes under the camera.

Procedures are shown in Fig. 2. For that first step is extraction of each frame from the video. Then some lower level processing i.e. pre-processing is applied. Pre-processing operations include resize each frame for increase the processing speed, gray scale conversion and Gaussian blur for smoothen and reduce noise at the first level from the frame.

Background/Foreground segmentation algorithm is used for separate foreground and background objects. Shadow detection and elimination is also done here. Morphological operations are used for better foreground objects. In morphological operation we need two inputs, the binary image and structuring element or kernel. Here we use two

kernels both are elliptical but with different sizes and both of them are used in different operations. Then contours for foreground objects in each frame are using for track each vehicle in the video. These tracked contours are used for calculate speed of the vehicle and count of vehicle.

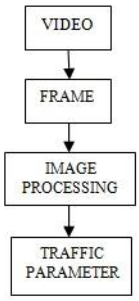

Figure 2. *Block Diagram of First phase.*

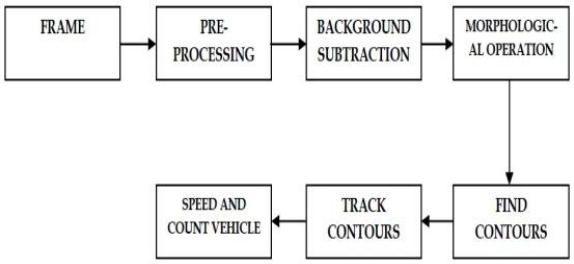

Figure 3. *Methods used in image processing.*

Second Phase:

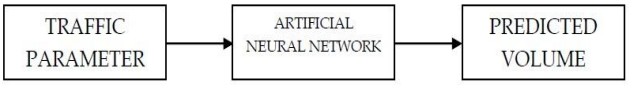

Figure 4. *Block Diagram of Data Mining.*

In this phase volume estimation and prediction process is carry out. Procedures are shown in Fig. 4. For this artificial neural network is use. In the neural network the network has four layers. Four layers are an input layer which have two neurons for two input variables, two hidden layers, one of them use four neurons and another use five neurons and an output layer which has one neuron. Rectified linear unit is use for activation function in input and hidden layers and linear activation function is use in output layer. At first weights for each of the connection in the network are randomly selected, when the calculations are start weights are adjusted so that a desire result will be obtained.

Third Phase:

In this phase validation of the system is check. Error in the model is evaluated using the statistical measure Mean Absolute Percentage Error (MAPE), given by the following equation [11]:

$$\text{MAPE} = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

Where, A_t is the real or actual values, F_t is predicted or forecast value and n is the number of fitted points

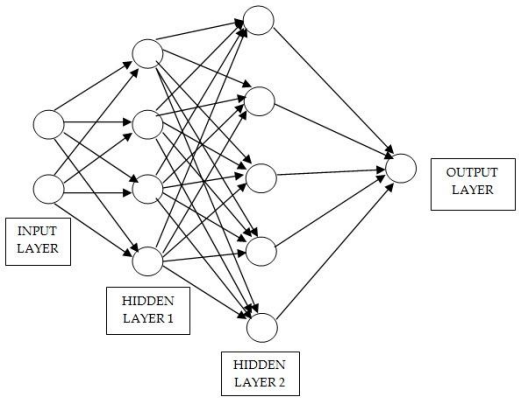

Figure 5. *Artificial neural network (ANN) diagram.*

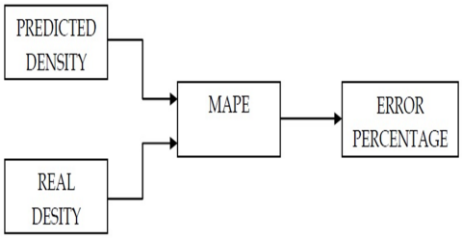

Figure 6. *System Validation Block Diagram.*

V. RESULT AND DISCUSSION

We have built the Image processing model for extraction of vehicle count and average speed of the vehicles at a constant time. Speed was measure in pixels per second.

Table-1: Vehicle count and avg. speed.

Vehicle Count	Avg. Speed(pixel/sec)
8	344.3511
8	236.2883
9	80.3526
7	306.7514
7	178.9181
8	119.7665
11	200.5078
7	155.3872
7	213.5526

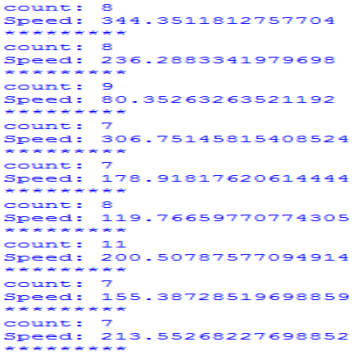

Figure 7. *Vehicle count and average speed of vehicle for 10 seconds interval.*

For the data mining part, we have used processed data from National Roads Authority of Ireland as we do not have sufficient amount of traffic video. Results for the data mining part are given below

We have shown some test case for our neural network model. Here Epoch is defined as the number of time the predicting algorithm runs and each time the predicting value is updated with some value that is calculated by the algorithm each time the algorithm runs.

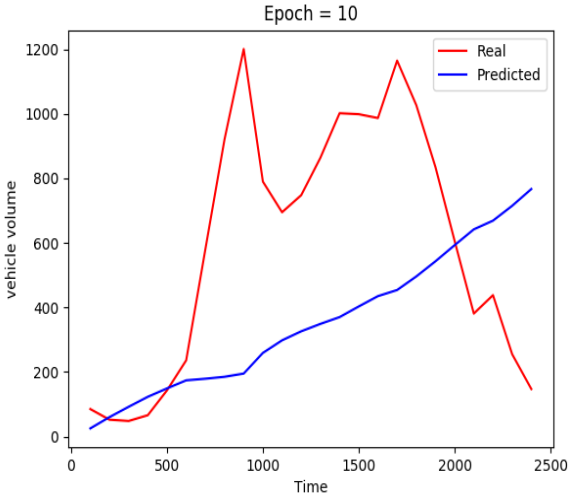

Figure 8. *Graph of real and predicted vehicle count for epoch = 10.*

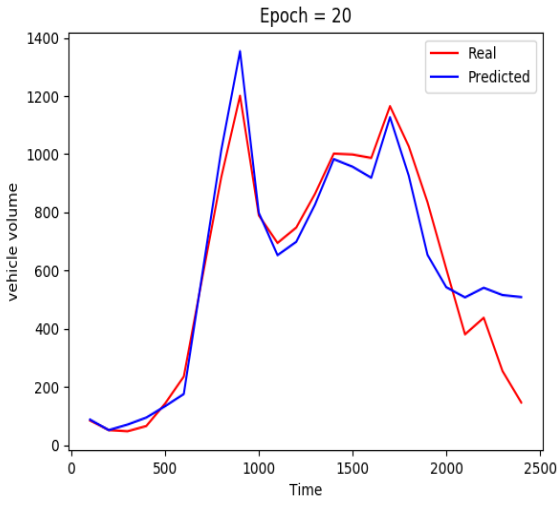

Figure 9. *Graph of real and predicted vehicle count for epoch = 20.*

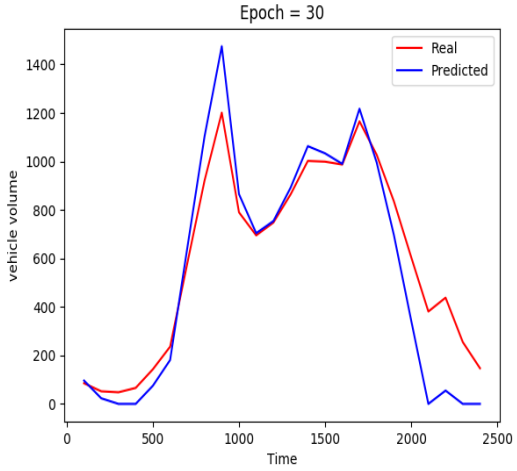

Figure 10. *Graph of real and predicted vehicle count for epoch = 30.*

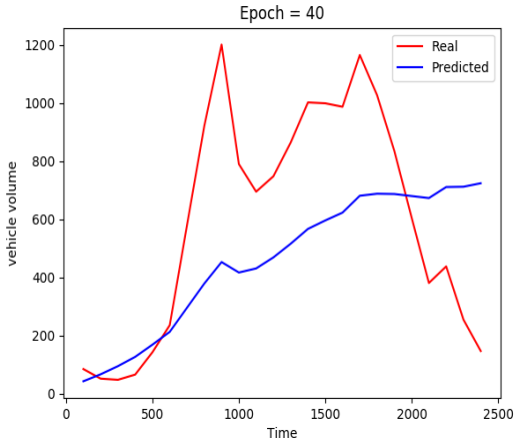

Figure 11. *Graph of real and predicted vehicle count for epoch = 40.*

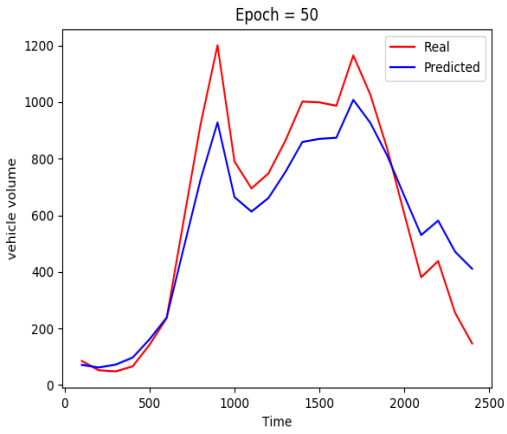

Figure 12. *Graph of real and predicted vehicle count for epoch = 50.*

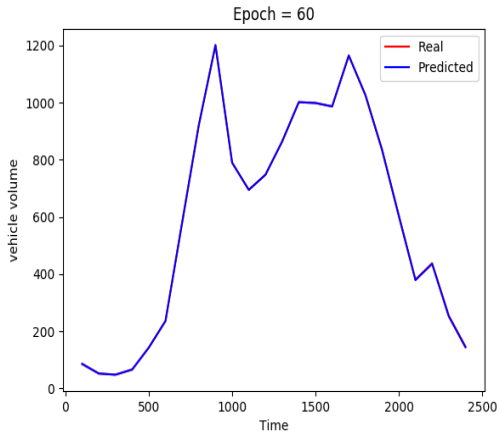

Figure 13. *Graph of real and predicted vehicle count for epoch = 60.*

For checking the model accuracy, we have calculated average error for 10 test cases. Average errors for the test cases are shown in the table below:

Table-2: Average error for 10 Test cases.

Epoch	Average Error
10	75.86487
20	26.557573
30	36.11237
40	65.362816
50	28.102245
60	0.46090466
70	1.1324096
80	1.0607804
90	0.03431835
100	0.2752794

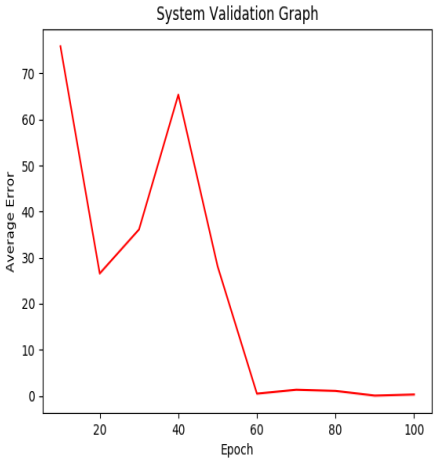

Figure 14. *System Validation Graph.*

From the system validation graph we have seen that as the epochs increase the average error of the model is decrease and the prediction is also become more accurate.

VI. Conclusion And Future Work

In this paper, we propose a system for calculate traffic vehicle count and vehicle speed from traffic surveillance video using image processing and we also propose a model for predict future trend in traffic using artificial neural network. We use background subtraction method for extracting foreground objects from the video frames then we find centroids for each of the foreground objects in each frame and use these centroids for tracking each vehicle in the video. These tracked foreground objects are used to measure vehicle count and vehicle speed.

From the validation we had found that as the number of iteration or epochs increase the system will predict more accurate traffic volume or density value.

In our future work we will build our own dataset with our system to predict the traffic volume value and to use this predicted value to find alternate route if there will be high congestion.

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