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Best Route Selection for Automobile Traffic Congestion Using Android App

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Abstract- Vehicle detection and classification of routes based on traffic congestion has a vital role in improving traffic conditions and fuel conservation, an important research area in Intelligent Transport Systems. This paper utilizes Image processing techniques for solving the traffic congestion problem. A real-time traffic monitoring system is developed to guide the driver on the less-congested route. The approach is based on real-time video input from a camera placed at a higher location on the road. The density of the traffic and average vehicle's speed is calculated using image processing techniques on the Image frames captured from the video. Based on the combination of traffic speed and density, routes are assigned different traffic congestion levels and the routing decision is taken. In addition, an android based application is also developed to guide the driver on choosing the less-congested route.

Keywords- Traffic density, traffic speed, Graying edge detection, dilation, Bounding box extraction, morphological filter.

I. Introduction

Traffic congestion is a state when vehicles travel at a slower speed because there are more vehicles than the road's capacity. This results in a longer trip time and increased car queuing. For many stakeholders, traffic congestion is a very serious problem. Along with creating anguish to those who need to reach their destination on time, it also causes excessive fuel consumption and atmospheric pollution. In recent years, more business opportunities and resulting economic growth of the society has improved the lifestyle of the people as well as purchase power. Most families have now more than one car, resulting in more traffic. Congestion problems can be solved by developing a traffic information system that can provide the latest information on congestion levels in any part of the region. This information can guide a driver to choose the least congested path. A prominent example is live surveillance camera footage that can be retrieved through the internet. Although the latest traffic conditions can be known from video streaming the traffic on every road, this system is designed for humans and it is not machine-friendly. Crowdsourcing is another method for traffic monitoring systems [1], which lets users know about the vehicles speed and location via mobile devices. This system simultaneously provides information to all users about the traffic levels in different areas.

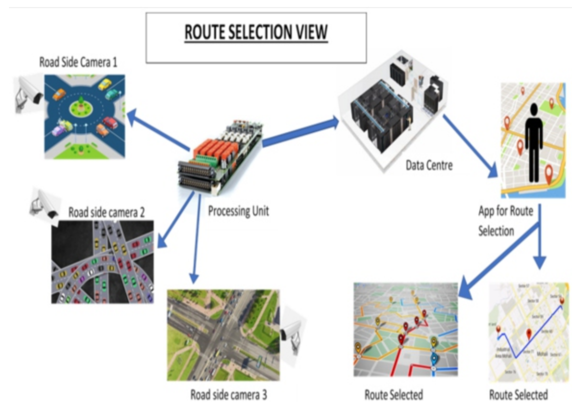

Figure 1: Context of traffic route-selection approach using image processing

This paper presents our approach that automatically recognizes the less-congested route from video streaming. Assuming a fixed camera and predefined road segment to monitor, our system is capable of estimating accurate traffic density and traffic speed. This helps in classifying routes based on traffic congestion levels. The context of our work is represented in Figure 1.

II. Related Work

To describe the condition of road traffic, traffic engineers often use parameters such as Density, Speed, Flow and Headway [2]. A number of earlier researches have focused on developing methods for determining traffic parameters. In [3], monitoring of a real-time system is proposed, which monitors the number of vehicles crossing a road segment. This task is performed by the system in two stages:

1. Recognition: In this stage, a background model is created which distinguish vehicles.

2. Tracking: By using the centroid algorithm the object tracking is performed.

In Chen et al. [4], traffic congestion and counting are presented. This paper developed a real-time vision based vehicle classification and counting system which includes establishing Time-Spatial Images (TSI) from input video, use the Support Vector Machine (SVM) and deterministic non model-based approach for removing shadows from the image, using morphology process to detect the region of interest (ROI), and finally processing occlusions using ROI accumulative curve method and Fuzzy Constraints Satisfaction Propagation (FCSP) and carry out classification of the vehicles and counting system. In this paper, at heavy traffic flow on small vehicles, the limitation occurred due to occlusion phenomenon.

In publication [5], a real time surveillance is used to monitor the volume of vehicles on a crowded highway and to detect the vehicles using virtual line graph, ranking of vehicle, and the number of vehicles that are present on the crowded highway. This publication proposed that detection of vehicles, classification and tracking of vehicles are performed in seven stages. (1) The highway is detected determining the correct boundary area for visual analysis. (2) An optimal virtual line is chosen, from the correct highway area. (3) Lanes are detected and their number determined. Lanes location and the vector of traffic motion is also determined. (4) This stage is a virtual line analyzer, which graphically represents the virtual line segments over time to identify the static background and eliminate them. (5) This stage shows the detection of the vehicle, indicating potential vehicles when they cross the virtual line. (6) This stage is the qualification of the vehicle, which determines the characteristics such as size and color. Stage (7) is a vehicle tracker, which tracks a single vehicle as they move through the video. Limitation in this publication is owing to errors of automatic counting of vehicles which is due to large trucks, long shadows, obstructed vehicles, and tailgating vehicles.

In [6], the authors recommend a system that uses standard GPS-assisted guidance through peer-to-peer wireless communication. The proposed system uses a combination of clustering and large-scale communication to find and spread dynamic traffic patterns.

In [7], the authors present the monitoring of traffic congestion intelligently and Measurement of System called a measurement of road traffic congestion and monitoring of traffic using vehicle whose examination is underway. To analyze the congestion pattern and movement of traffic this system offers a comfortable platform. This system uses Radio Frequency Identification (RFID) and Global Positioning System (GPS) to monitor and measure the traffic congestion.

Swaroop et al. [8] discuss the detection of traffic congestion in bad road conditions by using a low cost intelligent transport system techniques (ITS). This technique is based on exploiting variations of wireless connection functionality when there is a discrepancy between the wireless sender and the recipient view. This system consists of a one-way wireless sender and recipient. Sender sends the packet continuously and the receiver measure the strength of signal, quality of link and packet reception.

Ashlesh et al. [9] introduced a method for detection of congestion levels in traffic generated automated image processing mechanisms using CCTV cameras. This algorithm is specially designed for each traffic flow with low image quality. The CCTV cameras are fixed on the congested traffic road to show the live videos of each traffic road from multiple locations.

In [10], a new cooperative technique based on vehicle to vehicle communication, called Cooperative traffic congestion, is proposed that facilitates road traffic congestion. In this scenario, there is no need to deploy infrastructure sensors for detection. The proposed scheme is also able to accurately detect the severity and length of traffic congestion.

Some other related works on smart traffic management systems are [16, 17, 18]. In [16], the authors proposed a framework for smart traffic system based on cloud computing. Their approach uses data processing and intelligent decision systems using artificial neural networks. Similarly, [17. 18] have also utilized cloud computing for smart traffic management systems.

III. Proposed Approach

The monitoring of our traffic system is based on video input which is taken from a camera fixed at a higher location on a pole, facing one-way flow. Two parameters are used to detect the systems congestion level on different routes: (1) Density of traffic which measures road occupancy level. (2) Speed of traffic measures the average vehicle's speed. The overall methodology of our approach is depicted in Figure 2.

The Camera will be fixed at top of the road such that there is no tilting and panning movement and it will monitor the fixed road segment. Two parameters are related to the camera: (1) Mask of the road segment (2) Mask dimensions. Mask of the road segment is a convex quadrilateral. The length of the longer sides of the mask represents the length of the road while that of the shorter sides, its width. The mask dimension directly depends on road dimensions which are given below.

$$Roadwidth \propto Maskwidth, \quad Roadlength \propto Masklength$$

A. Traffic Density

After fixing the camera on the road, we apply road mask to the road segment image frame that contains images of vehicles in real-time.

Road segment image frames are converted to black-and-white, constituting shades of grey varying from black at the weakest intensity to white at the strongest intensity. The transformation of RGB to a grey image is to calculate the pixel value of grey image for all three components R, G and B [11].

$$I = \alpha . R + \beta . G + \gamma . B$$

Where α, β, γ are the weighted values of R, G and B respectively.

1. Edge Detection

Edge detection is an image processing technique used to find object boundaries in an image frame. For this purpose, we use a Sobel edge detection algorithm [12], which uses two masks one for estimating gradient in x direction of the road segment and other for estimating the gradient in its y-direction. The mask is scrolled on the road segment box by manipulating one square of pixels at a time. The gradient of image intensity at each point is calculated by using an algorithm and then finding angle provides the direction to increase the intensity of the image from light to dark.

$$|G| = \sqrt{Gx^2 + Gy^2} \tag{1}$$

$$|G| = |\, Gx \,| + |\, Gy \,| \tag{2}$$

$$\theta = \arctan\left(\frac{Gy}{Gx}\right) \tag{3}$$

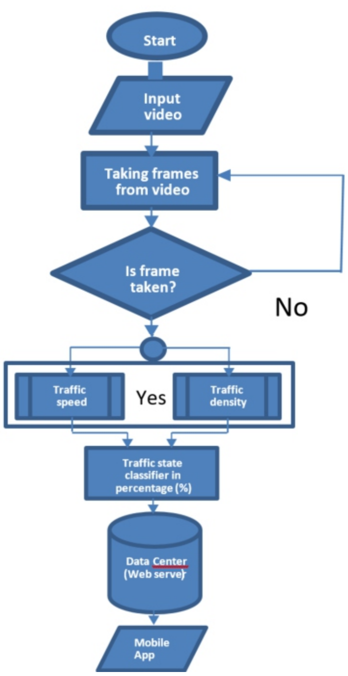

Figure 2: System model and flow chart

2. Dilation

Dilation is a morphological operation used for closing disconnected edges. This process will create a number of blobs for vehicles in the image.

The blob created for each vehicle is not perfectly filled and there are some holes left between in each blob. All empty holes except those that are connected to image boundaries are filled using flood fill operation.

3. Calculation of traffic density

The pseudo code for the calculation of traffic density is listed in Listing 1. The total area occupied by the blobs representing vehicles in an image segment, is calculated. The total area of the image frame is also calculated. The traffic density is calculated at a spot where the camera is fixed by dividing total area of all blobs by area of the whole image frame. Similarly, we can determine traffic density at different spots of the same road and find the average traffic density of all spots to find the overall traffic density of certain roads.

```
Procedure Traffic Density
V→ Read video
N→ Getting number of frames from V
R1→ Reference frame
R2→ Random selected frame
A_B→ Area of blobs
A_F→ Area of frame
D→ Density
For each frame I є N Do
    If I == R2 Then
    SR=R1-R2
    SR ← rgb2gray
        If SR==True Then
        Edge detection ↔ by sobel filter
            If edge detection==True then
            Image Dilation ↔ type Line
                If image Dilation==True Then
                Filling image ↔ type holes
                End if
            End if
        End if
    End if
    A_B→ finding area of filling image
    R1→ rgb2gray
    A_F→ finding area of R1
End for
D→ A_B divide by A_F
    End procedure
```

Listing 1: Pseudocode for traffic density

B. Traffic Speed

In traffic speed calculation, we address the problem of estimating the vehicle speed using very simple, concise and effective software written in MATLAB environment. A new approach is presented for extracting vehicular speed information, i.e., given a traffic video that is taken using MATLAB to capture the images of the road when the vehicle passes through and the images are then processed by the program.

First, we record the video and then take a reference frame to compare successive images of the continuous video with reference frame to extract various features as shown in Figure 3.

To find the traffic speed, bounding box extraction [13] is one of the methods used to filter out the area of interest in image or video. In Figure 4, bounding box extraction can be seen. The image is then converted into black and white of binary image in which each pixel takes normalized intensity value that lies in the range [0, 1] as shown in Figure 5.

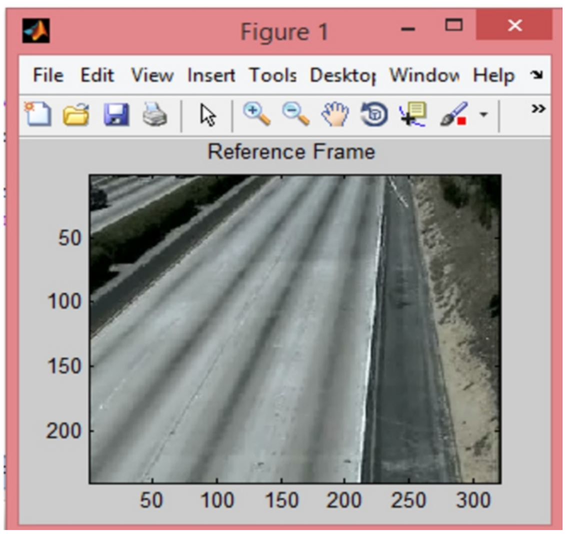

Figure 3: Reference frame

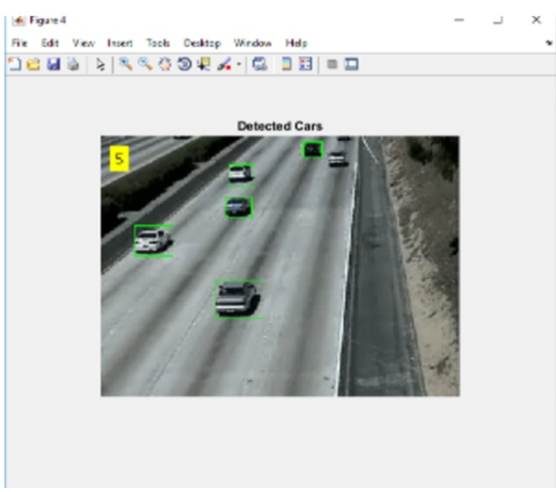

Figure 4: Bounding Box

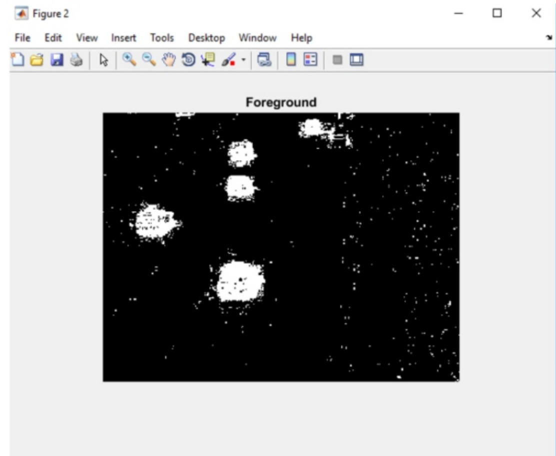

Figure 5: Converting into black & white

Md. Motiur Rahman et al. [14] propose an algorithm which adopted median to check whether PE and SE are corresponding image pixel or not.

From binary image remove salt-and-pepper noise which are unwanted pixel spots that may be seen occasionally on the image. Standard median filter (SMF) [15] and morphological filter are used for removing salt-and-pepper noise. In morphological filter a sliding window of size (2L+2) x (2L+1) centered at *lx,y* is defined in Table 2.

Table 1: Morphological filter

Ii-1, j-1	Ii-1, j	Ii-1, j+1
Ii, j-1	Ii, j	Ii, j+1
Ii+1, j-1	Ii+1, j	Ii+1, j+1

Bad or defective pixels are eliminated with high and low grey values using the following set of equations.

$$PE = \begin{cases} 3 \qquad\qquad 3 \\ \forall \quad \forall Max(I_{ij} \cup I_{ji}) \\ i=1 \qquad j=1 \end{cases} \tag{4}$$

$$SE = \begin{cases} 3 \qquad\qquad 3 \\ \forall \quad \forall Min(I_{ij} \cup I_{ji}) \\ i=1 \qquad j=1 \end{cases} \tag{5}$$

The optimal equation (4) eliminate pixel which is corrupted by high intensity value (white noise), while equation (5) calculate all rows and columns to a minimum, eliminating the pixels that are corrupted by low intensity (pepper noise).

To find the distance, the position of one pixel (*x1, y1*) in the first frame and second pixel in other frame (*x2, y2*) are noted and put into equation (6).

$$D = \sqrt{(x_2 - x_1)^2 - (y_2 - y_1)^2} \tag{6}$$

The displacement multiplies by the total number of frames which gives us the whole displacement then divides this displacement by total time of the video to give displacement covered in total time which is nothing but the speed of the object.

$$S = D/T \tag{7}$$

```
Procedure Speed Estimator
S → Speed
V → Read video
D → Distance
N → Getting frames from V
RF → Reference frame
NcF → Next coming frame
while I ϵ N Then
  RF → getting reference frame from V
Read entire video
end while
for each frame I ϵ N
NcF → getting next frame
if I == NcF Then
SB = RF-NcF
SB ← convert2binary
        if SB convert2binary == True Then
        SB ← Labeling
        if SB labeling True Then
        SB ← Regionprops
        if SB regionprops == True Then
         BB ← Bounding box
         X (I) = BB (1)
         Y (I) = BB (2)
         if SB bounding box == True Then
         D ← finding distance
         if D > 10 && D < 20
         Display ← Medium Speed
          else if D < 10
 Display ← Slow Speed
                 else
                  Display ← Fast Speed
                  end if
                  end if
                 end if
     end if
    end if
  end if
 end for
S ← divide by Time (Number of frames)
End procedure
```

Listing 2: Pseudo Code of Traffic Speed:

IV. Results and Discussion

This section discusses the results obtained from the two algorithms (listed in Listing 1 and 2) and design of the web page and android application.

A. Results of Traffic Density Algorithm

Traffic data from four different spots of the same road at different times is processed through our proposed algorithm the results shown in Table 2 and MALAB Figure 6.

Table 2: Traffic density values at four spots

Time	Spot 1	Spot 2	Spot 3	Spot 4	Avg density	Avg %
7am	0.6	0.55	0.68	0.75	0.645	64.5
8am	0.8	0.9	0.6	0.8	0.775	77.5
10am	0.31	0.23	0.28	0.39	0.303	30.25
11am	0.3	0.24	0.25	0.4	0.298	29.75
12am	0.45	0.84	0.67	0.57	0.633	63.25
1pm	0.6	0.65	0.88	0.9	0.758	75.75
2pm	0.7	0.82	0.5	0.68	0.675	67.5
4pm	0.2	0.22	0.2	0.35	0.243	24.25

It is evident from the table that the values of traffic density are different for different spots. At 7:00 am traffic densities calculated by our proposed algorithm at four different spots are higher and the highest traffic density is recorded at spot 4 which is 0.75. The values of traffic density at four different spots are averaged and the result is 0.645 or 64.5% at 7am. At 8am the values of traffic density at four different spots of same road slightly increase which also increases average value and percentage of traffic density to 77.5%.

At 10am to 11am our proposed algorithm calculated smaller values of traffic density at four different spots and the average percentage of traffic density is 30.25% and 29.75% respectively. Again, the values of traffic density at four different spots increases which also increases average values and percentage of traffic density between 12 noon and 1pm.

The bar graph and MATLAB graph shown in Figures 7 and 8 show the average value of traffic density of certain road at different times. It is obvious from both graphs that traffic is higher at 7am and it is highly congested at 8am. Between 9am and 10am the average traffic percentage decreases and this value slightly increases at 11am. The average traffic density value reaches its peak value at 12noon showing high traffic congestion on road. At 4 pm the road becomes less congested and the value of average traffic density decreases.

B. Results of Speed Calculation Algorithm

Real time traffic data from four different spots of the

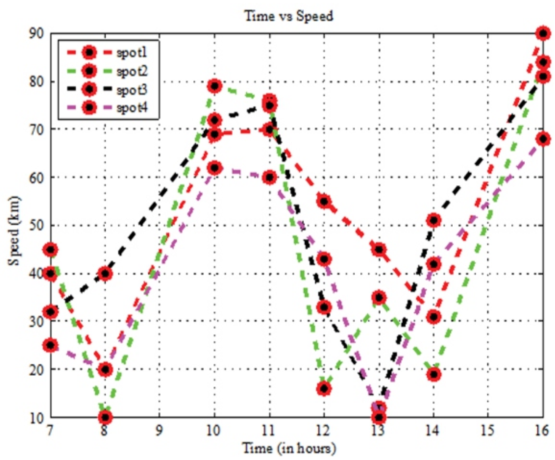

Figure 6: MATLAB Graph for Traffic density values at four spots

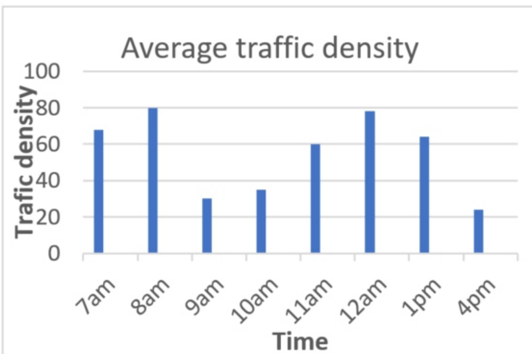

Figure 7: Bar graph of average traffic density of road at different timing

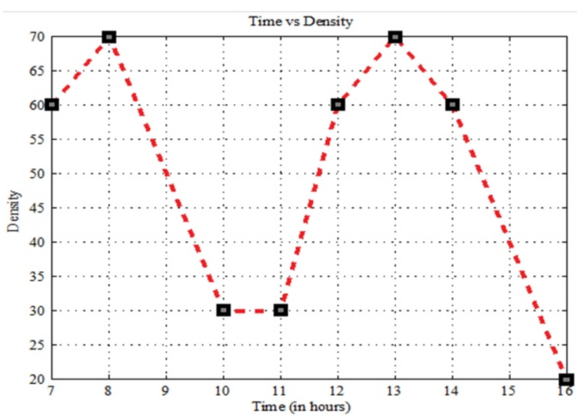

Figure 8: MATLAB Graph for average traffic density of road at different timings

same road is processed through our proposed algorithm which gives the speed of traffic at a certain spot as shown in table 3 and MATLAB Figure 9. It is obvious from Table 3 that at 7am speed of traffic at all four spots is smaller and lies in the range of 25 km/hr to 40km/hr and the average traffic speed of the road is 35.5km/hr. At 8am traffic speed at all four spots decreases which also reduce the average traffic speed of road which is recorded 22.5km/hr by our proposed algorithm.

At 10am traffic speed at four spot starts increasing, the calculated traffic speed of all four spots are 69km/hr, 79km/hr, 72km/hr and 62km/hr giving the average value of 70.5km/hr traffic speed of the road. At 11am traffic speed at all four spots slightly increases which also increase the average traffic speed of the road. Between 12 noon and 2pm traffic speed at all four spots and average traffic speed of road goes down and the calculated average traffic speed of traffic lies in the range of 25.5km/hr to 36.75km/hr. At 4pm the highest traffic speed recorded at all four spots and hence the average traffic speed of the road is 80.75km/hr.

Table 3: Traffic speed values at four spots

Timing	*Spot1*	*Spot2*	*Spot3*	*Spot4*	*Average Speed*
7am	40	45	32	25	35.5
8am	20	10	40	20	22.5
10am	69	79	72	62	70.5
11am	70	76	75	60	70.25
12pm	55	16	33	43	36.75
1pm	45	35	12	10	25.5
2pm	31	19	51	42	35.75
4pm	90	84	81	68	80.75

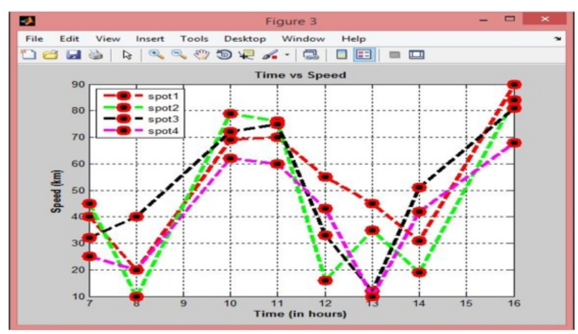

Figure 9: MATLAB Graph for Traffic speed at four spots

The bar graph and MATLAB graph as shown in Figures 10 and 11 show the average traffic speed of the road. It is evident from both the graphs that traffic speed is lower at 7am and has the lowest value at 8am. Then average traffic speed of road reaches the peak value showing less traffic on the road and cars are moving with high speed between 9am and 11am. The value of the average traffic speed of road again goes downward at between 12pm and 2pm showing highly congested state of the road and the cars are moving in lower speed. At 4pm the highest average traffic speed of the road is recorded showing the free movement of cars and there is no sign of congestion.

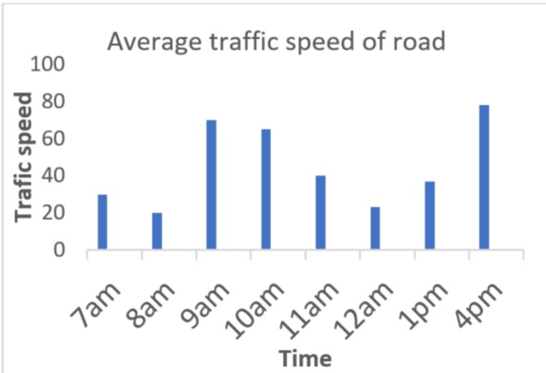

Figure 10: Bar graph of average traffic speed of road at different timing

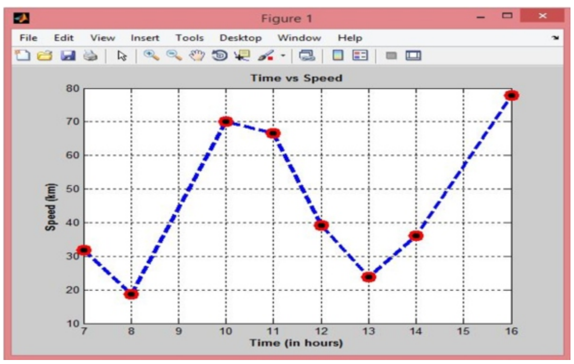

Figure 11: MATLAB graph of average traffic speed of road at different timings

C. Web Page

In this project, a web page is used for connecting the android app and MATLAB, it includes sidebar (dashboard) on the left side of page so that admin or user can add, delete, edit, view the different routes. This page consists of two components Front end and Back end.

The front-end includes everything visible to the user. This is designed using languages like Hypertext Markup Language (HTML), Cascading Style Sheet (CSS) and JavaScript. These languages (HTML, CSS) are the building blocks of web pages. CSS is the presentation of documents that are written in markup language. JavaScript adds powerful interactions to a website but is also the foundation of commonly used libraries like j query and frameworks like AngularJS, ReactJS and NodeJS. Here front end includes User login, add, view and map so that admin can add different roads through Add button by giving its latitude and longitude as shown in Figure 12. Admin can also check the location of the roads by clicking the map on the dashboard and can delete and edit through the view. In the Back-End or Server-side, the site works, updates and changes. It also discusses databases and servers and the people who work on Back-End are called developers and working with programming languages like PHP, Python and .Net.

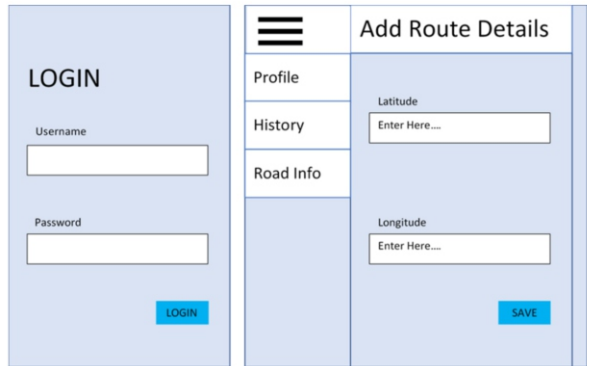

Figure 12: Interface of the web page

D. Android App

Android is the world's most popular and open-source operating system based on Linux kernel (depend on different devices). It runs on various varieties of hardware devices including smartphones, tablets, smart watches, televisions, cars, digital cameras and make human life easy.

Table 4: Traffic speed values at four spots

S.NO	*Timing*	*Traffic density*	*Traffic speed*	*Traffic state classifier*
1	7am	64.5	35.5	Medium
2	8am	77.5	22.5	Slow
3	10am	30.25	70.5	Medium
4	11am	29.75	70.25	High
5	12am	63.25	36.75	Medium
6	1pm	75.75	25.5	Slow
7	2pm	67.5	35.75	Medium
8	4pm	24.25	80.75	High

In order to facilitate people for selection of road in case of high traffic before joining it. For this reason, we developd an android application which uses the Google map interface and acquiring the road name, latitude, longitude and traffic percentage (%) from web server as input, then showing all these on mobile app as depicted in Figure 13.

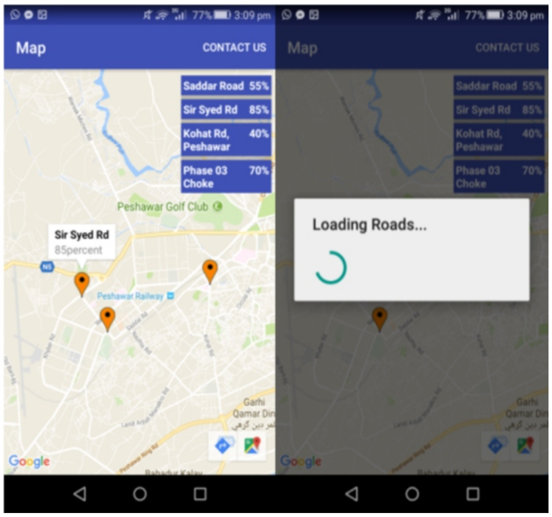

Figure 13: View and map interface

V. Conclusion and Future Work

In this paper, we have developed a solution for monitoring the traffic congestion level in real-time. Our approach is based on Image processing techniques to provide guidance to the driver on selecting the best route, i.e., less-congested. It consists of two phases (1) Calculating the traffic density by taking capturing random image frames from the real-time video of the road and applying edge detection, dilation of image and filling of empty holes (2) Calculating traffic speed via Bounding Box Extraction, Graying and Feature Extraction. Both parameters (traffic density and speed) are used to decide the level of traffic congestion which is further shown to the user via an android app for choosing the less-congested route.

We have tested our approach by performing a number of experiments to collect data at various times of the day where the traffic conditions vary. Also, data is collected by placing the camera at various spots on the road. Our obtained results demonstrate that our developed system can be used effectively facilitate drivers in the selection of less-congested routes with high accuracy.

In future, the current system can be enhanced to implement it for multi0sided road. Also, the feature of calculating time to reach the destination can also be added. The system can further be enhanced to simultaneously process images taken from multiple cameras placed on various roads. This will improve the accuracy of our approach. In addition, machine learning techniques can also be used on the collected data for predicting the traffic conditions at various times of the day.

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