Real –time Traffic light control and Congestion avoidance system:

Sabya sanchi kanojia
Electronics and Communication, Dev Bhoomi Institute of Technology,
Uttrakhand Technical University, Dehradun-0135

ABSTRACT

As the city road network is growing day by day, the question of how to obtain information about the road is becoming more and more challenging. Traffic problems nowadays are increasing because of the growing number of vehicles and the limited resources provided by current infrastructures. This paper presents an automatic road traffic control, monitoring system and an efficient way to avoid traffic congestion for daytime sequences using **Image processing** techniques and wireless communication networks. A camera will be installed alongside the road-side unit /traffic light. It will capture image sequences. According to traffic conditions on the road, traffic light can be controlled. Based on that analysis, system will wirelessly transmit the information (using **ZIGBEE** protocol) of road scene to the nearby Road –side units (RSU) and the message will be displayed there. It can help people by providing pre-knowledge of traffic congestion/jams.

Keywords: communication network, edge detection, Image processing, Road-side unit (RSU), Zigbee.

I. INTRODUCTION

In recent years, traffic congestion has become a significant problem .Traffic congestion and jams are one of the main reasons for increasing transportation costs due to the wasted time and extra fuel.

"Building new roads and lanes are just not possible any longer, but building intelligence into the roads and lanes — with advanced technology— is certainly possible.."

Hence, there is need for a better and efficient traffic congestion system.

With the advances in the technology of microelectromechanical systems (MEMS) and development in Wireless communications .It is possible to design such system to overcome daily problems of traffic congestion. The simplest way for controlling a traffic light uses timer for each phase. Another way is to use electronic sensors in order to detect vehicles, and produce signal that cycles. We propose a system for controlling the traffic light by image processing. The system will detect vehicles through images.

- Real time traffic light control.
- Automatic traffic monitoring.
- Detection of traffic density.
- Setting up a Road network.
- Reduce traffic congestion.
- In case of traffic jams, system wirelessly transmits the info to nearest monitoring center or Road-side unit using ZIGBEE module.

In this system we don't try to detect each individual vehicle and then to estimate its velocity,but instead of that we model a traffic flow on the road segment and thus derive directly the required traffic parameters from the data. Thus our traffic congestion detection method is based on the combination of various techniques: change detection, image processing and incorporation of prior information such as traffic model and road network. The change detection in two images with a short time lag is implemented using Canny edge detection method.

II. EXPERIMENTS AND METHODOLOGY:

2.1System design for present work:

- The traffic light is connected to a Road-side unit (RSU).
- This unit consists of a camera and a microcontroller based system .
- Communication Network.

2.2Software module used:

- MATLAB version 7.8 as image processing software comprising of specialized modules that perform specific task has been used.

- AVRstudio 4 software is used for programming of microcontroller based system**.**

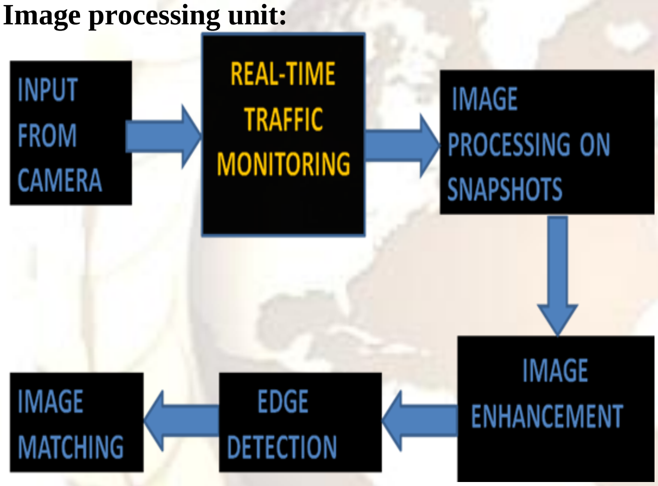
2.3Methodology :

- Capture of real time videos.
- Image acquisition on snapshots.
- Image enhancement.
- Image matching using edge detection.
- With the help of communication network a pre-knowledge of jams can be provided.

2.4Procedure:

There are three phases for designing and development of this system. Phase 1 and Phase 2 gives the analysis of road scene .Whereas Phase 3 deals about the transmission of message about road status to nearby road-side unit (RSU).

Image processing unit:



PHASE 1:

First image of the road is captured, when there is no traffic or less traffic on road.This image is saved as reference image at a particular location specified in the program. Now Image Enhancement is done.Edge detection of these enhanced images is done thereafter with the help of Canny edge detection operator.

PHASE 2 :

After edge detection procedure both reference and real-time images are matched and traffic lights can be controlled based on percentage of matching.

2.5 Image enhancement:

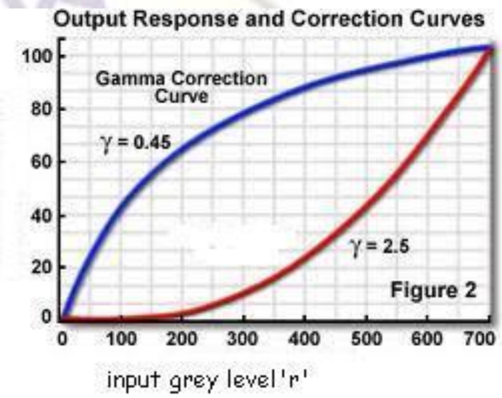
The objective of enhancement is to process an image so that result is more suitable than the original image for the specific application.

'Gamma Correction '(power law transformation) is used in this system to enhance the image. The power law transformations have the basic form:

$$S = cr^{\gamma}$$

Where 'S' is output gray level image, 'r' is input gray level, 'c' and 'γ' are positive constants. For various values of gamma applied on an acquired image we obtained the following graph shown in figure1.

Fig .1



[Source:www.mathworks.in/help/toolbox]

Value 'γ' =1 gives the best results in terms of making fine details identification.

As is evident the fractional values of **'γ'**can not be used since these attempts show a reverse effect of brightening the image which is undesirable for the present case as shown in fig 2,3.

Fig 2.

$\gamma = 0.4$

Fig 3.

γ = 2.5

2.6 Edge detection:
Among the key features of an image i.e. edges, lines, and points, we have used edge in our present work which can be detected from the abrupt change in the gray level. An edge is the border between two different regions.
Edge detection methods locate the pixels in the image that correspond to the edges of the objects seen in the image. The result is a binary image with the detected edge pixels. Common algorithms used are Sobel, Canny, Prewitt and Laplacian operators of MATLAB.

In this system we are using Canny edge detection. The Canny method finds edges by looking for local maxima of the gradient of I(image). The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges.
We have used gradient based Edge Detection that detects the edges by looking for the maximum and minimum in the first derivative of the image.
1. First derivative is used to detect the presence of an edge at a point in an image.
2. Sign of the second derivative is used to determine whether an edge pixel lies on the dark or light side of an edge.
The change in intensity level is measured by the gradient of the image. Since an image f (x, y) is a two dimensional function, its gradient is a vector

$$\begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{df}{dx} \\ \frac{df}{dy} \end{bmatrix} \quad (1)$$

The magnitude of the gradient is given by:

G [f (x,y)] = √ Gx^2 +Gy^2…(2)

The direction of the gradient is
B(x, y) = tan-' (Gy/G) ……… (3)
Where the angle *B* is measured with respect to the X-axis. Gradient operators compute the change in gray level intensities and also the direction in which the change occurs. This is calculated by the difference in values of the neighboring pixels, i.e., the derivatives along the X-axis and Y-axis. In a two-dimensional image the gradients are approximated by

Gx= f(i+1,j)-f(i,j) ……………(4)
Gy=f(I,j+1) -f(i,j) ……………(5)

Gradient operators require two masks, one to obtain the X-direction gradient and the other to obtain the Y-direction gradient. These two gradients are combined to obtain a vector quantity whose magnitude represents the strength of the edge gradient at a point in the image and whose angle represents the gradient angle.
The Canny method applies two thresholds to the gradient: a high threshold for low edge sensitivity and a low threshold for high edge sensitivity. This helps fill in gaps in the detected edges. If we define A as the source image, and Gx and Gy are two images which at each point contain the horizontal and vertical derivative approximations.

[Source:www.mathworks.com>MATLAB Central]

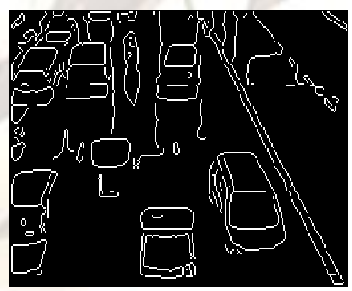


Fig 4. Canny edge detected image:

2.7 Image Matching:

Edge based matching is the process in which two representatives (edge) of the same objects are pared together. Any edge on one image is compared and evaluated against all the edges on the other image. Edge detection of reference and the real time images has been done using Canny operator .Then these edge detected images are matched and accordingly the traffic light durations can be set and on that basis only traffic congestion is avoided.

Fig 5. Reference image

Fig 6. **Real-time image**

Phase 3:

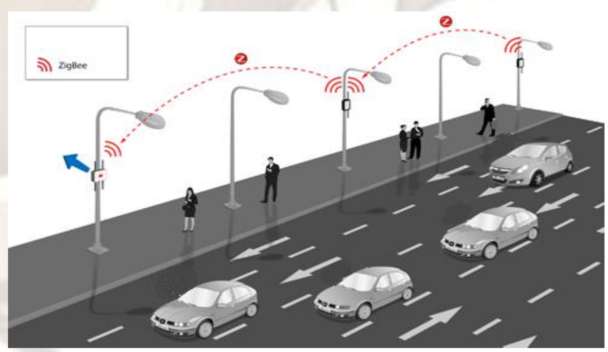
To form a communication network or road network, we have used Zigbee module.. Zigbee makes possible a complete network where all devices are able to communicate and be controlled by a single unit.

ZIGBEE CHARACTERISTICS:
> Low power consumption.
> Maximum data rates allowed for each of these frequency bands are fixed as 250 kbps @2.4 GHz.
>Master/slave topology.
>Automatic network configuration
>Dynamic slave device addressing
>Virtual peer-to-peer links (pairing)
>Full handshaking for packet transfers
>Up to 254 (+ master) network nodes.

Zigbee has high network capacity in a small area using multiple access. Generally, the traffic congestion is configured by enormous and uncertainty amount of terminals.
We use a kind of wireless personal area network IEEE 802.15.4 structuring network communicated enormous amount of terminals. ZigBee has 2^16 network capacities. So, it is able to communicate about 65000 terminals.
However, Terminal interference has problems when congestion network was using ZigBee that any terminals communicated in same timing. Consequently,we apply frequency division multiplex(FDM)to ZigBee for avoiding interference and debasement throughput.
[Source:www.zigbee.org/en/resources]

When image matching percentage is very less, then it means there is heavy traffic,in such case program will activate **ZIGBEE** module through microcontroller and a message will be transmitted to nearby Road-side unit(RSU) or RSUs along the same route. The message can be displayed at that RSU with the help of any displaying device. Message about heavy traffic/ jam on a route can help people to avoid it by rerouting.

Fig. 7 Road network through Zigbee :



III. RESULTS AND DISCUSSION:

Experiments are carried out and depending upon the intensity of the traffic on the road, traffic lights are controlled. According to the percentage of image

matching, traffic density can be analyzed and traffic light can be switch on/off for specific time.
An Example of results for traffic light control:
> Matching between 10 to 50% - green light on for 60 seconds
> Matching between 50 to 70% - green light on for 30 seconds
> Matching between 70 to 90% - green light on for 20 seconds

Same results are used to provide a pre-knowledge about traffic jams/congestion. This system will provide knowledge of traffic on a route and hence people will avoid that route, which will lead to reduction in traffic jams.

The study showed that this system is a better to control the state change of the traffic light. It shows that it can reduce the traffic congestion and avoids the time being wasted by a green light on an empty road. It is also more consistent in detecting vehicle presence because it uses actual traffic images.It is a simple yet effective system to avoid traffic congestion/jams, road accidents and save precious time of people.It is a cost-effective as well as feasible to implement.

This system can be modified (Future work) by adding some more features such as:

- Vehicle number plate detection.
- Detection of speed of vehicles on Road.
- Traffic monitoring at night.
- Uses of better communication system for wirelessly transfer of real-time videos of traffic scene.

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