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Smart Traffic Control System Using Image Processing

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Abstract – *The congestion of the urban traffic is becoming one of critical issues in cities. The number of vehicles is increasing rapidly due increase in population. Increase in vehicles leads to many traffic problems like traffic jams, accidents, time wastage, pollution, health problems and many more. As the problem of urban traffic congestion spreads, there is a need for introduction of advanced technology and equipment to improve the state-of-the-art of traffic control. Various traffic management techniques are used each having its own advantages and disadvantages. 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. In this paper, a system for controlling the traffic light by image processing is proposed. The system will detect vehicles through images instead of using electronic sensors. A camera installed alongside the traffic light will capture image sequences. The image sequence will then be analyzed using digital image processing techniques for vehicle detection, and according to traffic conditions on the road the traffic light are controlled. Use of digital image processing will help in better traffic management and also it is cost effective.*

Key Words: traffic problems, traffic jams, image processing, traffic management

1. INTRODUCTION

India is the second most populous country in the world and is a fast-growing economy. It is seeing terrible road congestion problems in its cities. The various Root Causes of traffic congestion are: bad road conditions, indiscipline of the drivers/motorists, high number of vehicles on roads, lack of knowledge & skill among the drivers.

Infrastructure growth is slow as compared to the growth in number of vehicles, due to space and cost constraints. It is in need of a traffic control solution. Traffic congestion is a very frequent problem on Indian roads and it is all the more prominent in many of our Metro Cities. There have been many surveys which state that Indians waste a lot of time and money travelling through traffic[1]. Mismanagement and Traffic congestion results in long waiting time, loss of fuel and money. It is necessary to have a fast, economical and efficient traffic control system for national development.

Traffic control is a critical element in the safe and efficient operation of any transportation system. Elaborated operational procedures, rules and laws, and physical devices such as signs, markings and lights are few of the components of any traffic control system. Traffic control can be considered initially as a need to control or influence large numbers of vehicles, it is important to realize that traffic is made up of a large number of individual operators who collectively must make consistent decisions in order for the systems to work safely and efficiently.

The operator is the principal decision-making unit in any traffic control system. The operator accepts inputs from a variety of sources, enters into a decision- making process, and determines the appropriate control actions to maintain vehicle operation. The operator receives most immediate and direct information from the vehicle. In addition to visual inputs regarding vehicle status that are provided by instrumentation, the operator receives information through physical sensation of movement like slowing and turning of a vehicle.

In addition to vehicle inputs, the operator's decision making is influenced by the information provided by the guideway and its associated infrastructure. Because infrastructure is man-made, it is one of the places where proper design and procedures provide an important foundation for operating safety.

In the currently available scenarios the traffic control system is based on the timer and sensors. This has got several disadvantages. For example, green light is kept on for a certain period of time irrespective of number of vehicles on the road. In order to overcome this, we have made an attempt to provide a Traffic Management strategy by using Real time image processing, so as to fit into the continuously changing real time traffic scenarios[2,3].

2. LITERATURE SURVEY

Vidya Patil et al [4] developed an intelligent traffic control system. Where, each vehicle is equipped with an RFID tag. When the vehicle comes in the range of RFID reader, it will send the signal to the RFID reader. The RFID reader will track how many vehicles have passed through for a specific period and determine the congestion volume. RFID systems can be easily disrupted. Since RFID systems make use of the electromagnetic spectrum like Wi-Fi networks or cell phones, they are relatively easy to jam using energy at the right frequency. Vismay Pandit et al [5], developed a technique for moving vehicle detection using removal shadow technique in RGB colour space and frame difference technique. In RGB colour space, the luminance and chrominance value are being tuned to

remove shadow. The result shows about75% of shadow can be removed from image moving object detection.

A. Panda Ankita et al [6], proposed a new approach to background subtraction algorithms to extract video objects from a sequence. Rather than working with a fixed, flat background, the system relies on a virtual 3D model of the background that is automatically created and updated using a sequence of images of the environment. Each time an image is captured, the position of the camera is estimated and the corresponding view of the background can be rendered. The subtraction between the frame and the view provides video objects not present in the background. The system works correctly in real environments, over 20 frames per second. It recovers from illumination changes and automatic white balance (AWB) thanks to our background updating algorithm.

Prashant Jadhav et al [7], developed a method for estimating the traffic using Image Processing. This is done by using the camera images captured from the highway and videos taken are converted to the image sequences. Each image is processed separately and the number of cars has been counted. If the number of cars exceeds a specific threshold, warning of heavy traffic will be shown automatically. At first, film of a lane is captured by a camera and images are taken. Then these images are efficiently processed to know the traffic density. According to the processed data from MATLAB, the controller will send the command to the traffic LEDs to show particular time on the signal to manage traffic.

3. METHODOLOGY

The proposed method focuses on reducing the traffic jams that occur on roads, considering a junction which has 4 roads intersecting each other. The flow block diagram of the proposed method is as below.

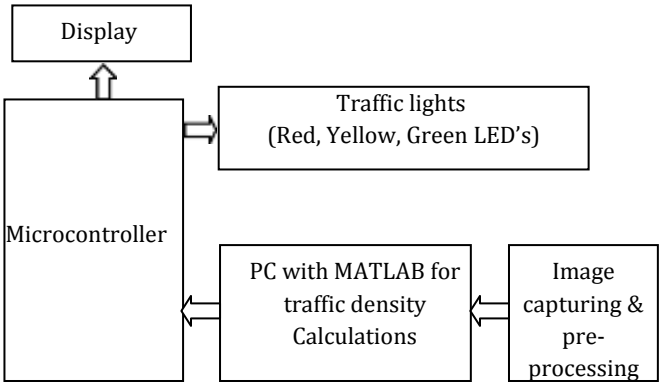

Figure 1: Block diagram of the proposed method

A camera module is used to capture real time footage of the vehicle traffic. High resolution colour camera is mounted near the signals to capture the vehicles on road in each direction. Then the captured images are sent to a computer wherein the Traffic Density is calculated using MATLAB software. MATLAB is preferred because it has so many inbuilt functions also it is a very powerful software for image processing. This makes the image processing work simpler and reduces the coding.

The steps involved in image processing are as follow:

Image Capturing: In this project video is captured and that video is converted into frames (images) to be processed .Video captured is analog and it is captured live from the road or any place with moving object. Video signals those are taken by camera are converted into digital format and then it is stored in storage device.

RGB to grey conversion: the captured colour images are first converted to grey scale, because processing of RGB images takes more time because in RGB images each pixel is represented using 24 bits where as in grey images 8 bits are used for each pixel. The images are converted to grey scale using luminosity method.

Image resizing: the captured images may be of different size due to various camera focusing conditions. to apply a standard and same algorithm for all the images the images are resized to a standard value of 512*512.

Image enhancement: The goals of image enhancement include the improvement of the visibility and perceptibility of the various regions into which an image can be partitioned and the detecting ability of the image features inside these regions.

These goals include tasks such as: cleaning the image from various types of noise; enhancing the contrast among adjacent regions or features; simplifying the image via selective smoothing or elimination of features at certain scales and retaining only features at certain desirable scales. Image enhancement is usually followed by (or is done simultaneously with) detection of features such as edges, peaks, and other geometric features which is of paramount importance in low-level vision.

Background subtraction: Background subtraction, also known as Foreground Detection, is a technique in the fields of image processing and computer vision wherein an image's foreground is extracted for further. Generally an image's regions of interest are objects (humans, cars, text etc.) in its foreground. Background subtraction is a widely used approach for detecting moving objects in videos from static cameras.

The idea in the approach is that of detecting the moving objects from the difference between the current frame and a reference frame, often called "background image", or "background model". Background subtraction is mostly done if the image in question is a part of a video stream.

A motion detection algorithm begins with the segmentation part where foreground or moving objects are segmented from the background. The simplest way to

implement this is to take an image as background and take the frames obtained at the time t, denoted by I(t) to compare with the background image denoted by B. Here using simple arithmetic calculations, we can segment out the objects simply by using image subtraction technique of computer vision meaning for each pixels in I(t), take the pixel value denoted by P[I(t)] and subtract it with the corresponding pixels at the same position on the background image denoted as P[B].

In mathematical equation, it is written as:

$$P[F(t)] = P[I(t)] - P[B] \quad \ldots\ldots(1)$$

The background is assumed to be the frame at time t. This difference image would only show some intensity for the pixel locations which have changed in the two frames. Though we have seemingly removed the background, this approach will only work for cases where all foreground pixels are moving and all background pixels are static. A threshold "Threshold" is put on this difference image to improve the subtraction.

Morphological filtering: Mathematical morphology is a tool for extracting image components useful in the representation and description of region shape, such as boundaries, skeletons and convex hulls. The language of mathematical morphology is set theory, and as such it can apply directly to binary images: a point is either in the set (a pixel is set, or put to foreground) or it isn't (a pixel is reset, or put to background), and the usual set operators (intersection, union, inclusion, complement) can be applied to them. Basic operations in mathematical morphology operate on two sets: the first one is the image, and the second one is the structuring element (sometimes also called the kernel, although this terminology is generally reserved for convolutions). The structuring element used in practice is generally much smaller than the image, often a 3x3 matrix.

The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood.

It is shifted over the image and at each pixel of the image its elements are compared with the set of the underlying pixels. If the two sets of elements match the condition defined by the set operator (e.g. if the set of pixels in the structuring element is a subset of the underlying image pixels), the pixel underneath the origin of the structuring element is set to a pre- defined value (0 or 1 for binary images). A morphological operator is therefore defined by its structuring element and the applied set operator.

Vehicle detection: The basis of vehicle detection can be based on texture color vertices, shadows, corners etc… In the proposed method, colour based vehicle detection is implemented. When one needs to track a single entity out of a variety of multiple sources then it is possible on various parameters. One such parameter is color.

This is one distinctive feature that separates a vehicle from others. Hence the prerequisite is a colour based object detection algorithm for proper differentiation that leads to easier detection of vehicles and further tracking. Upon successful detection, abounding box will be applied over the detected vehicle. Bounding boxis used for better visibility. MATLAB provides a series of add-ons which helps to spread the applications to a wider oriented approach such as traffic control with priority given to ambulance etc.

Based on the traffic density calculated by MATLAB the signals are send to the Arduino controller. Arduino takes the input signals from the MATLAB and processes them to calculate the required timing signals. The hardware contains four sets of signal LED's (Red, Green and Orange) on four different directions of the road. Among the four directions where ever the traffic density is more the green light for that line is turned on and the same time the remaining three lines are given as red signal.

4. PERFORMANCE ANALYSIS

The hardware setup consisting of a camera module placed on the top of miniature traffic model is shown in Figure 2

Figure 2: Hardware Setup

The captured images undergo image processing steps such as RGB to GRAY conversion, image enhancement, background subtraction, filtering, colour based vehicle detection and applying bounding box. Vehicles are detected.

Table 1: Vehicle Detection Analysis

Actual vehicles in the Road Junction	Detected vehicles in the Road Junction	Accuracy Percentage
13	13	100
8	6	75

In the first case, the actual vehicles in the road and the detected vehicles by the algorithm are the same. Thus, the result obtained is 100% accurate. In the second scenario, the actual vehicles in the road are eight but the vehicles detected by the algorithm is six, which also includes the red light of the traffic signal detected as a vehicle. The reason is that the red light of the traffic signal is exposed to the camera's view which is wrongly counted as vehicle by the algorithm. This can be prevented by using a proper casing for the traffic signals such that it is not visible in the field of view to the camera. The Vehicles in the road are detected by means of color based detection. Few vehicles may be undetected if the threshold for the particular color of the object is not accurate. This can be overcome by using a higher resolution camera or by incrementing and decrementing the threshold values of the colour which went undetected.

5. CONCLUSIONS

The proposed system analyses the traffic density on each of the roads. The road having the highest traffic density is allotted more amount of green time and the road having least traffic gets less amount of green time.

Human intervention is minimized to a large extent. This means that the whole process is automated. So the entire process will have lesser errors and will work more efficiently. Also every time there is an error it can be solved easily as the whole process is less complicated.

Looking into the future enhancements, changes in the present system can be brought about easily. The product developed also supports systems with more than four lanes. The present system can be modified further to work efficiently. Thus our project is very feasible and will be definitely helpful to the traffic conditions today and even in future.

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