

Design of Traffic Control based on Digital Image by Intelligent Systems

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ABSTRACT: Population in metro and urban cities and usage of vehicles on the road are increasing day by day. As the problem, traffic congestion spreads, there is a pressing need for the introduction of advanced technology and equipment to improve the state-of-the-art of traffic control. Traffic Control is considered as one of the fastest emergent technologies in the world. There are many reasons behind today's traffic problem, one of the reasons is the techniques that are used for traffic management. Today's traffic management system has no prominence on live traffic scenario, which leads to ineffective traffic management systems. One such method is control by traffic cameras. The first installation of cameras for traffic monitoring were developed in the 1960s. This development leads to the growth of multi-purpose traffic cameras in numerous countries across the globe. By incorporating a closed loop system using camera, it is possible to predict the exact time on traffic light timers. If the traffic light timers are showing correct time to regulate the traffic, then the time wasted on unwanted green signals (green signal, when there is no traffic) will be saved. Timer for every lane is the simplest way to control traffic. And if those timers are predicting exact time then there will be automatically the system become more efficient.

The project that has been implemented by using the Matlab software and it mainly aims to prevent heavy traffic congestion. The project has following steps for implementation 1) Image acquisition 2) RGB to greyscale transformation 3) Image enhancement 4) Edge Detection and 5) Image Matching.

KEYWORDS: Controller, Image acquisition, Image enhancement, Image processing, Traffic camera, Edge Detection

I. INTRODUCTION

Image Processing [1] is a technique to enhance raw images received from cameras/sensors placed on space probes, aircrafts and satellites or pictures taken in normal day-today life for various applications. An Image is rectangular graphical object. Image processing involves issues related to image representation, compression techniques and various complex operations, which can be carried out on the image data. The operations that come under image processing are image enhancement operations such as sharpening, blurring, brightening, edge enhancement etc. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video; the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Image processing usually refers to digital image processing, but optical and analogy image processing are also possible.

Niksaz et. al.[2] propose a system that estimates the size of traffic in highways by using image processing has been proposed and as a result a message is shown to inform the number of cars in highway. This project has been implemented by using the Matlab software and it aims to put off heavy traffic in highways. Moreover, for implementing this project following steps must be considered: 1) image acquisition 2) RGB to gray scale transformation 3) image enhancement and 4) morphological operations. At first, a camera captures film of highway has been installed in highway. Then, the film comes in the form of consecutive frames and each frame is compared with the first frame. After that, the number of cars in highways is specified. At the end, if the number of cars is more than a

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threshold, a message is shown to inform the traffic status. By this message, we can predict the need to reduce the size of traffic carried. Experiments show that the algorithm will work properly.

In this research paper, they have used video camera. Camera is shooting video and the video is then converted to sequence of images by taking snapshots. This is quite difficult as we are nothing to do with video coverage. So, we avoided this method and decided to use a simple camera only.

Chandrasekhar. M, Saikrishna.C, Phaneendra Kumar [3] propose the implementation of image processing algorithm in real time traffic light control which will control the traffic light efficiently. A web camera is placed in each stage of traffic light that will capture the still images of the road where we want to control the traffic. Then those captured images are successively matched using image matching with a reference image which is an empty road image. The traffic is governed per percentage of matching.

The key point of the paper is the technique which is used for image comparison. The authors have used image matching technique. SIFT algorithm is been used in this paper and this is very effective and simple.

There is another method proposed by Vikramaditya Dangi, Amol Parab, Kshitij Pawar & S.S Rathod[4] the way to implement an intelligent traffic controller using real time image processing. The image sequences from a camera are analysed using various edge detection and object counting methods to obtain the most efficient technique. Subsequently, the number of vehicles at the intersection is evaluated and traffic is efficiently managed. The paper also proposes to implement a real-time emergency vehicle detection system. In case an emergency vehicle is detected, the lane is given priority over all the others.

The key point of this paper is the technique which is used for edge detection. The authors have given the comparison of various edge detection techniques and conclude that canny edge detection is the best method for edge detection. Thus, we are using canny edge detection.

Pallavi Choudekar et. al [5] they propose a system for controlling the traffic light by image processing. The system will detect vehicles through images instead of using electronic sensors embedded in the pavement. A camera will be installed alongside the traffic light. It will capture image sequences. The image sequence will then be analysed using digital image processing for vehicle detection, and according to traffic conditions on the road traffic light can be controlled.

Omkar Ramdas Gaikwad et.al [6], propose traffic light controller and implemented by using the Matlab software and it aims to prevent heavy traffic congestion. This project does not actually measure the number of vehicles present on the road, but measures the area covered by vehicles on the road. Moreover, for implementing this project following steps must be considered: 1) image acquisition 2) RGB to grayscale transformation 3) image enhancement. At first, a camera captures film of highway has been installed in highway. A web camera is placed in a traffic lane that will capture images of the road on which we want to control traffic. 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 timer to show particular time on the signal to manage traffic.

II. RELATED WORK

1.1 Need for Image Processing in Traffic Light Control

We propose a system for controlling the traffic light by image processing[7]. Vehicles detected by the system through images instead of using electronic sensors embedded in the pavement. A camera will be placed alongside the traffic light. It will capture image sequences. Image processing is a better technique to control the state change of the traffic light. It shows that it can decrease the traffic congestion and avoids the time being wasted by a green light on an empty road. It is also more reliable in estimating vehicle presence because it uses actual traffic images. It visualizes the practicality, so it functions much better than those systems that rely on the detection of the vehicles' metal content.

Automatic traffic monitoring and surveillance [8] are important for road usage and management. Traffic parameter estimation has been an active research area for the development of intelligent transportation systems (ITS). For ITS applications traffic- information needs to be collected and distributed. Various sensors have been employed to estimate traffic parameters for updating traffic information. Magnetic loop detectors have been the most used technologies, but their installation and maintenance are inconvenient and might become incompatible with future ITS infrastructure. It is

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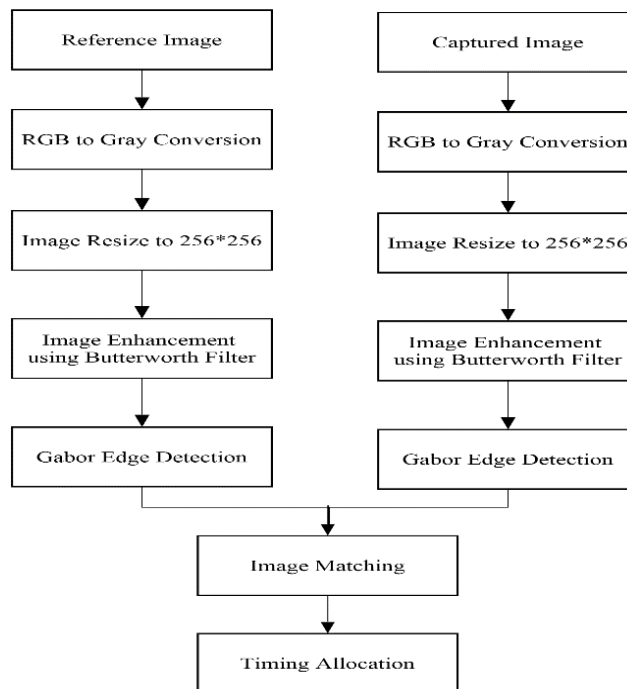
well recognized that vision-based camera system is more versatile for traffic parameter estimation [9]. In addition to qualitative description of road congestion, image measurement can provide quantitative description of traffic status including speeds, vehicle counts, etc. Moreover, quantitative traffic parameters can give us complete traffic flow information, which fulfils the requirement of traffic management theory. Image tracking of moving vehicles can give us quantitative description of traffic flow [10,11]. In the resent work, the designed system aims to achieve the following.

- Distinguish the presence and absence of vehicles in road images;
- Signal the traffic light to go red if the road is empty;
- Signal the traffic light to go red if the maximum time for the green light has elapsed even if there are still vehicles present on the road.

II. METHODOLOGY

Following are the steps involved in designing the project,

- Image acquisition
- RGB to Gray conversion
- Image enhancement
- Image matching using edge detection



Block Diagram of Proposed Method

2.2 Image Acquisition:

Image acquisition [12] in image processing is broadly defined as the action of retrieving an image from the source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. The image that is acquired is completely unprocessed and is the result of whatever hardware was used to generate it. Image enhancement-it refers to accentuation, or sharpening, of image features such as boundaries, or contrast to make a

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graphic display more useful for display or analysis. This process does not increase the inherent information content in data. It includes Gray level and contrast manipulation, noise reduction, sharpening, filtering and magnification and so on.

2.2 RGB to Gray Conversion:

A greyscale image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort also called black and white images. This conversion is required because grayscale images are easy to process as less image data is concerned. The intensity of a pixel is expressed within a given range between a minimum and maximum, inclusive.

2.3. Image Enhancement

The acquired image in RGB is first converted into gray. Now we want to bring our image in contrast to background so that a proper threshold level may be selected while binary conversion is carried out. This calls for image enhancement techniques [13]. The objective of enhancement is to process an image so that result is more suitable than the original image for the specific application. There are many techniques that may be used to play with the features in an image but may not be used in every case.

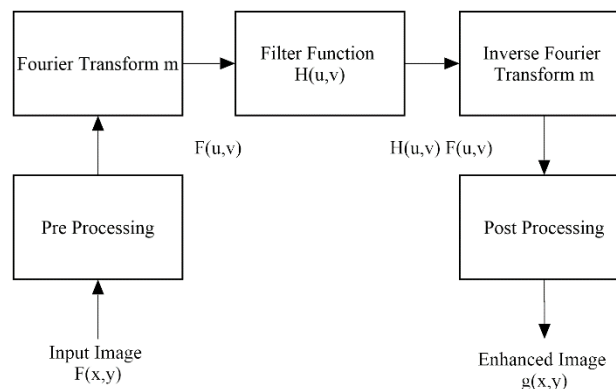


Fig 1: Frequency Domain Butterworth Filtering Operation

2.3.1 Highpass Butterworth Filter (Sharpening)

A high-pass filter [14] is a filter that passes high frequencies well, but attenuates frequencies lower than the cut-off frequency. Sharpening is fundamentally a high-pass operation in the frequency domain. There are several standard forms of high-pass filters such as Ideal, Butterworth and Gaussian high-pass filter. All high-pass filter (Hhp) is often represented by its relationship to the low-pass filter (Hlp):

$$H_{hp} = 1 - H_{lp}$$

2.4 Edge Detection Techniques

Different colors have different brightness values of color. Green image has more bright than red and blue image or blue image is blurred image and red image is the high noise image [15].

2.4.1 Canny Edge Detector

The canny edge detection algorithm [16] is an edge detector with good performance. However, image smoothing by gaussian filtering may lead to higher edge location error and corner roundness in application. The first and most obvious is low error rate. It is important that edges occurring in images should not be missed and that there be NO responses to non-edges. The second criterion is that the edge points be well localized

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The Canny edge detection algorithm operates on the whole image and has a latency that is proportional to the size of the image. While performing the Canny algorithm at the block-level would speed up the operations, it would result in loss of significant edges in high-detailed regions and excessive edges in texture regions. Natural images consist of a mix of smooth regions, texture regions and high-detailed regions and such a mix of regions may not be available locally in every block of the entire image.

The magnitude, or EDGE STRENGTH, of the gradient is then approximated using the formula:

$$|G| = |G_x| + |G_y|$$

2.4.2 Sobel Method

The operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One kernel is simply the other rotated by 90°.

-1	0	+1		+1	+2	+1
-2	0	+2		0	0	0
-1	0	+1		-1	-2	-1
G_x				G_y		

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these G_x and G_y). The gradient magnitude is given by:

$$|G| = \sqrt{G_x^2 + G_y^2}$$

Typically, an approximate magnitude is computed using:

$$|G| = |G_x| + |G_y|$$

2.4.3 Roberts Operator Edge Detection

The Roberts Cross operator performs [17] a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of 2×2 convolution kernels as shown in Figure. One kernel is simply the other rotated by 90°. This is very like the Sobel operator.

+1	0		0	+1
0	-1		-1	0
G_x			G_y	

These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these G_x and G_y). These can then be combined to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

although typically, an approximate $|G| = \sqrt{G_x^2 + G_y^2}$ magnitude is computed using:

$$|G| = |G_x| + |G_y|$$

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2.4.4 Prewitt's Operator

Prewitt operator [18] is like the Sobel operator and is used for detecting vertical and horizontal edges in images.

$$h_1 = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \quad h_3 = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian Smoothing filter in order to reduce its sensitivity to noise. The operator normally takes a single graylevel image as input and produces another graylevel image as output.

The Laplacian $L(x,y)$ of an image with pixel intensity values $I(x,y)$ is given by:

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

Since the input image is represented as a set of discrete pixels, we must find a discrete convolution kernel that can approximate the second derivatives in the definition of the Laplacian. Three commonly used small kernels are shown below,

0	1	0
1	-4	1
0	1	0

1	1	1
1	-8	1
1	1	1

-1	2	-1
2	-4	2
-1	2	-1

2.4.5 Gabor Edge Detection

The steps of proposed technique are as follows [19]:

Step 1: Gray image pixel values ($P_{ixel}T$) are the input data set $\bar{x} = \{x_1, x_2, \dots, x_n\}$.

Step 2: Standard deviation (σ) is calculated:

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^2}$$

Where n is the total number of pixels and \bar{X} is the arithmetic mean of the values $X = \{x_1, x_2, \dots, x_n\}$, defined as

$$\bar{X} = (x_1 + x_2 + \dots + x_n) / n$$

Step 3: $f(x,y)$ denotes the input image and $G(x,y)$ is the Gabor function. A smoothed image $f_s(x,y)$ is formed by convolution of G and f : $f_s(x,y) = G(x,y) f(x,y)$

Step 4: The gradient magnitude ($M(x,y)$) and direction ($\alpha(x,y)$) [22] are calculated:

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$$\text{grad}(f_s) \equiv \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f_s}{\partial x} \\ \frac{\partial f_s}{\partial y} \end{bmatrix}$$

$$M(x,y) = \text{mag}(\text{grad}(f_s)) = \sqrt{g_x^2 + g_y^2}$$

and,

$$\alpha(x,y) = \tan^{-1}(g_y/g_x)$$

Step 5: Thinning: *non-maxima suppression modified with rough-clustering based Pawlak's accuracy*: d_1, d_2, d_3, d_4 denotes four basic edge directions - $0^\circ, 45^\circ, 90^\circ, 135^\circ$ for a 3X3 region centred at $p_5(x,y)$ with its eight connected neighbours

$p_1(x-1, y-1)$	$p_2(x-1, y)$	$p_3(x-1, y+1)$
$p_4(x, y-1)$	$p_5(x,y)$	$p_6(x, y+1)$
$p_7(x+1, y-1)$	$p_8(x+1, y)$	$p_9(x+1, y+1)$

Fig.1. Eight-connectivity of a pixel $p_5(x,y)$

The direction dk , that is closest to $\alpha(x,y)$ is found. Along this direction dk , we calculate *P-lower* and *Pupper* approximations of $M(x,y)$ denoted as $P^*(M)$ and $P^+(M)$: if the value of $M(x,y)$ is less than at least one of its two neighbours along dk , then it belongs to $P^*(M)$, otherwise $P^+(M)$. The *Pawlak's accuracy* (α_P) is calculated:

$$\alpha_P(M) = |P^+(M)| / |P^*(M)|$$

if $(\alpha_P(M) < T)$

$$g_N(x,y) = 0$$

else

$$g_N(x,y) = M(x,y)$$

T is a threshold [22-23] value ($0 \leq T \leq 1$) and $g_N(x,y)$ is the rough-clustering based non maxima suppressed image.

Step 6: To detect the final edges, *hysteresis thresholding* [24] is used as *Canny edge detector* [1]. [*used convention*: edge pixel color = white, non-edge and background pixel color = black].

2.5 Image Matching

Edge based matching [20,21] is the process in which two representatives of the same objects are paired together. Any edge or its representation on one image is compared and evaluated against all the edges on another image. Edge detection of reference and the real-time images has been done using Canny operator. Then these edges detected images are matched and accordingly the traffic light durations can be set

2.6 Calculation of Matching and Timing Allocation:

After edge detection procedure both allusion and real time images are matched and traffic lights [22] can be controlled based on percentage of matching.

- If the matching is between 0 to 10% - green light is on for 90 seconds.
- If the matching is between 10 to 50% green light is on for 60 seconds.
- If the matching is between 50 to 70% green light is on for 30 seconds.
- If the matching is between 70 to 90% green light is on for 20 seconds.
- If the matching is between 90 to 100% - red light is on for 60 seconds.

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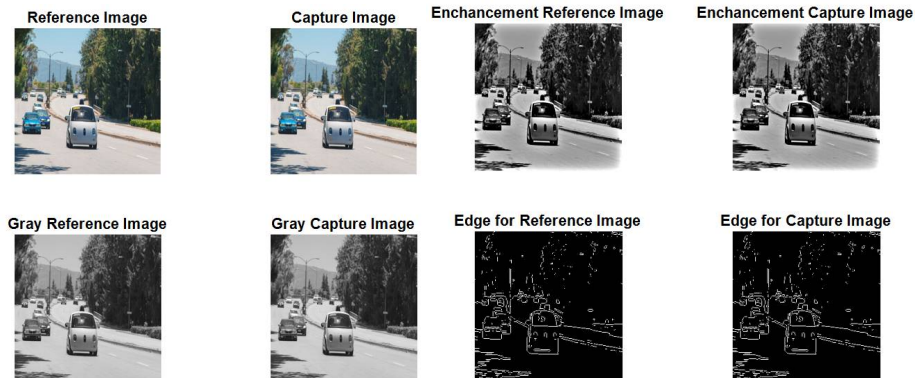
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III. EXPERIMENTAL RESULTS

To compare between various types of edge detection algorithms we tested their performance for various images taken from real traffic intersections. After finding the edges, the picture was subjected to an object counting algorithm. The performance of the edge detector algorithms was defined by the number of vehicles accurately detected. The results show that Gabor Edge detector was found to be the best among those compared. Experiments are carried out and depending upon the intensity of the traffic on the road we get the following results regarding on time durations of various traffic lights.

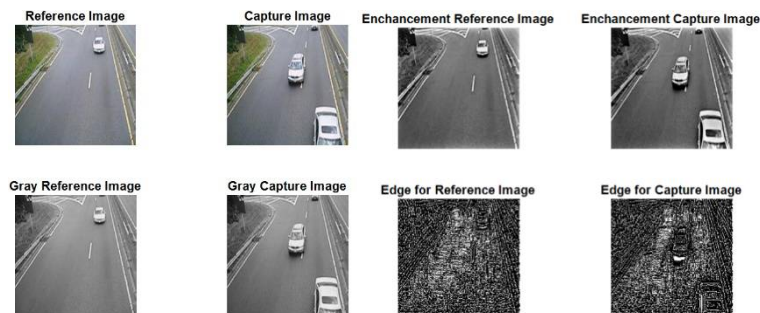
CASE: 1 RED LIGHT WITH GABOR EDGE DETECTION



Red Light is on for 60 seconds

In the above figure the reference and capture images are matching is between 90 to 100%, So Red light on for 60 seconds.

CASE: 2 GREEN LIGHT WITH GABOR EDGE DETECTION



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Green Light is on for 60 seconds

In the above figure the reference and capture images are matching is between 10 to 50%, So Green light on for 60 seconds.

IV. CONCLUSION

We propose overcomes all the limitations of the earlier (in use) techniques used for controlling the traffic. Earlier in automatic traffic control use of timer had a drawback that the time is waste by green light on the empty. This technique avoids this problem. Upon comparison of various edge detection algorithms and image enhancement technique, it was inferred that Gabor Edge Detector technique along with Butter Worth Filter based image enhancement is the most efficient one. The project demonstrates that image processing is a far more efficient method of traffic control as compared to traditional techniques. The use of our technique removes the need for extra hardware such as sound sensors. The increased response time for these vehicles is crucial for the prevention of loss of life. Major advantage is the variation in signal time which control appropriate traffic density using Image matching. The accuracy in calculation of time due to single moving camera depends on the registration position while facing road every time. Output is clearly indicated some expected results. It showed matching in almost every interval that were decided as boundaries like 10%, 35%, 68% etc.

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