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Real Time Traffic Light Control System (Hardware and Software Implementation)

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Abstract

Road traffic congestion is a recurring problem worldwide. This is primarily because infrastructure growth is slow compared to growth in number of vehicles, due to space and cost constraints. This paper proposes a new vehicle density measurement method using camera sensor and computational technology. The striking feature of the proposed system is that it is fully implemented on an embedded platform. We use a commercially available single board computer based on the Broadcom BCM2835 SOC, which includes an ARM1176JZF-S core as the computational unit. The embedded software acquires traffic image from an on-system camera, detects and counts moving vehicles, estimates the traffic density and controls the traffic signals according to processed results. The simulation results show that the proposed system is effective and intelligent for traffic control in a real road intersection.

Keywords: Embedded system, computational technology, real time traffic control, camera, road traffic.

1. Introduction

Traffic congestion nowadays are increasing because of the infrastructure growth is slow compared to growth in number of vehicles. Due to traffic congestion there is more wastage of time and fuel. High fuel cost and environmental concerns also provide important for minimizing traffic delays. An intelligent transportation system (ITS) estimates the traffic parameters and optimizes traffic signal to reduce vehicle delays and stops.

To estimate the traffic parameter ITS uses various technique such as inductive loop detectors offer good accuracy for counts and presence detection, their installation and maintenance causes traffic disruption. Sensors that are placed on the pavements (magnetometers, road tubes) can be damaged by snow removal equipment or street sweepers. In order to overcome these deficiencies many researchers have applied image processing and computer vision techniques for making the traffic system fully adaptive and dynamic [2].

The traffic control system based on image processing used to calculate the traffic density and tries to reduce possibility of traffic jams, caused by traffic light. In this paper, we propose a system which uses image processing technique to traffic density measurement and regulate the traffic light and implemented on Broadcom BCM2835 SOC, which includes an ARM1176JZF-S core.

The real time traffic light control system contain hardware and software module. Hardware module contains a Broadcom BCM2835 SOC which runs Linux kernel based operating system. A camera is connected via a 15 way ribbon cable to the board. Python 2.7 used to implement the image processing algorithm.

2. Image Processing Algorithm

In this section we describe the image processing algorithm used for vehicles counting and detection system. Figure1 shows the flow chart of image processing algorithm. The following sections describe each of these in more details.

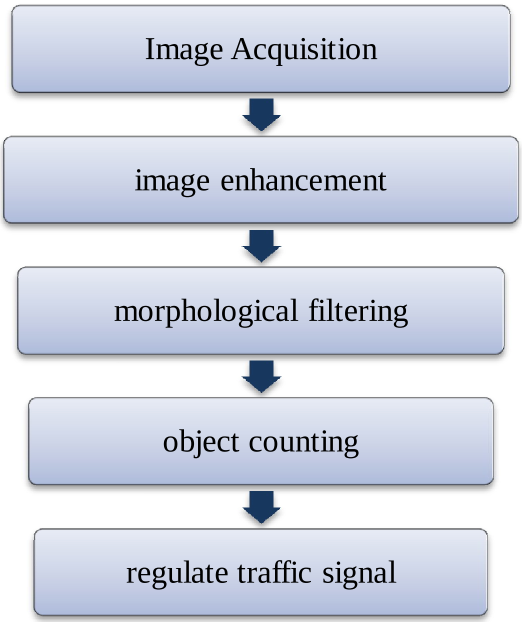

Fig. 1: Flow chart of algorithm.

Image Acquisiton

An image is a two dimensional function f(x,y) where x and y are the spatial (plane) coordinates and the amplitude of f at any pair of coordinates (x,y) is called the intensity of the image at that level. The images are generated by the combination of an illumination source and the reflection or absorption of energy from that source by the elements of the scene being imaged.

Omni vision image sensor is used to transform the illumination energy into digital images. Each sensor transforms the incoming energy into voltage by the combination of the input electrical power and the sensor material that is responsive to the particular type of energy being detected.

Image Enahancement

Image enhancement is processing of images for feature extraction or image interpretation. image enhancement techniques which converts the low quality image to high quality image for human viewing, removing blurring and noise, increasing contrast and gray scale conversion are example of enhancement operation. In these enhancement operations we use gray scale conversion for enhancing the image.

Gray scale conversion is a technique of image enhancement which is mapping three dimensional color information onto a single dimension while still preserving the original appearance, contrast and finest details.

Gray scale conversion can be performed using the following function.

$y = f(x)$

Where x is the original input data and y is the converted output data.

Linear Conversion is given by

$y = ax + b$

Where a is gain and b is the offset.

Contrast stretch is one of linear conversion as follow

$$Y = \frac{y_{max} - y_{min}}{x_{max} - x_{min}}(x - x_{min}) + y_{min}$$

Morphological Filtering :

Morphological operation mainly developed for bilevel images (binary images) for shape and features manipulation. Morphological techniques can be extended to greyscale images[1].The morphological filtering is done by passing a structing element over the image a convolution like operation. Morophological filter is widly used in noise removal and suppressing, image segmentation, etc.

Erosion filter applied an image, tends to reduce the sizes of bright image by correlation with adjacent dark areas. Erosion of set F with a structuring element H is represented by and is defined H is represented by,

$$F \Theta H = \{x\ (H)_x \subset F\}$$

Erosion with small (e.g. 2×2 - 5×5) square structuring elements shrinks an image by stripping away a layer of pixels from both the inner and outer boundaries of regions.

Object Counting

After the gray scale conversion and morphological operation we get a binary eroded image. To count the number of vehicles we applied labeling on binary erode image. After labeling we set a threshold to specify different size ranges to classify the various types of vehicles. This gives us a measure of the traffic density on road at the intersection.

3. Results

After applying the above described algorithm following results are found. In Fig. 2 original traffic images are shown in which no of vehicles in image1, image2, image3, image4, image5, and image6 are 2, 5, 7, 4, 5, and 10, respectively, by manually counting. Fig. 3 shows the resultant images after applied the above algorithm. Using the above technique no of vehicles detected in image1, image2, image3, image4, image5, and image6 are 2, 4, 6, 4, 5 and 8 respectively. This result shows that the above algorithm is efficient and accurate for vehicle detection. According to the traffic density we can regulate the traffic signal or vary the traffic light time.

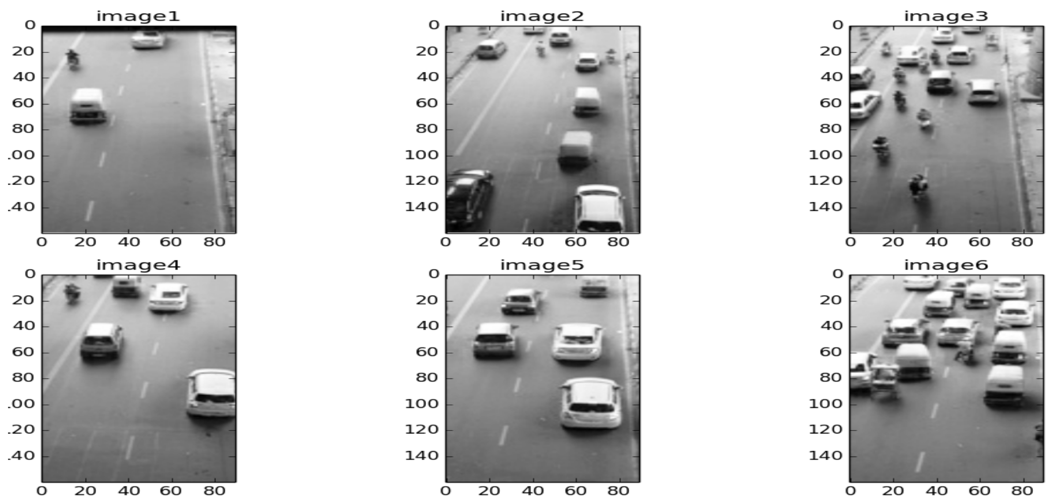

Fig. 3: Original traffic images.

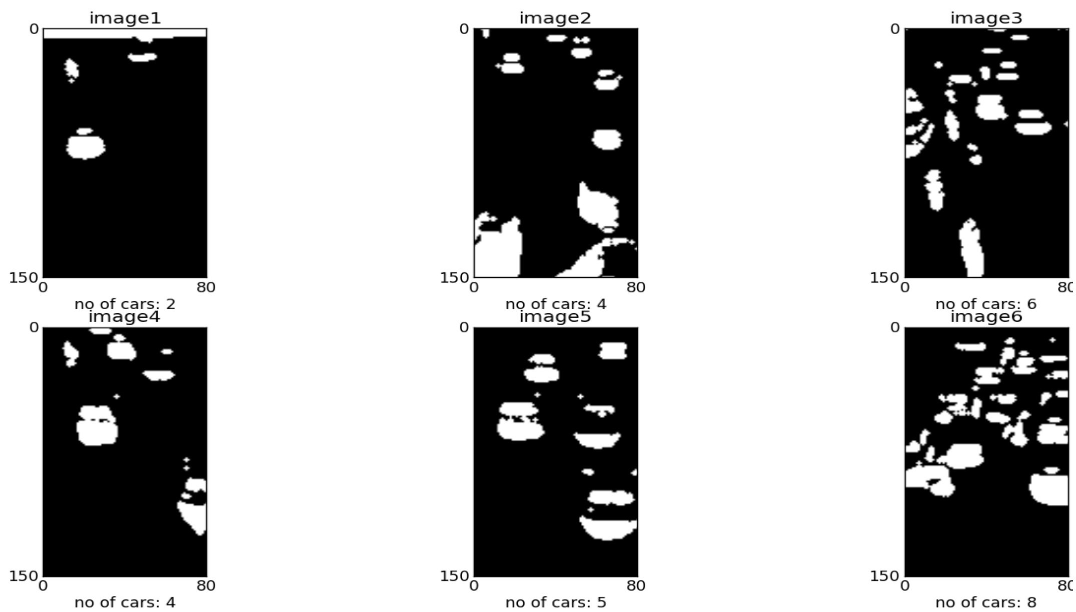

Fig. 4: Resultant images with no of vehicles detected

4. Conclusions

Above algorithm applied on real time traffic images and get the following results. In resultant image shows also the no of vehicles detected. By the comparison with original images detected no of vehicle using image processing algorithm are approximate equal.

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