Intelligent Traffic Control System with Priority to Emergency Vehicles

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Abstrac t. Traffic is the most critical problem in metropolitan cities. Traffic control becomes more necessary to provide problem-less, peaceful driving and pollution-less life to people. The work is designed to develop a density based dynamic traffic signal system. The signal timing changes automatically on sensing the traffic density at the junction. The traffic system is structured with a camera. The image captured by the camera is processed in order to calculate the number of vehicles present in the image. The camera also identifies the siren and allo ws the green light for emergency vehicles like ambulance, fire engine etc. In this paper, masking algorith m is used to process the image and find the vehicle count on the road. This algorithm shows only the required portion of the image and masks the unnecessary details. The visual basic programming is used to control the glowing time of traffic light based on the vehicle count on the road. The Arduino controller is a single board microcontroller used for instructing the LED to glow. This method can be used to detect road accidents and identify violat ions of the spiral movements of cars. The whole system when installed on road, provides a way for easy traffic clearance for emergency vehicles without a need of sergeant.

Ke ywords: Traffic, Image, Vehicles, Camera

1. Introduction

Traffic control systems are used to control more than two passage paths of vehicles or wherever the pedestrians passage used to cross a road. Also used, when two paths cross each other in the case of a four way lane. The purpose of a traffic control system is to control the vehicle flow through a lane and to prevent accidents or a road blockage. In our country, sequential logic traffic system is used at present in which the control lights used for present traffic system are namely, red, yellow and green for stop, get ready and go respectively in which each light operates on after another for a given period of time. The delay parameters on which the traffic load depends are time, day, season, weather and unpredictable situations such as accidents or constructional activities. The congestion problem can be solved by construction of new roads. The only drawback is that the surroundings also becomes more congested. There exists a need to change the traffic system rather than creating new infrastructure twice.

These problems can be solved by continuously sensing and adjusting the traffic lights timings depending on the actual traffic load, what is called an intelligent traffic control system, which can be achieved by the image processing techniques. The presence or absence of vehicles within certain range can be detected by the proper camera. The traffic signal gets changed based on traffic density. The key features of developing an intelligent traffic control system is to decrease congestion and costs, to enable alternate routes and to improve the infrastructure capacity. In the field of image processing, edge detections play a vital role in which the image boundaries incorporate problems. Theses can be resolved by identifying the sudden change in the gray/texture level in an image.

The first objective of the paper is to observe the traffic lights and density variation by applying suitable processing techniques. The paper targets to design a system that would be adaptable to the existing conditions at the traffic junction. This involves minimal physical changes in the intersection and provides the fastest clearance to vehicle/pedestal traffic in all possible directions. This in turn provides flexible traffic light system that ensures changes in the traffic density, in addition reduces the stress of traffic warder and accidents. The traffic congestion creates no issues in the case of emergency requirements and reducing the accidents. Thereby controlling traffic without the need of a sergeant and the proposed system saves the life and valuable time of people. Typical applications include license plate recognition and detection of theft vehicles etc.

Traffic congestion is considered to be the biggest problems in the urban environments. Traffic problems will be widely increasing as an expected result of the growing number of transportation means and current low quality infrastructure of the roads. In addition, many studies and statistics were generated in developing countries that proved that most of the road accidents are due to narrow roads and the destructive increase in the transportation means. The timer based traffic system is suitable only for light traffic which uses a predefined time setting for its processing. For heavy traffic system, an adaptive system is required which could manage the traffic density. The main drawback of generalized traffic control system is high priority situations and emergency conditions are difficult to detect. This urges the need of smart traffic control system to make it suitable to handle all conditions and to take decisions automatically.

Further, the rest of the paper is organized as follows. Section 2 explains the literature survey of the existing traffic systems. In section 3, the proposed traffic system is discussed with the block diagram and its functions. Section 4 describes the methodology adopted for achieving smart traffic system. Section 5 summarizes the masking algorithm adopted for the proposed traffic system. Section 6 illustrates the results and discussion with the different images captured. Finally, section 7 concludes with the advantages of the traffic system designed depending on traffic density.

2. Literature Survey

Kouvelas et al. [3] implemented an webster method for fixed traffic signal control derivation at isolated junctions and used for real-time operations. It is also proved that this approach is suitable for saturated traffic conditions through simulation results. This method avoids the need for pre-specified fixed signal traffic plan and it gives more accurate results than the method discussed in [1].

The scheme proposed by Zhang et al. [4] applies lagrange coordinates, discrete model and a continuous model and an correlation exists, by which the approximation using the increment M vanishes. This been verified by numerical simulations and applying the theoretical knowledge on lagrange operation. This leads to the development of Kerner's three phase traffic theory which explains the empirical features of traffic breakdown to resolve the congested real traffic patterns.

Bauza et al. [5] presented a Cooperative Traffic Congestion detection (CoTEC) method for cooperative vehicular traffic system. The performance evaluation of this method is done using a unique open source simulation platform called iTETRIS. The results show that the method provides better and accurate results for different traffic scenarios with congestion problems.

Traffic congestion on road networks occurs by slower speeds, longer trip times and augmented conveyance queuing. The most communal example is the physical use of roads by vehicles. When traffic postulate is great enough, the interaction between vehicles slows the traffic speed that results in some congestion. As demand approaches the competency of a road (or of the intersections along the road), extreme traffic jam sets in. When vehicles are fully stopped for epoch of time, this conversation is known as a traffic jam. For this, we must need an efficient traffic control system. Automatic traffic control and surveillance are the important factors for road usage and management. Timers for each stage are the simplest way to control the traffic. Another way is the usage of electronic sensors that can be used to find out vehicles and to produce signal as discussed by Chandrasekhar et al. [7].

Advanced Driver Assistance Systems (ADAS) implemented by Zhao et al. [6] describes the demand for high precision navigation in urban environments using low cost sensors by employing a sliding window smoothing estimator on tightly coupled differential global positioning system. The paper suggest a traffic system using masking algorithm to control the traffic density. For capturing still images of traffic on roads, web camera is used in each stage of traffic. After which, image matching is done using an reference frame.

3. Proposed Method

The traffic system has to give more priority to emergency situations. The present traffic system incorporates several traffic problems due to the lack of awareness in the traffic density. The traffic rules to be strengthened to avoid accidents. There exists a need to solve these problems for efficient functioning of existing traffic system.

In the proposed system, the vehicles are sensed and processed through imaging techniques . This avoids the need of electronic sensors. A web camera is placed with the traffic light to capture image frames. The purpose of the proposed system is to reduce the congestion and to reduce the time taken for the system in the absence of vehicles on road. It takes more consideration for the vehicle estimation by predicting the metal content of each vehicle.
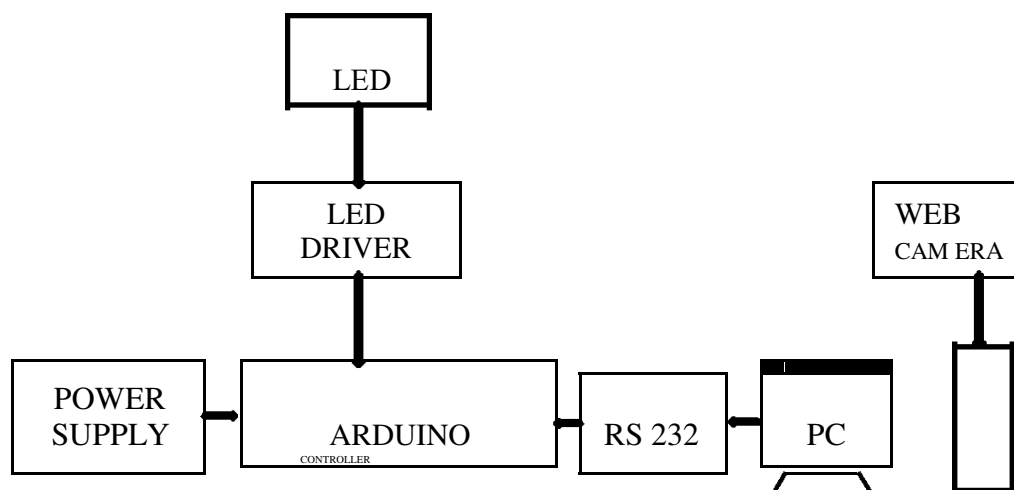

Figure 1. The overview of proposed traffic control system

The figure 1 shows the overview of the traffic control system that we have implemented in our prototype model. The brief explanation of each block is explained as follows.

3.1. Hardware module
In this paper, a USB based web camera has been used. A general purpose PC as a central unit for various image processing tasks has been used. The platform consists of a few toy vehicles and Light Emitting Diodes (LEDs) that can be used as a prototype of the real world traffic light control system. LED is used to represent the traffic signal system and drivers are used as the resistors to control voltage flow to LED.

3.2. Software module
MATLAB is used for simulation and testing purpose of each modules. The open source Arduino software is also used in addition to write code and upload to the board and also to control the LED lights.

3.3. Interfacing
The hardware and software interfacing can be achieved using a serial communication interface RS 232 with a speed of 19,200 baud rate.
The steps involved in this method are described as follows:
- Initial step is image acquisition can be done with the help of web camera.
- The image of the road is captured using web camera, when there exists traffic on the road.
- For processing purpose, conversion from RGB to gray scale is done on the image.
- To remove the noise present in the image, median filter is used , which is followed by candy edge detection operation.
- Distinguish the presence and absence of vehicles in road images.
- The visual basic program reads the object count on the road and controls the glowing time of the traffic lights accordingly.
- The embedded C program instructs the LEDs to glow according to the information read from PC.
- The analysis for the detection of emergency vehicles is achieved through their flashing red 89lights.

4. Methodology

4.1. Image Acquisition
An image in general is considered to be an two-dimensional function f(x,y) (here x and y are plane coordinates). At any point in an image, the amplitude is referred as intensity/ grey level of the image at that point. It is necessary to convert the x and y values to finite discrete values to form a digital image. The input image shown in Figure 4.1 gives a view of 4 cross road. The analog to digital image conversion process is done and each digital image is composed of a finite elements called a pixel.

Figure 2. Input image

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4.2. RGB to gray conversion

Humans perceive colour through wavelength sensitive sensory cells called cones. Three cones with different wavelengths and are sensitive to green, red and blue light. The color RGB image perceived by the eye has to processed by gray scale image conversion. We will be able to differentiate the total amount of emitted light for each pixel; little light gives dark pixels and much light is perceived as bright pixels. When converting an RGB image to gray scale, we have to consider the RGB values for each pixel and make as output a single value reflecting the brightness of that pixel.

4.3. Image filtering and filling

Median filtering is a nonlinear operation and is more effective than convolution when the goal is to simultaneously reduce noise and to preserve edges. The function B = medfilt2(A, [m n]) performs median filtering of the matrix A in two dimensions. Each output pixel contains the median value in the m by n neighbourhood around the corresponding pixel in the input image. medfilt2 pads the image with 0s on the edges, such that the median values for the points within [m n]/2 of the edges might look distorted. B = medfilt2(A) performs the median filter operation of the matrix A using the default 3-by-3 neighbourhood. B = medfilt2(A, 'indexed', ...) processes A as an indexed image, padding with 0s if the class of A is uint8, or 1s if the class of A is double. B = medfilt2(..., padopt) controls how the matrix boundaries are padded. padopt may be 'zeros' (the default), 'symmetric', or 'indexed'. If padopt is 'symmetric', A is symmetrically extended at the boundaries. If padopt is 'indexed', pad A with ones if it is double; otherwise pad with zeros.

4.4. Edge detection

Edge detection is a basic tool in machine vision, computer envisage, particularly in the area of feature reveal and extraction of images. The existing edge detection methods are sobel edge technique, prewitt, boolean, marr-hildreth and canny detection techniques. Here in our work, we choose canny edge detection technique for its accuracy. Table 1 summarises the comparison between various existing techniques of edge detection. It gives the accuracy in which various techniques detect an image.

Table 1. Comparison of edge detection techniques

Image	Actual no of objects	Boolean	Marr Hildreth	Sobel	Prewitt	Canny
1	4	2	6	2	2	4
2	3	0	4	1	1	2
3	4	2	3	2	3	4
4	5	2	3	2	3	6
5	5	2	3	3	3	6
6	7	3	5	3	2	6
7	4	1	5	1	1	4
8	5	2	5	3	2	5
9	3	0	3	0	1	2
10	6	4	3	3	3	6
Accuracy%		39.13	84.78	41.30	45.65	93.47

5. Masking algorithm

Masking algorithm is an algorithm implemented in MATLAB software. It shows only the required part of the image and masks the unnecessary details. This algorithm overcomes the drawback in capturing the image that may not be suitable to detect the object count on the road.
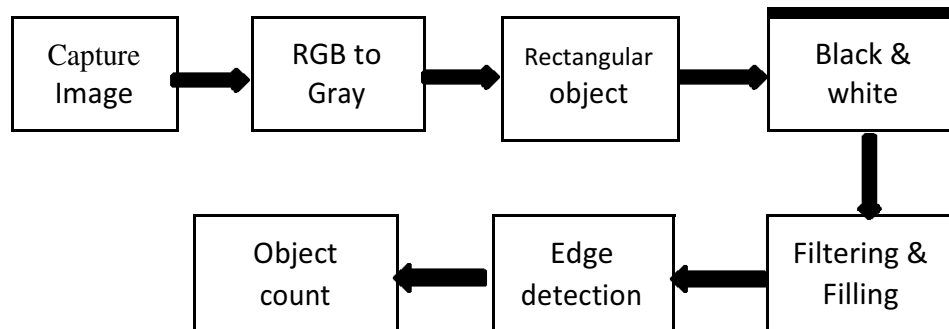
Figure 3. Algorithm flow diagram

The steps for masking algorithm as shown in figure 3, are summarized as follows:
1. The camera takes the snapshot of the roads.
2. Separation of four roads (i.e., road 1, 2, 3, 4).
3. Conversion of color image to gray scale image of road 1.
4. Rectangular shaped image is found.
5. Conversion into black and white image.
6. Performs median filtering of the black and white image.
7. Fill image regions and holes.
8. Edges are detected using canny edge detection method.
9. Rectangular images are counted.
10. The counted value is written on notepad.
11. In addition, when the emergency vehicles are also detected, the lane is given the higher priority over the others.
12. The steps (3-8) are repeated for the next 3 roads.

6. Results and discussion

6.1. Input image

Congestion considered to be one of the traffic problems in the urban environments. It depends on the increase in transportation means and due to the low quality roads. The The captured image is considered as the input as shown in Figure 4, and it is processed with the help of image processing.
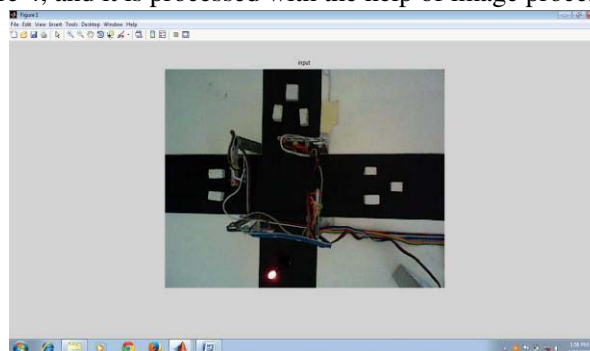

Figure 4. Captured image of the road

6.2. Processing of an image

Masking algorithm is an algorithm simulated in MATLAB software. It shows only the required part of the image and masks the unnecessary details. This algorithm removes the objects in the background frame and the vehicles left is been added to the successive frames. In figure 5, the roads are displayed separately after separation of roads. Figure 5 shows the number of vehicles and ambulance in four lane road.
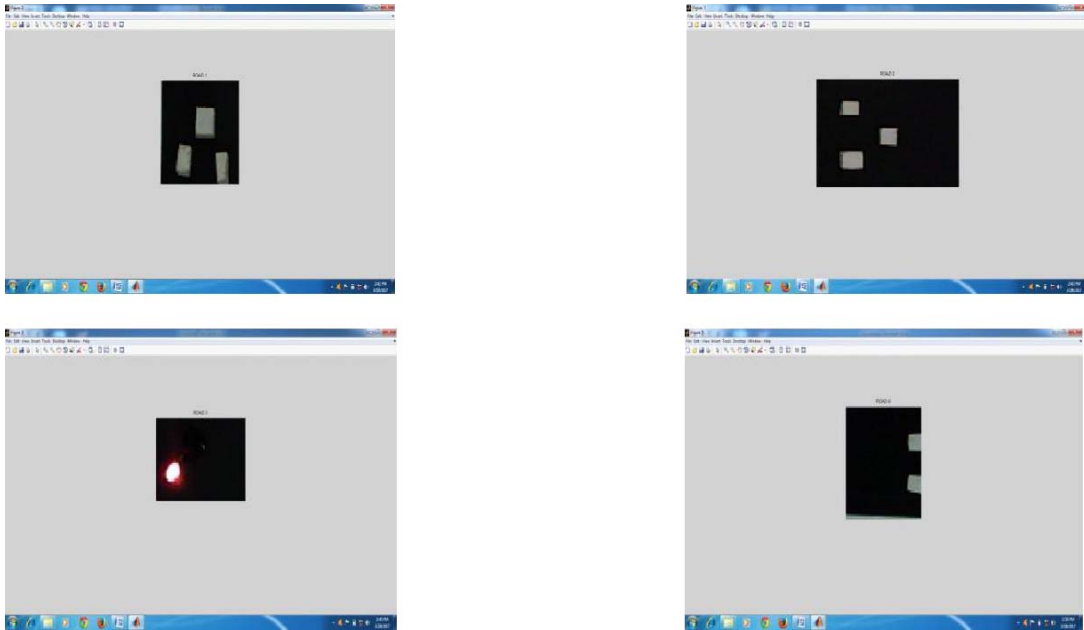

Figure 5a. Road Separation from the captured image

After the roads get separated, the image is converted into black and white image. From that image all the noises are filtered and the holes created by the noises are filled as shown for road 1 in figure 6.
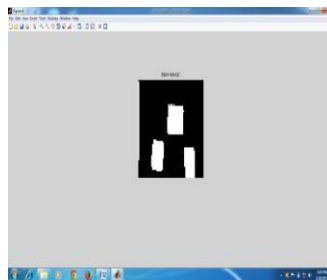


Figure 6. Converted images

Edge detection is a well developed field on its own within image processing. Edge is the important characteristic of image. Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edges typically occur on the boundary between two different regions in an image. Edge detection allows user to observe those features of an image where there is a more or less abrupt change in gray level or texture indicating the end of one region in the image and the beginning of another. Therefore, Edges are detected from the filled image of road.

6.3. Output image

From the edge detected images, the rectangular objects are counted for all the roads. Figure 7a shows the object count on each road, number of seconds allocated for road and a block to show presence of ambulance. For example, the road 1 has count 3 which indicates the number of vehicle is three. Each road is allotted with time depending on number of vehicles. The road with ambulance is detected by assigning the glowing time of LEDs based on its density as shown in Figure 7b. When an ambulance is detected on a lane, then the first priority will be assigned to that lane. In absence of ambulance, the road with more number of vehicles is given the highest priority to reduce the traffic. The number of seconds allotted for each road lane depends upon the number of vehicles on that particular road. Here 30 seconds time is allotted for each vehicle and the reverse counting is done based on the traffic count in each lane.
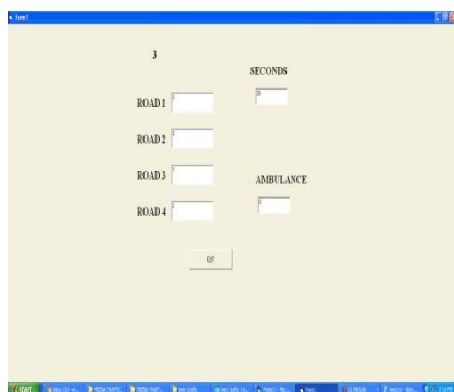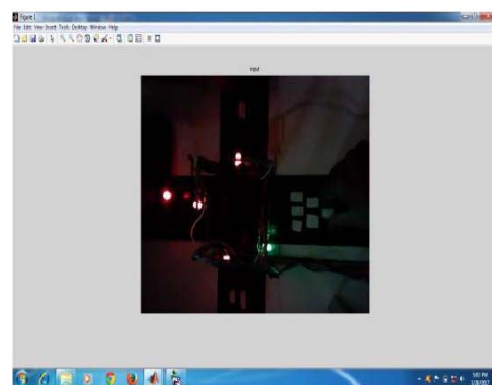
(a)   (b)

Figure 7a. Object count in each road
Figure 7b. LED output based on traffic density

7. Conclusion and future work

The prototype for real time image processing to automate traffic signal system based on density estimation and emergency vehicle detection such as ambulance is done. The benefits of this new method include non-use of sensors or RFID tags which reduces the stress of traffic sergeants. MATLAB simulation reduces the production costs and helps to achieve high speed and accuracy. Further with improvements, this work can be extended to detect road accidents and to identify violations that occurs in the spiral car movements. The accuracy of this work can be improvised further by doing thermal image processing. Thermal image processing is effective even during extreme weather conditions such as, mist or fog. Secondly, cloud computing can be done for the road data analysis.

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