

Image processing based Adaptive Traffic Control System

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ABSTRACT: Through this paper we intend to present an improvement in existing traffic control system at intersection. System is made more efficient with addition of intelligence in term of artificial vision, using image processing techniques to estimate actual road traffic and compute time each time for every road before enabling the signal. System is clever enough to provide priority to authorized emergency vehicles with the help of GSM at a particular intersection. This model is resemblance of traditional traffic police man who takes better decision every time and smoothen traffic flow. Unpredicted growth of traffic today has created serious problem in metro cities. Existing automatic traffic control system at intersection with preset timing signals is proved to be inefficient for the reason that system is not intelligent enough to make judgment of varying road traffic density and fail to allocate specific time to clear it. Unnecessary waiting till preset time lapse or wait for multiple round of turns to clear the traffic

Keywords - Artificial intelligence, GSM, Image processing, Traffic,

I. INTRODUCTION

With the increasing buying power of common man today the number of vehicles on the road is creating heavy traffic that is difficult to control and maintain safety. This problem is much serious and unsafe for pedestrian, especially in large cities like „Pune“, „Bangaluru and „Mumbai“. Growth of traffic here is non linear as compared to the development of infrastructure like roads, intersections and bridges. It is difficult for most of the time and sometimes impossible to modify or broaden them in existing cities. New construction takes its own time with all constraint. To smoothen flow of traffic at intersection, options available with traffic control department are to impose „one way“, use „traditional traffic monitoring and controlling“ in addition to existing automatic signaling system.

Traditional system is effective but is limited by the time human can work. Human intervention is there to take clever, critical decision and handle emergencies. Traffic policemen decide time for traffic signal control depending on the density at particular lanes. Existing automatic system uses preset signal timings to control traffic at intersection. Time to be Preset time is again decided by the traffic officer depending upon his/her survey about traffic condition for a particular intersection. Most of the time, these methods are ineffective, because of sudden fluctuation in flow of traffic apart from peak hours. The cyclic signaling method with existing preset timing in automated system will be inappropriate in situation of waiting, even if few or no vehicles available on the other road. Fixed timing will not be inappropriate in case large number of vehicles waiting to cross the junction. Inconvenience will be caused by unnecessary waiting; people will lose time, miss opportunities and get frustrated. Traffic congestion problems create a deep impact on companies“ production and transportation of goods. Need is for automatic adjustment of the signal timing with changing traffic conditions, in similar fashion as to what the officer does in traditional system. System must be capable to handle emergencies.

II. PREVIOUS WORK TO IMPROVE TRAFFIC AND SAFETY

Safety and time saving is top most priority in traffic control. Several systems have been implemented and proposed so far for traffic on straight road, in cities, at junctions. Implementation of artificial intelligence in traffic control system is being used in Europe and western countries, round the clock to handle heavy traffic, provide safety to human being and save the travelling time and money. This is possible and viable with latest technologies hence initiative is being taken in the subject through research. Systems are designed with artificial vision with the help of good quality outdoor camera, sensors, supporting hardware and software.

Parking and double parking is growing issue in cities creating unsafe road condition to traffic on lane besides the parking lane. [1] The detection of such illegal stopped, parked or unwanted incidence of vehicle is needed. The technique used which extracts low level feature points to create spatiotemporal maps which will talk about the actual happening on the road. Data would be used to regularize the traffic flow by removing hurdle of illegally parked vehicle and smoothen traffic flow in close by lane. Providing safety to human in different scenarios of crossing the street, lane the effective and fast acting system [2] would have the artificial

vision along with sensors mechanism to detect the pedestrian in limited areas of concern. System uses laser scanner along with fusion of vision to detect and predict pedestrian move and avoid collision or accident by controlling braking system of vehicle. System is fitted on vehicle and detects danger within less time since limited area. system can control the vehicle speed by applying automatic brakes. System turns out to be cost effective in identification for moving or static object under the critical area only. Easy availability and low cost of video camera made its use grow on roads and interaction leading to difficulties in management of such huge continuous recordings. Some companies have come up to provide service in traffic video analysis [3], [4]. Idea presented in [5] speaks of surveillance system using multiple cameras, to get different and enlarge view of traffic under surveillance. A distributed cooperative multi-camera system is used. Trajectories could be plotted through multi-target tracking to understand location, speed and objects. This application is used in specific task surveillance. It overcomes occlusion effect created by other objects such as vehicles, trees etc. [6] Installation of cameras at road intersection faces practical problem of height at which it would be mounted. Limited available height generally gives low camera angle. It is not possible to identify individual vehicles. But the group of vehicles is identified. The occluded vehicle behind big vehicle like truck or partially occluded cars remain through out the scene. Estimation of actual occupancy of backside vehicles in the queue would have to be handled separately because the vehicle is hidden behind the front vehicles. Hence counting of vehicle would be inaccurate. The method presented here utilizes 3-D perspective mapping from scene to image. Technique can identify number and location of vehicles. Various technologies and techniques are being developed for detecting and estimating number of vehicles. [7]

Artificial vision along with image processing techniques is used to separate background from the area of interest leading to the extraction of objects and with the help of morphological processing, removes the small lines and shapes. Finally remaining contours area is calculated. This is compared with experimentally obtained rate to determine the occupancy level of road. Known occupancy level is used to calculate time for signal lights control.

III. PROPOSED SYSTEM

Objective of proposed system is to improve efficiency of existing automatic traffic signaling system. The system will be image processing based adaptive signal controlling. The timing will be calculated each time change automatically depending upon the traffic load. Proposed system will be functioning based on traditional system along with automated signaling. System will have artificial vision with the help of digital camera mounted on motor for its rotation to face lanes and sense the traffic on the road. The camera is controlled by PC through microprocessor to change its direction in steps of 90 degree to face each lane and capture image. This single image of lane will be processed using image processing techniques to estimate traffic load. Estimated traffic load on particular road will be used to calculate the required time duration for controlling of signal lights based on in comparison with experimental results. System will be intelligent and will calculate the time every time and operate in a cyclic clockwise signal lights control. Maximum and minimum time limit will be maintained to prevent over waiting of vehicle in queue of other lanes which would be found out experimentally. Controls of the signal will be routed through the microcontroller. MATLAB® programming environment will be used for simulating and developing the proposed system. Further the emergencies will be handled using GSM techniques. The signal will be controlled by interrupting the normal functioning. The emergency will set the priority and the requested lane will be open closing all others. After emergency is removed the system starts normal functioning. The block diagram of the proposed system is as shown in figure.1

IV. METHODOLOGY

1. Controlling of signal lights

The signaling is cyclic in clockwise direction starting from first road, through fourth sequentially. The timing is set after its calculation from the estimated density with the help of image processing technique on the captured image. Digital monochrome or color camera is used. The timing calculated is passed on to Microcontroller 89s52, 40 pin DIP with necessary RS232 interface. Microcontroller operates the signal lights with the help of necessary driver circuitry. We are using single camera at present, which is placed at the centre of intersection mounted on rotary platform at sufficient height to get enough elevation for vision that is required to view predefined length of vehicles. Figure 2. The camera is rotated by a DC motor driven by microcontroller via driver circuit.

2. Emergency

GSM technique is used to handle emergency. The authorized emergency vehicle like Police, firefighter or ambulance are given priority to cross the intersection after the request raised by them with the help of SMS send as it approach the intersection. The signal remains on till it crosses the junction and can be put off to resume the normal operation by sending other SMS Refer figure 3. At vehicle end we have GSM transmitter and at

Intersection we have receiver. Correct lane number to intersection will have to be transmitted to raise priority. In case of more than one emergency arise, then first come first serve mechanism is exercised in setting the priority. This scenario is rare but provision is made to make system more clever decision.

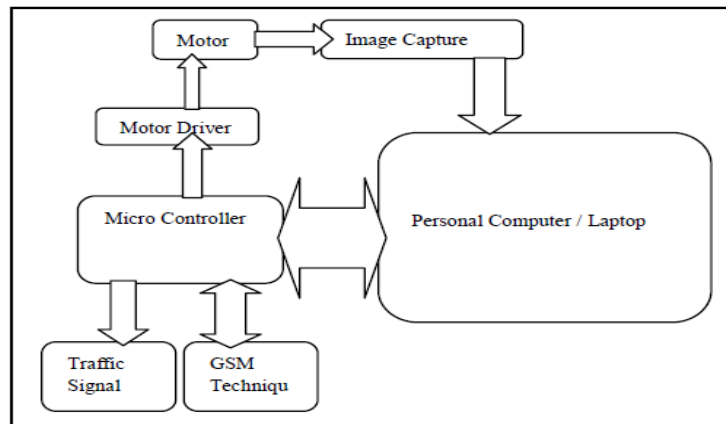


Figure 1 Block Diagram of Image processing based Adaptive Traffic Control System.

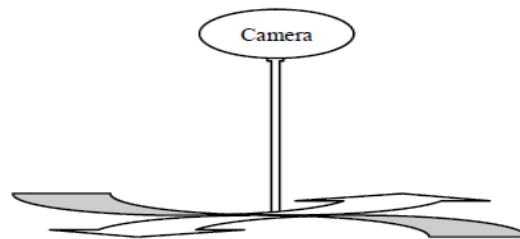


Figure 2 Camera mounting at center

V. FUNCTIONING AND ALGORITHM

Table 1: functioning of lights in actual as shown in table

Camera	Road A	Road B	Road C	Road D	Duration (s)
Initial CAPTURE	R	R	R	R	8
Starts with high den	G	R	R	R	15
	Y – Blink	Y – Blink	R	R	4
	R	G	R	R	10
		Y – Blink	Y – Blink		4
	R	R	G	R	20
	R	R	Y – Blink	Y – Blink	4
	R	R	R	G	18
Emer. at C aftr 5 s			Y – Blink	Y – Blink	4 (5+4)
	R	R	G	R	Till emergency
Emergency Cleared	Y – Blink		Y – blink		
Normal Cycle	G	R	R	R	

1. Normal mode

The function is shown in Table 1; the signal is cyclic in clockwise direction. The minimum signal time set is experimentally found and would be time taken to cross the intersection 1.5 to 2 times for safety. Signal Change from C to D road with set time is 18 second. After 4 sec emergency is detected. The signal goes green at C, again after 5 seconds which is minimum time of signal control (yellow light). After emergency the normal operation continues.

2. Caution mode

In caution mode the system will switch off the signal control and will keep only RED light blinking on the roads of intersection to caution vehicles to slow down while approaching the intersection during night time and afternoons (If required in some cases only) for the time period that will be set experimentally. Night caution mode is after 10 PM. Caution mode is started after the preset time and when the system detects and calculates less than minimum control for at least 3 turns of signal. The system will be back into normal mode on preset time (experimentally decided eg. morning 7:30am.).

3. Image processing

The steps followed in processing of a captured image includes experimentally found out results along with simplified consideration.

- i. Fixing queue area: The predefined length L1 as queue length and road width gives maximum area of queue. „T, is time required to clear the 100% queue area, and this will be maximum time setting for the control of signal at that intersection. This area of interest can be obtained by installation of camera at height and angle facing towards road. Hence L and T are experimentally found.
- ii. Region of interest (ROI) : Area of queue is region of interest (ROI) and could be freed by generating a cropped image of empty road or normal image scene. Captured image when saved is in matrix form I_{mn} . Final cropped image F_{mn} will be product of C_{mn} . Figure 4.

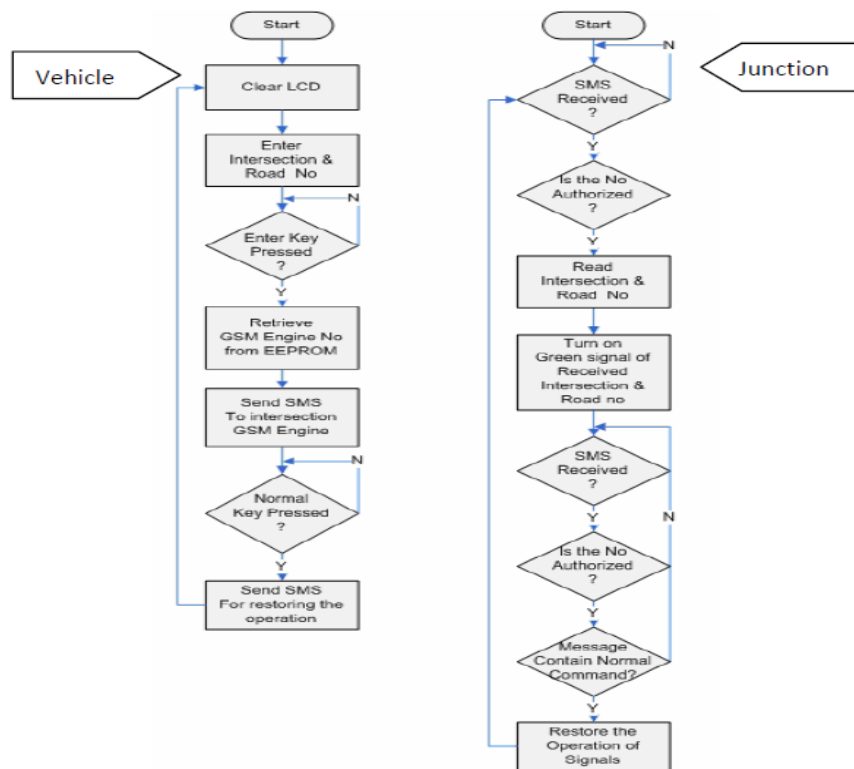


Figure 3. Emergency handling through GSM through sending SMS to set priority clearance.

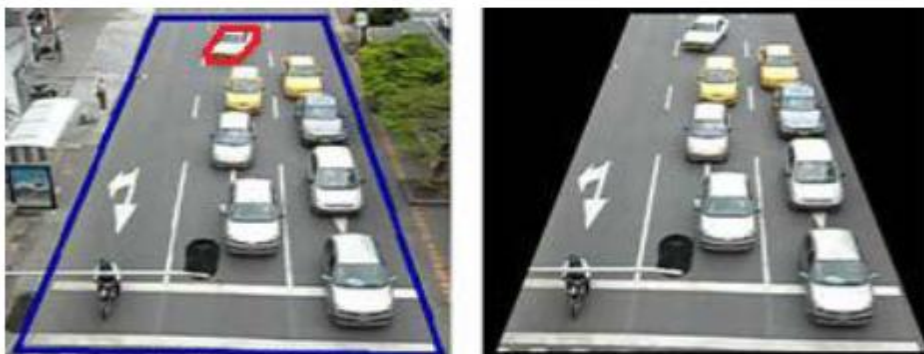


Figure 4. Selection of region as ROI, Cropped image

- iii. Conversion to gray scale :Capture an image, if it is color, convert it into gray scale image. MATLAB® functions „rgb2gray(x)“ and *adapthisteq(x)*“ could be used. 3.4 CONVERSION TO BINARY Some threshold could be used while conversion from grayscale to binary. MATLAB® function „im2bw(x,0.3)“ could be used. This conversion may be dropped and directly we can go to next step.
- iv. Subtracting : Subtract cropped image of scene from the ROI to get area occupied by vehicle . This can be achieved by anding operation on cropped captured image scene and ROI. The logic is, structure generated by asphalt image in ROI and the changed structure due to occupied vehicle. The changed structure could be separated from unchanged structure after Anding.
- v. Time calculation: We know maximum „T“, for complete ROI. Now in above step we have found out the percentage occupancy. Hence percentage of „T“ will be final time Tf , that would be applicable for the control of signal. The microcontroller drives the final signal lights for the calculated time.

VI. CONCLUSION

System is estimated to be accurate 80% and even more depending on the accuracy of ROI used to estimate occupancy. Major advantage is the variation in signal time which control appropriate traffic density using artificial vision. The accuracy in calculation of time due to single moving camera depends on the registration position while facing road every time. The handling of emergency with the help of assigning priority has an advantage since safety human is maintained. Limitation of GSM network may sometime create problem of delay in delivery of message, but is not frequent phenomenon and could be taken care with the help of service provider. Automatic caution mode is new feature of this system that will ensure the withdrawal of signal control at night after predefined time when the traffic is lowest and brings it normal when needed. Thus the system will be close to traditional system with improved efficiency and safety.

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