

Review on Traffic Congestion Detection using Image Processing

Sahana Kulkarni¹, Sumit Ugale², Himanshu Jawale³, Dr. Amita Shinde⁴

^{1, 2, 3, 4}(Department of Instrumentation, AISSMS Institute of Information Technology, Pune, Maharashtra, India)

¹Corresponding Author: sahanaskulkarni22@gmail.com

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Abstract: This paper presents a review on various image processing techniques used to detect traffic congestion. The conventional traffic light system has a fixed time cycle regardless of the traffic congestion. To reduce traffic congestion, system that controls the traffic lights based on number of vehicles can be designed. Heavy flow of vehicles at any particular side can be given higher priority for efficient vehicle management. Detection of real-time traffic congestion is necessary. In this paper, various image processing algorithms such as background subtraction, edge detection, etc. are discussed.

Keywords: Traffic Congestion, Image Processing, Background Subtraction, Edge Detection

I. Introduction

In developing countries, the number of vehicles and the population is increasing day by day which leads to road traffic problems, especially in urban cities. Traffic fatalities has increased by about 5% per year from 1980 to 2000, and since then have increased by about 8% per year for the four years for which statistics are available. According to a case study, Delhi, Mumbai, Kolkata and Bangalore have 5% of India's population but about 14% of its registered vehicles. In metropolitan cities the vehicles spend more time in traffic jam which leads to health problems, environmental hazards, degradation of economy of country and accidents tend to occur. To reduce this one of the several solutions is efficient traffic management.

To overcome these problems some cities like Mumbai, Jabalpur has incorporated traffic signals based on traffic congestion which also includes Surveillance System, Red Light Violation Detection (RLVD) System, Automatic Number Plate Recognition (ANPR) System, Speed Violation Detection (SVD) System, E-Challan System. The objective is to design a dynamic system, that is able to modify the time allocation based on real time traffic congestion. This system will reduce the waiting time on signals and improve the efficiency of traffic signal systems. It also supports sustainable development to meet the growing traffic demand of the cities.

II. Literature Survey

Rao et.al[1]has proposeddynamic traffic system based on real time detection of traffic congestion. This systemmakes use of image processing techniques such as background subtraction, canny edge detection by using a camera module to detect the density of traffic. The camera module takes in the video footage of traffic and processes it frame by frame. The main objectiveis to detect the dynamic objects. OpenCV software is used to perform background subtraction. A background model is created by comparing the input frames, the images which are static in nature. This background model is subtracted from the next frame, therefore creating a foreground mask which consist of the dynamic objects. Further canny edge detection algorithm is used to detect the edges of the dynamic objects. The results are such that dynamic and static objects are black and white pixels respectively. The prediction mechanism using clustering is also included to plan for the future congestion beforehand.

Ng et.al [2]has proposed ahybrid intelligent traffic light system for solving traffic congestion in Hong Kong.In this algorithm a set of conditions is specified for building an intelligent traffic light system (ITLS). A pygame simulator is built to simulate the visualization of traffic. A regression model is built by training using simulation results to predict the average waiting time for different parameter sets. Camera is used to record the video at the intersection. This generated video frames are processed by the object detection application and machine

learning algorithms. The application uses TensorFlow. This application recognizes the road users i.e. vehicles as well as pedestrians. The proposed algorithm calculates the waiting time for vehicles and pedestrians based on factors which include vehicles queuing at the intersection, pedestrians queuing, extension period of flashing green light for pedestrians e.g. elderly, disabilities, or pedestrians are still on the crossing line. Various set of parameters are taken into consideration to find the optimal parameter set.

Guchhait et.al [3] has developed multiple vehicle detection model using C-OFDM based RADAR for advanced collision warning. In this RADAR signal is combined with C-OFDM which is used to detect the vehicles on roads. Arbitrary Waveform Generator (AWG) is used for signal generation and is transmitted and received through two horn antennas. To replicate multiple vehicles on roads, multiple flat plates are kept with slight distance between them. The distance between the radar antenna and the target is calculated by delay in the received RADAR echo signal. The system is able to successfully detect multiple targets which are displayed on network analyzer. The conventional RADAR system fails to detect multiple objects accurately due to background clutter which is detected and eliminated by COFDM. It also eliminates the probability of undetectable target due to blind speed.

Lam et.al[4]has proposed areal-time traffic congestion detection system using on-line images. This uses on-line real-time traffic congestion images. It uses real-time but low-resolution images through stationary cameras installed from different locations. There are three main parts in the proposed real-time traffic congestion detection system. First, real-time on-line images provided by the government website are downloaded continuously into a local storage, which are used to estimate the number of vehicles in the images using Haar-like features. The congestion condition is determined using image correlation coefficient. Two degrees of traffic congestion are considered: NORMAL and CONGESTED. When the number of vehicles and the correlation coefficient between consecutive images are greater than a pre-set threshold at the same time, the system will change the traffic status to CONGESTED, otherwise, it will be in the NORMAL. Both thresholds are determined by trialanderror experimentation using a large number of images. Finally, the traffic congestion information is stored in the database and then extracted by the road users and the government agencies through mobile applications or a website.

Khalil et.al [5]has proposed paper on traffic congestion detection by use of satellites view. Satellites are used as a source to detect the congestion on roads in high resolution. This video is extracted into frames. Image processing techniques like background extraction and frame difference are applied on these frames to detect the static and dynamic objects, here vehicles. Masked image is generated which is the binary image of particular area captured by satellite. Required active area, roads in this case, are detected by subtracting frames from masked image. Roads and other area are white and black respectively. To detect the moving vehicles background subtraction is applied on the current frame with reference to the previous frame. If the vehicle is detected to be moving, they are marked with yellow color while the static vehicles are marked red.

Ellappanet.al [6]has discussed multi-intelligent traffic light optimization techniques by applying modified component analysis algorithm. This estimates the traffic flow using image analysis and machine learning. Real time video is acquired using camera and traffic density information is obtained using Principal Component Analysis (PCA) algorithm. The Hog Feature Extraction is implemented on images from the video which are pre-processed. These results are fed to the trained k-NN classifier. This algorithm is simulated using MATLAB based GUI. If low volume of vehicle congestion is detected then, the traffic signal will have high waiting time to maintain the average waiting time and vice-versa. In this way traffic volumes are estimated.

Sarath et.al [7]has proposed priority based real time smart traffic control system using dynamic background. This algorithm explains that if emergency vehicles such as ambulances, fire engines and police vehicles are detected, the priority of that lane increases. In pre-processing step streaming of video data and RGB to HSV color space conversion is done. After obtaining the binary image and performing morphological dilation and erosion operations, priority vehicle is detected. Traffic density is found using combination of gradient magnitude and direct subtraction method. By using Dynamic Background Traffic Cycle Calculator Algorithm (DBTCA), the traffic cycle is calculated and based on that a weight factor is determined to allocate time for each road. The presence of priority vehicle will increase the priority of that lane and thereby increasing the time.

Chowdhury et.al [8] has proposed avehicle detection technique for traffic management using image processing algorithms. Day and night images are differentiated and two different methodologies are used to detect the number of vehicles during daytime and night. Foreground RGB image is converted to HSV and then v-histogram is computed. By comparing v-components value with threshold value, day and night is differentiated. To detect the number of vehicles in daylight, RGB images are converted to gray scale images and binary is extracted. By comparing the vehicle areas and threshold value, vehicles are counted. To detect night time vehicles, the foreground image is converted to binary, to filter only the pixels with high intensity thus extracting the headlights. Object counting methodology is used to detect boundaries with no holes and the circularity of the white areas is calculated

and compared with a threshold value to distinguish the areas which are more probable to be headlights and the reflections are ignored.

Anandhalli et.al [9] has proposed vehicle detection and tracking algorithm based on color feature. HSV color image are filtered, so that the vehicle colors are extracted apart from any other environmental colors. Before applying blob analysis, morphological operations are applied in order to reduce the noise. Blob analysis is done to detect the number of blobs i.e. the number of vehicles. To determine blobs in a regular shape, convex hull technique is used. Centroids of blobs are calculated. Total number of blobs is defined by total number of centroids. These centroids are tracked by multiple Kalman filter. Data association is used to allocate the same centroid to the Kalman filter which it is tracking. Data association is a matrix where in the detected centroid points are arranged in the matrix form. After mathematical modelling the results are such that columns define the distance and row define the tracker.

Lakshmi et.al [10] has proposed intelligent traffic signal system. Total amount of pixels in a video frame are calculated which corresponds to the amount of area of occupied by vehicles on the road, thus detecting amount of congestion. The obtained foreground and background images are processed such as removal of noise. After application of Sobel Edge Detection technique, moving objects are detected by background subtraction method. Morphological Image Closing Operation is used to preserve structuring element, while eliminating all other regions of background pixels. To fill the holes in the objects with closed contours, flood filling operation is used. Traffic density is calculated by adding the total pixel values in the final binary image. Based on algorithm in MATLAB traffic cycle is estimated which is considered as the function of traffic density. The signal time is transmitted to Arduino from the MATLAB interface which controls signal lights. A comparison of various image processing methods used for traffic congestion detection is given in Table 1.

Table 1. Comparison Table

Sr. No.	Title of Paper	Authors	Method	Results
1	Dynamic Traffic System Based On Real Time Detection Of Traffic Congestion	Aditya Rao, Akshay Phadnis, Atul Patil, Tejal Rajput, Dr. Prof. Pravin Futane	1. Image Processing: - Background Subtraction using OpenCV software - Canny Edge Detection 2. Prediction mechanism using Clustering 3. Timer Allocation and Communication using Socket Software	The dynamic system outputs the timer for each signal which is calculated based on the current traffic congestion. The total time of a given cycle remains the same, with the time allocation to each signal varying between them.
2	A Hybrid Intelligent Traffic Light System for Solving Traffic Congestion in Hong Kong	Sin-Chun Ng, Chok-Pang Kwok, Yui-Chung Fung, Chun-Yung So, Yuen-Ho Lam	Tensorflow is applied in object detection to recognize the vehicles and pedestrians from the recorded videos. A regression model has been built to predict the optimal parameter set using simulation results.	<u>For Non-peak Traffic Hours:</u> about 40% to 60% reduction of the total waiting time as compared to the fixed cycle traffic light system. <u>For Peak Traffic Hours:</u> about 50% to 55%
3	Multiple Vehicle Detection using C-OFDM Based RADAR for Advanced Collision Warning	Arghya Guchhait, B Maji, Debdatto Kandar	RADAR signal combined with C-OFDM is transmitted through a horn antenna. The indoor control unit of the RADAR system analysis the multiple targets	The conventional RADAR system detects a single target (when two objects were kept) whereas the proposed model detected accurately by eliminating background environment clutter
4	A Real-Time Traffic Congestion	Chan-Tong Lam, Hanyang Gao, Benjamin Ng	- real time images by government website - to detect the number of	This system provides a more economical solution compared to traditional traffic congestion estimation systems

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	Detection System Using On-Line Images		vehicles, Haar-like features technique is used - image correlation coefficient used to determine congestion condition	
5	Traffic Congestion Detection By Use Of Satellites View	Mudassir Khalil, Jianping Li, Abida Sharif, Jalaluddin Khan	Satellites are used to capture pictures and videos of a specific point. Image processing techniques like background subtraction and frame difference are applied on these frames to extract out vehicles.	All detected vehicles are counted and marked with yellow color. Vehicles which do not change position in previous frame and in current frame are stopped vehicles and mark as red
6	Multi Intelligent Traffic Light Optimization techniques by applying Modified Component Analysis Algorithm	V.Ellappan, B.Sindhusaranya, TadesseHailu	Video is acquired using WebCam. Pre-processed images are fed to Hog Feature extractor and passed to k-NN classifier.	Numerical experiments of proposed work shows that the average travel time is reduced to 20.6% while comparing to the fixed-time signal control.
7	Priority Based Real Time Smart Traffic Control System Using Dynamic Background	Sarath S, Deepthi L.R.	Dynamic background traffic cycle calculator algorithm (DBTCA) is used to calculate traffic density and time is allocated for each road. If emergency vehicle is detected, the time increases.	It was observed that traffic density was proportional to priority while VIP traffic was given highest priority.
8	A Vehicle Detection Technique for Traffic Management using Image Processing	Partha Narayan Chowdhury, Tonmoy Chandra Ray, Jia Uddin	Daytime or night time is differentiated. During day time, comparison is done between foreground image with the background image to count the vehicles. During night time, the intensity of the image is analyzed to differentiate between headlights and ambient light.	Accuracy results of vehicle detection during Night time – 94.10% Accuracy results of vehicle detection during Day time – 95.08%
9	Vehicle Detection and Tracking Based On Color Feature	Mallikarjun Anandhalli, Vishwanath P. Baligar	The algorithm is evaluated based on four steps i.e. Vehicle color extraction, Filtering and shaping of blob, Data association, Vehicle tracking	An average detection rate of the proposed algorithm was of 93% when tested on traffic videos of urban road for detection of the vehicles, tracking and to determine the density of the vehicles. The collected video sequences were both high and low resolution.
10	Intelligent Traffic Signaling System	Ch.Jaya Lakshmi, S.Kalpana	Computation of the amount of area occupied by vehicles on the road rather than finding number of vehicles. The greater the amount of area occupied by vehicles on the road the greater the amount of traffic congestion.	Variable traffic cycle is selected depending on the total traffic density of all the roads at the junction. Depending on the traffic density a weight is determined for each road and total traffic cycle is weighted for the roads.

III. Conclusion

Cameras are commonly used for detecting the traffic conditions. Object detection is an appropriate method for checking the real time traffic condition because it can provide more details. Apart from the number of vehicles on the road, traffic factors like weather, time intervals, and road type should also be considered. Detection of emergency vehicles is inevitable. Such factors affect the scheduling plan of the traffic light switching. Existing solutions do not consider the situation of the pedestrians crossing the road. Hence, an optimized intelligent traffic light system can be designed for the betterment of road users and road usage optimization.

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