Review on Traffic Density Analysis Techniques using Image Processing

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Abstract— From city roads to highways, a lot of traffic problems occur everywhere in today's world. An Excessive number of vehicles on roads and improper methods of controlling the traffic creates traffic congestion which leads to wastage of time and increases the pollution. This frequent traffic jams problem leads to a rise of the need for an efficient and proper traffic management system. Existing methods work well in free-flow traffic but in the case of heavy congestion, these methods face challenges. Current traffic control techniques involving magnetic loop detectors buried inside the road, infra-red and radar sensors on the side provide limited traffic information. The use of image processing helps in the proper management of traffic even in shadows and various lighting conditions and it is also cost effective as the devices it requires like sensors, cameras are cheaper than for other solutions. Comparison and survey of all these methods is shown in this paper which concluded that use of canny edge detection method makes an analysis of traffic comparatively efficient.

Key words: Image Processing, Edge-Detection, Traffic Management, Traffic Density, Traffic Controller, Sobel Operator, Prewitt Operator, Robert Operator

I. INTRODUCTION

With the development in many aspects of life traffic congestion becomes a challenge for all large and growing urban areas and becoming one of the daily concern of all the individuals. The traffic jams not only affects the human routine lives but also lead to a rise in the cost of transportation. Traffic congestion is a condition on a road that is caused due to slower speeds and increased vehicular queuing. Today, the number of vehicles is increasing day by day. But, at the same time road infrastructure cannot be increased which leads to increasing traffic congestion. Therefore an automated and smart traffic system is required to manage the traffic congestion problem smoothly and for safe running of the civilization, which leads us towards proper analysis of traffic, distribution of controlling signals and adjustment of control management.

There have been drastic changes in management techniques of traffic jam compared to old methods. Different methods used for traffic management:

A. Manual Controlling

The basic approach is to employ a person in some areas to control traffic according to different states and countries. The traffic police need a signboard, sign light and whistle to control the traffic. But as the amount of traffic is so increasing day by day that police persons have to face many difficulties in controlling the traffic manually and avoids frauds done by people.

B. Automatic Controlling

Timers and electrical sensors are used in automatic controlling of traffic light/signals. In this, every time a constant numerical value is loaded in the timer after fixed interval of time. Depending on this values, the light automatically gets ON and OFF. The availability of the vehicle on each phase are captured by the sensors and depending on the signal the lights automatically gets change. This method helps to control heavy traffic based on timing attributes.

C. Magnetic Loop Detectors (MLD)

Magnetic loop detectors use magnetic properties to count the number of vehicles on the road. Current traffic management techniques like magnetic loop detectors in which MLD are buried inside the road. It leads to the requirement of separate systems for proper counting of traffic and correct supervision.

D. Inductive Loop Detectors (ILD)

This method provides a cost-effective solution for traffic controlling but along with this, it is also true that their failure rate is high when they are installed on poor road surfaces, leading to falling in pavement life. At the time of maintenance and repair, it obstructs the traffic.

E. Use of light beams

Light beams like infrared rays, LASER etc. are also used for controlling the functioning of traffic. But, the light beams are obstructed traffic flows which lead to improper results.

F. Use of image processing

A Traffic jam can be easily detected by human eyes. The human brain comes within a second with a decision of whether a jam has occurred or not by processing the image, detecting and analyzing objects. Computers can only process binary data. The picture on the road is actually a binary data, which is need to be represented as a digital. It is used as a primary input. The image when captured is unformatted and raw. For the efficient processing, programmers need to process that raw image and extract information from them. Several fields like image processing, object recognition, computer vision, etc. have emerged due to a need of extracting information from images.

Researchers are engaged in exploring different technologies to detect traffic congestion and making traffic management more efficient. Review of all the existing methods shows that use of image processing overcomes many of the disadvantages of other existing algorithms.

II. COMPARATIVE STUDY OF THE IMAGE PROCESSING ALGORITHMS

Image processing is any form of signal processing for which the input is an image, such as a image or video frame; the output of image processing may 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. The image of a road can be represented as digital data i.e. binary data but it needs to be processed before using so as to extract relevant information from it. This is to be done because when the image is captured from a natural environment, the image is raw and unformatted. Therefore operations like image enhancement, edge enhancement, brightening etc. are used.

A common architecture of the system for traffic density calculation can be as follows-

1) Image acquisition
2) Preprocessing
3) Density calculation
4) Traffic control

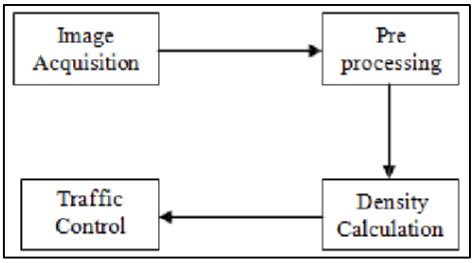

Fig. 1: Basic architecture of system for traffic density calculation

All the techniques reviewed in this paper follow the same common architecture. So a comparison of all the techniques is made based on these four modules.

A. Image Acquisition

All the methods or techniques discussed in this paper make use of cameras for image acquisition. A camera is installed at any of the tall structures like polls at the traffic junctions so that it can capture the overlook of the traffic scene on the road. These images are then analyzed and pre-processed to detect and count the vehicles present or the vehicle density.

B. Preprocessing

Preprocessing is done to get a clear image. Since the images are extracted from real-time video frames the images can be blurred or dark or distorted etc. like images can be blurred when the weather is foggy or rainy. Similarly, images can be darker when captured at night time conditions or can be too bright when it's very sunny (like in afternoon).Therefore different preprocessing methods are applied on the images to improve the quality of the image, according to the objective of the user.

In Static background subtraction method, the images captured are first converted into grayscale. Later the grayscale is converted into binary. After that erosion and dilation are applied according to the requirement for a clearer image [1].

In Canny edge detection method, first the image is converted to grayscale and then every frame is applied with background subtraction for object detection [2].

In Dual method technique, combination proposes to use grayscale conversion along with background subtraction to detect foreground objects on a fixed background [4].

In the Gradient based image enhancement method [5] [6], the author makes use of gamma correction for image enhancement.

Preprocessing plays an important role as the images are captured from the live videos so they can be affected by the surrounding conditions of the road. The images can be blurred, distorted, very bright or very dark etc. So preprocessing helps to improve the quality of the image that further helps in better analysis of the image and traffic density calculation also.

C. Density calculation or vehicle count

In the background subtraction technique [1] a combination of motion detection and vehicle detection is used. For motion detection, analysis of two consecutive frames is taken into account, in which the histogram of key region parts of the frames is analyzed. The histogram is then compared with the determined threshold. A constraint stated with this method is that the key region should be at least 3-pixel wide profile of the image along the road. The difference between these profiles then shows the displacement or motion of the object. For vehicle detection, the image of the road is divided into subparts. Then background subtraction technique is used.

In the Canny edge detection method [2] an adaptive background subtraction is used. After that, canny edge detection method is applied for edge detection of the vehicle which will detect all the edges of the vehicles present in the image. Canny edge detector may prove to be effective as it considers all neighborhood pixels while detecting edges. For object detection, Moore neighborhood algorithm is used along with Jacob's criterion. This method is supposed to give better results as compared to static background subtraction.

In the Dual method technique [4] the author uses a combination of gradient magnitude and direct subtraction techniques to detect vehicles present on the lanes. The reason for using these two techniques simultaneously is that each of them overcomes the disadvantage of the other. In direct subtraction method color of a vehicle can be problematic in finding density. This problem is resolved using gradient magnitude.

In gradient magnitude method, there can be situations where detected edges may not form closed contour. This problem is resolved using direct subtraction. In the Gradient method technique [5] the author proposes to use edge detection for making vehicle count. Edge detection in this method is done using canny edge detector and gradient based edge detection.

According to the review done, the Canny Edge Detection technique [2] gives the most explanatory and proving results as compared to all other methods discussed in this paper.

Methods	Image Acquisition	Preprocessing	Density calculation
Background Subtraction technique	Uses cameras	Grayscale conversion, Binary scale conversion, Erosion, Dilation	Motion detection using Consecutive frame comparison based on histogram key region and Vehicle detection using background

Canny Edge Detection Technique	Uses cameras	Grayscale conversion, Background subtraction	Canny edge detection for vehicle edge detection, Moore neighborhood algorithm for object count
Dual 1method technique	Uses cameras	Grayscale conversion	using a combination of gradient magnitude and direct subtraction techniques to detect vehicles
Gradient Method	Uses cameras	Grayscale conversion, Gamma correction	using canny edge detector and gradient based edge detection

Table 1: Comparison of all methods [3]

D. Traffic Control

The calculation of vehicle count/density is utilized for further traffic control for different purposes in different methods.

In the background subtraction method, the vehicle count is used to develop an android app that will give the user details about the traffic jam conditions at any particular location.

In the canny edge detection method, the density calculation helped in automatic traffic lights switching for better traffic management. It contributed to a special feature, i.e. detection of a presence of an emergency vehicle on the lane. When this happens, then that lane is given preference over others and the traffic lights are switched accordingly.

Similarly, in Dual method and gradient method, the traffic density/traffic count calculation helps in an automatic switching of traffic signals, based on the number of vehicles present at any particular lane at any instance of time. The comparison of these algorithms shows that vehicle density calculation can be achieved with the help of various algorithms. Table I briefs the whole comparison of the five methods discussed.

III. Comparison of Edge Detection Techniques

The comparison of various edge detection algorithms shows that Canny Edge detector is the best. It gives about 93.47% accuracy.

Image	Actual Number	Boolean	Sobel	Prewitt	Marr-Hildreth	Canny
1	4	2	2	2	6	4
2	3	0	1	1	4	2
3	4	2	2	3	3	4
4	5	2	2	3	3	6
5	5	2	3	3	3	5
6	7	3	3	2	5	6
7	4	1	1	1	5	4
8	5	2	3	2	5	5
9	3	0	0	1	3	2
10	6	4	2	3	3	6
accuracy		39.13	41.3	45.65	84.78	93.4

Table 2: Comparison of Edge Detection Techniques [9]

IV. Advantages and Disadvantages

All the algorithms reviewed in this paper are based on the use of image processing techniques for calculating the traffic density present at a particular road, at any instance of time. As it can be seen from the discussion in the previous section, all the methods have some similarities and some dissimilarity also. Each method poses some advantage and some disadvantage at the same time. These advantages and disadvantages are briefed up as follows in Table 2 below.

Method	Advantages	Disadvantages
Background Subtraction technique	Cost effective, Scalability	No solution for robustness to occlusion, Not practically implemented, No hard results of performance
Canny Edge Detection technique	Cost effective, Scalability, Improved vehicle detection efficiency	No solution for robustness to occlusion, Time consuming, Not consistent with changing environment
Dual Method Technique	Less installation cost, system considers situations of occlusion	The proposed method seems to be complex, Does not work well in low light conditions
Gradient Method	Cost effective, method proposed seems simple, makes use of canny edge detector which is quiet efficient	Proposed system does not apply for night time, image matching for vehicle count does not seem to be very efficient

Table 3: Advantage and Disadvantages of All Image Processing Methods [3]

V. Conclusion

The study infers that image processing is an efficient and effective method of controlling traffic jam compared to other traditional methods of controlling traffic jam. It works much better and is more consistent compared to systems, which depend on detection of vehicles metal content because it uses actual traffic frames The use of image processing is good for traffic management but it still requires much improvement. The review on the above discussed algorithms for estimating traffic density at a particular time on a particular lane shows that accuracy of vehicle detection using image processing techniques can be increased to a further extent by introducing changes in the algorithms discussed. Like in background subtraction method [1] dynamic background subtraction can be introduced for better results. Similarly, in Canny edge detection method [2] solutions for occlusion problem can be introduced for more accurate results. In Dual method technique [4] solutions for performing the density calculation in night time conditions also. Another change that can be done is making use of thermal cameras. For object counting, Canny edge detector has proved to be the most efficient according to the literature survey done as it is not susceptible to noise interference and it also detects true weak edges [7] [8].Introducing such changes can help getting better results

and thus making image processing better method for traffic density calculation than any other method.

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