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A New Method to Control Traffic Congestion by Calculating Traffic Density

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Abstract: Congestion in huge cities around the world has recently become one of their biggest issues. The rapid growth of automobiles and the lack of appropriate roads to handle a big number of vehicles are the causes of the traffic jams. Various existing methods like Conventional or static time-based traffic management system provides drawbacks such as low edge detection accuracy, image blurring, etc. In this paper to improve these drawbacks Capacity map Generator (CmapGen) algorithm is proposed. The proposed CmapGen algorithm uses image processing methods to determine the current area-wide traffic density at the intersection of traffic lights. The traffic density calculated for the live roads using the CmapGen method will be used to identify the available traffic light durations. The vehicle density will be determined using the frames produced from the traffic video files. The outcome demonstrates that by processing the edge detection technique results through several image processing techniques like thresholding, blur, etc., the suggested CmapGen algorithm increases the edge detection technique's accuracy. The proposed method is contrasted with other approaches, including Canny techniques and conventional or static time-based traffic management systems. The average traffic density for Canny is 23.91, whereas it is 31.12 for CmapGen. The suggested CmapGen has a higher average traffic density as compared to the traditional Canny approaches. The proposed technique yields superior results compared to the canny edge identification method. Therefore, it is more beneficial in a smart traffic control system to determine when to change traffic lights by computing the area-based traffic density in real time.

Keywords: *Canny, CmapGen, Detecting Edges, Image processing, Traffic density, Vehicles*

1. Introduction

One of the major and crucial problems in many large cities across the world is traffic management. Accidents brought on by poor traffic management can occasionally result in serious injuries and even fatalities. Most vehicle accidents that result in fatalities in cities are caused by traffic accident congestion. In order to address the shortcomings of current traffic management circumstances, new strategies must be introduced as more vehicles move into congested traffic roadways. Since creating new flyovers, elevated expressways, highways, etc. is becoming very expensive, Additionally, it can take a while to finish. Therefore, the primary objective is to create a novel traffic control method while utilizing the most recent technological advancements and current infrastructures.

There is a lot of digital and visual data in the world today and processing that data using different technologies results in the pro[1]duction of a lot of information. Closed-circuit television (CCTV) cameras have been installed throughout all major urban areas of the world, including at traffic light intersections. A lot of data is captured and stored by these CCTV cameras. The analysis and development of a solution to the traffic issue that plagues many large cities in most nations can greatly benefit from this data. To comprehend and evaluate this enormous body of data, numerous image data analysis techniques are being developed, particularly with regard to the picture data captured and stored by CCTV cameras placed at traffic intersections. One of the many approaches for analyzing image data that has several uses in a real-time setting is the edge detection technique.

One of the major challenges faced by many large cities across the world is traffic congestion. In recent times accidents due to ineffective traffic management are more which lead to the loss of lives of many people and loss of

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property. This specific research work contributes to reducing or optimizing accidents that would happen because of the inefficient existing traffic controlling system.

The rapid growth of automobiles and the lack of appropriate roads to handle a big number of vehicles are the causes of the traffic jams. Various existing methods like Conventional or static time-based traffic management system provides drawbacks such as low edge detection accuracy, image blurring, etc. This work introduced the CmapGen algorithm, which uses image processing techniques to determine the real-time area-wide traffic density at the traffic signal junction, in order to address the current shortcoming. The traffic signal durations will be established using the CmapGen method based on the traffic density computed for the live roadways. The vehicle density will be determined using the frames produced from the traffic video files.

2. Literature Review

Additionally, traffic jams cause a wide range of other serious concerns that are often the cause of fatalities [26–28]. These challenges affect many people's daily lives and routines. Consider the scenario where an ambulance carrying a patient who needs immediate medical attention is traveling to the hospital. The likelihood of getting the patient to the hospital in the anticipated or required amount of time will be significantly decreased at this point if the emergency vehicle is hit in the bottleneck brought on by heavy traffic. And this will be a really big problem. It is vital to establish and develop an intelligent traffic light management technique that intelligently controls and manages the signal at the junction in order to prevent frequent crashes, traffic congestion, and accidents [27,28,37].

Several technologies have been put forth in the past, including RFID and IoT [1-2], traffic congestion estimation methods [34], big data and neural networks [14-22], real video analysis technique [33], image processing [3-8], machine vision technology [35-36], accident detection and ambulance control [32], traffic prediction techniques [31], smart home [38-39], and fuzzy logic [9-13]. A few of the shortcomings of current methods can be realized via the analysis of both those and current technology [23]. Using a density-based traffic control system is the best way to get around many of the problems that are currently present [24].

The suggested approach uses a picture-processing-based estimate location algorithm to calculate the website traffic density. The intelligent traffic signal administration system makes use of the computed traffic thickness values. The region engulfed by the vehicle borders can be used to accurately measure the density of web traffic using the proposed method. In comparison to prior existing conventional methodologies, the approximation area-based method of traffic density estimation will be more useful for managing smart traffic regulating lights. In image processing, Prewitt and Canny edge detection methods are increasingly widely used, and canny edge detection approaches produce high accuracy results [28–29]. Vehicle density is discovered using the canny edge detection technique in [30], and the determined density is used to govern the intelligent traffic system. However, it is just providing the boundaries of the vehicles visible in the supplied photographs. Actually, we require the space that cars take up on the road. Therefore, in order to obtain vehicle density more precisely, the edges area must be increased. The CmapGen algorithm suggested increasing edge areas. This study uses the CmapGen algorithm to determine the location of the vehicles in the collected live traffic image. This technique provides us with the traffic density at that time, and we can utilise this number to regulate traffic signals intelligently and make decisions.

The paper is organized as prosper: Area 1 defines the Intro, Area 2 clarifies Associated jobs, Area 3 explains regarding proposed formula as well as methodology, and Area 4 discusses the speculative results and also conversation. Finally, Area 5 goes over regarding verdict and future work which is succeeded with the references utilized in this work.

3. Methodology

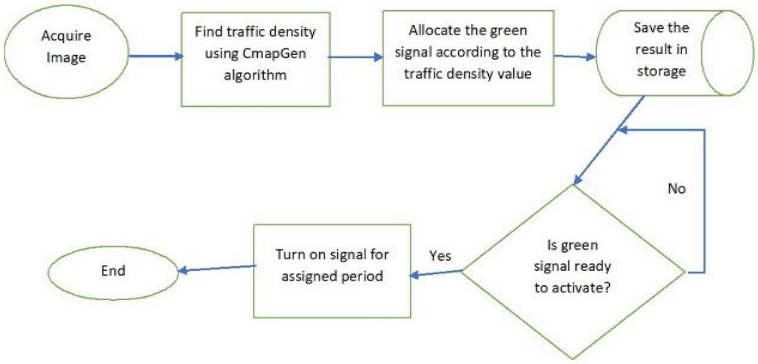

Figure 1- Model for allocating green light time in the new traffic control system

Figure.1 illustrates the proposed green light time allocation model for the new traffic control system. The traffic image

is given as input and then the traffic density can be determined using the CmapGen algorithm. The second stage is to assign the green signal based on the value for traffic density before saving the outcome in the storage. The next step is an activation of the green signal. If the green signal is not ready to activate means, then the signal is sent back to the storage. If the green signal is ready to activate means, the signal is turned on for the assigned period. Then calculate the moving vehicle's density at the traffic junction and then a smart traffic management system is controlled. This research can be improved to determine the density of moving cars at the intersection of traffic lights, allowing for the calculation of real traffic density and the use of that information to operate smart traffic systems.

3.1 Proposed CmapGen Algorithm

To determine the traffic density of vehicles near the traffic light, many researchers developed canny edge detection methodology. All of the vehicles in the input traffic image will have their edges found using the Canny approach. The canny technique will detect only the edges, So the traffic density of the input image or frame calculated using the canny algorithm accuracy was very low because it detects only the edges of the vehicles present in the input image but not the entire vehicle occupancy of the road. To improve the accuracy of canny edge detection method results, in this project, processing the result of canny images using various image processing algorithms like thresholding, blur, and generating capacity maps. This technique gives good results than the canny edge detection algorithm. In this approach, generating the capacity maps using the features of programming language, this algorithm is named as CmapGen algorithm.

In this project, traffic video datasets downloaded from Kaggle are used as input. Frames are generated from the input traffic video. These frames are processed through

the steps mentioned in the CmapGen algorithm and obtained the density of traffic present in all the frames. Figure 2 represents the data flow of the implementation process of the CmapGen algorithm.

In this CmapGen algorithm, the first selected traffic video is given as input, then this video is processed and frames are generated from this video. These frames are processed through the below steps to get the capacity or density of all types of vehicles available in the frame.

CmapGen Algorithm:

Step1: Mask the Region of Interest (RoI) in the input frame. In this method, finding the density of vehicles present in the RoI only. The input image may cover more area than the required area, so in the first step mask the focused area and name it RoI. The example image for masking RoI is shown in figure 3.

Step 2: Count the non-zero pixels in the RoI area and store them in a variable N. Now N holds the absolute number of pixels of identified RoI area from the input frame. This will help in finding the density of the vehicles in step 8.

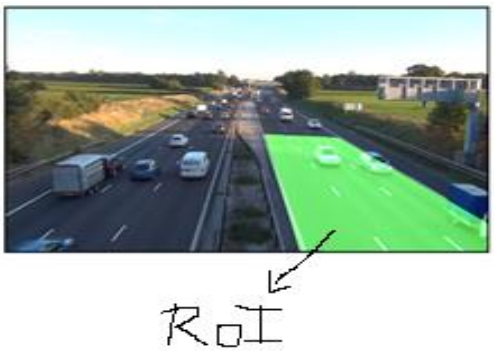

Figure 2- Region of Interest (RoI) Marked Image

Step 3: Use the canny edge detecting method. In the supplied image, this algorithm will find the edges of any automobiles and other objects. The task is to determine how many pixels the automobiles in the RoI area occupy. To find this continue the processing of the frame through the following steps.

Step 4: Complement the output image from the previous step's outcome. i.e. Complement the canny edge output image.

Step 5: Process the complemented canny output image using blur and thresholding image processing techniques. These techniques will increase the area of the edges present in the result of the canny edge detection algorithm, In this way, we are improving the accuracy of the result.

Step 6: Perform Bitwise AND operation in the area of RoI.

Step 7: Count the pixels in the RoI area that are not zero and add that number to a variable called M. The number of pixels occupied by vehicle edges in RoI is now displayed in M. The capacity or density of the cars present in the image is determined using this M value, which represents the presence of automobiles in the image.

Step 8: Using the mathematical formula below, determine the density of automobiles in the image. Display the results or transmit them for additional processing.

$$\text{Capacity} = [\ 1 - (M / N)\ ] * 100$$

Step 9: The capacity map is plotted with the help of functions available in our python programming platform and also displayed the capacity value in that image. The example image that displays the capacity value is shown in figure 4.

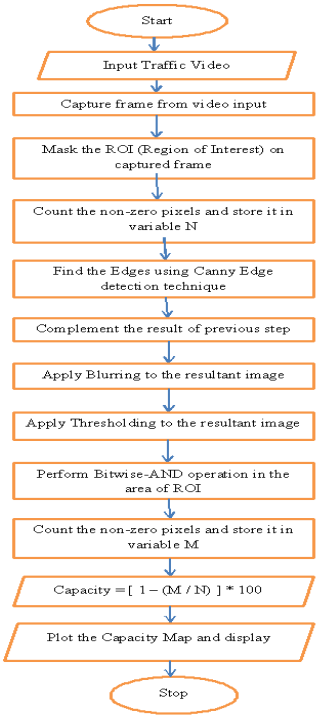

Figure 3- Flow chart of CmapGen Algorithm

The dataset used in this is a traffic video, which is given as input to the proposed model. Initially, frames are generated from the video, the dataset can generate 30 frames per second. As the number of frames is more, instead of using the latest frame density to decide traffic light duration, finding the average traffic density of recent 10 frames. This average traffic density will be used to control the smart traffic management system.

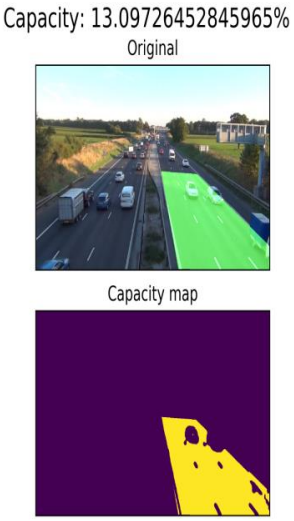

Figure 4- Image consisting of the original image, plotted Capacity map, and Capacity value

4. Results

In order to evaluate the CmapGen algorithm, a video traffic dataset was provided as input to the project. The given traffic video was then processed via the methodology's phases to produce outputs utilising capacity maps. Canny edge detection algorithm was also implemented for the same dataset and compared with the results of Canny and CmapGen algorithms. The sample result images i.e. the capacity maps are shown in Figures 5, 6, 7, and 8. Capacity values displayed in these Cmaps are the calculated approximation density of the vehicles present in the frames which are generated using the traffic video dataset.

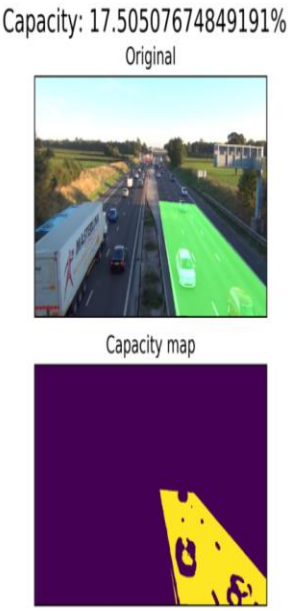

Figure 5- Generated Capacity map sample result1

Figure 6- Generated Capacity map sample result2

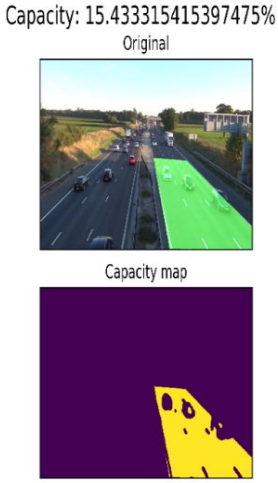

Figure 7- Generated Capacity map sample result3

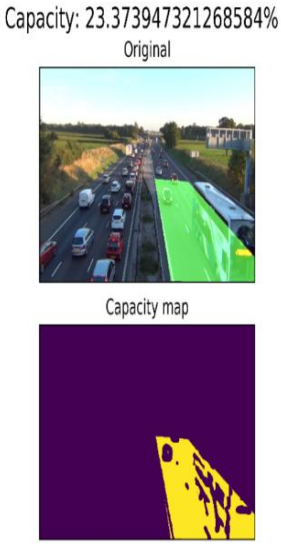

Figure 8- Generated Capacity map sample result4

The Calculated traffic density values and its average traffic density values using canny edge detection and CmapGen algorithms of 10 frames are stored in table 1.

The average traffic density value is used to manage the smart traffic lights management system. A graph is plotted using table 1 values and represented in figure 9. As per the experimental results shown in table1, figure 9 and figure 10, For all the input frames CmapGen algorithm-generated density values are greater than the canny algorithm-generated density values. The proposed CmapGen algorithm outperformed the canny algorithm due to added blur and thresholding features.

The green time allocation to the signal is determined by the traffic density value found using the CmapGen method. The proposed green light time allocation is purely an estimation-based model shown in figure 1. the estimation-based model uses the analogy i.e. If there are a greater number of vehicles then more edges will be detected leading to more traffic density value, so green time allocation will be done proportional to the traffic density value found using the CmapGen method.

Table 1. Traffic Density of 10 frames and its Average Density

Frame Number	CmapGen	Canny
1	46.64	39.43
2	31.25	26.90
3	17.50	14.82
4	8.04	7.09
5	30.91	24.85
6	24.14	20.92
7	29.15	21.09
8	53.47	34.97
9	20.79	17.19
10	49.35	31.93
Average Traffic Density	**31.12**	**23.91**

Table.1 shows the Traffic Density of 10 frames and the Average Density of the proposed method with the Canny method.

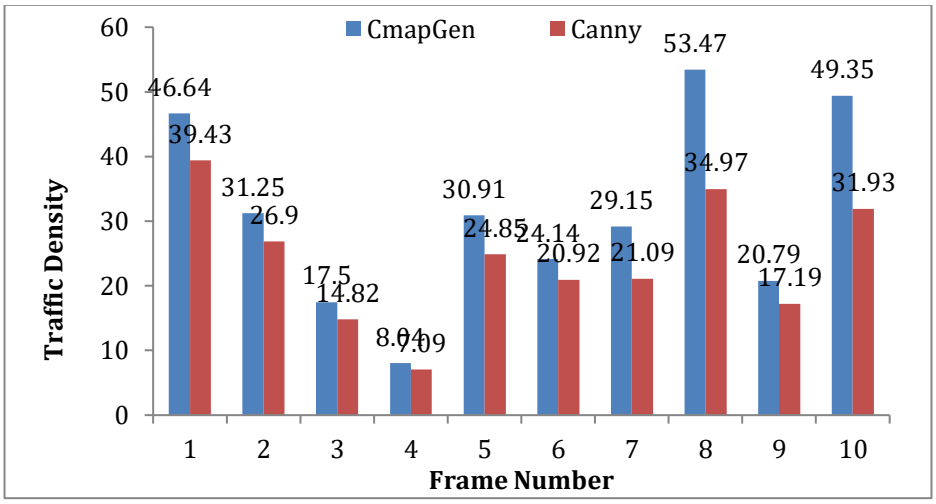

Figure 9-Graph showing the Traffic Density Values of 10 frames found using CmapGen and Canny Techniques

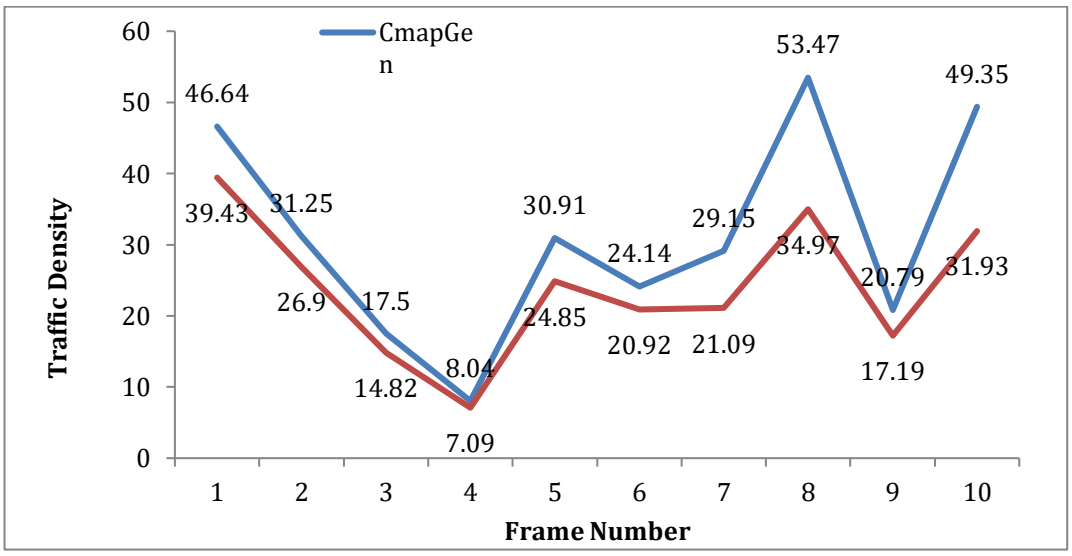

Figure 10-Graph showing the Traffic Density Values of 10 frames found using CmapGen and Canny Techniques

Table 2 displays the suggested green light allocation period based on estimates of traffic density. If the traffic density value falls below a certain threshold (in this study, the threshold value is 20), it is inferred that there is less traffic and no green light is given. Otherwise, the values shown in table 2 are given the all-clear.

Table 2. Greenlight allocated time, based on traffic density value range

Traffic Density Value using CmapGen Method	Estimated green light allocation time
40 – 50	60 Sec
30 – 40	45 Sec
20 – 30	30 Sec
Less than 20	0 Sec

5. Discussion

CmapGen algorithm gives good results than the canny edge detection algorithm. CmapGen algorithm improves the accuracy of the edge detection technique by processing the edge detection technique results through various image processing techniques like thresholding, blur, etc. The proposed method is contrasted with other approaches, including Canny techniques and conventional or static time-based traffic management systems. The findings of our trial demonstrated that our method considerably reduces traffic congestion and, as a result, accidents. Our results also have low latency and good accuracy.

6. Conclusion & Future Work

This study presents a novel method for estimating the density of vehicles on the road at traffic light intersections using features and image processing methods. The CmapGen technique is utilized in this paper to obtain the findings. In comparison to the clever edge detection approach, the proposed algorithm produces better results. Therefore, it is more beneficial in a smart traffic control

system to determine when to change traffic lights by computing the area-based traffic density in real time.

Only static images will be compatible with this method. This research can be improved to determine the density of moving cars at the intersection of traffic lights, allowing for the calculation of real traffic density and the use of that information to operate smart traffic systems. Lessen average vehicle traffic density is regarded as the restriction. In the future, the traffic management system and the typical vehicle traffic density will both be improved.

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