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IMAGE PROCESSING BASED INTELLIGENT TRAFFIC CONTROL SYSTEM USING OPENCV

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Abstract: This paper presents the design and building of an intelligent traffic light control system. This is a comprehensive software prototype for a smart traffic system that has been demonstrated. Based on the volume of traffic on either side of the junction, the system regulates the traffic lights. Real-world hardware implementations may make advantage of infrared sensors and cameras. This research use image processing methods to count the number of vehicles before allocating timings based on a simple mathematical calculation for relative traffic density. The gaussian algorithm and the morphological algorithm approaches are the algorithms we employed in this research. By giving the cars on the busiest route greater space to pass than those on other, less busy roads, you may easily relieve traffic congestion. The system need to be capable of making daily priority decisions. In this method, the waiting time for drivers on roads with larger densities is essentially decreased. The photos for each lane are captured and analysed concurrently as a result, and a judgement is made about which lane should be given the most time and attention.

***Index Terms* – Traffic Sign, Congestion, Gaussian Algorithm, Morphological Algorithm, Intelligent system, Camera.**

I. INTRODUCTION

In the modern world, the majority of traffic signal systems in our cities employ a fixed-time, methodical control that does not adapt to changing traffic circumstances, wasting time and fuel. Why make the busy route wait by wasting time by flashing the green light on an empty road? Typically, the systematic traffic system wouldn't adapt to the environment. Additionally, time is very valuable in the ever-changing society we live in. Even though intelligent traffic control has made significant progress, many nations still rely on fixed-time or programmable traffic control systems. Fixed time and programmable traffic control systems waste more fuel, which raises the degree of pollution in the world today.

One can only image the psychological annoyance felt by drivers who are in a hurry and are abruptly halted by a traffic signal with no other cars on the opposite sides of the junction. Through the use of vehicle identification algorithms, this research aims to develop a practical prototype that addresses these issues. Our intelligent traffic control systems calculate the time of each cycle dynamically depending on relative traffic density while performing the aforementioned tasks. To assess traffic density, a variety of technologies have been utilized, including inductive-loop detectors, video image processors, infrared sensors, radar sensors, and ultrasonic sensors. Other traffic monitoring and control techniques, such as the identification of speed limit violations, red light runners, collision avoidance systems, automated number plate recognition, and information synchronization with databases, may also be used by these systems.

There have also been a number of research on intelligent traffic control models. In our experiment, traffic density is assessed using video image processing. High quality photos may be saved using the method we used for further processing. We tested our idea with top-notch video samples. A software prototype for a density-based traffic system is shown in this study. In order to cut down on waiting time at traffic signals, timing for each cycle was dynamically approximated. Methods were used to evaluate each's effectiveness and drawbacks.

The main goal of the work is to develop an image processing-based self-adaptive traffic light control system. Traffic that is unbalanced and varied in separate lanes causes each of them to use the same time slot less effectively, which results in slower speeds, longer travel times, and more congestion. To develop a system that will allow the traffic management system to allocate time for a specific lane based on the volume of traffic on other lanes using cameras and image processing modules. To overcome the drawbacks and begin implementing in the quickly changing environment, we must do rid of the methodical fixed cycle of traffic lights.

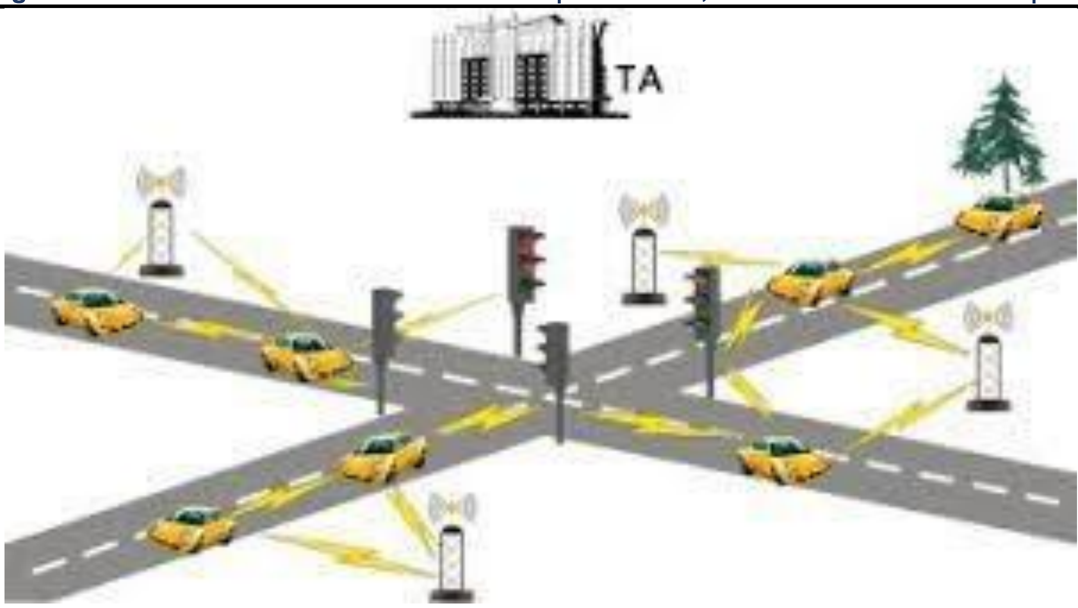

Fig. 1. Intelligent traffic control applied in 4 lane road

II. Recent Works

With a thorough study of the works pertaining to traffic state prediction and intersection-signal-control models, this review paper explores the key public datasets useful in constructing models to solve the stated challenges. According to our analysis, deep-learning-based methods for multi-intersection signal control and short-term traffic state forecasting produced acceptable results but lacked robustness for unusual circumstances, particularly in oversaturated conditions. These issues can be resolved by explicitly addressing these cases, which could result in significant system improvements overall. However, there is still a long way to go before these models can be used successfully and securely in real-world situations [1].

The amount of vehicles on the road network rises due to the quick expansion of the road infrastructure, which causes traffic congestion. In the Sultanate of Oman, the similar situation is present. One of the biggest issues in Muscat and other cities in the Sultanate of Oman is traffic congestion. This is mostly driven by the quick increase in vehicle numbers over a short period of time. It is necessary to create an IoT-based traffic control system to mitigate the effects of traffic congestion. A measurement of the actual traffic density on the route would serve as the foundation for the suggested system. Real-time video and image processing tools would be used for this. In order to determine the density, the photographs that were taken and saved on the server will be compared to the live images from the camera. The focus is on managing traffic by calculating the amount of traffic on either side of the street and giving users the ability to regulate traffic signals through software applications [2].

The massive expansion of the vehicle fleet and the resulting rise in traffic volume is not always accompanied by an expansion of the available road space. Most metropolitan regions experience traffic congestion as a result of this. We need to come up with a method to prevent gridlock. Many technologies were created and solutions were made in earlier decades to make road ways safer. Some of these strategies are incorporated, while others were traditional. With the aid of intelligent transportation systems, newly developed technologies are capable of educating drivers about the traffic conditions and potential risks of the route. This project suggests using Internet of Things (IoT) technologies to address issues caused by traffic congestion, which reduces pollutants due to increased traffic. The hardware module and the software module make up this architecture. The system makes use of cutting-edge technology for real-time data collecting, organization, and transmission, which gives traffic-aware apps the knowledge they need to predict traffic density accurately [3].

It is necessary to have an effective traffic management system in place since key intersections often experience traffic congestion. These solutions may be used to completely eradicate the consequent time wasted and pollution rise on a city-wide basis. Using real-time image processing, the article suggests implementing an intelligent traffic controller. In order to find the most effective approach, the picture sequences from a camera are examined using a variety of edge detection and object counting algorithms. The intersection's vehicle count is then assessed, and the flow of traffic is effectively controlled. A real-time emergency vehicle detection system is another idea put forward in the study. An emergency vehicle is granted precedence over all other vehicles in the lane in such situation [4].

The safety of people, property, and the economy all depend on an effective traffic infrastructure. Here, we describe a low-cost, low-power-consumption, and more dependable infrared-based intelligent traffic system. The system uses a wireless network and includes an infrared receiver and transmitter, each of which has its own unique identification number. When a car violates traffic laws, the system may respond quickly and display the outcome as well as the monitored ID of the offending vehicle on an LCD (Liquid Crystal Display). Infrared communication is used in this system to define a very precise traffic system. High precision and increased efficiency are achieved by this method at four-way terminals. Both road dividers and four-way terminals are compatible with this technology [5].

The development of intelligent systems for managing traffic on roads is offered as an architecture. The system is totally automated, improves traffic flow and safety, operates in real-time, and eliminates the need for expensive, ongoing human intervention. It is based on the straightforward idea of RFID car monitoring. The benefits ITCS may provide were thoroughly shown, attesting to its efficiency in traffic control systems. It is questionable, however, if it is ethically permissible to track every car and whether it goes against a fundamental civic right to privacy [10].

III. METHODOLOGY

The traffic light control and red-light camera were both parts of the intelligent traffic light control system. A computer received video of all 4 lanes of the junction after being alerted to it. The computer system analyses each frame of the brief video clip that was collected using PYTHON and OPENCV algorithms in order to determine the density for the intersection's four lanes. The computer system keeps track of all sides' and lanes' detected vehicle counts. Based on the relative traffic density and these data, the algorithm allocates the time for the green light.

There are several algorithms or strategies to adhere to and put into practice for video image processing procedures. When processing an image or a video, we are often interested in recognizing the items that are shown in it so that we carry out further analysis on them, such as counting them or determining their sizes. The idea of edges, or the lines that indicate a change from one group of related pixels in the picture to another group that is dissimilar, is crucial for identifying objects in images.

The following image processing methods were used in our project: Algorithms for morphological analysis and Gaussian blur.

A. Gaussian Blur Algorithm:

In order to determine the modification to be applied to each pixel in the picture, the Gaussian Blur filter utilizes a Gaussian function, which also describes the normal distribution in statistics. The picture is filtered by a Gaussian process to remove noise and smooth it out. The action is symbolized by;

$$g(m, n) = G\sigma(m, n) * f(m, n) \quad (1)$$

where f(m, n) is the image, and G(m, n) is the Gaussian filter given by;

$$G\sigma = 1 \ \sqrt{} \ 2\pi\sigma2 \ \exp -m2 + n2 \ 2\sigma2 \quad (2)$$

B. Morphological Algorithm:

A morphological operation known as morphological method is performed on a binary picture to produce a new binary image in which each pixel only has a non-zero value if the test performed at that particular position in the input image is successful. A tiny binary picture, or a small matrix of pixels, each with a value of zero or one, serves as the structural element.

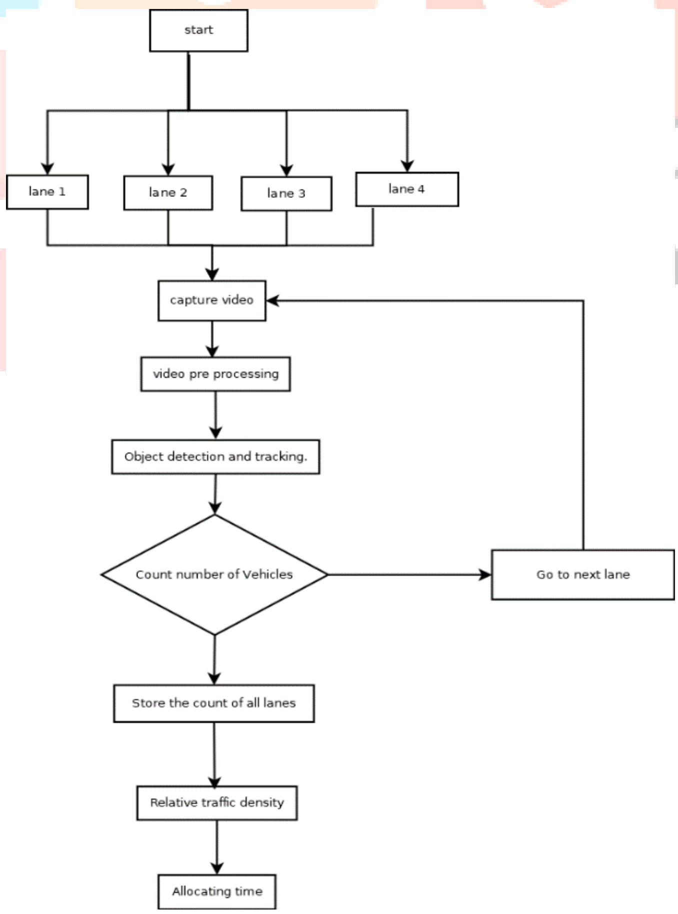

Fig. 2. Flow Diagram of the proposed system.

In Fig.2, the suggested system's flow diagram is shown. It illustrates the working approach by gathering data from four lanes to characterise the traffic, count the number of cars, track and detect, and determine when the lanes need to be changed by allotting suitable time and based on relative traffic density.

C. Relative Traffic Density Calculation:

For the green light, a time window of 5s to 30s was taken into consideration. To determine the relative traffic density and assign a certain number of seconds to each lane, a simple mathematical calculation was applied. Using I as the number of automobiles counted in each lane and base time as 120 seconds.

Traffic Density = i/(total number of cars)*120 (3)

The lowest green signal is provided if the value is less than 5 seconds, and the maximum green signal is given if the value is larger than 30 seconds. In the event that the value falls between, that number of seconds is taken into account. Pre-processing is a method used to turn an RGB picture into a grayscale one. Utilizing the luminance converter indicated in the following equation, it is done.

IS=0.2896*IR+0.5870*IG+0.1140*IB (4)

Where IS is the grey level image. IR, IG, IB are the luminance in red, luminance in green and luminance in blue.

When compared to an unenhanced photograph, an improved image offers better contrast and a more detailed image. Filtering using morphological operators including dilate, erosion, and structuring element approaches are some of the picture enhancing techniques. Object boundaries are represented by an image's edges. These edges are nothing more than pixels where a brightness change may take place and where the behavior of an adjacent pixel's image function is computed. For object identification, many morphological approaches are used.

We need to know specifics about the number of cars and circumstance in order to avert the issue of traffic in particular. To determine traffic density, an algorithm search of linked pixels is necessary. The contours algorithm is used. The work carried out has been explained in the following key points below:

1) A brief video clip of each and every lane was recorded constantly, one after the other.

2) With the use of backgroundsubtractorMOG and several morphological approaches, regions of interest were located and utilized to create masks. The areas of interest were those that the cars were using as lanes.

3) The video's frames are turned into grayscale. The frames are changed from grayscale to binary. White was used to replace any pixels whose brightness was higher than the threshold, and the value 0 was used to replace any other pixels (black). The operation to dilate does this.

4) On the video, a reference line is drawn, and counting begins only when an item passes the line. On the item, boxes with rectangular shapes are drawn to depict the cars' detection and tracking.

5) To find the borders of the automobiles, edge detection and contours were utilized. This edge detection technique uses a Gaussian filter to smear the picture. A double-thresholding method is used in the approach to find and connect edges, which makes it particularly successful on noisy pictures.

6) To make the edges stand out and fill in any gaps, the lines of the edges were widened. The picture had no gaps at all. For all the automobiles that were on the road, this resulted in a reliable production. In order to further allocate timings based on relative traffic density, the vehicle count for each lane is employed.

IV. Results And Discussion

The cameras read the colour video frames, which are then regarded as a lane's input;

Fig. 3. Vehicle count as captured from the testing environment.

After the color image, the RGB is now converted into the gray color image. This process is called Pre-processing.

Fig. 4. Gray Scale Image

The grey colour picture now has a salt and pepper noise added to it. The gaussian blur technique is used to blur the images or video.

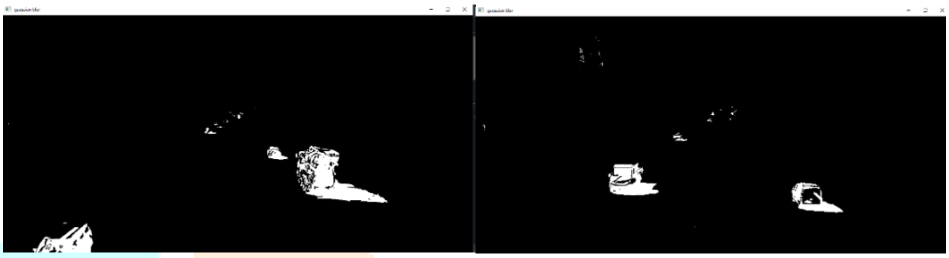

Fig. 5. Gaussian filter application on the traffic scene.

Morphological approaches dilate the input, making it simpler for the programme to recognise and count items. These steps are repeated for the full movie and then for the following upcoming lanes, providing the desired outcomes. Finally, utilising contours and edge detection, the count may be calculated. Tracking and detection are also carried out. This counts and shows the number of cars seen during the video.

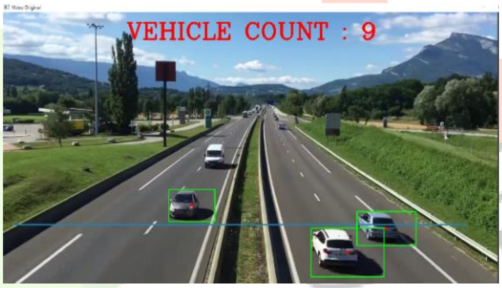

Fig. 6. Vehicle Count, Detection and Tracking.

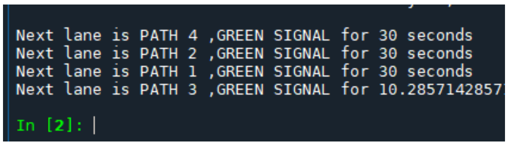

Fig. 7. Time allotted correctly to all the lanes based on current traffic.

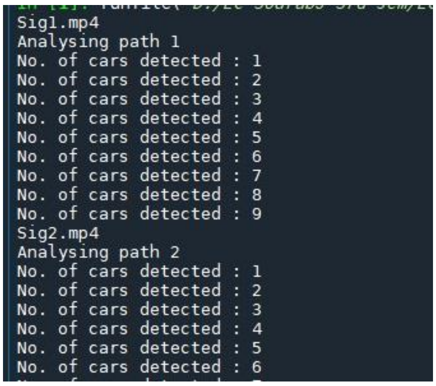

Fig. 8. Number of Vehicles detected in all 4 lanes.

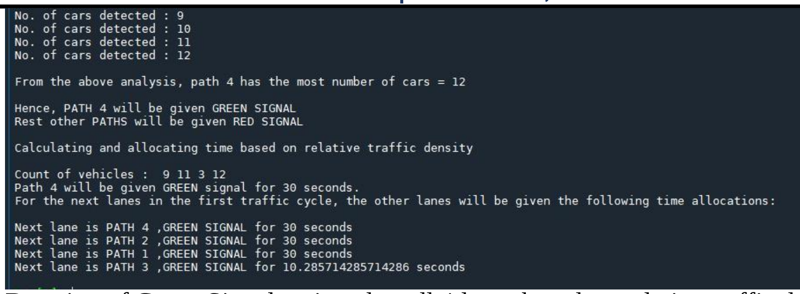

Fig. 9. Duration of Green Signal assigned to all 4 lanes based on relative traffic density.

V. Conclusions and Future Scope

Vehicle utilisation has expanded dramatically in our contemporary period as the population has grown fast. It is caused by high traffic. To overcome this issue, we need use new communication techniques, such as image processing-based intelligent traffic regulating and monitoring systems. Thus, based on the above theory, we can deduce that by adopting density-based traffic signal regulation, we can save a significant amount of time, fuel, unneeded pollution, and also avoid excessive traffic jams, resulting in smooth traffic flow. Many add-ons, such as information on cars at certain intersections through internet access, violation of rules detection, and many more, may be developed on this project. This is better for the people, the city, and the environment.

In actuality, we now use time-based traffic light regulation in India, and we are suffering widespread traffic congestion, which wastes time and fuel. We hope that these approaches will be implemented as soon as feasible so that the constraints of the current method may be addressed. Advanced study and implementation of different machine learning and image processing approaches will improve its realism and dependability.

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