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REAL-TIME INTELLIGENT TRAFFIC CONTROL SYSTEM USING IMAGE PROCESSING AND EDGE DETECTION TECHNIQUES

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ABSTRACT
An efficient management system is imperative to address the frequent traffic congestion experienced at major intersections. This paper proposes the implementation of an intelligent traffic controller that utilizes real-time image processing. By employing various edge detection algorithms and object counting methods, the camera footage is analysed to effectively manage the traffic flow. Previously, a matching method was employed, wherein cameras were installed alongside traffic lights to capture sequential image sequences. These images were then compared to a reference image depicting an empty road. However, in my paper, a filtering method is utilized instead. This method effectively filters out unwanted objects, focusing solely on vehicles, and accurately determines the number of cars present in each image. The software presented in my paper is specifically designed to process both images and videos. Its purpose is to be adaptable for future use in controlling traffic light signals. By considering the number of cars present in each direction, the software allocates sufficient time for each traffic signal, ensuring efficient traffic management.

Keywords:
Automatic Traffic, Computer Vision, Image Processing, Edge Detection

I. Introduction
Object recognition technology in computer vision is used to identify and select objects in images or video sequences, even when they vary in size, scale, rotation, or are partially obstructed. Traffic congestion is a growing problem, leading to accidents and other challenges. By foreseeing traffic patterns and spotting bottlenecks, Intelligent Transportation Systems (ITS) seek to resolve these problems [6]. However, computer vision systems still face difficulties in these tasks. To detect and count vehicles on roads, traditional methods involve motion detection or laser installations, which can be complex and labour-intensive [4]. Alternatively, our paper proposes an image processing approach for vehicle counting, providing a smart traffic control solution. By utilizing filtering techniques instead of background subtraction, our method accurately counts cars in videos or images without requiring human intervention. Overall, our methodology aims to automatically detect and count vehicles on highways, contributing to effective traffic congestion evaluation without relying on time-consuming hardware setups or manual intervention [3].

II. Literature
Edge detection plays a crucial role in image processing and computer vision, aiming to identify significant local changes in intensity. It is fundamental in object detection, segmentation, and recognition. Various approaches have been developed to accurately detect edges while minimizing the effects of noise. Techniques such as Sobel, Laplacian, and Canny edge detectors are widely studied and applied. The Sobel operator emphasizes central pixels for edge detection using gradient approximation. Laplacian methods focus on second-order derivatives but are sensitive to noise. Canny edge detection, known for its precision, includes steps like Gaussian smoothing, gradient calculation, and non-maximum suppression. It also uses hysteresis thresholding to connect edge pixels effectively. Each method has its strengths and limitations, making technique selection application-dependent. This

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survey reviews key edge detection algorithms, highlighting their mechanisms and practical considerations in digital image analysis.

2.1 Edge Detection Techniques

A. Edge

Edges are many times an assortment of bended line sections comprised of the places where a picture's brilliance suddenly changes. It is feasible to classify the edges that are separated from a two-layered portrayal of a three-layered scene as point of view ward or perspective free. An edge that is autonomous of the perspective as a rule reflects highlights that are intrinsic to three-layered objects, like surface stamps and surface structure. Ordinarily mirroring the calculation of the scene, for example, objects impeding each other, a perspective ward edge might modify as the perspective changes. A commonplace edge may be, for instance, the line isolating a block of red from a block of yellow. Conversely, a line can be few pixels of an alternate variety on a generally constant foundation. For a line, there may in this way typically be one edge on each side of the line.

B. Steps In Edge Detection

1. **Filtration**: Each picture is related with some force values, arbitrary change in these qualities can bring about clamor. Some normal commotion is: salt and pepper clamor, drive commotion and so forth. Commotion can bring about hardships in powerful edge recognition; subsequently picture should be sifted to lessen the clamor content that prompts loss of edge strength [2]. It is likewise named as Smoothening.
2. **Enhancement**: Working on the nature of picture is named as improvement. It intends to create a picture which is preferable and more reasonable over unique. A channel is applied to improve the nature of edge in picture [5].
3. **Detection**: A few techniques are taken on to figure out which focuses are edge focuses and which an edge pixel ought to be disposed of as commotion. These means ought to be followed cautiously to distinguish the edges effectively, as the subsequent stages are exclusively subject to edges identified.

C. Different Edge Detection Techniques

1. **Sobel Edge Detection Technique:** The Sobel is one of the most customarily used edge identifiers. Irwin Sobel has proposed the Sobel edge discovery strategy in 1970. The Sobel piece relies upon the focal distinction, however while averaging it gives more weight to focal pixel. It relies upon convolving the image with somewhat, separable, and entire number regarded divert in level and vertical course and is consequently commonly sensible in regards to estimations. The Sobel edge detection method contains the pair of 3x3 convolution masks illustrated in Figure c in experimental result. One mask is just to other rotated by 90 degrees. This mask can deal with the edges which are running 45 degrees to the pixel grid. This mask can deal with the edges which are running 45 degrees to the pixel grid. This mask can be put on distinctly to the input image to give gradient components in every orientation [7].
2. **Laplacian Edge Detection**: Laplacian is to some degree not quite the same as the technique we have talked about up to this point. Not at all like the Sobel edge finder, the Laplacian edge indicator utilizes just a single part. It registers second solicitation auxiliaries in a lone pass. For a beginning, the LaPlace numerical cycle should be explained.[8]:

$(x, y) = \delta\ 2f(x, y)\ \delta\ x\ 2 + \delta\ 2f(x, y)\ \delta\ y\ 2$ ------------- (1,2)

We note the Laplace given in condition (1,2). It is a nonstop subsidiary of the subsequent degree, the 3*3 Laplace veil utilized in handling computerized pictures. The Laplace veil is definitely not an arranged cover, so we don't control the heading and decide its attributes. Along these lines, it has equivalent detail every which way [1]. It is crucial for note that the slant or slant given to change the worth of the point, and due to the cover Laplace fixed turn is a benefit in support of its on the grounds that all bearings are equivalent simultaneously. Subsequently, we reason that the hindrances of the

Laplace cover are amassed in the way that it can't decide the course and is impacted by the presence of commotion in the picture to be uncovered its edges Two commonly used small kernels are:

0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

These veils are extremely susceptible to clamor because they approximate a second subordinate estimation on the image. To address this, the image is every now and again Gaussian smoothed before applying the Laplacian channel.

3. **Canny Edge Detection**: John Vigilant presented the watchful edge identification method at MIT in 1983. It is the norm, strong and typically utilized edge location technique. It isolates the commotion from the picture prior to removing edges. Vigilant is a superior technique for extricating the edges than other existing strategies and produces the great outcome.

The Vigilant administrator has some control over various subtleties of edge picture and can stifle the commotion effectively. This strategy follows following advances:

3.1. For smoothing the picture, the Gaussian channel is utilized with the distinguished worth of sigma which decreases commotion.

3.2. At each point, the edge course and nearby slope are determined. According to the edge point, this is the slope course point with the highest local strength.

3.3. The edge point increments edges in the angle picture greatness. In this calculation, top of these edges are thought of and gives no worth to all pixels that are not on the edges top. Then, at that point, as result, a slender line is created. This interaction is called non most extreme concealment [9].

Then, at that point, hysteresis thresholding is utilized here to edge the edges pixel. It has two limit values like T1 and T2.

Case1: If T1>T2, the ridges' pixel value is greater than the threshold T2, indicating sharp edge pixels.

Case2: If T2>T1, the ridges' pixel values are lower than the threshold T2, indicating a weak edge pixel.

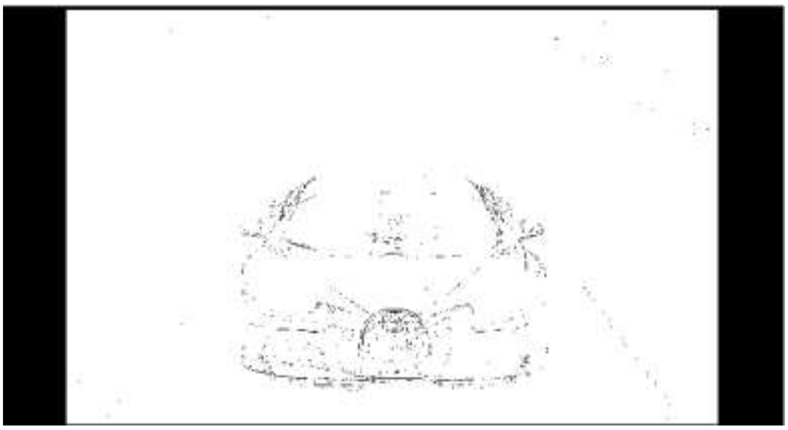
3.4. At Finally, the edge connecting process executes by coordinating the frail pixels that having 8-pixel network serious areas of strength for to. Initial two stages are extremely straight forward, note that in the second step we are additionally registering the direction of slopes "theta = arctan(Gy/Gx)" Gy and Gx are angle x heading and y bearing separately. Hysteresis is an approach to connecting the wrecked lines created in the past step.

This is finished by repeating over the pixels and checking in the event that the ongoing pixel is an edge. In the event that it's an edge, check encompassing region for edges. In case they have comparative bearing, we mark them as an edge pixel. We likewise utilize 2 limits, a high and low.

In the event that the pixels are more prominent than lower limit it is set apart as an edge. Then, at that point, pixels that are more noteworthy than the lower limit and are more prominent than high edge, are additionally chosen areas of strength for as pixels. We come to a stop when there are no more changes to the image.

2.2 Experimental Result

(Fig-a) Original Image



(Fig-b) After performing Laplacian Edge detection technique

(Fig-c) After performing Sobel Edge detection technique

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(Fig-d) After performing Canny Edge detection technique

III. Proposed Methodology

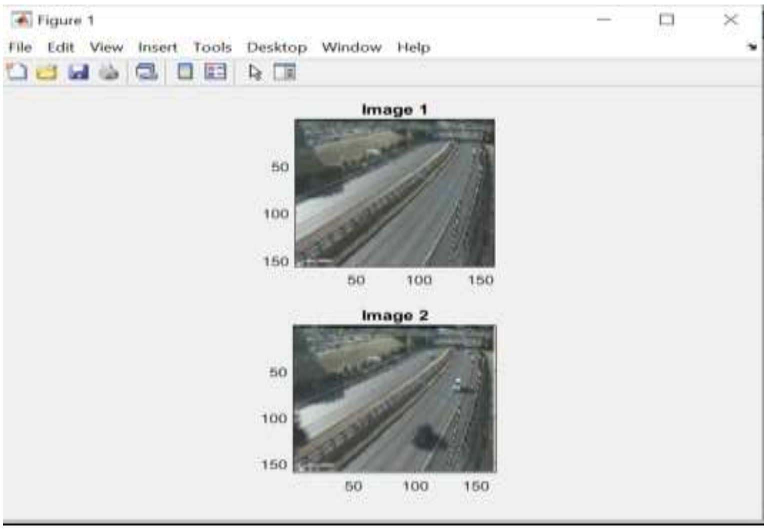
A. System Overview

The proposed intelligent traffic management system utilizes real-time image processing to analyse traffic conditions at major intersections. The system consists of the following components:

1. **Cameras**: Installed at strategic locations to capture live footage of the traffic.
2. **Image Processing Unit**: A computer system that processes the captured images.
3. **Traffic Control Unit**: Interacts with traffic lights based on the processed data.

B. Image Acquisition

Cameras capture real-time video footage of the traffic intersection. These cameras are positioned to provide a clear view of each direction of traffic flow.



(Fig-e) Reference Image and Real time Image

C. Image Preprocessing

The captured images are pre-processed to enhance their quality. This includes:

1. **Grayscale Conversion**: Converting the image to grayscale for simpler processing.

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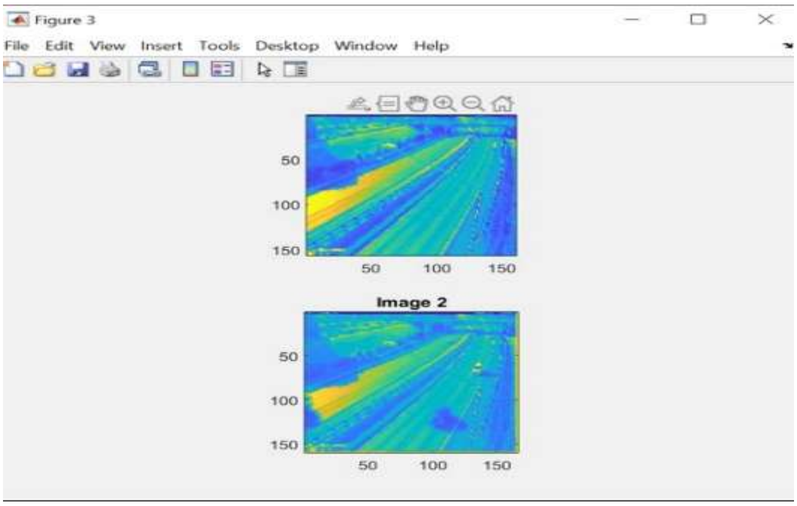


(Fig-f) Result after RGB to GREY conversion

D. Edge Detection

Edge detection algorithms are employed to identify the boundaries of objects within the images. Common edge detection methods used are:

• Canny Edge Detection
• Sobel Edge Detection

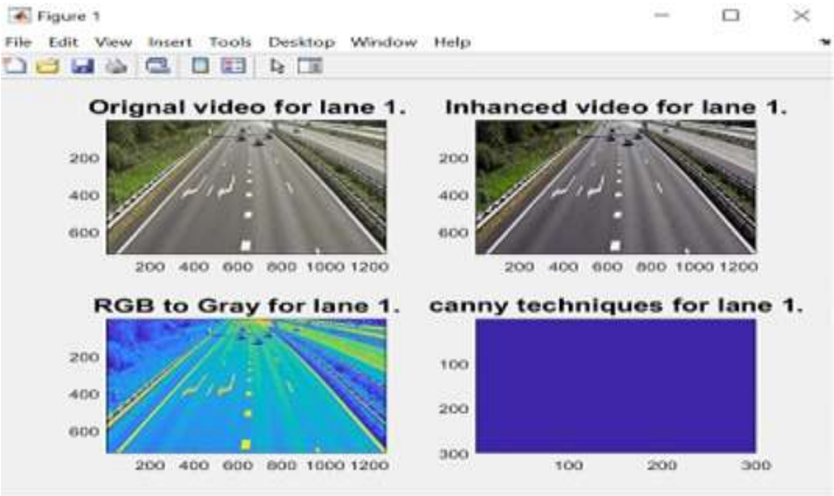
These algorithms help in identifying the contours of vehicles in the traffic footage.

E. Object Filtering and Counting

The filtering method focuses solely on vehicles by removing unwanted objects such as pedestrians and static objects. This involves:

• Background Subtraction: Removing the background to focus on moving objects.
• Object Classification: Classifying objects as vehicles using pre-trained machine learning models.

The number of vehicles in each frame is then counted.



(Fig-g) Integrated operation on lane 1

F. Traffic Signal Allocation

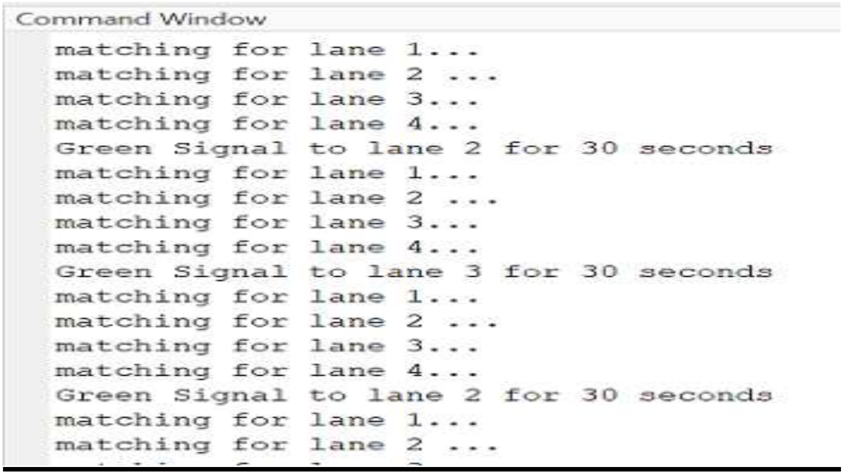
Based on the vehicle count in each direction, the software calculates the optimal duration for each traffic signal. The traffic control unit then adjusts the traffic lights accordingly to ensure efficient traffic flow.

G. Software Implementation

The software is designed to process both images and videos, making it adaptable for real-time traffic management. It integrates with the traffic control unit to dynamically adjust signal timings [10].

IV. Result Analysis Summary

A. Reference and Real-Time Image Acquisition:
• Selected a busy crossroad and captured a Reference Image with minimal traffic.
• Collected real-time video footage, converted it to images, and selected frames at fixed intervals for analysis.
B. Image Processing and Enhancement:
• Enhanced the quality of both the Reference and Real-Time Images.
• Converted images from RGB to Grayscale to reduce complexity.
C. Edge Detection and Vehicle Counting:
• Applied Canny Edge Detection to identify vehicle edges in the images.
• Performed lane-wise processing and matched real-time images with the Reference Image to calculate traffic congestion percentages [11].
D. Traffic Signal Allocation:
• Analysed congestion levels based on percentage matches.
• Allocated green signal durations to lanes according to congestion, ensuring efficient traffic management.



(Fig-h) Result Output

V. Conclusion

Since edge discovery is the underlying move toward object limit extraction and article acknowledgment, knowing the distinctions between various edge location operators is significant. In this paper an endeavour is made to survey the edge location strategies which depend on brokenness power levels. The general exhibition of different edge identification strategies is done with a picture by utilizing MATLAB programming. Vigilant outcome is better one when looked at than for a chose picture since various edge location work better under various circumstances. Regardless of such countless edges identification strategies are accessible in the writing, since it is a moving undertaking to the examination networks to recognize the specific picture without commotion from the first picture. As the future work, we can plan the new channel over the constraint to get better picture quality with the goal that the picture can be upgraded by diminishing the commotion.

VI. Acknowledgement

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VII. Future Scopes

A. Scalability and Deployment:

Extend the system to multiple intersections in urban areas, creating a network of intelligent traffic controllers.

B. Integration with Smart City Infrastructure:

• Integrate with existing smart city systems for real-time data sharing and coordinated traffic management.

C. Advanced Vehicle Classification:

• Implement advanced machine learning models to classify different types of vehicles, enhancing traffic flow analysis and signal allocation.

D. Adaptation to Varying Traffic Conditions:

• Develop adaptive algorithms that respond to changing traffic patterns, such as peak hours and special events.

E. Environmental Impact Reduction:

• Incorporate eco-friendly traffic management strategies to reduce emissions and fuel consumption through optimized traffic signal timings.

F. User Feedback and System Improvement:

• Utilize feedback from traffic authorities and users to continuously improve system accuracy and efficiency.

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