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DENSITY BASED SMART TRAFFIC CONTROL SYSTEM USING EANNY EDGE DETECTION ALGORITHM

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Abstract:
As the problem of urban traffic congestion intensifies, there is a pressing need for the introduction of advanced technology and equipment to improve the state-of-the-art of traffic control. The current methods used such as timers or human control are proved to be inferior to alleviate this crisis. In this paper, a system to control the traffic by measuring the real-time vehicle density using canny edge detection with digital image processing is proposed. This imposing traffic control system offers significant improvement in response time, vehicle management, automation, reliability and overall efficiency over the existing systems. Besides that, the complete technique from image acquisition to edge detection and finally green signal allotment using four sample images of different traffic conditions is illustrated with proper schematics and the final results are verified by hardware implementation.

I.INTRODUCTION

The rapid growth of urbanization and motorization has led to severe traffic congestion in metropolitan cities worldwide. Traditional traffic control systems, which rely on fixed-time signals and manual interventions, often fail to adapt to real-time traffic density variations. This results in unnecessary delays, fuel wastage, and increased air pollution. To address these challenges, smart traffic control systems have emerged as a solution, integrating real-time data analytics, image processing, and automation to optimize traffic flow dynamically. A promising approach in this field involves the use of image processing techniques, such as Canny edge detection, to assess vehicle density at intersections. By analyzing the number of vehicles present in each lane and adjusting traffic signal timings accordingly, these systems can significantly reduce waiting times and improve overall traffic efficiency. The proposed research introduces a density-based traffic control system using the Canny Edge Detection algorithm to analyze live video feeds and make intelligent traffic signal decisions, offering a robust, cost-effective, and automated alternative to conventional systems. Traffic congestion is one of the major modern-day crisis in every big city in the world. Recent studyof World Bank has shown that average vehicle speed has been reduced from 21 km to 7 km per hourin the last 10 years in Dhaka [1]. Intermetropolitan area studies suggest that traffic congestionreduces regional competitiveness and redistributes economic activity by slowing growth in countygross output or slowing metropolitan area employment growth [2].As more and more vehicles arecommissioning in an already congested traffic system, there is an urgent need for a whole newtraffic control system using advanced technologies to utilize the already existent infrastructures toits full extent. Since building new roads, flyovers, elevated expressway etc. needs extensiveplanning, huge capital and lots of time; focus should be directed upon availing existinginfrastructures more efficiently and diligently. glean traffic data. Some of them count total numberof pixels [3], some of the work calculate number of vehicles [4- 6].These methods have shownpromising results in collecting traffic data. However, calculating the number of vehicles may givefalse results if the intravehicular spacing is very small (two vehicles close to each other may becounted as one) and it may not count rickshaw or auto-rickshaw as vehicles which are the quotidianmeans of traffic especially in South-Asian countries. And counting number of pixels hasdisadvantage of counting insubstantial materials as vehicles such as footpath or pedestrians. Someof the work have proposed to allocate time based solely on the density of traffic. But this may bedisadvantageous for those who are in lanes that have less frequency of traffic.

II.LITERATURE SURVEY

Several research efforts have explored intelligent traffic management using sensors, computer vision, and artificial intelligence. Early works utilized infrared sensors and pressure plates to detect vehicle presence; however, these methods proved to be expensive and required extensive infrastructure. Recent developments have focused on video surveillance and image processing for more scalable and real-time solutions. According to Saini and Dhanraj (2018), image-based traffic density estimation is more flexible and cost-effective compared to hardware sensors. Canny edge detection, proposed by John Canny (1986), is one of the most effective edge detection techniques in image processing, known for its noise reduction and accuracy in identifying object boundaries—including vehicles.

Kumar and Jha (2020) employed edge detection for vehicle detection and reported improved traffic flow efficiency. Other researchers, such as Sharma et al. (2019), integrated real-time video processing with adaptive traffic light control but faced challenges in accuracy due to poor image quality and noise. Machine learning models such as CNNs have been applied for classification, but they require significant training data and computational resources. In contrast, Canny edge detection is lightweight, fast, and suitable for real-time applications, especially in developing nations with limited infrastructure. However, its performance can be further enhanced when coupled with adaptive algorithms that consider environmental factors like lighting and weather.

III.EXISTING SYSTEM

The existing traffic control systems in most urban areas are static or semi-dynamic, relying on predefined time cycles or limited sensor inputs such as magnetic loop detectors or ultrasonic sensors. These systems lack the flexibility to respond to real-time traffic conditions, often resulting in inefficient signal phases, prolonged congestion, and driver frustration. In some regions, manual control is still employed by traffic police, especially during peak hours or emergencies, which introduces human error and inconsistency. While some cities have adopted adaptive traffic control systems using camera-based inputs, the implementation is generally limited to high-priority intersections due to high costs and complex maintenance requirements. Furthermore, image processing techniques used in current systems often suffer from poor accuracy in low-light or high-noise environments, making them unreliable. These limitations highlight the need for a cost-efficient, accurate, and real-time adaptive traffic management system.

IV.PROPOSED SYSTEM

The proposed Density-Based Smart Traffic Control System using Canny Edge Detection

Algorithm addresses the limitations of traditional systems by employing real-time video analysis to dynamically control traffic signals based on vehicle density. The system captures live video from traffic cameras positioned at each lane of an intersection. These video frames are processed using the Canny edge detection algorithm, which identifies the edges of vehicles by detecting intensity gradients and filtering out noise. The number of detected edges in a region of interest correlates with the vehicle density in that lane. Based on this density count, the system prioritizes traffic lanes with higher congestion by allocating longer green signal durations, while minimizing waiting time for less busy lanes.

The Canny edge detection algorithm is chosen for its high accuracy, computational efficiency, and robustness in detecting vehicles in noisy or variable lighting conditions. The processed data is fed into a decision-making unit that dynamically controls the signal phase, ensuring optimized traffic flow. The system is fully automated, requires minimal human intervention, and can be deployed using low-cost hardware and open-source software. Compared to existing systems, the proposed model is more adaptable, responsive, and efficient, making it ideal for both urban and semi-urban deployments.

V.SYSTEM ARCHITECTURE

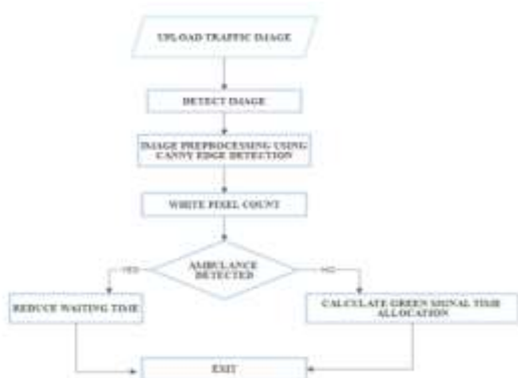

Figure 1 Block Diagram of the proposed methodology

Fig 5.1 System Architecture

The proposed system architecture is designed to dynamically manage traffic signal timing based on vehicle density and emergency vehicle detection, using image processing techniques—specifically the Canny Edge Detection algorithm. The system begins with the upload or capture of traffic images through a surveillance camera or input device at the intersection. These images are then passed through a detection module, which identifies the relevant portion of the frame (road lanes) for further analysis.

Next, the image undergoes preprocessing using the Canny Edge Detection algorithm, which accurately identifies the edges of vehicles within the image by analyzing pixel intensity gradients. This preprocessing stage converts the image into a binary edge map, where the number of white pixels corresponds to the presence and density of vehicles. A white pixel count is computed to quantify traffic congestion in each lane.

An important decision-making step follows: the system checks whether an ambulance is detected in the frame using shape detection or visual markers. If an ambulance is detected, the system immediately prioritizes that lane by reducing waiting time, enabling emergency vehicles to pass quickly. If no ambulance is found, the system proceeds to calculate optimal green signal time allocation for each lane based on the vehicle density derived from the white pixel count. This dynamic adjustment ensures that congested lanes receive more time while lightly trafficked lanes receive less, optimizing flow and reducing idle time.

Finally, after executing the signal timing logic, the system returns to an idle or exit state, ready to process the next incoming traffic image in real time. This architecture is highly adaptable and can be integrated with existing traffic signal infrastructure to create an intelligent, automated traffic control system that prioritizes both traffic density and emergency response.

VI.IMPLEMENTATION

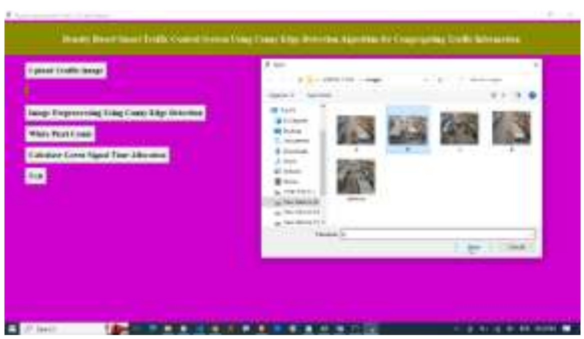

Fig 6.1

Fig 6.2

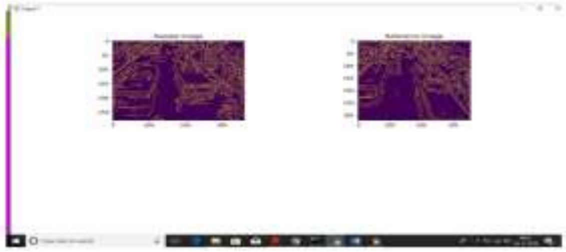

Fig 6.3

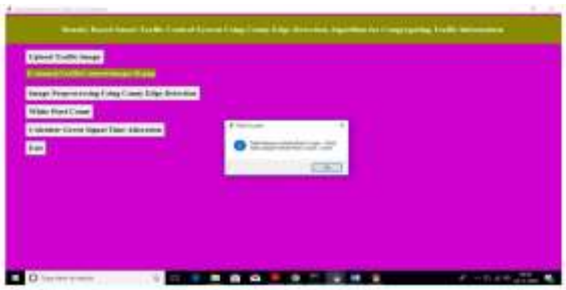

Fig 6.4

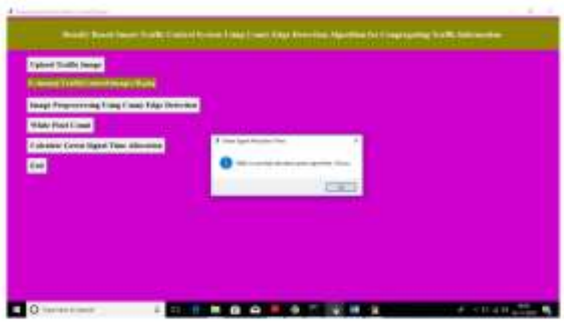

Fig 6.5

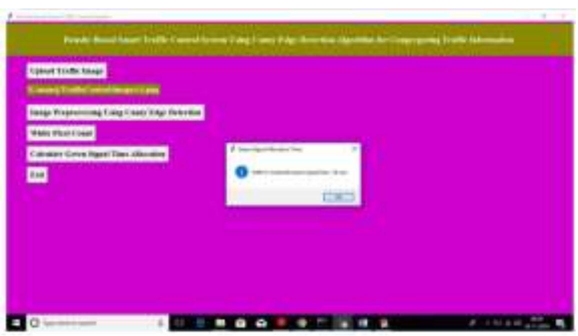

Fig 6.6

VII.CONCLUSION

The integration of Canny edge detection in a smart traffic control system represents a significant advancement in intelligent transportation systems. By leveraging real-time image processing to assess vehicle density, the proposed system offers a practical solution to the growing problem of urban traffic congestion. The algorithm's precision in edge detection ensures accurate vehicle counting, which forms the foundation for making intelligent traffic signal decisions. Unlike traditional fixed-timer systems or hardware-intensive models, this approach is lightweight, scalable, and cost-effective, making it suitable for large-scale deployment. The system enhances traffic flow, reduces vehicle idling time, and contributes to environmental sustainability by lowering fuel consumption and emissions.

VIII.FUTURE SCOPE

The proposed system opens several avenues for future research and enhancement. Integration with machine learning models could improve accuracy by enabling the system to learn from historical traffic patterns and predict congestion trends. Weather adaptation algorithms can be added to improve performance during fog, rain, or low visibility conditions. The system can be extended to support vehicle classification (e.g., differentiating between cars, trucks, and bikes) to make more refined traffic control decisions. In addition, cloud-based central traffic monitoring and IoT integration can facilitate data sharing between intersections for coordinated signal control across the city. Mobile applications and dashboards could be developed for real-time traffic updates and remote control by traffic authorities. Ultimately, this system could be a stepping stone toward fully autonomous traffic ecosystems in smart cities.

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