SMART TRAFFIC LIGHT CONTROL USING ARTIFICIAL INTELLIGENCE

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INDIA – 799046
MAY – 2024

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Report Submitted to the
National Institute of Technology, Agartala
for the award of the degree

of

Bachelor of Technology

by

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DEDICATION

We extend our gratitude to Dr. Mrinal Kanti Deb Barma, Professor in the Department of Computer Science and Engineering (CSED) at NIT Agartala. We appreciate his continuous support, valuable guidance, and unwavering confidence in our project. We also acknowledge the collective contribution of all the department's faculty members who played a significant role in our professional development and aided us in accomplishing our goals.

Our sincere thanks go out to everyone who has played a part in the development of this project and offered their support.

REPORT APPROVAL FOR B.TECH

Date:..........................

Certified that the project report entitled ***'SMART TRAFFIC LIGHT CONTROL USING ARTIFICIAL INTELLIGENCE'*** submitted by ***Arijit Debnath (20UCS111), Debajeet Das (20UCS128), Akash Chowdhury (20UCS141), Santanu Rakshit (20UCS109)*** to the National Institute of Technology, Agartala, for the approval has been reviewed and accepted by the designated examiners. The group has successfully presented and defended the project in the viva-voce examination held at the National Institute of Technology, Agartala.

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DECLARATION

We collectively say announce that this composed accommodation speaks to our thoughts in our claim words, and where others' thoughts or words have been included, we have enough cited and referenced the unique sources. We too announce that we have followed to all standards of scholastic genuineness and judgment and have not distorted, manufactured, or misrepresented any thought, information, reality, or source in our accommodation. We get it that any infringement of the over will be cause for disciplinary activity by the Established and can too bring out correctional activity from the sources that have hence not been appropriately cited or from whom appropriate consent has not been taken when required

Date:____________ Signature of the students

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(Arijit Debnath)

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(Debajeet Das)

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(Akash Chowdhury)

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(Santanu Rakshit)

CERTIFICATE

This is to certify that the project entitled ***'SMART TRAFFIC LIGHT CONTROL USING ARTIFICIAL INTELLIGENCE'***, submitted by ***Arijit Debnath (20UCS111), Debajeet Das (20UCS128), Akash Chowdhury (20UCS141), Santanu Rakshit (20UCS109)*** to the National Institute of Technology, Agartala, is a record of bonafide research work carried out under our supervision. This work has not been submitted elsewhere for a degree. We consider it worthy of consideration for the meeting the prerequisites for the completion of the B.Tech 8th Semester Project Report of the Institute.

Dr. Mrinal Kanti Deb Barma
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Acknowledgments

We take this opportunity to express our sincere gratitude to all who have played a role, whether direct or indirect, in the completion of this project work.

First and foremost, our heartfelt thanks go to our supervisor, Dr. Mrinal Kanti Deb Barma, who has been an exceptional mentor and the best guide we could have wished for. His advice, encouragement, and constructive critiques have been a constant source of innovative ideas and inspiration, leading to the successful completion of this report. The confidence he instilled in us has been a major driving force. Working with him over the past six months has been a privilege.

Our gratitude extends to all the faculty members of the Computer Science and Engineering Department for their unwavering support and encouragement. Special thanks to Prof. (Dr.) Sarat Kumar Patra, Director of NIT Agartala, and Dr. Suman Deb, Head of the Department of CSED, for providing excellent computing facilities and other resources, without which the quality goals of this work could not have been achieved.

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Contents

List of Figures

Abstract

With a rising number of people living in cities and cars, one of the main problems is traffic congestion. In addition to adding to drivers' stress and delays, traffic bottlenecks also result in higher fuel usage and air pollution. Megacities seem to be the most afflicted, even though it seems to be present everywhere. Furthermore, due to its ever-increasing nature, real-time road traffic density calculations are required for improved signal control and efficient traffic management. One of the key elements influencing traffic flow is the traffic controller. Consequently, there is a need to optimize traffic control in order to better meet this growing demand. Our suggested solution uses artificial intelligence (AI) and image processing to calculate traffic density using real-time photos from traffic junction cameras. It also emphasizes the algorithm that adjusts traffic lights based on vehicle density to minimize congestion, enabling people faster utilization of transit and minimizing off pollution.

Keywords: Transportation management, intelligent transportation systems, traffic control, and traffic light systems YOLO, object recognition, machine learning, and smart surveillance.

Dedication

We extend our gratitude to Dr. Mrinal Kanti Debbarma, Professor in the Department of Computer Science and Engineering (CSED) at NIT Agartala, for generously sharing his valuable knowledge, providing continuous encouragement, and consistently expressing confidence in our abilities. The collective efforts of the department's faculty have significantly contributed to our professional growth, guiding us toward the successful accomplishment of our objectives.

Our sincere thanks to all individuals who have played a role in the development of this project and offered their support.

CHAPTER 1

Introduction

Urban centers are always growing, and this is being matched by an increasing number of automobiles that are constantly flooding road systems. The weakness of traditional traffic management systems—their reliance on static signal timers—has been made evident by the unstoppable increase in traffic volume. These strict timetables are dreadfully insufficient at controlling traffic because they ignore the constantly changing fluctuation of vehicles. This research suggests a novel solution to this urgent problem: a traffic signal controller enabled by computer vision's powerful capabilities.

1.1 Motivation

This idea was motivated by the intrinsic shortcomings of conventional traffic control techniques. Although manual control provides some flexibility, it also requires a significant human resource investment, which is frequently depleted. On the other hand, static timers are less dependent on human intervention, but they cannot adjust to the constantly fluctuating traffic patterns. Although they are a more advanced method, electronic sensors are frequently limited by the compromise between coverage and precision. Budgetary restrictions frequently prevent the nationwide adoption of complex and costly technology that are required for high-fidelity data collecting. Moreover, a huge number of scanners is required to attain full coverage due to the limited effective range of the majority of sensors, which drives up project costs even more.

1.2 Project goal

The goal of this project is to create a revolutionary traffic light regulator that can estimate traffic density and classify vehicles in real time by utilizing computer vision. Based on the quantity and kind of vehicles at an intersection, this intelligent technology will automatically modify the green signal time. This initiative aims to enhance circulation of traffic, reduce congestion, and speed up vehicle passage across crossings by continuously adjusting timing of signals to the current traffic conditions.

1.3 Contribution of the project

By leading the way in the use of artificial intelligence and computer vision for adaptive traffic signal control, this project hopes to make a lasting impact on the field of automated transportation systems (ITS). By optimizing traffic flow, reducing congestion and related wait times, and reducing the use of fuel and the harmful emissions it emits, the proposed system has the potential to completely transform traffic management. This project can help create a more environmentally friendly and greener urban environment by promoting optimum traffic circulation.

CHAPTER 2

Literature review and theoretical background

2.1 Literature Review

Video processing is proposed as a solution in Reference [2]. The live feed's video is first processed before being forwarded to the servers, where a C++ based algorithm produces the desired output. When the approaches of mechanically written and dynamic coding are compared, the dynamic algorithm performed 35% better.

An Arduino-UNO driven system is proposed in Reference [3] with the goal of lowering waiting times and traffic congestion. This system uses a camera to capture photos, which are then processed in Python to determine traffic density and transform the image to a minimum image by reducing saturation and colors. Preinstalled simulation packages and USB cables are employed to link Python. The length of the green signal for each lane is set by the Arduino based on traffic volume and density. However, there are certain issues using this method. Calculating the number of cars on the road is challenging since they frequently run into one another. Additionally, other things tampered with the detection since they were also turned dark and white and it was difficult to make a distinction between common objects like trees, poles, and billboards and vehicles in motion.

A fuzzy logic-controlled light system that can be adjusted to the current traffic conditions is suggested in reference [4]. For the main and secondary driveways, this system uses two fuzzy control devices with three inputs and one output. Python was used to do a simulation, which improved traffic conditions at low traffic densities.

An intelligent traffic signal system employing artificial neural networks and a fuzzy controller is suggested in Reference [5]. Images from cameras positioned at traffic sites are used by this system. The image is first normalized and then transformed to a monochromatic image. After counting all cars, regardless of size, segmentation is done using the sliding window technique. An ANN is then run over the segmented image, and the output is used in a fuzzy controller in order to set durations for the green and red lights using crisp output. The outcomes showed a 2% average inaccuracy and a 1.5-second execution time.

Image processing techniques are employed with a support vector machine algorithm in Reference [6]. Images in tiny frames are taken from live video, and the algorithm is then utilized. Before implementing SVM, the images are transformed to grayscale using OpenCV, which is used for image processing. This device can identify red light breaches in addition to traffic density.

According to reference [7], traffic density and image processing methods can be used to implement adaptive light timer control. This system is composed of Python, a traffic light timer controlled by a microcontroller, high-resolution image sensor devices, and UART-based transmission. Nevertheless, neither authorized rescue vehicles nor the intersection's accidents are detected by this system.

Reference [8] examines a number of traffic light management system techniques. This study notes that all approaches share a common architecture, which consists of selecting incoming data, processing it, obtaining traffic parameters from it, figuring out density, and updating parameters.

1. In the first travel, each vehicle's geolocation as well as additional data is collected via VANETS and sent to the closest Intelligent Traffic signal. Leveraging the installed GPS These ITLs will additionally deliver latest statistics to surrounding vehicles. In case of a vehicle collision, drivers would get data advising them to select a different path in order to avoid traffic. However, due to the high cost of deployment, this plan of action is not feasible.

2. In the second travel, both transmitters and receivers serve to capture each car's unique ID using microcontrollers based on infrared sensors. Vehicles can be identified in an emergency for the radio frequency tags, and they also allow other vehicles to pass. Red light offences are found utilizing this method. Yet as infrared sensors must be apparent, the approach is not flexible.

3. The third method renders use of the fuzzy logic technology. Three controllers with fuzzy logic are used: one for signal optimization and the other for extending the road's green phase at an intersection. Video cameras at the incoming and outgoing cables act as the sensors that collect the input data. The controller then minimizes the target function through employing the data collected by such sensors to make the most appropriate decisions.

4. The fourth method employs fuzzy logic, and the input parameters comprise the average speed of the traffic in each direction and the number of cars. Sensors placed on the road may be utilized for measuring the quantity of vehicles on the road in addition to the average speed of traffic.

5. The fifth look at combines distributed photoelectric sensors that collect data and relay it to a traffic cabinet, which calculates each road's weight and alters the traffic signal accordingly. Yet the cost in care is really important.

6. The data was recorded through video imaging in the sixth method. For taking an adequate image of the vehicle, various morphological procedures which includes dynamic backdrop subtraction are used. A fresh rectangle is generated and the vehicle count grows each time a new vehicle reaches the area of interest. Since the strategy is easy to use, it is unable to manage shadow overlapping or occlusion.

CHAPTER 3

Proposed System

3.1 Overview

The method we propose utilizes identifying objects and image processing to calculate the traffic density in real time making use of an image from CCTV cameras at traffic signals. This image is transmitted to the YOLO based vehicle understanding algorithm, as illustrated in Fig. 3.1. To determine the traffic density, the total amount of vehicles in every class—such as automobiles, bicycles, buses, and trucks—is tallied. This density, in addition to some additional factors, is used by the signal switching algorithm to determine when to start the green signal in the timer for each track. In accordance, the red signal timings are adjusted. To prevent limiting of an individual lane, the green signal time is limited to a maximum and minimum value. Also, a simulation is developed that emphasizes the effectiveness of the system.

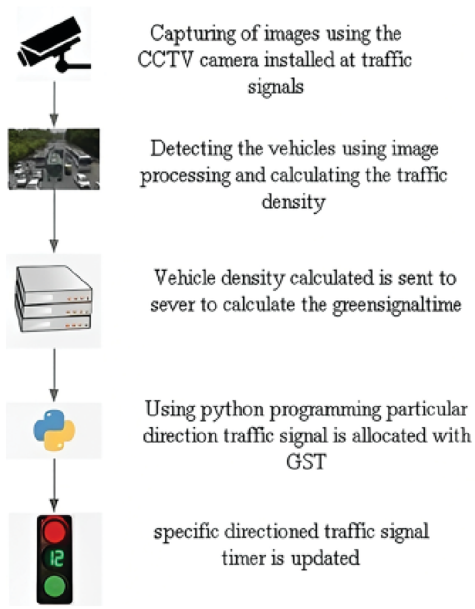

Figure 3.1: Proposed System Model

3.2 Object Detection

The proposed method detects vehicles using YOLO (You only look once), which provides the intended result accuracy and processing latency. To learn how to recognize cars that fall into different classes, involving vehicles, bikes, heavy vehicles (such as buses and trucks), and rickshaws, a unique YOLO model was trained.

A smart convolutional neural network (CNN) termed YOLO has the potential of real-time object detection. The whole picture is initially processed by a single neural network, after that it is split into regions and bounding boxes and probabilities are predicted for each region. The anticipated probabilities serve to weight these bounding boxes. YOLO is popular since it is able to function in real-time can achieve great accuracy. For it to generate predictions, the algorithm "only looks once" at the image—that is, it has to run past the neural network once in forward propagation. The object detection approach outputs recognized objects in addition to bounding boxes after nonmax suppression, which ensures that each object is identified only once. With YOLO, one CNN can predict multiple events concurrently.

The design could be done to further minimize the YOLO backbone CNN with the goal to quicken up processing. An open-source neural network framework developed using CUDA and C is referred to as Darknet. It integrates CPU and GPU calculating and is easy to

Figure 3.2: Vehicle Detection Results

setup. YOLO achieves 72.9% top-1 efficiency and 91.2% top-5 efficiency on ImageNet using DarkNet. The hidden web mostly employs 1 × 1 filters to reduce the output channels and 3 × 3 filter to extract features. It also predicts using global average pooling.

Using the graphical image annotation use LabelIMG, a dataset for training an algorithm was generated by labeling by hand Google image scrape. Afterwards, the pre-trained weights got from the YOLO website were used to train the model. In order to adhere to the specifications of our model, the configuration of the file was changed. By changing the 'classes' variable, the number of output neurons in the last stage was set to the number of classes the model is projected to detect. This amount to 4 in our system: car/van/suv/minivan/taxi/policecar/garbagevan, bicycle/motorbike/scooter/wheelbarrow, bus/truck/minibus/human hauler/pickup/army vehicle/ambulance, and rickshaw/auto rickshaw/three wheelers -CNG. That is also required to alter the number of filters using the formula 5*(5+ number of classes), which in our case equals 45.The approach was trained until the loss was significantly lower and no longer seemed to be decreasing after these configuration modifications. With this, the training came to a close to, and the weights were adjusted for meeting our needs. The OpenCV library was subsequently utilized to detect cars utilizing these weights which were just imported into the code. The smallest amount of confidence required for a successful detection is termed as a threshold. Upon model installation and image feeding, the model returns its findings in JSON format, or key-value pairs, where labels are keys and associated confidence and coordinates are values. Another time, the bounding boxes over the photos may be drawn using OpenCV from the descriptions

Test images that were taken to apply our vehicle detection model are displayed in Fig. 3.2. The figure's left side shows the original image, while the right side displays the output—complete with bounding boxes and relevant labels—after the vehicle verification model had been applied to the image.

3.3 Switching Signal Algorithm

The vehicle recognizing module's traffic density is utilized by the Signal Switching Algorithm to set the green signal timer and update the red signal timers of other signals. In line with the timers, it also alternates between the signals on a cycle.As was pointed out in the before section, the algorithm receives as input data from the detection module regarding the automobiles that were found. This is in JSON format, wherein the values are the confidence and coordinates, and the key is the label of the stuff that was identified. After that, this data is assessed to figure out the number of vehicles there are overall in each class. The green light period for the signal is then established and allocated, and the red signal durations of each of the other lights are adjusted accordingly. It is possible to change the algorithm to handle every amount of junction signals.

While creating the algorithm, the following elements were taken through account:

1. When to take a picture is determined by how long the algorithm takes to process the traffic density and green light length.

2. The overall quantity of lanes.

3. total number of automobiles in each type, including cars, trucks, and motorcycles.

4. Measured traffic density using the above mentioned factors.

5. Time added as a result of the irregular increase in delay that each of the cars in back experience, as well as the latency that each vehicle experiences upon launch.

6. Neither the average time required for every category of traffic to pass the signal's line nor the mean speed of all vehicles at the beginning of the green light.

7. The shortest and longest times of the green signal's duration are intended to avoid starvation.

The approach initializes the default time for its initial signal and modifies it dynamically for each subsequent signal. Separate threads will be used to handle vehicle detection and signal timers. When the current signal's green timer or the following signal's red timer is about to expire in five seconds, detection threads take a picture for the next route. After processing, the start time of the subsequent signal is modified. This effective process prevents delays. Once the green period on the at present signal ends, the following signal turns green in accordance with the algorithm's settings.

The system takes a picture when the subsequent signal blows green, which is in five seconds. Within this 10-second interval, it analyzes the picture, calculates the total amount of vehicles in every category, calculates the indication of green period, and adjusts the periods for both the present and future signals. Depending on the number of vehicles, the algorithm determines the optimal timing to turn on the green indicator by taking into account average vehicle speeds during startup and acceleration times. This data provides an estimate of the typical time it takes for each type of vehicle to travel through an intersection. The analysis of this data is the last step in determining the green signal timing.

$$GST = \left[\frac{\sum \text{ No of vehicles }_{\text{(vehiclesclass)}} * \text{ average time }_{\text{(vehiclesclass)}}}{\text{No of tracks}} \right] \tag{3.1}$$

- GST is the green signal Period.
- No of vehicles is the number of every category of vehicle that the vehicle detecting module counted at the indicator.
- The average time that a class of vehicles takes to travel through an intersection is indicated by the term "average time."
- The amount of tracks at the point of intersection is indicated by the total amount of tracks.

The median time for each type of vehicle to travel through a crossing can be adjusted based on location, such as zone, town, area, and even intersection-wise depending on the features of the intersection, to improve traffic management. Statistics by the relevant transportation departments could stem from examined for this.

The signals change cyclically instead of going along the path that is densest first. This is consistent with the current design, where traffic signals turn green sequentially in a predefined order, saving drivers from having to change their routes or generate confusion. The signal sequence remains the same as it does in the current system, and care has also been given to the yellow signals.

Signal sequence: Red Signal $\rightarrow$ Green Signal $\rightarrow$ Yellow Signal $\rightarrow$ Red Signal .

3.4 Simulation

Pygame was implemented to develop a simulation from scratch that simulates practical problems traffic. It facilitates a system analysis with the existing static system and system visualization. A four-way intersection there with 4 signals. On top of every signal is a timer that shows the duration of time it will require for an indicator to transition between green signal to yellow signal, yellow signal to red red signal, or red signal to green signal. The total number of cars that have crossed the intersection is also shown next to each light. Vehicles of many kinds, including rickshaws, buses, lorries, bikes, and cars, are arriving. To make the simulation more realistic, some of the cars within the rightmost track rotate to cross the crossing. Unpredictable numbers are also utilized to determine whether a vehicle will turn or not when it is generated. It also has a timer that shows how much time has elapsed since the simulation began. A screen grab of the simulation's final output is shown in Fig. 3.3.

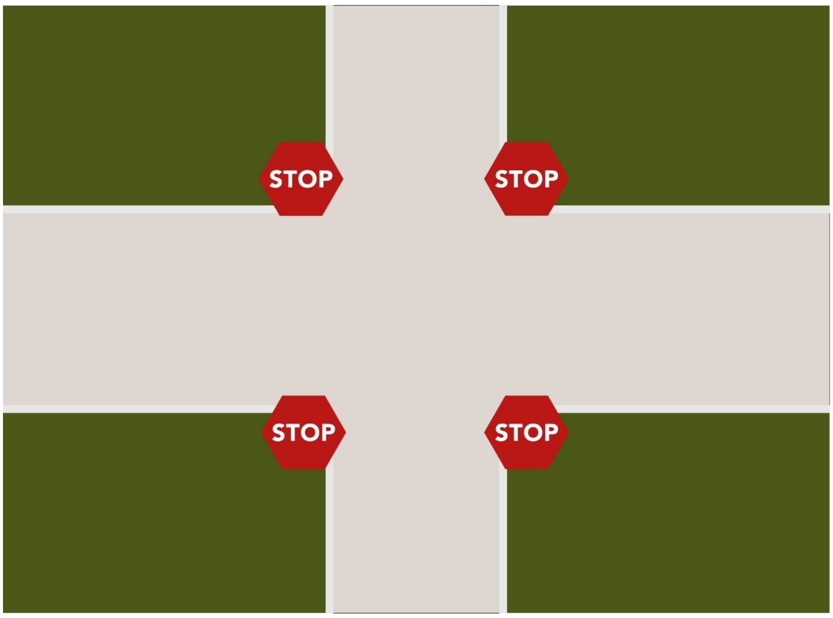

Figure 3.3: Simulation output

A collection of Python modules entitled Pygame is cross-platform and intended for use in game development. The Python programming language may be used with computer sound and graphics packages that are provided. On base of the brilliant SDL library, Pygame adds abilities. This makes it possible for users to write applications for multimedia and fully functional games in Python. Pygame works on nearly all platforms and operating systems and is properly portable. It is available for free under the LGPL.

3.5 Approach Adopted in YOLO

The YOLO algorithm's traffic management extension is the smart traffic detection model used in this study. This algorithm's object detections help allocate the present-day signal timer. It takes some time for R-CNN algorithms to detect multiple pictures. In spite of its great computational complexity, YOLO was created in 2011 following extensive research into image processing techniques to efficiently identify a lot of pictures in a short period of time. The correctness of the algorithm has been shown by a simulation where different traffic ratios at crossings vary at random intervals in all directions. The signal switching method ensures that vehicles move properly and continuously by maximizing the number of automobiles that can move through in a specific amount of time as opposed to the typical vehicle passing using the set in stone method. We effectively use the fifteen seconds that the algorithm spends each time to identify vehicles in photos in order to minimize congestion in traffic. The proposed model's lineage of steps appears in Fig. 3.1. It starts with high-resolution images from CCTV footage and ends with a timer-assisted controlled traffic signal.

CHAPTER 4

Results and Analysis

By modifying green signal timings (GST) in response to many variables, including the quantity and kind of cars identified, the average time taken by vehicles in each class to reach the intersection, and the number of lanes present, the study aimed to optimize traffic flow at intersections. The capacity to modify the average time for various vehicle types to pass through the junction depending on the surrounding environment was one important finding. This adjustment might be made at the regional, city, or even local level to improve the effectiveness of traffic management. A consistent pattern of green signals was made possible by exchanging the signals cyclically as opposed to relying on density. Drivers were able to anticipate changes in signals and modify their routes accordingly because to this technique. The study also underlined how crucial it is to take intersection attributes into account while changing signal timings. This could be carried out at many levels, such as locality, city, region, or area, in order to better enhance traffic control tactics. The YOLO method for object detection during daylight crossings was also implemented and evaluated as part of the analysis. This algorithm made it easier to identify various car kinds, analyze traffic density at traffic signals, and follow moving objects. It also gave important insights for optimizing traffic management.

4.1 Analysis of the Traffic Detection Module

The accuracy of detection for the car identification module was determined to be between 75 and 80% after it was evaluated using a range of test photos with different numbers of cars. A few test results are displayed in Fig. 3 above. While adequate, this is not ideal. The absence of an appropriate dataset is the main cause of low accuracy. To improve on this, the model can be trained using actual traffic camera footage, increasing the system's accuracy.

4.2 A study of the suggested adaptive system

Fifteen models if the two structures, any enduring five seconds and with diverse activity disseminations in each of the four bearings, were conducted to compare the execution of the proposed versatile framework to the current inactive framework. How numerous cars may pass the crossing in a certain sum of time was utilized to gage execution. Expressed in an unexpected way, the comparison is made between the intersection's sit out of gear time, or the minute when the turn flag is green but no vehicle is passing through. This influences how long cars must hold up as well as how long lines get at other signals. The conveyance [a,b,c,d] implies that the likelihood of a vehicle being in track 1, track 2, track 3, and track 4 is a/d, (b-a)/d, (c-b)/d, and (d-c)/d, separately. For illustration, in simulation 1, the dissemination is [700,800,900,1000] which means probabilities of 0.7, 0.1, 0.1, and 0.1. The comes about obtained were organized in the shape of number of vehicles passed lane-wise and the add up to number of vehicles passed.

Table 4.1: Results of the Current Static System's Model

SL.	Allotment	Track 1	Track 2	Track 3	Track 4	Total
1	[300,600,800,1000]	70	52	52	65	239
2	[500,700,900,1000]	112	49	48	31	240
3	[250,500,750,1000]	73	53	63	62	251
4	[300,500,800,1000]	74	44	65	71	254
5	[700,800,900,1000]	90	32	25	41	188
6	[500,900,950,1000]	95	71	15	14	195
7	[300,600,900,1000]	73	63	69	24	229
8	[200,700,750,1000]	54	89	10	67	220
9	[940,960,980,1000]	100	10	8	4	122
10	[400,500,900,1000]	81	29	88	37	235
11	[200,400,600,1000]	42	47	54	86	229
12	[250,500,950,1000]	39	52	93	22	206
13	[850,900,950,1000]	74	10	13	17	114
14	[350,500,850,1000]	49	46	69	50	214
15	[350,700,850,1000]	51	64	37	43	195

Table 4.2: Results of the Proposed System's Model

SL.	Allotment	Track 1	Track 2	Track 3	Track 4	Total
1	[300,600,800,1000]	87	109	41	50	287
2	[500,700,900,1000]	128	55	49	25	257
3	[250,500,750,1000]	94	50	60	58	262
4	[300,500,800,1000]	89	46	69	59	263
5	[700,800,900,1000]	185	25	23	28	261
6	[500,900,950,1000]	94	118	11	16	239
7	[300,600,900,1000]	87	68	70	33	258
8	[200,700,750,1000]	56	108	19	78	261
9	[940,960,980,1000]	193	6	5	7	211
10	[400,500,900,1000]	97	29	100	34	260
11	[200,400,600,1000]	26	52	67	99	244
12	[250,500,950,1000]	52	75	101	7	235
13	[850,900,950,1000]	154	17	12	18	201
14	[350,500,850,1000]	64	53	80	47	244
15	[350,700,850,1000]	66	82	40	48	236

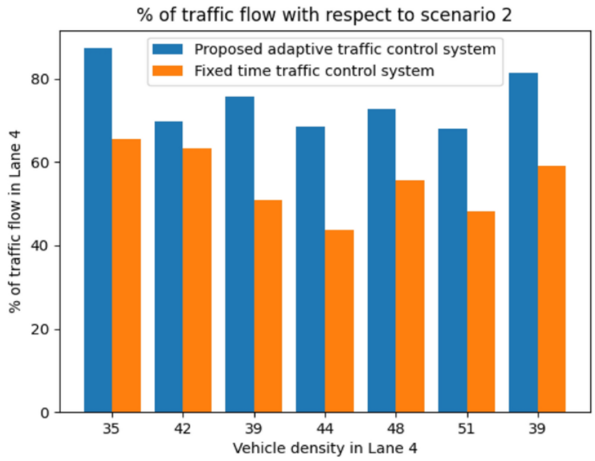

Figure 4.1: Compare between the suggested adaptive system and the existing static system

Figure 4.1 outlines how, in any dissemination, the proposed versatile framework reliably beats the existing inactive approach. The degree to which activity is moved over the paths decides how much execution moves forward. The more skewed the activity dispersion is, the way better the performance.

1. The proposed strategy beats the existing framework by a little edge when activity is conveyed equitably or about similarly among the four paths. In recreations 1, 2, 3, and 4, this is the circumstance. In this case, the execution pick up is generally 9%.

2. The recommended arrangement beats the existing one by a expansive edge when its activity dissemination is a bit uneven. In reenactments 5, 6, 7, 8, 14, and 15, this is the circumstance. Here, there has been a 22% boost in execution. This sort of activity dispersion is regularly watched in real-world situations.

3. The proposed approach performs altogether superior than the existing framework at whatever point the activity dissemination is exceedingly skewed. This is seen in recreations 9 and 13, where there is a critical hole between the ruddy and green lines and a sensational decrease in the ruddy line. In this case, the execution enhancement is generally 36%.

The models were run for an aggregate of one hour and fifteen minutes, in 300 seconds, or five minutes, for each distribution. All modeling conditions, such as the traffic transportation, vehicle speeds, turning chance, gap between vehicles, and so on, were the same. It was discovered that, on average, the proposed system outperformed the current system with fixed times by roughly 23This suggests that both the amount of time that vehicles must wait and the idling green signal time will decrease.

The suggested system outperforms some of the alternative adaptive systems when these results are compared to them. provides, for instance, a precision of 70% as opposed to the suggested system's 80%. When compared to static systems, the reference system performs 12% better on average, whereas the suggested system performs 23% better.

CHAPTER 5

Limitations and Discussion

5.1 Limitations

The high initial cost of this initiative, which requires a significant investment for the installation and upkeep of recording devices and accompanying equipment, is one of its limitations. In addition, bad weather like rain or fog can make it difficult to see the road, which affects traffic counts and results in estimates that are off. Another prerequisite for efficient functioning is enough street lighting, which is necessary for operating at night.

Additionally, given the value of human safety, the system's architecture needs to be meticulously designed to guarantee flawless performance. Even slight imperfections in the system have the potential to cause mishaps. Additionally, it might be difficult to precisely determine vehicle numbers when there are no dedicated lanes for each type of vehicle, particularly when larger cars may cover smaller vehicles, such as two-wheelers. The precision of vehicle counts could be jeopardized as a result.

5.2 Discussion

This concept offers a viable way to improve traffic control using cutting-edge technologies. It seeks to promote environmental sustainability by lowering traffic, delays, and fuel consumption by dynamically modifying signal timings in response to current traffic conditions. To guarantee its efficacy, a number of obstacles and restrictions must be overcome.

There are a number of obstacles, including the high initial cost of installation and maintenance and the negative effects of bad weather on system accuracy. Furthermore, the necessity of careful system design and adequate street illumination highlights how important safety issues are in such undertakings.

Furthermore, counting cars correctly in a mixed-traffic environment is a significant difficulty, especially for smaller cars that could be hidden by bigger ones. Notwithstanding these difficulties, the project is worthwhile since it has the potential to improve safety and traffic flow. The entire potential of this technology can be realized through additional research and development initiatives aimed at resolving these constraints, opening the door for enhanced and environmentally friendly urban transportation systems.

CHAPTER 6

Conclusion and future direction of work

6.1 Conclusion

In summary, the proposed technique adjusts the green signal length according to traffic density, guaranteeing that directions with high traffic volumes have longer green signal durations than those with lower traffic volumes. This strategy seeks to reduce waiting times, traffic, and delays; as a result, it uses less fuel and emits less pollutants. The simulation results demonstrate tremendous development, with vehicles crossing crossings with a notable 23% improvement over current methods. Even greater performance could be achievable with more refinement and the use of real-world CCTV information for model training.

Furthermore, the suggested system has benefits over current intelligent traffic management systems, such as Infrared sensors and pressure mats. Because it makes use of already-existing CCTV camera video at traffic signals and frequently doesn't require extra gear, deployment costs are negligible. In comparison to systems like pressure mats, which experience wear and tear from continuous road pressure, maintenance costs are also lower. In large cities, integration with CCTV cameras can greatly improve traffic management.

6.2 Future Work

To improve traffic management and reduce congestion, the project can be further expanded to include the following features:

- **Identification of Traffic Violations:** Vehicles breaking traffic laws, such running red lights or changing lanes without permission, can be recognized from photos or video feeds by drawing a violation line and applying image processing algorithms or background subtraction. When a car crosses the infraction line while a red light is on, the number plate is captured.
- **Accident and Breakdown Detection:** Minimizing traffic, cutting down on delays, and saving lives all depend on the prompt and accurate identification of accidents or breakdowns at intersections. This can be done by identifying—apart from parked vehicles—vehicles that stay still for an extended amount of time in improper locations.
- **Traffic Signal Synchronization:** By reduction of the need for frequent stops, synchronizing traffic signals at several intersections along a street can enhance commuter experience. This makes it possible for traffic to circulate smoothly after cars hit the street.
- **Identifying Emergency Vehicles First:** Ambulances and other emergency vehicles need to go through traffic lights more quickly. In addition to detecting cars, the model can be trained to identify emergency vehicles. In this way, timers can be set to prioritize the passage of these vehicles and guarantee that they can cross the signal quickly.

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