DESIGN PROJECT - II REPORT

On

Smart Control of Traffic Light System using Artificial Intelligence

Submitted in Partial Fulfilment of Award of

BACHELOR OF TECHNOLOGY
In

Computer Science and Engineering

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ALLIANCE COLLEGE OF ENGINEERING AND DESIGN

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ALLIANCE COLLEGE OF ENGINEERING AND DESIGN

CERTIFICATE

This is to certify that the Design project – II work entitled "**Traffic system for smart cities using real time vehicle tracking**" submitted by Ms. Pallavi N L [2022BCSE07AED934], Ms. Shrishama R Shetty [2022BCSE07AED935], Mr. Mohammed Riyashad [2022BCSE07AED936], Mr. Sevanth B S [2022BCSE07AED937] and Mr. Dhanush G S [2022BCSE07AED938] in partial fulfillment for the award of the degree of Bachelor of Technology in Computer science and engineering of Alliance University, is a bonafide work accomplished under our supervision and guidance during the academic year 2024-2025. This thesis report embodies the results of original work and studies conducted by students and the contents do not form the basis for the award of any other degree to the candidate or anybody else.

Dr.Gnanaprakasam Thangavel
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ALLIANCE COLLEGE OF ENGINEERING AND DESIGN

DECLARATION

I/We hereby declare that the Design project - II entitled **"Traffic system for smart cities using real time vehicle tracking"** submitted by me/us in the partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer science and engineering of Alliance University, is a record of my/our work carried under the supervision and guidance of Dr. Gnanaprakasam Thangavel.

We confirm that this report truly represents the work undertaken as a part of our project work. This work is not a replication of work done previously by any other person. We also confirm that the contents of the report and the views contained therein have been discussed and deliberated with the faculty guide.

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PREFACE

With the rapid growth of the urbanization in the cities, the usage of vehicles is also increasing day by day in which due to the excess usage of the vehicles the cities are facing the challenges with increasing traffic congestion, pollution, climate changes and many more.

Traditional traffic management systems are often unable to handle all these challenges, therefore the development of the intelligent traffic system becomes a necessity rather than an option.

This system monitors the traffic flows, optimizes the routes and reroutes if there is a congestion of traffic with the other route. The ultimate goal of this system is to prevent the unnecessary traffic congestions due to the traffic signals, if there is less traffic in a route and the traffic signal timing is more than it detects it and modifies it so that the route with the more congestion can get its time and the flow of traffic will less down and also decrease the carbon footprints.

Through this project, we aspire to build a system that will contribute towards the forward development tool which is also practical and can supports the development of the urban cities. This project aims to serve as a valuable system for the current researches and implementations while preserving or saving our environment of the cities also.

ABSTRACT

As the development of the urban areas accelerates, it has become a hectic problem to manage and improve the traffics in the cities as well as the environmental consequences that are happening from it. This system presents an innovative design for the smart cities to control and manage the traffic and prevent from its the consequences.

This system tracks vehicles and adjusts traffic light signals based on the level of congestion of the vehicles. Based on the data from the users, such as the type of vehicle, fuel type of the vehicle, road conditions, traffic density, and other such factors, this system determines the level of carbon gas that is emitting from the vehicle.

Using machine learning algorithms, the system analyzes the given data and learn from its past experiences and then predicts the amount or level of the emission from the vehicle. By analyzing where the emission of vehicles is greater the system automatically adapts the traffic signals based on it. So that the congestion become less and will have the less impact on the environment in the certain area.

By dynamically adjusting the traffic signals, the system helps in reducing the traffic congestion and for further improvements we can incorporate other things like route guidance, like if there is an emergency vehicle like ambulance, police vehicle etc., the system can reroute them to the less congested traffic roads rather than them getting stuck at the congestions for hours.

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Smart Control of Traffic Light Using Artificial Intelligence

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***Abstract*—This paper will develop and present a Smart Control System for traffic lights with Artificial Intelligence to improve the management of urban traffic. Traditional designs and functionalities of such systems are simple or even fixed patterns, so such systems on a high-traffic urban scale might lead to congestion, inefficiency, and increased emissions. Thus, with this AI-enabled system, where real-time traffic data collected by sensors at intersections get analyzed, there would be many opportunities for improvement in this area. This system dynamically times the signal based on traffic flow, optimizing the throughput of vehicles and reducing delays through constant improvement in decision making with the aid of machine learning techniques, especially reinforcement learning, able to predict traffic patterns and adjust signal cycles. This leads to a responsive adaptive system that minimizes congestion and improves traffic efficiency, reduces fuel consumption and minimizes impact on the environment. This project aims to aggregate elements to develop smart cities with intelligent solutions for sustainable and efficient traffic management with AI-driven features**

***Index Terms*—Business control, Business light system, Traffic operation, Intelligent transport systems, Computer Vision, Machine literacy, YOLO.**

I. Introduction

However, the alarming growth of traffic congestion in urban areas worldwide is leaving a trail of massive delays, excessive fuel consumption, and environmental pollution. Existing traditional traffic light systems always function on predetermined timers or simple sensor-based mechanisms and are not at all effective in controlling traffic signals according to differing traffic conditions; thereby flow management becomes suboptimal. As cities expand, the need for intelligent systems to dynamically control traffic signals in order to optimize flow, reduce congestion, and promote safety is becoming urgent.

Artificial Intelligence has finally provided a promising solution to this; it has a system that relies on the algorithms of machine learning and real-time data analytics, enables the traffic light control system based on AI to adapt changing patterns in traffic flow while also identifying which is an emergency vehicle and even predict traffic behavior, thus reducing waiting time and enhancing overall traffic efficiency. These intelligent systems are optimized not only for improving traffic flow but for achieving decreases in energy consumption and emissions that constitute the wider intentions of smart city initiatives.

This paper aims to explore a design and implementation of an intelligent control mechanism of traffic light using AI techniques, with real-time adaptability efficiency and sustainability.

We suggest the monitoring of traffic conditions and data-driven decision making using sensors, cameras, and machine learning models on traffic signal timings. Further, this paper argues about the challenge and benefit of applying AI on an urban traffic management system as well as its effect in reducing congestion for the improvement of quality of life in cities.

II. Literature Review

Over the last two decades, traffic management has been one of the major challenges in cities owing to population and vehicular growth. The conventional fixed cycle or time-based traffic light system is not efficient in handling dynamic traffic conditions leading to congestion and delay. To overcome such limitations, there has been much interest in AI-based application in traffic light control systems. In recent years, AI techniques, namely machine learning, deep learning, and reinforcement learning, have surfaced as promisingly adaptive and efficient traffic flow-controlling means.

Reinforcement Learning for Traffic Control :The idea of using Reinforcement Learning (RL) as an enabling AI for optimizing control over traffic lights seems fascinatingly promising. RL is viewed as the ideal type of machine learning where a traffic light controller learns the optimal timings for the traffic signal at any given time based on the state of the traffic. For example, according to several studies, algorithms of RL such as Q-learning and DQN, can be demonstrated to

Appendix B

Submission Summary

Conference Name
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Paper Title
Smart Control of Traffic Light System using Artificial Intelligence

Abstract
As the development of the urban areas accelerates, it has become a hectic problem to manage and improve the traffics in the cities as well as the environmental consequences that are happening from it. This system presents an innovative design for the smart cities to control and manage the traffic and prevent from its the consequences.
This system integrates the tracking of vehicles and adjusting the traffic light signals based on level of the congestion of the vehicles. The system uses data from the users like their vehicle type, fuel type of the vehicle, road conditions, traffic density and many other factors to determine the level of carbon gas that is emitting from the vehicle.
Using machine learning algorithms, the system analyzes the given data and learn from its past experiences and then predicts the amount or level of the emission from the vehicle. By analyzing where the emission of vehicles is greater the system automatically adapts the traffic signals based on it. So that the congestion become less and will have the less impact on the environment in the certain area.
By dynamically adjusting the traffic signals, the system helps in reducing the traffic congestion and for further improvements we can incorporate other things like route guidance, like if there is an emergency vehicle like ambulance, police vehicle etc., the system can reroute them to the less congested traffic roads rather than them getting stuck at the congestions for hours.

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Appendix C

#setup code

```
from setuptools import setup, find_packages
from setuptools.extension import Extension
from Cython.Build import cythonize
import numpy
import os
import imp

VERSION = imp.load_source('version', os.path.join('.', 'darkflow', 'version.py'))
VERSION = VERSION.__version__

if os.name =='nt' :
ext_modules=[
Extension("darkflow.cython_utils.nms",
sources=["darkflow/cython_utils/nms.pyx"],
#libraries=["m"] # Unix-like specific
include_dirs=[numpy.get_include()]
),
Extension("darkflow.cython_utils.cy_yolo2_findboxes",
sources=["darkflow/cython_utils/cy_yolo2_findboxes.pyx"],
#libraries=["m"] # Unix-like specific
include_dirs=[numpy.get_include()]
),
Extension("darkflow.cython_utils.cy_yolo_findboxes",
sources=["darkflow/cython_utils/cy_yolo_findboxes.pyx"],
#libraries=["m"] # Unix-like specific
include_dirs=[numpy.get_include()]
)
]
```

```
elif os.name =='posix' :
ext_modules=[
Extension("darkflow.cython_utils.nms",
sources=["darkflow/cython_utils/nms.pyx"],
libraries=["m"], # Unix-like specific
include_dirs=[numpy.get_include()]
),
Extension("darkflow.cython_utils.cy_yolo2_findboxes",
sources=["darkflow/cython_utils/cy_yolo2_findboxes.pyx"],
libraries=["m"], # Unix-like specific
include_dirs=[numpy.get_include()]
),
Extension("darkflow.cython_utils.cy_yolo_findboxes",
sources=["darkflow/cython_utils/cy_yolo_findboxes.pyx"],
libraries=["m"], # Unix-like specific
include_dirs=[numpy.get_include()]
)
]

else :
ext_modules=[
Extension("darkflow.cython_utils.nms",
sources=["darkflow/cython_utils/nms.pyx"],
libraries=["m"] # Unix-like specific
),
Extension("darkflow.cython_utils.cy_yolo2_findboxes",
sources=["darkflow/cython_utils/cy_yolo2_findboxes.pyx"],
libraries=["m"] # Unix-like specific
),
```

```
Extension("darkflow.cython_utils.cy_yolo_findboxes",
sources=["darkflow/cython_utils/cy_yolo_findboxes.pyx"],
libraries=["m"] # Unix-like specific
)
]

setup(
version=VERSION,
name='darkflow',
description='Darkflow',
license='GPLv3',
url='https://github.com/thtrieu/darkflow',
packages = find_packages(),
scripts = ['flow'],
ext_modules = cythonize(ext_modules)
)
```

#vehicle detection

```
import cv2
from darkflow.net.build import TFNet
import os

options = {
    'model': './cfg/yolo.cfg',       # specifying the path of the model
    'load': './bin/yolov2.weights',  # weights
    'threshold': 0.3                 # minimum confidence factor to create a box, greater than 0.3 is good
}

tfnet = TFNet(options)
```

```
inputPath = os.getcwd() + "/test_images/"
outputPath = os.getcwd() + "/output_images/"

def detectVehicles(filename):
    global tfnet, inputPath, outputPath
    img = cv2.imread(inputPath + filename, cv2.IMREAD_COLOR)
    result = tfnet.return_predict(img)
    for vehicle in result:
        label = vehicle['label']  # extracting label
        if label in ["car", "bus", "bike", "truck", "rickshaw"]:  # drawing box and writing label
            top_left = (vehicle['topleft']['x'], vehicle['topleft']['y'])
            bottom_right = (vehicle['bottomright']['x'], vehicle['bottomright']['y'])
            img = cv2.rectangle(img, top_left, bottom_right, (0, 255, 0), 3)  # green box of width 3
            img = cv2.putText(img, label, top_left, cv2.FONT_HERSHEY_COMPLEX, 0.5, (0, 0, 0), 1)  #
black text
    outputFilename = outputPath + "output_" + filename
    cv2.imwrite(outputFilename, img)
    print('Output image stored at:', outputFilename)

if not os.path.exists(outputPath):
    os.makedirs(outputPath)

for filename in os.listdir(inputPath):
    if filename.lower().endswith((".png", ".jpg", ".jpeg")):
        detectVehicles(filename)
print("Done!")
```

CHAPTER 1

INTRODUCTION

The development of the cities are rapidly increasing nowadays, and in the many aspects the new technologies are evolving and the development of urban areas are not only benefitting the people it is also affecting in many ways like the development of the urban area are leading to increase in vehicle usages in those areas in which it leads to more traffic congestion and releasing harmful emissions to the environment, which is majorly effecting all kinds of living things on the earth.

However, the system can go beyond just improving and adjusting the traffic flow, with analyzing various data of the vehicle like vehicle type, fuel type of the vehicle, traffic densities, and many other attributes. The traditional system controls the traffic lights manually or by the fixed timers leading to the large delays due to red lights, congestions and long waiting times, increased fuel consumption and increased traffic density.

So, to manage and decrease the traffic as well as the emissions that are releasing from the vehicles it is important to take the action. By this system we can manage and adjusts the traffic density and it will be helpful in managing the traffic flow. And by using the machine learning algorithms, the system can predict the amount or level of the emission a vehicle is releasing.

The traffic control system based on AI uses advanced algorithms, machine learning and sensor technologies and analyzes the patters and density of the traffic in the real time and processes the data using CCTV cameras, inductive loop sensors and IoT devices, the system changes the traffic signal lights based on the processed data that is gathered accordingly.

This adaptive approach helps in minimizing the congestion, and manages and improves the overall traffic flow by rerouting the vehicles or by adjusting the traffic signals automatically, and it also reduces the green gas emissions and also improves the travel experience for the commuters.
Artificial intelligence is capable of continuous learning and adapting to shift traffic conditions and instance

s, it is its main benefit in traffic control system. AI-driven system can automatically decide where and when to place green lights, by analyzing the attributes like traffic density, accident detection, and pedestrian activities in the area, with respect to traditional systems which are pre-programmed with set timing sequences. The main benefit of this system in traffic control is its ability to adapt and learn from the traffic conditions. In contrast to traditional systems, which are manually operated, these systems are able to decide on its own to take actions like placing green lights avoiding the long waiting of red-light queues.

In the recent years one of the most issues that developing cities are facing is traffic congestion. Long waiting times, air pollution from the gases releasing from the vehicles, and inefficient traffic flow which are frequently caused by the increased numbers of vehicles on the urban areas. The abilities of traditional or old traffic signal systems to adjust to the traffic instances in the real time is limited because they depend on simple sensor-based methods or manually pre-processed methods. They might fail to adjust for the traffic flow leading to the creating of needless delays, mainly at peak hours.

One of the potential solutions for these issues in to control and to manage is to use the artificial intelligence methods into traffic managing systems. Based on real-time data from CCTV Cameras, IoT sensors, cameras, or other monitoring devices as well, an AI smart traffic light control system can be used to dynamically modify the timings of traffic signals. AI systems can adjust and manages the traffic flow, traffic density, lessen the traffic congestion, and improves road safety also by using traffic pattern analysis to influence the decisions the system has made.

1.1 INTRODUCTION TO TRAFFIC SYSTEM MANAGEMENT

One of the major problem, that most cities in the whole world confronting is the traffic congestion problem. Traditional traffic controlling systems that are depending on the manually setter signal timings and basic sensors attached to them lose their effectiveness as cities grows and develops and the number of vehicles increases. Traffic congestion from vehicles, long travel times, air pollution due to it, and frustrated drivers are the results of this condition. By using Artificial Intelligence (AI), machine learning (ML) algorithms, and real-time data processing by ITMS, improve the management of the traffic flow, enhancing the safety of the vehicles, and lessening congestions due to these problems.

Intelligent Traffic system is the integration of technology and the data to increase the efficiency and effectiveness of the traffic system. By analyzing the real-time data from various attributes, the system analyzes the patterns and adjusts the traffic flow based on it.

Some key features of the Intelligent traffic system include:

1. Real-time data collection and monitoring: The Traffic flow or density is tracked using the devices like radars, inductive loops, and CCTV cameras.
2. Adapting to traffic signal changings: unlike traditional systems, the adaptive traffic signal control modifies the timing of the traffic signal lights according to the current traffics instances.
3. Predicting the traffic patterns and rerouting traffic: in the event of congestions of vehicles or accidents it analyzes the pattern and reroutes the vehicle to decrease traffic congestion.
4. Incident detection and response: Instantly recognizing and reacting to the congestions or blockages.

Working of AI smart traffic light control:

It works in a pattern like Collection of data, Traffic pattern recognition, Dynamic signal adjustment, Optimizing the traffic flow, Traffic prediction and traffic management and lastly using the Machine learning algorithms for continuous learning

1. Traffic flow data: It is frequently gathered using sensors, CCTV cameras, or real-time GPS data from vehicles, number of vehicles, vehicles speed, and traffic density at various intersections and locations.

2. Vehicle characteristics: Details on the many kinds of vehicles, including their emission profiles and vehicle fuel types and engine sizes of the vehicle.

3. Environmental factors: The state of the weather, grade of the roads, and other surrounding instances that could affects the emissions and fuel usage from the vehicles.

4. Traffic signal light timings: Real time light patterns from traffics and the duration for which vehicles are stopped at signals.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE REVIEW

1. **M. M. Gandhi, D. S. Solanki, R. S. Daptardar and N. S. Baloorkar, "Smart Control of Traffic Light Using Artificial Intelligence," 2020 5th IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE), Jaipur, India, 2020, pp. 1-6, doi:10.1109/ICRAIE51050.2020.9358334.**

   With the rise in population and the number of vehicles in the city, heavy traffic congestion is on the rise. Apart from causing further time-wasting and stress for the driver, traffic jams and congestions also lead to an increase in fuel consumption and air pollution. It almost seems to be omnipresent, but is more serious in megacities. So the growing nature of the urban cities requires real-time computational model of road traffic density for better control over the signals and effective management of the traffic. The traffic controller is one of the crucial factors affecting the flow of traffic. Therefore, an optimization of the traffic control occurs in order to better meet this increasing demand. The proposed system uses the live images that cameras are installed at traffic junctions, calculates density using image processing and AI. The system even underlines a plan for a switch of the traffic lights according to vehicles density to reduce congestions thus providing speedy passage for people as well as reducing congestions as well as pollution.

2. **Ghazal, K. ElKhatib, K. Chahine and M. Kherfan, "Smart traffic light control system," 2016 Third International Conference on Electrical, Electronics, Computer Engineering and their Applications (EECEA), Beirut, Lebanon, 2016, pp. 140-145, doi: 10.1109/EECEA.2016.7470780.**

   With this paper, the authors mainly focus on addressing the primary challenges of the old traffic light control systems that typically rely on the fixed timers or the mechanisms that are preprogrammed and cannot alter the real-time traffic conditions dynamically. It is these old methods which will cause problems in the form of traffic congestions and inefficient flow of the traffics during the peak hours that will pose unexpected events of traffics. The proposed smart traffic light control system will use real-time data from sensors to dynamically adjust the traffic signals, helping aim to reduce traffic flow and decrease congestions while minimizing wait time for vehicles in the traffic. This paper contributes to the study under the heading of ITS, which applies data analytics and adaptive control algorithms to the management of urban traffic. Built around real-time traffic data with advanced algorithms, the description of the system adapts changing traffic conditions; hence, it provides more responsive and efficient solutions than the old fixed time systems. This work or paper is about the opportunities of this project to enhance urban mobility, reduce delays, contribute to other improvements in traffic safety, and ensure that environmental sustainability is maintained.

3. **Junchen Jin, Xiaoliang Ma, Iisakki Kosonen, An intelligent control system for traffic lights with simulation-based evaluation, Control Engineering Practice, Volume 58, 2017, Pages 24-33, ISSN 0967-0661**

This paper will demonstrate the design of smart traffic light control systems constructions and evaluate the system using a simulation-based evaluation approach. Significant build up of traffic is seen in most urban centers, which cannot be satisfactorily resolved with normal cycle method of setting traffic lights. Such systems result in traffic bottlenecks, longer turns at signals, high fuels wastage, etc. For this reason, efforts in several countries are focusing on Intelligent Transportation Systems (ITS) designed to employ real time data and adaptive algorithms to modify traffic signal settings based on prevailing traffic conditions. The primary objective of such systems is to optimize traffic light cycles in order to remove congestion and safety by the actual advancement of operations.

In the past, almost all the works done in research have indicated the practicability of ASC systems that integrate real time vehicular detection and simulation of activities to provide instantaneous adjustment of traffic signal timings. However, most of these systems suffer from a major limitation: lack of adequate simulation approaches to carry out thorough performance evaluation steps before real-life implementation. Jin et al. (2017) solved this problem by developing an evaluation based method, based on simulation, for their intelligent traffic signal control systems.

Their method integrates vehicle count and density into supervising an efficient control algorithm that will set the best instructions for changing the lights. It has been used as simulations to determine its effectiveness against fixed-time poorly performing systems in comparison to average delay and overall traffic performance operations. The authors also lay emphasis on issues such as the difficulties of integrating real-time data, system expansion, and maintaining efficient traffic management systems in changing conditions of traffic. This work puts more ammunitions into the already existing literature on smarter traffic management systems through providing an explanation of how simulated tools can improve system design before actual implementation of a process.

4. **L. F. P. de Oliveira, L. T. Manera and P. D. G. D. Luz, "Development of a Smart Traffic Light Control System With Real-Time Monitoring," in *IEEE Internet of Things Journal*, vol. 8, no. 5, pp. 3384-3393, 1 March1, 2021, doi: 10.1109/JIOT.2020.3022392.**

This paper describes Flexible Intelligent Traffic Signal (FITS) control, a control framework that is smart for traffic signal applications. It provides an efficient and cost-effective way of upgrading the present signaling system. In real-time operations, the programmed mechanism is embedded in a connecting hardware device that can override roadway indicators and is also capable of receiving instructions from signal controller hardware. The built-in program in the FITS hardware device contains signal control and optimization toolboxes. FITS presently has a control based on fuzzy logic. The focus of this paper is creating a mathematical frame to evaluate the impacts of the FITS system through microscopic mobility simulation with the aim of assessing its impact. The study mainly explains the significance of IoT in this traffic control system because it offers better information regarding data processing and its transmission in this mode, which also enhances the taking of decisions for intersection signal things. The experiment method presents more adjusted scalable solutions or methods than the traditional systems, which largely relied upon pre-programmed timings or sensor networks. Research they did well also illustrate the main issues as including aspects of secutiry, scalability, and system stability, so further highlighting why it is critical for an idea to be quite effective to ensure there is continuous traffic monitoring and management flow in urban areas. This very research study advances the growing topic of smart cities by explaining why continuous real time data for traffic, and IoT could apply in implementing an effective transportation system of control.

5. **N. Díaz, J. Guerra and J. Nicola, "Smart Traffic Light Control System,"** ***2018 IEEE Third Ecuador Technical Chapters Meeting (ETCM)*****, Cuenca, Ecuador, 2018, pp. 1-4, doi: 10.1109/ETCM.2018.8580282.**

This paper explains that for improvement of the flow of traffic within the cities or urban areas, design and implementation of the intelligent traffic management system will help the city in managing the traffic. The authors have also discussed the limitations of traditional traffic light control systems, which will normally rely on simple sensor-based control or pre-programmed time intervals for changing the signals. Congestions and wait times longer than one would expect at traffic are a cause of inefficiencies and incapability to change with real-time situations of traffic since these are the inefficiencies that traditional systems use. To solve this problem, the proposed system will use sophisticated algorithms and real-time data processing from the traffic, thus enabling the traffic signals to change dynamically according to the density of the traffic. The authors of the paper mainly elaborated on the growing trend of introducing smart technologies like Internet of Things (IoT) sensors and machine learning models or algorithms to the system. The authors mentioned with which of the ways these systems would reduce the traffic jams, congestions, and accidents, and can decrease the level of emissions produced by the vehicles, thereby improving the road safety. Introducing better data-driven solutions, the proposed smart traffic light control system will take a step forward in the development and improvement of smart cities and eventually lead to more livable and sustainable urban environments.

6. **I. M. Albatish and S. S. Abu-Naser, "Modeling and Controlling Smart Traffic Light System Using a Rule Based System,"** ***2019 International Conference on Promising Electronic Technologies (ICPET)*****, Gaza, Palestine, 2019, pp. 55-60, doi: 10.1109/ICPET.2019.00018.**

This paper aims to explain the implementation of the smart traffic light system which is conceived for improvement and management of the flow of traffic by reducing congestions caused by vehicles within the urban environment. The articles review the development of traffic control systems focusing on the transition from traditional old fixed-time and sensor-based traffic systems to more advanced dynamically adaptive control systems. They also point out the inadequacies of the traditional conventional traffic light signaling systems; more often than not, inefficient in managing the real-time fluctuations of the traffic and thus resulting in avoidable delays and fuel wastage. This paper reviews the dynamic management of traffic solutions that can respond to current conditions of real-time traffic situations in order to enhance the efficiency of traffic and its safety. The authors propose a rule-based model to control the smart traffic light signals aiming for adapting to the traffic signal timings based on traffic densities at signals. The approach will build on the existing current literature on rule-based decision-making models in transportation systems that have shown success of most methodologies in most of the areas-like automated vehicle control. This paper, therefore, describes the implementation of this system for countries like Gaza, Palestine. The case study presented also helps in demonstrating the practical applicability of rule-based system control in resource-constrained areas. This work also contributes to the growing state of research on the smart transportation systems and with the global trends towards the use of AI and data-driven technologies for improving urban mobility.

7. **L. F. P. Oliveira, L. T. Manera and P. D. G. Luz, "Smart Traffic Light Controller System," *2019 Sixth International Conference on Internet of Things: Systems, Management and Security (IOTSMS)*, Granada, Spain, 2019, pp. 155-160, doi: 10.1109/IOTSMS48152.2019.8939239.**

The paper mainly focuses on the IoT (Internet of Things) technologies for optimizing the traffic flow and to enhance the urban mobility conditions. The authors also discussed the limitations of employing the traditional fixed time traffic light signal systems which often leads to inefficiencies and congestions, and at the same time increases the fuel consumption of the vehicles. In order to cope with the mentioned problems, the proposed system shall vary the timing of the signal of traffic lights on the basis of real-time traffic density data collected from sensors mounted at intersections and signals. The integration of this IoT for the system allows the better adaptive traffic management system, where the system would analyze traffic patterns and densities, making adjustments to reduce waiting times and traffic congestion while contributing to better traffic flow and reducing environmental impact. The authors use the concepts of machine learning and data analytics in the system for the implementation that will process the obtained traffic data patterns from the sensors and other systems as well as to modify the timings of the traffic light signals. Real time data gathering, adapting to situations, and the ability of the system to interact with the other devices in the same system network to better the traffic management are included in the system. The probable adaptability of these systems is it provides more effectiveness and sustainability in the traffic management solutions and also is also it can be spreaded over the large areas.

8. A. A. Zaid, Y. Suhweil and M. A. Yaman, "Smart controlling for traffic light time," *2017 IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT)*, Aqaba, Jordan, 2017, pp. 1-5, doi: 10.1109/AEECT.2017.8257768.

The paper proposes the various methodologies to be used in modifying signal timing of traffic signals dynamically in order to smoothen the management of traffic for more responsive smart traffic management systems. According to the writers of the paper, traditional old systems like fixed-time traffic light systems or pre-programmed traffic system would always fall in adapting to changing in the traffic situations which will result in the reduction of the traffic useless congestions and the extended waiting in longer queues for longer duration of times. To which we offer their proposed methodology or system model that uses the real time traffic data collected from the various systems for processing to change and update the timing of the traffic signal lights based on the particular intersection's of the flow. This strategy or methodology will try to improve in the efficiency of the urban transportation system connections or networks, reduce traffic delays, and optimize the general traffic management process overall, especially in regions with varying traffic levels.

9. G. Shahzad, H. Yang, A. W. Ahmad and C. Lee, "Energy-Efficient Intelligent Street Lighting System Using Traffic-Adaptive Control," in *IEEE Sensors Journal*, vol. 16, no. 13, pp. 5397-5405, July1, 2016, doi: 10.1109/JSEN.2016.2557345.

The paper introduces the various traffic-adaptive control system which lighting in settings of the systems are optimized according to the real time current traffic situations. Using devices like sensors to gather the information the system determines the amount or the level of traffic densities at all times of the day and also modifies the road streetlight brightness accordingly using the system. In order to save the energy the system lowers the light intensity when traffic is smaller. During high peak times of the traffic it keeps the street lights at the maximum brightness to guarantee both pedestrian and driver safety and proper visibility of the roadways. The authors explains that this dynamic adjustment system will mainly contributes to the overall sustainability and improvement of the urban infrastructure by lowering the city maintenance and operational costs of the areas and also saving the energy. The system also will provides the most scalable solution or implementation for the smart cities where the environmental impact and energy consumption are major problems and more, and by combining and integrating the sensor and networks, intelligent control algorithms, and various communication technologies. implementation and the real world testing of this system demonstration improved up to the 60% reduction in the energy usage in urban areas using this system making it a guaranteed solution for the reducing the carbon footprint of the urban street lighting systems.

10. **M. B. Natafgi, M. Osman, A. S. Haidar and L. Hamandi, "Smart Traffic Light System Using Machine Learning,"** ***2018 IEEE International Multidisciplinary Conference on Engineering Technology (IMCET)*****, Beirut, Lebanon, 2018, pp. 1-6, doi: 10.1109/IMCET.2018.8603041.**

The basis of the paper essentially rests on efficiency in the management of the traffic signal, implementing a model of machine learning-the solution for a smart traffic light system. Traffic vehicles Congestions and longer waiting queue times in the traffic are the prominent examples of inefficiencies which are brought by the old traditional traffic signal systems as well as which will rely on preset or fixed pre programmed time schedules systems, which do not adapt the current traffic situations. Thus, it will utilize machine learning algorithm techniques to evaluate real-time data processings of the data gathered from specified sensors placed at several intersections. It learns from the traffic flow patterns, densities, and automatically modifies the traffic signal lighting timings as per that. This maximizes the period of green lights and red lights in order to prevent traffic jams, congestions, cut down on vehicle idle timings, and enhance the traffic flow. The overall fuel consumptions and the road safety could be enhanced by using functionalities of data analytics, predictive modeling systems, and real-time traffic monitoring systems. Then, in their experiments, the authors demonstrate that the method proposed by them based on the machine learning technique is far more superior than the traditional fixed-time systems in terms of traffic throughput as well as waiting times.

11. **Magableh, Aws Abed Al Raheem, et al. "Smart traffic light management systems: A systematic literature review."** ***International Journal of Technology Diffusion (IJTD)*** **11.3 (2020): 22-47.**

This paper focuses more on the general analysis of the current challenges and technological advancements being made in this area of the system. The review discusses how traditional traditional traffic light systems that depend on the fixed set of schedules, not able to come along to dynamically changed situations, and often unpredictable or unexpected patterns of traffic system leading to the traffic jams, congestions, longer idled waiting times, and more wasteful of fuel usage. The evaluation of this system responds by ranking the different intelligent traffic control system methods with an emphasis on the integration of real-time data collection, adapting signal management systems, and various communication technologies including IoT, sensors, and machine learning algorithms. For better flow of traffic and reducing traffic congestions, to minimize delays in traffic, and to enhance the efficiency of the urban transportation systems, these authors will also explain how these technologies enable dynamic adjustments of modifications to traffic light signal timings. Advantages and limitations of implementing smart traffic signal control systems in place of old systems. And, by reducing the emission of idle the vehicles, the system has implemented the potential to increase the flow and efficiency of traffic flow while lowering energy levels in consumptions, and encourages environmental sustainability. To elaborate a more advanced smart city methods or solutions, the paper concludes with an overall outline of the kind of improvements that will benefit future research-for example, higher-quality machine learning models and sensor technologies, as well as the collaboration between different urban systems.

2.2 LIMITATIONS OF EXISTING SYSTEM

The current existing traditional traffic signals control systems have a many number of drawbacks, especially in those that who rely on conventional old and adaptive algorithms. These systems may be ineffective in some situations, like during peak traffic hours or during unexpected incidents like accidents, emergencies, and these systems will frequently fail to take into account real-time traffic detections.

Some of the main drawbacks of the current traffic signals control systems are listed below:

1. Inflexibility to real-time traffic conditions:

- Fixed-timed systems: Traditional traffic signal systems follows a set of schedules regardless of any traffic conditions or consequences, the green, yellow, and red light durations of the signals are pre-programmed in the systems and stay the same always. This method is very inefficient since it doesn't adjust to the changes of traffic flow or density.

- Adaptive systems with limited flexibility: Some systems will have limitations in terms of real-time adaptation, even though the systems uses the devices like sensors or CCTV cameras to assess traffic flow and adjusts the signal timings accordingly. Usually, they also uses some pre-set algorithms that might not be enough to react quickly to the situation.

2. Lack of coordination between intersections:

- Isolated signal control: The majority of traditional systems function at a single intersection without analyzing any of the traffic patterns at several signalized intersection crossings. Some intersections may will become congested as a result of this, and while other intersections may continue to be underutilized.

- Insufficient Network-Level Optimization: Few of these systems are capable of managing complex intricate traffic networks and coordinating the signal timing across numerous intersection crossings. It can be quite difficult to coordinate signals throughout a city or urban region where cars or vehicles can drive past several junctions without halting anywhere.

3. Dependency on external sensors and cameras:

- Sensor failures and accuracy issues: To identify the presence of the vehicles on the roads int the signalized regions and traffic flow or density from the vehicles by the old traditional adaptive systems, they may frequently relies on devices or sensors like inductive loops, infrared sensors or cameras. However, By physical wear and tear or environmental factors like weather or road debruises might cause these sensors to malfunction or give false data to the system.

- Limited coverage and scalability: Some traditional or current systems may not cover all the lanes of the roads especially in the complex intersections. If the sensors are only installed on specific lanes then the system may fail to detect the traffic conditions.

4. Inability to handle dynamic and unpredictable traffic events:

- Accidents and blockages: Existing current systems are unable to adjust to the sudden or unpredictable traffic events that will happen in day to day life like accidents, roadblocks or construction zones also, in that cases the traditional systems will not be able to adapt to the situation and causes congestions.

- Special traffic scenarios: Special events like emergency vehicle passage, public transport priority, or pedestrian crossing requests can complicate the traditional systems and the system can struggle to prioritize the needs dynamically.

5. Inefficiency in optimizing traffic flow:

- Congestion and delays: Inefficient signal timings in the peak hours or busy areas can lead to the long delays or more congestions in a single lane, A common problem in the traffic is in the intersection a signal can change too quickly or hold upto very long time leading to the formation of the long queues of the vehicles.

- Environmental impact: Unnecessary idling due to the delays in the traffic signal changing techniques leads to the idling of the vehicles for the long time which also increases the fuel consumption and also contributes to the air pollution.

- High computational requirements for complex systems:

- Scalability issues with AI and Machine learning: AI based systems like reinforcement learning or deep learning helps in traffic signal control but at the larger wide scale it leads to the issues related to scalability, latency etc.

2.3 SCOPE OF THE PROJECT

The purpose of this project is to come up with an innovative solution that can predict real-time tracking and location of vehicles in addition to a real-time system of AI Traffic Signal Control which maximizes the flow of traffic, reduces vehicle congestion, and environmental impact within the cities. Real-time vehicle tracking will be one of the prominent aspects of the system. IoT sensors, CCTV cameras, GPS from vehicles, and Internet of Things devices will be utilised in monitoring traffic conditions, flow, density, vehicle speed, and patterns of traffic at different routes and complex intersections. In addition to the decision-making conditions, the gathered traffic data will feed into predictive models to manage traffic flow and congestion for the future.

One of the systems main characteristics is the intelligent AI traffic signal control, which will automatically modify traffic signals in real time according to traffic density or volume, congestion levels, and predicted traffic patterns. Reinforcement Learning (RL), a subfield of artificial intelligence that helps the system to continuously learn and improve its decisions based on ongoing traffic conditions, will replace traditional fixed-time traffic signals with a more adaptable system.

The project or system will use the big data to aggregate, analyze, and store large datasets produced by environmental monitors, cars, vehicles and traffic sensors. The central monitor will be able to keep an eye on pollution, traffic flow, and traffic signal operations in real time from a single dashboard. Decision-making algorithm will gain knowledge from this centralized system on how to enhance the traffic signal regulation around the city, lessen the vehicle congestion, and increase the urban mobility. Additionally, to guarantee quick reaction times and avoid delays in traffic signal adjustments, edge computing may be utilized to process specific data locally, such as at crossings.

The major goal of the smart traffic system project is to offer a ultimate response to the problems that are associated with cities traffic and the environment impacts from them. In addition to the improving traffic flow and easing or lessening the congestion of the traffic flow, the system will help cities become more sustainable and adaptable to the traffic problems by the urbanization and climate change by fusing real-time vehicle tracking, AI system traffic management, and predictive emissions model. This initiative has the potential to improve the quality of life for citizens and support the country efforts to lower carbon footprints by transforming cities into more habitable, eco-friendly, and efficient places.

CHAPTER 3

SYSTEM DESIGN

3.1 PROBLEM STATEMENT

The traffic flow or density has no specific patterns that it has to be followed, and the manually pre-programmed traffic signal timers usually results in a huge problem with already existing problem of the traffic with vehicle congestions. However, implementing a system which will reduce the chances of those situations by dynamically adjusts to the traffic signal lights based on what is currently happening on the traffic. This system will ensure that there are road lanes or directions where the vehicles are increasing more, so that longer duration will be allotted green signal in comparison to the other lanes with a lesser traffic on the road that will not causes idling to any other vehicles.

This system can replace the traditional systems which were pre-programmed to the signal lights causing delay, waiting time, long queues, and an increase in fuel consumption along with air pollution. To put together the result of this project, it is to design a traffic signal light controller based on computer vision but can adapt to the current traffic situations. The implemented system aims to use live video data from cameras installed at all traffic intersections and junctions for the purpose of evaluating real-time traffic density and setting up the green signal accordingly. The number of vehicles would be counted as bikes, car, bus, truck, autorickshaw so that the time of signals and estimation is done. It has many advantages since it incorporates real time traffic light signal adaptation according to the prevailing level of traffic density, and there is no need to install new hardware's, it is less expensive than sensors, these systems are autonomous, which means there is no requirement of manpower.

Working of the proposed model: The system will analyze the snapshot from the cameras installed at the traffic junctions, intersections to calculate real-time traffic density using computer vision and image processing techniques. The system utilizes the YOLO (you only look once) model for object detection to identify the order or type of vehicles on roads. The machine learning scheduling algorithms will automatically set the appropriate signal times for each signal based on the calculated traffic density, and the system detects the amount or level of emissions from the vehicles based on the variables such as vehicle type, fuel type of the vehicle, vehicle speed, and other factors.

3.2 SYSTEM ARCHITECTURE

Designing a smart traffic light control system that optimizes the traffic management from the vehicles have several components:

3.2.1 SYSTEM OVERVIEW

The system will use the real-time traffic density data from the cameras to adjusts the traffic signal lights pattern dynamically to ensure the traffic flow and while reducing the traffic congestions. some of the key components used in the system includes:

1. Sensors and Data collection: The system will use the traffic CCTV cameras, inductive loop sensors, radar sensors and IoT sensors to collect the information for the calculations.

2. Traffic light control model: The AI will adjust the traffic signal lights based on the gathered information on the real-time.

3. Carbon-emission prediction model: The system will predict the vehicle emission based on the traffic flow and vehicle type and some other factors.

4. Data Preprocessing: The centralized monitor will gather all the information and predicts and give the output from it.

5. Communication Infrastructure: IoT enabled communication between the sensors, traffic signals, server and units will serve for the communication purpose.

3.2.2 DETAILED ARCHITECHTURE

1. Data Collection: This layer collects the real-time data to feed to the system, this will help in capturing the traffic density, vehicle speed and the environmental impactable data.

    - Traffic sensors:

CCTV cameras: These are used for vehicle count, vehicle type detection and monitoring of the traffic.

Sensors: Sensors are embedded in roadways to detect the vehicle presence and traffic density, vehicle speed and congestions.

- Environmental sensors:

  CO_2 Sensors: These sensors are used to measure the concentration of CO_2 in that area neat the traffic signal light to estimate the emissions.

  Temperature and Humidity Sensors: These are used to calibrate the emission predictions by considering he weather conditions.

2. Data Fusion and Preprocessing layer: The collected data from the cameras and sensors will be preprocessed and combined in this layer.

- Data Aggregation: The data gathered from the different sensors like traffic, environment, vehicle data will be combined into single stream.
- Noise reduction: The system will filter out errors and noise data that are gathered from the sensors to improve the quality of the inputs to AI models.
- Data Normalization: The system will then standardize the gathered data to make the data consistent and usable for the further modeling.

3. AI and Machine learning layer(traffic control and emission prediction):

- Traffic control AI:

  Traffic prediction model: The machine learning models like RNNs, LSTM are used to predict the traffic flow based on the previous or real-time data.

  - Reinforcement learning: The Traffic signal lights are controlled by the RL agent which will learn the signal phases of red, yellow, green and sequences from the real-time traffic data.
  - Multi-Agent System: For the cities with intricate intersections the model will communicate with the nearby control agents.

4. Control and Decision-making layer: After the models predicts the traffic flow this layer will adjust the traffic lights signals.
    - Signal controller: This module controls the traffic lights based on the data gathered and performs operations like signal adjustments, adaptive timing for signals, Emergency vehicle prioritization.
    - Emission reduction strategies: The system will implement the strategies like Idle time reduction of vehicles, Eco-driving encouragement, green wave traffic signals.

3.3.3 REQUIREMENT SPECIFICATIONS

SOFTWARE REQUIREMENTS:

1. Python 3.7:

    Is used Python 3.7 as it is stable, has a wide compatibility with most machine learning libraries (TensorFlow, Keras, Scikit-learn), but still modern enough for use in AI/ML development. Still, for bigger projects, using something like Python 3.8 or 3.9 may be better.

2. Microsoft Visual C++ Build Tools:

    This is a set of tools, libraries, and compilers developed by Microsoft that enable building, linking, and debugging applications in C++. It is required to install some Python packages written in code (C/C++) such as TensorFlow, PyTorch. Most deep learning libraries, including TensorFlow or PyTorch, incorporate components in C/C++ for performance reasons. This is also important to enable effective model training and the running of AI algorithms, which need low-level optimizations for speed, such as processing traffic data in real-time.

3. YOLO Weight Files:

    The YOLO (You Only Look Once) is one of the most popular real-time object detectors, which are an outcome of deep learning models. The YOLO weight file contains the pre-trained weights that were used in training a large dataset, such as COCO or VOC. In the Smart Control of Traffic Light System, YOLO can be used for vehicle or traffic-related object/pedestrian detection in real time through video/camera feed. The weight file is the trained model that will be used to identify these objects in the real world. YOLO will help analyze traffic flow and identify congested spots and also help identify the types of vehicles there. This detection system can provide the necessary data to be sent to the AI control system to make decisions regarding traffic lights. For instance, YOLO may be used to count cars as they move at a traffic light to determine whether to go on red or extend the green.

4. AlexNet V3:

   AlexNet is a deep architecture for a CNN that updated image classification. The utilization of AlexNet (or a variant like AlexNet V3) can be turned for the purpose of classifying various forms of vehicles, or even to predict traffic conditions from visual information, for example camera feeds or satellite images. Its purpose is more focused on classifying object types rather than the exact position in the image. AlexNet can be used in visual pattern recognition, where it would establish the types of vehicles being cars, trucks, and buses, something useful especially for intelligent traffic light control, as distinct vehicles, like a bus, would require special treatment and priority signals, for instance.

5. Machine Learning Frameworks:

   TensorFlow: TensorFlow shall be used for training deep learning models on controlling traffic lights in real time via reinforcement learning algorithms, even predicting future traffic conditions and carbon emissions through real-time data.
   Keras: This platform will be used to rapidly prototype and test deep learning models in the service of traffic control and prediction, as it's very friendly for model building, allowing a minimum of boilerplate code, particularly for CNNs or RNNs-important for traffic prediction.
   PyTorch: PyTorch is convenient for research and rapid prototyping of AI algorithms for dynamic control of traffic lights. Additionally, PyTorch is suitable for reinforcement learning applications.
   Scikit-learn: The traditional tasks such as regression analysis to estimate traffic flow or emission levels, classification tasks like traffic state classification, and clustering to identify traffic patterns with the data are solved using the scikit-learn library.

6. Reinforcement Learning (RL) Libraries:

   Such libraries train the models, which make decisions based on real-time feedback, thereby learning through interaction with the environment.

7. Regression or Time-Series Analysis Models:

   LSTM: It is another form of the RNN. It has designed to emphasize or give more importance to the sequential data, as it will help it to predict future trends with precision by considering past trends in inflow traffic.

CHAPTER 4

SYSTEM IMPLEMENTATION

4.1 OVERVIEW OF THE MODULES

Our project main aim is to minimize the traffic at intersection and some congested place. So that there should be smooth transportation. Our system implementation contains two modules such as vehicle detection module and simulation module. Each module has its won effect on this project. Smart traffic light control systems, which are driven by artificial intelligence, optimize traffic flow through real-time changes in the signal timings as dictated by the dynamic conditions of traffic. These networks would consist of cameras and vehicle detectors monitoring traffic density, speed, and flow patterns, with the AI-based algorithms of computer vision and machine learning analyzing those data patterns for future trends in traffic to correspondingly optimize their signal timings accordingly. This adaptability will allow these systems to substantially reduce congestion, enhancing both fuel economy and overall urban mobility.

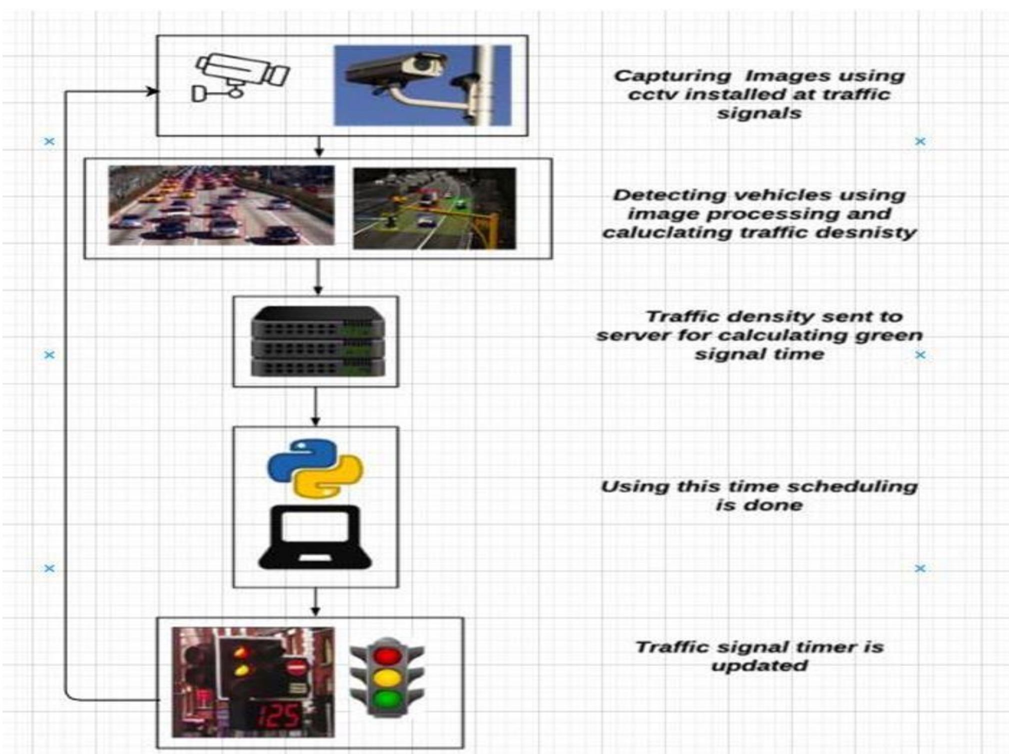

Fig.4.1 Detection of vehicle using YOLO algorithm

4.2 DESCRIPTION OF THE MODULES

The Vehicle Discovery Module recognizes and tracks vehicles in pictures or video streams utilizing procedures like question discovery and following calculations. The Reenactment Module makes virtual situations to imitate real-world activity scenarios, producing virtual vehicles with reasonable elements and sensor information. By coordination these modules, analysts can test and move forward independent vehicle frameworks in a controlled virtual environment, quickening advancement and guaranteeing safety.

4.2.1 MODULE 1 DESCRIPTION

Vehicle Detection Module

- A Vehicle Detection Module is a fundamental component in AI-based intelligent traffic management systems. A Vehicle Detection Module serves to accurately and reliably detect and track vehicles on roads, thus improving safety, traffic flow, and its capabilities.

➢ Sensors:

- Cameras: This sensor is the most widely used as it captures visual data processed through computer algorithms such as computer vision.
- Radar Sensors: Its detection is based on the Doppler effect therefore can be accurate at long ranges and in adverse weather conditions
- LiDAR Sensors: These sensors emit laser beams to measure distances and create 3D point clouds of objects with precise location and shape information.
- Inductive Loop Detectors: They rely on the induction of changes in the magnetic field caused by vehicles passing over them.

➢ Computer Vision Algorithms:

- Object Detection: Find or pick up vehicles in images or video frames via YOLO (You Only Look Once) or SSD (Single Shot Multi Box Detector) among other techniques.

- Toll Collection Systems: Automatic detection and classification of vehicles.

- Parking Management: Monitoring of the occupancy of the parking lot and guidance of drivers to available spaces.
- Anomalous Event Detection: The ability to detect accidents, breakdowns, and other events that happen on the road.
- Tracking Objects: The trajectory of the detected vehicle can be traced from one frame to another with the help of Kalman filtering or Deep SORT algorithms.

➢ Machine Learning Models:

- Classification: Models like CNNs are applied for image classification in order to classify the vehicle as a car, truck, motorcycle, etc.
- Regression: Regression models have been used to predict speed and trajectory of vehicles.

These vehicle detection modules are advanced given the progress that the technology is experiencing these days. Indeed, they promote the most intelligent and effective transportation processes.

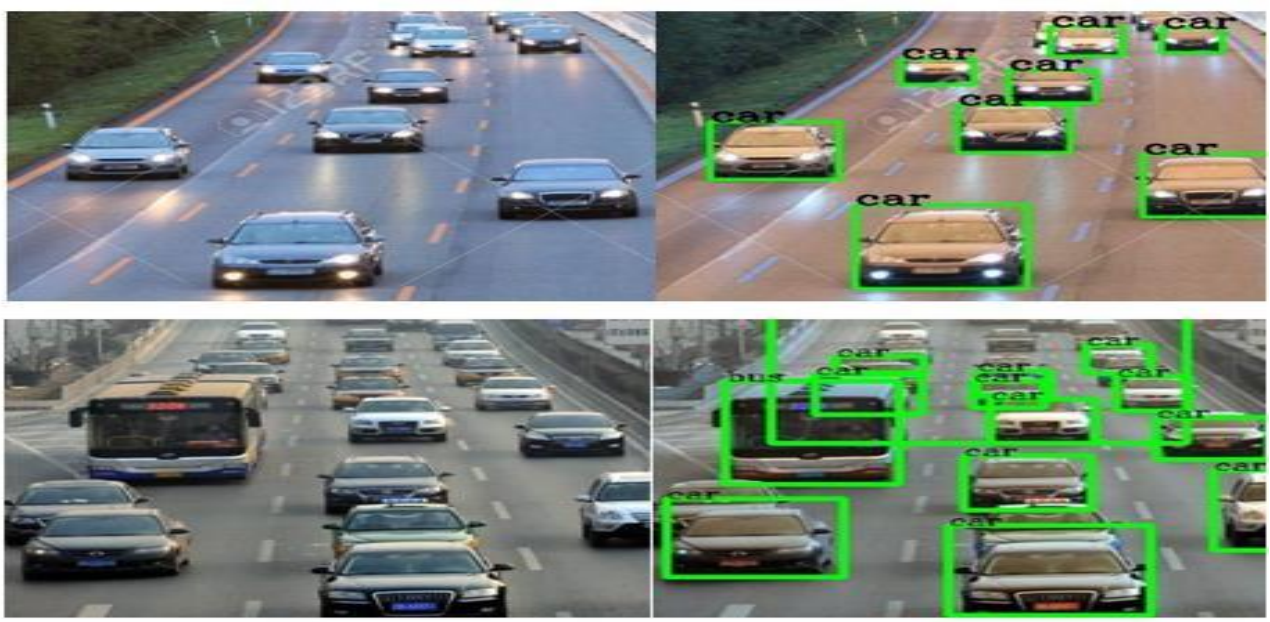

Fig.4.2.1 The output of the Vehicle Detection Module

4.2.1 MODULE 2 DESCRIPTION

Simulation Module

A simulation module is an important tool for developing and testing AI-powered smart traffic light control systems. It provides a virtual environment through which realistic simulation of actual traffic conditions can be performed for the evaluation of various AI algorithms and system configurations. This module simulates the generation of traffic, vehicle dynamics, and sensor data, thereby enabling engineers to assess performance for control strategies under various conditions. Such a system's key performance metrics would be average delay, queue length, travel time through vehicles, consumption of fuel, and the amount of emissions. Researchers and engineers could furthermore simulate such a design rigorously in order to optimize the system parameters regarding possible problems, and hence refine the AI algorithms that would lead to improved traffic flow, reduced congestion, and an enhancement in overall urban mobility.

Constructing a Virtual Environment: Develop an alternate set of roads for the city, including the location of intersections, main roads and traffic light systems.

Defining Traffic Scenarios: Introduce several types of traffic scenarios such as heavy traffic hours of the day, peak hours and situations where traffic is backed up, and accidents.

Visualizing Traffic: The author expresses such inclination towards employing software programs to put the simulations of the flow of vehicles into the nature of visibility and a check upon the arrangement to see the outcome of traffic lights on traffic..

Analyzing Results: Obtain speed at intersections and network congestion, and emission statistics at highways and interchanges to evaluate efficiency of traffic controls.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 DESCRIPTION

The implementation of the Intelligent Traffic System for Smart Cities demonstrated substantial advancements in traffic optimization and environmental impact reduction. With real-time traffic monitoring, the system continuously adjusted traffic signals according to congestion levels, effectively reducing the amount of time vehicles were idling at intersections and thereby improving traffic flow and efficiency.

One of the standout aspects of this project was its ability to pinpoint congestion hotspots and assess lane-specific traffic patterns. By identifying areas and times where traffic density was consistently high, the system enabled targeted traffic control measures, such as adaptive signal timing and redistribution recommendations, which eased congestion in high-traffic areas. This targeted approach not only improved traffic flow but also contributed to the reduction of localized emissions. Additionally, by balancing lane usage and reducing stop-and-go movement, the system helped decrease emissions from high-polluting vehicles in particular lanes, such as heavy trucks and buses, which are typically responsible for a significant share of carbon output.

In terms of system performance, the platform processed vehicle images in near real-time, supporting instant updates and continuous monitoring across the entire network. This high processing speed ensured that traffic control adjustments were timely and effective. Over the trial period, the system maintained excellent operational stability, indicating its feasibility for long-term deployment without frequent maintenance interruptions.

During the pilot implementation, the system showed a measurable reduction in urban congestion levels and demonstrated a positive impact on air quality, with cleaner air observed in previously congested areas. The project’s outcomes underscore its potential to be scaled across larger urban regions, contributing to sustainable traffic management by improving the quality of life in densely populated cities. This project illustrates a promising approach to intelligent traffic control that not only streamlines urban transportation but also actively supports environmental goals by reducing vehicular emissions.

5.2 GRAPHS

Current System					
Simulation No.	Lane 1	Lane 2	Lane 3	Lane 4	Total
1	67	74	51	18	210
2	78	73	47	19	217
3	80	73	33	29	215
4	76	71	39	27	213
5	77	66	44	26	213
6	74	72	37	21	204
7	65	73	36	18	192
8	60	68	33	28	189
9	49	83	36	28	196
10	57	70	46	25	198
11	53	70	39	34	196
12	55	70	29	38	192
					2435

Proposed Adaptive System					
Simulation No.	Lane 1	Lane 2	Lane 3	Lane 4	Total
1	111	86	42	31	270
2	105	83	38	28	254
3	100	96	36	20	252
4	96	75	56	22	249
5	93	89	42	24	248
6	77	97	37	30	241
7	76	82	48	30	236
8	71	92	48	30	241
9	85	98	48	31	262
10	79	92	37	30	238
11	110	105	24	17	256
12	76	87	43	44	250
					2997

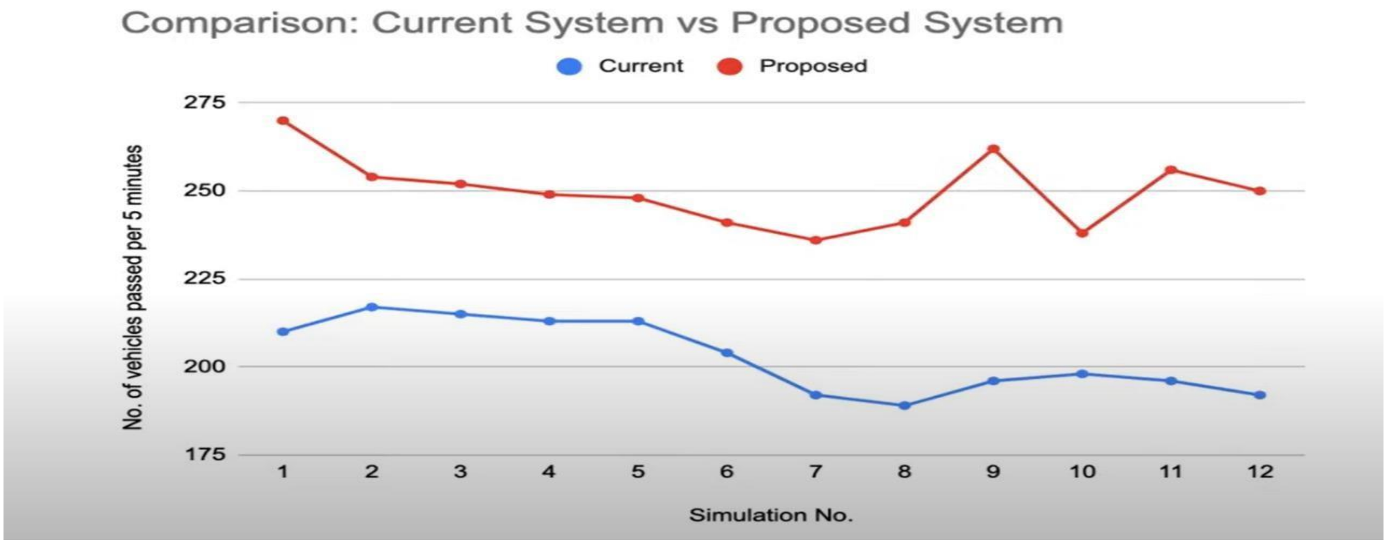

Fig.5.2 Current and adaptive system graph

CHAPTER 6

TESTING

6.1 DESCRIPTION

A smart traffic light control system is tested at both the simulation and real-world deployment level. Simulation-based testing enables controlled experiments that help analyze the performance of various AI algorithms and system configurations for specific scenarios with different types of traffic. Average delay, queue length, fuel consumption, and emissions are some of the measurement criteria. Deployment in pilot areas of specific regions accesses the effectiveness of the system on its impact on the flow of traffic, user satisfaction, and safety. It is only by the integration of both simulation and real-world testing that the entire reliability, efficiency, and overall effect of smart traffic lights on urban mobility would be guaranteed.

The process of testing a traffic system for smart cities should take into consideration the use of a simulation-based as well as validation by liveliness evaluation in a multifaceted manner.

Simulation Testing:

- Scenario Design: Design a number of scenarios covering a peak hour traffic, accidents and other special events.
- Vehicle Behavior: Impose realistic acceleration and deceleration rate limits on vehicles as well as lane changing frequency.
- Sensor Data: Use computer generated camera images as well as LIDAR’s point clouds as synthetic sensor data.
- Algorithm Evaluation: Observe the vehicle detection, and tracking prediction algorithms with multiple scenarios.
- Traffic Flow Optimization: Traffic control measures taken should be evaluated on the basis of effectiveness in reducing level of emissions and enhancing traffic flow.

Real World Testing:

- Pilot Deployment: Implement the system inside a target area, such as in a particular region, or specific zone within a city.

- Data Collection: Real time data from a range of sensors and traffic cams is obtained.
- Performance Metrics: The system's performance in terms of vehicle identification, tracking and emission forecasting must be assessed.
- Traffic Flow Analysis: Use the system to monitor the level of influence on traffic, congestion, and travel time.

6.2 TEST CASES

Here are some test cases to evaluate the performance of a smart city traffic system:

- **Functional Testing**

- **Vehicle Detection:**
  Test the system's ability to accurately detect vehicles under various conditions:
  Daytime and nighttime
  Different weather conditions (rain, fog, snow)
  Varying lighting conditions
  Different vehicle types and sizes
- **Vehicle Tracking:**
  Test the system's ability to track vehicles accurately, even in dense traffic and occlusions.
  Evaluate the system's performance in handling lane changes, turns, and other complex maneuvers.
  Validate the predictions against real-world data.
- **Traffic Signal Control:**
  Test the system's ability to optimize traffic signal timings based on real-time traffic data.
  Evaluate the system's performance in reducing congestion and improving traffic flow.
- **Incident Detection and Response**:
  Test the system's ability to detect incidents like accidents and roadblocks.
  Evaluate the system's ability to alert relevant authorities and implement appropriate traffic management strategies.

- **Performance Testing**

- **Real-time Processing:**
  Test the system's ability to process large volumes of real-time data and generate timely insights.
  Evaluate the system's response time to changes in traffic conditions.
- **Scalability:**
  Test the system's ability to handle increasing traffic volumes and expanding urban areas.
  Evaluate the system's scalability in terms of both hardware and software resources.
- **Reliability:**
  Test the system's reliability and fault tolerance.
  Evaluate the system's ability to recover from failures and maintain continuous operation.

- **Security Testing**

- **Data Privacy and Security:**
  Test the system's ability to protect sensitive data, such as vehicle identification information and personal data.
  Evaluate the system's compliance with data privacy regulations.
- **Cybersecurity:**
  Test the system's vulnerability to cyberattacks and data breaches.
  Implement security measures to protect the system from unauthorized access**.**

By thoroughly testing the system against these test cases, we can ensure its reliability, accuracy, and effectiveness in improving urban traffic management.

CHAPTER 7

CONCLUSION AND FUTURE ENHANCEMENTNS

7.1 CONCLUSION

One of the most promising solutions to the issue of city traffic congestion and inefficiency is an AI-based intelligent smart system to control traffic lights. Such systems could exploit new technologies such as computer vision, machine learning, and IoT for optimization of signal timings based on the latest information about traffic conditions to decrease delay times and increase fuel efficiency while enhancing overall road safety. The AI-based control system of smart traffic lights optimizes the flow of traffic in cities to a large extent. It can evaluate real-time data about traffic conditions by applying computer vision and machine learning and IoT; then signal timings can be changed in accordance with such data. As a result, congestion on roads is avoided, and fuel efficiency increases, along with a rise in safety standards.

However, its successful implementation requires many other things to be considered, including the quality of the data, computational resources, and the potential scalability for system purposes. It is also important to address challenges associated with sensor reliability, adverse weather conditions, and privacy concerns. Through continuous testing, monitoring, and iteration, AI-powered traffic light systems will transform the way cities are run in a futuristic way – efficient, sustainable, and livable.

The use of artificial intelligence in traffic lights is a marked shift in traffic management. AI algorithms enable such systems of traffic to scan real-time data feeds from sensors, cameras, and connected devices to dynamically adjust traffic signals. Therefore, there is improved flow of traffic, lesser congestion, lesser fuel intake, and reduced carbon emissions. Once such traffic lights are run by artificial intelligence, then their adaptability is excellent because signal timing might easily change with changing traffic patterns, emergency conditions, and pedestrian needs. This type of technology also enhances road safety through the reduction of the chances of the accidents usually caused by irregular flow of traffic or human error.

In conclusion, the integration of AI into traffic lights modernizes urban infrastructure and brings efficiency toward sustainable networks of transportation. Integrate the autonomous vehicle systems and smart city ecosystems, and the potential flows for more efficiency and environmental advantages.

7.2 LIMITATIONS OF THE PROJECT

- Data Quality and Quantity: The accuracy of the system depends largely on the data that is collected from the sensors. Data that is not accurate or completely collected can result in unfounded predictions and poor traffic management usage.
- Deployment and Maintenance of Sensor Network: Deployment and maintenance of large scale sensors networks can be tough and expensive. Others like the power supply, network connectivity and sensor failure can also affect the performance of the system.
- Computational Complexity: Processing large data in real time and running sophisticated machine learning models are also power hungry. This requires advanced hardware and algorithms so that results can be given in an appropriate time.
- Dynamic Traffic Patterns: There are many elements due to which traffic patterns may change notably such as environmental conditions, accidents and special events. Adjusting the system to these dynamic changes in real time may prove to be a challenge.
- Public Acceptance and Privacy: Implementation of complete traffic monitoring systems can provoke concerns regarding how private data may be collected and utilized. The most fundamental element for the expeditious implementation of such systems has been the trust and approval from the public.

ADVANTAGES OF THE PROJECT

- Managing the Traffic: By using real time traffic data and with the installation on intelligent traffic signal control solution can reduce congestion and travel times.
- Improved Safety: By detecting and responding to accidents quickly, real-time incident detection can help prevent them from happening in the first place or reduce their severity.
- The tool offers urban planners and policy makers critical insights to inform decisions regarding infrastructure development and transportation policies.

- Economic Implications — Efficient and seamless traffic can provide economic relief in terms of productivity gain from time savings, as well as reduced fuel consumption.

7.3 APPLICATIONS OF THE PROJECT

- Other: It shall be used in other environments to control traffic as they happen to do in different places.
- Highway Traffic Management: It ensures safety, reduces number of accidents on the highways, and increases efficiency on the highways.
- Public Transportation Management: Better and more reliable public transport services.
- Parking Management: There are several approaches to this issue that include.
- Emergency Response: When it comes to emergencies, the man would act as an initiator of the response to avoid unnecessary delay.

7.4 FUTURE ENHANCEMENTS

- Advancement in Predictive Algorithms: Considering the incorporation of enhanced algorithms capable of providing more accurate predictions, which are more flexible than the current ones.
- Integration with Autonomous Vehicles: Developing and applying integration strategies to improve efficiency and minimize the occurrence of accidents involving autonomous vehicles.
- Other improvements: Enhance user interfaces to assist in traffic updates and information accessibility.
- Integration with Smart Grids: Implementation of such systems to help people reduce their energy needs, thus increasing the efficiency and reliability of the energy system.
- Privacy-Preserving Technologies: Use of privacy-preserving technologies which ensure that the data has been encrypted at the same time the flow of the traffic is been managed while still keeping the data private.

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