ADAPTIVE TRAFFIC CONTROL SYSTEM

A PROJECT REPORT

Submitted by

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in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY
in
PROGRAMME OF STUDY

SCHOOL OF COMPUTING SCIENCE AND ENGINEERING

VIT BHOPAL UNIVERSITY

KOTHRIKALAN, SEHORE
MADHYA PRADESH - 466114

FEBRUARY 2022

A PROPOSED DESIGN AND IMPLEMENTATION OF YOLO BASED SMART TRAFFIC CONTROL SYSTEM

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BONAFIDE CERTIFICATE

Certified that this project report titled **ADAPTIVE TRAFFIC CONTROL SYSTEM”** is the bonafide work of “**RAJAT KABRA [21BSA10069], ADITYA BHARDWAJ [21BSA10022], PRATEEK SONKAR [21BSA10033], SIDDHARTH TYAGI [21BSA10071], ANSHUL MALIK [21BSA10089]”** who carried out the project work under my supervision. Certified further that to the best of my knowledge the work reported at this time does not form part of any other project/research work based on which a degree or award was conferred on an earlier occasion on this or any other candidate.

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Last, but not least, I am deeply indebted to my parents who have been the greatest support while I worked day and night for the project to make it a success.

LIST OF ABBREVIATIONS

LQF: Longest Queue first

YOLO: You Only Look Once

RL: Reinforcement Learning

TLCS: Traffic Light Control System

ERP: Experience Replay mechanism

AI: Artificial Intelligence

DNN: Deep Neural Networks

py: Python

XML: eXtensible Markup Language

pip: Python3

JPG: Joint Photographic Experts Group

PNG: Portable Network Graphics

IoT: Internet of Things

SQL: Standard Query Language

PCA: Principal component analysis

LDA: Linear discriminant analysis

LBPH: Local Binary Pattern Histogram

SVM: support vector machine

LIST OF FIGURES AND GRAPHS

ABSTRACT

Our proposed system takes an image from the CCTV cameras at traffic junctions as input for real time traffic density calculation using image processing and object detection. This system can be broken down into 3 modules: Vehicle Detection module, Signal Switching Algorithm, and Simulation module. As shown in the figure below, this image is passed on to the vehicle detection algorithm, which uses YOLO. The number of vehicles of each class, such as car, bike, bus, and truck, is detected, which is to calculate the density of traffic. The signal switching algorithm uses this density, among some other factors, to set the green signal timer for each lane. The red signal times are updated accordingly. The green signal time is restricted to a maximum and minimum value in order to avoid starvation of a particular lane. A simulation is also developed to demonstrate the system's effectiveness and compare it with the existing static system.

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1. PROJECT DESCRIPTION AND OUTLINE

1.1 Introduction

Design of an adaptive traffic control system using YOLO algorithm software. The system requires a video capture device and the running python and ml-algorithm to be implemented successfully. It detects the traffic on a lane and set the timer accordingly. This system will prevent unnecessary wastage of time of lanes that is usually wasted in the form of empty lanes. Traffic congestion is becoming a serious problem with a large number of cars on the roads. Vehicles queue length waiting to be processed at the intersection is rising sharply with the increase of the traffic flow, and the traditional traffic lights cannot efficiently schedule it. In fact, we use computer vision and machine learning to have the characteristics of the competing traffic flows at the signalized road intersection.

The existing system widely used are traffic signals with pre-set timers which operate under fixed time operation and display green light to each approach for the same time every cycle regardless of the traffic conditions. This may be best suited for heavily congested areas but for low traffic density, the sequence is not as beneficial as no vehicles are waiting. With advancements in technology, the Adaptive Traffic Signal Control System has been developed in Bhubaneswar city. The system gets input from sensors embedded in the road and synchronizes the group of traffic signals accordingly. This signalling system is run on solar power.

The system is infeasible and costly since it requires a system embedded in roads. LQF scheduling algorithm minimizes the queue sizes at each approach to the intersection. The goal is to lower vehicle delay as compared to a current state signal control method. A focus is given by giving preference vehicles (such as emergency vehicles or large trucks). As the system concentrates on reducing the queue length, the stability of the system is a major concern. Therefore way out for this issue is a Traffic Control System using reinforcement learning (RL) an AI structure that endeavours to estimate an ideal basic leadership policy.

The framework gives a solution for diminishing traffic in metropolitan urban areas by contemplating constant traffic situations and the reinforcement learning algorithm to improve after some time. Since the traditional traffic control framework utilizes basic convention that alternate green and red light for a fixed interval. Such traffic control frameworks work admirably when there is a limited amount of traffic network. To build up a traffic control framework that handles and directs the traffic shrewdly using reinforcement learning algorithm and to accomplish smooth transportation of vehicles and to curb natural issues like raised air pollution, wastage of fuel and danger of mishap.

In contrast, the adaptive traffic control system offers a response to reduce traffic in metropolitan urban networks by considering continuous traffic circumstances and reinforced learning computation to improve over time. The system will without a doubt examine a 4-way intersection for the incoming traffic density to take an optimized step towards reducing it. The estimation used learns over a while so the fundamental periods of system most likely won't give perfect results for the recognized traffic.

As a result, a reinforcement learning algorithm that naturally extracts all highlights helpful for versatile traffic signal control from raw real-time traffic data furthermore and learns the ideal traffic signal control arrangement is needed.

1.2 Motivation for Work

The work to create and customize new things seeing the future. The 21st Century is technology robust and we will be surrounded with smart technology and gadgets. By seeing this we get a motivation to contribute something to our society. Every time when we are working in making and upgrading our project we get a feel to make it better and better. Our project is making the ease of people going to institutions, schools, companies to make their regular work efficient on time. So we are working continually to upgrade and fix the bugs with a tremendous power and energy.

1.3 About Introduction to the project including techniques

In modern times, traffic management has become one of the key aspects of computer vision. There are at least two reasons for this trend; the first is the commercial and law enforcement applications, and the second is the availability of feasible technologies after years of research. Due to the very nature of the problem, computer scientists, neuroscientists and psychologists all share a keen interest in this field. In plain words, it is a computer application for automatically identifying a vehicle from a still image or video frame. In this paper we proposed an adaptive traffic control system. This system based on detection and recognition algorithms, which automatically detects the vehicle strength on lane and saving the time. This is done by a state-of-the-art, real-time object detection based on a deep Convolutional Neural Networks called You Only Look Once (YOLO). Then traffic signal phases are optimized according to collected data, mainly queue density and waiting time per vehicle, to enable as much as more vehicles to pass safely with minimum waiting time. YOLO can be implemented on embedded controllers using Transfer Learning technique.

1.4 Problem Statement

The existing system widely used are traffic signals with pre-set timers which operate under fixed time operation and display green light to each approach for the same time every cycle regardless of the traffic conditions. This may be best suited for heavily congested areas but for low traffic density, the sequence is not as beneficial as no vehicles are waiting. With advancements in technology, the Adaptive Traffic Signal Control System has been developed in Bhubaneswar city.

The system gets input from sensors embedded in the road and synchronizes the group of traffic signals accordingly. This signalling system is run on solar power.

The self-adaptive traffic light control system based on YOLO. Disproportionate and diverse traffic in different lanes leads to inefficient utilization of same time slot for each of them characterized by slower speeds, longer trip times, and increased vehicular queuing. To create a system which enable the traffic management system to take time allocation decisions for a particular lane according to the traffic density on other different lanes with the help of cameras, image processing modules.

1.5 Objectives

The objective of this project is to design an adaptive traffic control system. In the early 21's, when government of India noticed that they had increase trend in the weight of the metropolitan area population, personal motorized mobility, and increase in inclination of using private car; mobility government had decided:

- Calling for an integrated intervention strategy, both on private and public transport;
- Aiming at the substitution of large part of private car trips by the use of public transport;
- Requiring a public transport better service quality in order to reach the objective;
- Recognizing the need of the development of public transport infrastructural interventions on the long terms, and of mobility telematics applications on the short period.

The aims of the proposed Project are the following:

- Improving traffic flows and safety
- Reducing environmental pollution caused by traffic
- Improving efficiency and quality of public transport
- Providing real-time information services to travelers
- Development of a strategic supervisory system for all Transport Telematics sub-systems
- Extension of the existing Urban Traffic Control and bus priority facilities over a wider area of the urban network
- Extension of the functions of the Public Transport Management System to include user information and passenger counting
- Development of a system for keeping citizens better informed about mobility services
- Functional integration of traffic control systems with the environmental monitoring and forecasting system.

The proposed Project long-vision goals and prediction in the start of the project, are stated as it follows: when extended over the whole urban area would grant:

- Average origin-destination travel time: - 25%
- Mobility related air pollution and energy consumption: - 18%
- Improve modal split towards the public transport.

1.6 Organization of the project

The adaptive traffic control system is organized into various components such as sensors, actuators, and a control center. The sensors collect real-time traffic data, including vehicle volume, speed, and travel time. The actuators, such as traffic signals, dynamically adjust based on the information received from the sensors and control center. The control center, usually a central computer, analyzes the traffic data and generates control strategies to optimize traffic flow and reduce congestion. The control center communicates with the actuators to implement the strategies in real-time. In addition to the components mentioned above, the adaptive traffic control system may also include communication networks, such as wired or wireless networks, to transmit data between the sensors, actuators, and control center. The control algorithms used in the system may be based on various optimization techniques, such as linear programming, genetic algorithms, or artificial intelligence algorithms, to make real-time decisions about traffic signal timings.

The system can be configured to prioritize different objectives, such as minimizing overall delay, reducing stops, or reducing emissions. It can also incorporate real-time information from other sources, such as incident data, weather data, and public transportation schedules, to provide a more comprehensive view of traffic conditions.

1.7 Summary

The adaptive traffic control system is designed to improve traffic flow, reduce congestion, and provide a safer and more efficient transportation system. By continuously monitoring and adjusting traffic signal timings, the system can respond to changing traffic conditions in real-time, resulting in improved traffic flow and reduced congestion. There are problems in every project but since improving them day by day and fixing up the bugs will be a been to society. The motivation to fixing issues will make us prominent.

2. RELATED WORK INVESTIGATION

2.1 Introduction

In modern times, traffic management has become one of the key aspects of daily life. An adaptive traffic control system is a dynamic system that aims to optimize traffic flow and reduce congestion by continuously monitoring and adjusting signal timings in real-time based on current traffic conditions. In recent years, many research studies have been conducted to improve the performance of these systems and to develop new algorithms and technologies to address the challenges associated with urban traffic management.

This section of our research paper aims to review the previous work that has been done in the area of adaptive traffic control systems. The goal of the related work investigation is to identify existing solutions and technologies, to compare their strengths and weaknesses, and to provide a comprehensive overview of the state-of-the-art in this field. Additionally, this section will highlight the gaps in the current research and identify opportunities for future work.

2.2 Core area of the project

Systems design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development. The proposed adaptive traffic control system can be divided into five main modules.

2.3 Existing Approaches/Methods

The modules and their functions are defined in this section. The five modules into which the proposed system is divided are:

2.3.1 Traffic Data Collection

This includes the development of sensors, cameras, and other data sources to collect real-time traffic data, such as vehicle counts, speeds, and travel times.

2.3.2 Traffic Signal Control:

The system needs to have the capability to control traffic signals based on the collected traffic data and adjust signal timings in real-time to optimize traffic flow and reduce congestion.

2.3.3 Traffic Modeling:

This involves the use of mathematical models to simulate traffic behavior and predict traffic conditions, taking into account factors such as road geometry, traffic demand, and signal timings.

2.3.4 Decision-Making Algorithms:

The system must have algorithms that analyze the traffic data and make decisions on signal timings and other traffic management strategies to optimize traffic flow and reduce congestion.

2.3.5 User Interfaces:

The system must have an easy-to-use interface for traffic engineers and operators to monitor the system's performance, access traffic data, and adjust control parameters as needed.

2.3.6 Integration with Other Systems:

The adaptive traffic control system should be able to integrate with other transportation systems, such as public transit and active transportation, to provide a more comprehensive solution to urban traffic management.

2.3.7 Evaluation and Testing:

Finally, the system should be tested and evaluated in real-world environments to assess its performance and make improvements as needed.

2.4 Pros and cons of the stated Approaches/Methods

The various approaches and methods used for adaptive traffic control systems each have their own advantages and disadvantages. Some of the pros and cons of the most commonly used approaches are as follows:

1. Fixed-Time Signal Control:

   Pros: This approach is simple to implement and does not require any real-time traffic data. Cons: It does not take into account current traffic conditions, which can result in congestion and reduced traffic flow.

2. Actuated Signal Control:

   Pros: This approach adjusts signal timings based on real-time traffic data, which can improve traffic flow and reduce congestion.

   Cons: It can be complex to implement and may require significant investment in infrastructure, such as sensors and cameras.

3. Optimized Signal Control:

   Pros: This approach uses advanced algorithms to optimize signal timings based on real-time traffic data, which can significantly improve traffic flow and reduce congestion.

   Cons: It can be complex to implement and may require specialized software and hardware.

4. Intelligent Transportation Systems (ITS):

   Pros: ITS integrates multiple technologies, such as real-time traffic data, advanced algorithms, and communication systems, to optimize traffic flow and reduce congestion.

   Cons: It can be expensive to implement and requires significant investment in infrastructure and technology.

5. Artificial Intelligence (AI) and Machine Learning (ML) Approaches:

   Pros: AI and ML algorithms can process large amounts of data and make accurate predictions and decisions, leading to improved traffic flow and reduced congestion.

Cons: It can be complex to implement and may require significant investment in hardware and software, as well as expertise in AI and ML.

In conclusion, each approach has its own advantages and disadvantages, and the most appropriate approach will depend on the specific needs and requirements of the traffic control system being implemented.

2.5 Issues/observations from investigation

Based on the related work investigation, the following issues and observations can be made regarding adaptive traffic control systems:

1. Lack of standardization: There is a lack of standardization in the field of adaptive traffic control systems, with different systems using different approaches, algorithms, and technologies. This can make it difficult to compare the performance of different systems and to integrate them with other transportation systems.
2. Limited data availability: A major challenge in developing adaptive traffic control systems is the availability of real-time traffic data. In some cases, there may be limited data available or the data may be of poor quality, which can negatively impact the performance of the system.
3. Complex algorithms: The optimization algorithms used in adaptive traffic control systems can be complex, requiring specialized software and hardware. Additionally, the algorithms may need to be continually updated and improved to take into account changing traffic conditions.
4. High cost of implementation: Implementing an adaptive traffic control system can be expensive, requiring significant investment in infrastructure, such as sensors and cameras, as well as software and hardware.
5. Limited real-world testing: While many studies have been conducted to improve the performance of adaptive traffic control systems, there is a need for more real-world testing and evaluation to assess the effectiveness of these systems in real-world environments.

2.6 Summary

In conclusion, the related work investigation highlights several key challenges and limitations in the field of adaptive traffic control systems, including the lack of standardization, limited data availability, complex algorithms, high cost of implementation, and limited real-world testing. These issues and observations highlight the need for further research and development in this area.

3. REQUIREMENT ARTIFACTS

3.1 Introduction

There are specific prerequisites for each platform that run applications based on the Traffic Control System. Minimum requirements that the clients must have in order to run this program and acquire great outcomes.

3.2 Hardware and Software requirements

- Hardware Specification: Processor: -

1. 7th generation i3.
2. RAM: - Minimum 4 GB.
3. Hard Disk: - Minimum 500 GB.
4. Camera: - High quality.

- Software Specification:

1. Platform: - Windows 8 or 10,
2. Linux Language Used: - Python
3. Frontend tools: - PyCharm IDE, or Visual Studio
4. Backend: - Database Directory, Attendance Excel Sheet, Project

3.3 Specific Project requirements

3.1.1 Data requirement

We require to store the images and can train at first so that camera can process the vehicle and lane density for further processing of time. We want the image in .jpg or .png form with the name of file as it’s the Vehicle Number Plate or Car Name.

3.1.2 Function Requirement

The function requirements for an adaptive traffic control system include:

- Real-time traffic data collection: The system must be able to collect and process real-time traffic data from a variety of sources, such as sensors, cameras, and other data sources.
- Dynamic traffic signal control: The system must be able to dynamically adjust traffic signal timings based on real-time traffic conditions.
- Centralized control: The system must have a central control center that can analyze traffic data and generate control strategies to optimize traffic flow and reduce congestion.
- Communication: The system must have effective communication between the sensors, actuators, and control center to ensure timely and accurate data transmission.
- Scalability: The system must be scalable to accommodate growth in traffic volume and changing traffic patterns.
- Adaptive algorithms: The system must incorporate adaptive algorithms that can adjust to changing traffic conditions in real-time and continuously improve traffic flow.

- Multiple objectives: The system must be able to prioritize different objectives, such as minimizing overall delay, reducing stops, or reducing emissions, based on user-defined criteria.
- Integration with other systems: The system must be able to integrate with other systems, such as public transportation systems and incident management systems, to provide a comprehensive view of traffic conditions.
- User-friendly interface: The system must have a user-friendly interface that allows for easy configuration and monitoring of the system.
- Reliability: The system must be reliable and have built-in redundancy to ensure continuous operation even in the event of equipment failure.

3.1.3 Performance and security requirement

The performance and security requirements for an adaptive traffic control system include:

- Performance: The system must be able to process and analyze large amounts of traffic data in real-time and make decisions quickly to optimize traffic flow and reduce congestion.
- Accuracy: The system must provide accurate traffic data and control decisions to ensure that traffic signal timings are optimized and traffic flow is improved.
- Reliability: The system must be reliable and have built-in redundancy to ensure continuous operation even in the event of equipment failure.
- Scalability: The system must be scalable to accommodate growth in traffic volume and changing traffic patterns.
- User-friendly interface: The system must have a user-friendly interface that allows for easy configuration and monitoring of the system.
- Security: The system must have secure communication channels and access controls to prevent unauthorized access to the data and control systems.
- Data privacy: The system must protect the privacy of sensitive data, such as license plate numbers and travel times, and comply with relevant privacy laws and regulations.
- System integrity: The system must maintain the integrity of the data and control systems to ensure that traffic signal timings are adjusted accurately and the system operates as intended.
- Compliance: The system must comply with relevant standards and regulations, such as those related to data privacy and cybersecurity.
- Maintenance: The system must be designed for easy maintenance and include procedures for regular system checks and upgrades to ensure continuous operation and optimal performance.

3.1.4 Look and Feel Requirement

The look and feel requirements for an adaptive traffic control system refer to the design and user interface of the system. Some of the key requirements in this area include:

- User-friendly interface: The system must have a user-friendly interface that allows for easy configuration and monitoring of the system. The interface should be intuitive and easy to navigate, with clear and concise information displayed in a visual format.
- Customization: The system should allow for customization of the interface, including color schemes and data display options, to meet the specific needs of different users.
- Responsive design: The interface should be responsive and adapt to different screen sizes and resolutions, allowing for effective use on desktop computers, laptops, and mobile devices.
- Clear and concise information: The information displayed in the interface should be clear and concise, with visual aids such as graphs and charts used to provide a clear understanding of traffic conditions and control decisions.
- Consistency: The interface should be consistent in terms of layout, font, and color, creating a seamless and professional appearance.
- Ease of use: The interface should be designed with ease of use in mind, with clear instructions and prompts provided for each step in the configuration and monitoring process.
- Accessibility: The interface should be accessible for users with disabilities, including support for screen readers and keyboard navigation.

These look and feel requirements are important for ensuring that the adaptive traffic control system is user-friendly, effective, and appealing to the end-users. A well-designed user interface can improve the overall usability and effectiveness of the system, making it easier for users to monitor traffic conditions and adjust traffic signal timings.

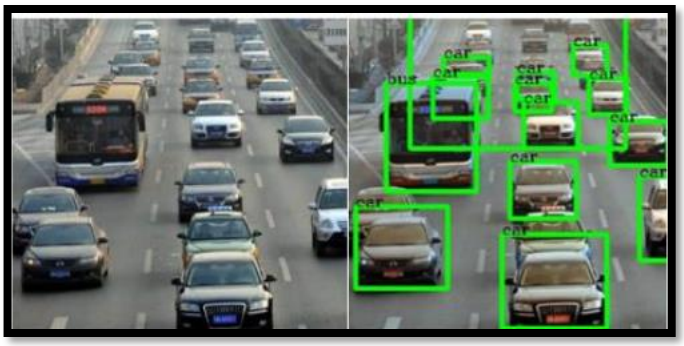

Figure 1: Outcome of Face Recognition

4. DESIGN METHODOLOGY AND ITS NOVELTY

4.1 Methodology and goal

The main goal of this optimizer is to minimize the delay. Consequently decrease the travel time of vehicles. In this regard the Cycle optimizer would consider one region at a time. The goal of an adaptive traffic control system project is to improve traffic flow and reduce congestion, thereby improving mobility and quality of life for the end-users. The system should be designed to meet the specific needs and requirements of the target users and be scalable, flexible, and adaptable to changing traffic conditions. The project should also be designed to be sustainable, with provisions for regular maintenance, upgrades, and technology refreshes to ensure the continued operation and effectiveness of the system.

4.2 Functional Module and Design Analysis

- The proposed system uses YOLO (You only look once) for vehicle detection, which provides the desired accuracy and processing time. A custom YOLO model was trained for vehicle detection, which can detect vehicles of different classes like cars, bikes, heavy vehicles (buses and trucks), and rickshaws.
- The dataset for training the model was prepared by scraping images from google and labelling them manually using LabelIMG, a graphical image annotation tool.
- Then the model was trained using the pre-trained weights downloaded from the YOLO website. The configuration of the .cfg file used for training was changed in accordance with the specifications of our model. The number of output neurons in the last layer was set equal to the number of classes the model is supposed to detect by changing the 'classes' variable. In our system, this was 4 viz. Car, Bike, Bus/Truck, and Rickshaw. The number of filters also needs to be changed by the formula 5*(5+number of classes), i.e., 45 in our case.
- After making these configuration changes, the model was trained until the loss was significantly less and no longer seemed to reduce. This marked the end of the training, and the weights were now updated according to our requirements.
- These weights were then imported in code and used for vehicle detection with the help of OpenCV library. A threshold is set as the minimum confidence required for successful detection. After the model is loaded and an image is fed to the model, it gives the result in a JSON format i.e., in the form of key-value pairs, in which labels are keys, and their confidence and coordinates are values. Again, OpenCV can be used to draw the bounding boxes on the images from the labels and coordinates received.

4.3 Software Architectural Design

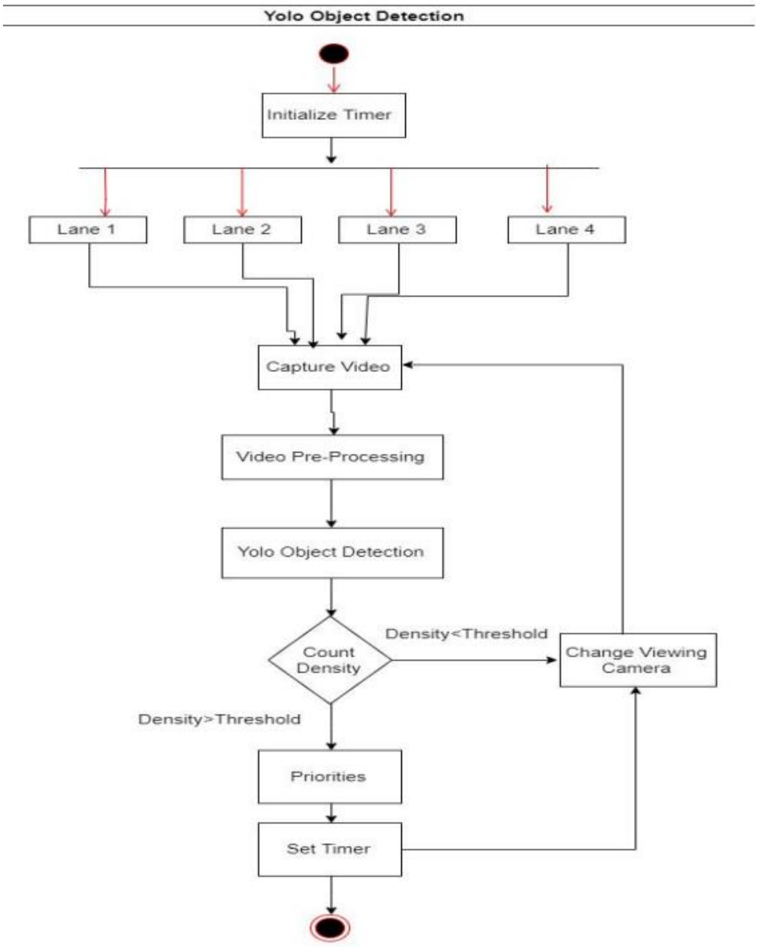

Figure 2: Architectural Design

4.4 Subsystem Services : Simulation Module

A simulation was developed from scratch using Pygame to simulate real-life traffic. It assists in visualizing the system and comparing it with the existing static system. It contains a 4-way intersection with 4 traffic signals. Each signal has a timer on top of it, which shows the time remaining for the signal to switch from green to yellow, yellow to red, or red to green. Each signal also has the number of vehicles that have crossed the intersection displayed beside it. Vehicles such as cars, bikes, buses, trucks, and rickshaws come in from all directions. In order to make the simulation more realistic, some of the vehicles in the rightmost lane turn to cross the intersection. Whether a vehicle will turn or not is also set using random numbers when the vehicle is generated. It also contains a timer that displays the time elapsed since the start of the simulation

4.5 User Interface Designs

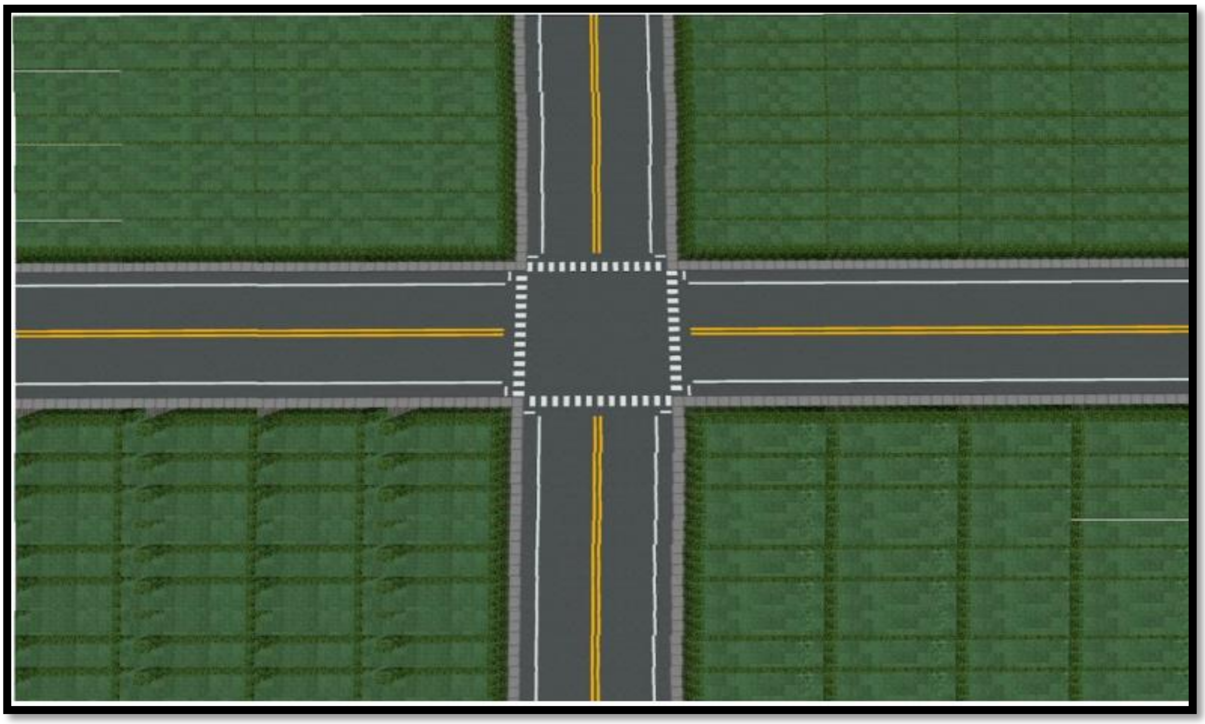

Figure 3: Interface Designs

4.6 Summary

The design of our project is simple interface that is user-friendly. It will help for the people who can are able to understand the computer architecture easily. This will help them to understand real life application as well as configure and access there area traffic system using a single click. We are regularly trying and updating the user interface so that it can be user-friendly as well as secured.

5. TECHNICAL IMPLEMENTATION AND ANALYSIS

5.1 Outline

A simulation was developed from scratch using Pygame to simulate real-life traffic. It assists in visualizing the system and comparing it with the existing static system. It contains a 4-way intersection with 4 traffic signals. Each signal has a timer on top of it, which shows the time remaining for the signal to switch from green to yellow, yellow to red, or red to green. Each signal also has the number of vehicles that have crossed the intersection displayed beside it. Vehicles such as cars, bikes, buses, trucks, and rickshaws come in from all directions. In order to make the simulation more realistic, some of the vehicles in the rightmost lane turn to cross the intersection. Whether a vehicle will turn or not is also set using random numbers when the vehicle is generated. It also contains a timer that displays the time elapsed since the start of the simulation.

5.2 Technical Coding and Code solutions

5.2.1 Python:

Python is an interpreted, high level and general purpose programming language used all over the world. I have chosen python language to design this project because of its simplicity and code readability. Whereas, there are various other modules which make it easier for any programmer to develop a software using this language. The system should be able to collect real-time traffic data from various sources, such as sensors, cameras, and other data sources. This can be done using code solutions such as Python or MATLAB to collect and process the data.

5.2.2 MATLAB:

Traffic Modeling system should be able to model traffic behavior and predict traffic conditions, taking into account factors such as road geometry, traffic demand, and signal timings. This can be done using code solutions such as MATLAB or Python to develop and run traffic simulation models. Decision-Making Algorithms should have algorithms that analyze the traffic data and make decisions on signal timings and other traffic management strategies. This can be done using code solutions such as MATLAB, Python, or R to develop and implement algorithms for decision-making.

5.2.3 HTML/CSS:

The User interfaces should have an easy-to-use interface for traffic engineers and operators to monitor the system's performance, access traffic data, and adjust control parameters as needed. This can be done using code solutions such as JavaScript or HTML/CSS to develop user-friendly interfaces. The adaptive traffic control system should be able to integrate with other transportation systems, such as public transit and active transportation. This can be done using code solutions such as APIs or web services to communicate and exchange data between different systems.

5.2.4 YOLO:

YOLO (You Only Look Once) can be used in an adaptive traffic control system to improve the accuracy and efficiency of object detection in real-time traffic scenes. The system can use YOLO to detect objects such as vehicles, bicycles, and pedestrians, and use this information to make informed decisions about traffic signal timings, lane management, and other traffic control strategies.

5.3 Working Layout of Forms

The working of our model is on Visual Studio. We have two forms of working the back-end and the user interface through which admin and traffic management authorities can access the different signals in city. All the records are saved in SQL file.

5.4 Prototype Submission

The prototype of our project is already submitted to respected Supervisor Dr. Hariharan R.

5.5 Test and Validation

1. Took an image of a 4-way intersection as background.

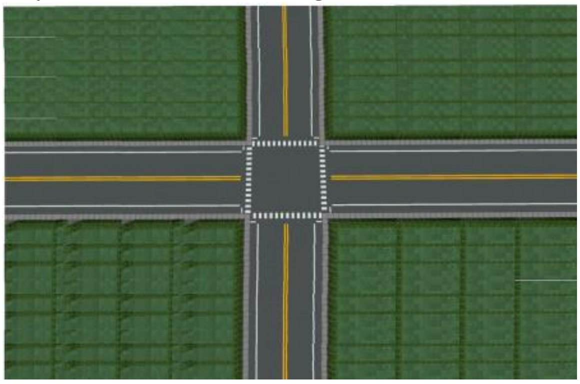

Figure 4: 4-Lane Background

2. Gathered top-view images of car, bike, bus, truck, and rickshaw.
3. Resized them.

Figure 5: Resized Images of Vehicles

4. Rotated them for display along different directions.

Figure 6: Rotated Images of Vehicles

5. Gathered images of traffic signals - red, yellow, and green.

Figure 7: Traffic Signals

6. Code: For rendering the appropriate image of the signal depending on whether it is red, green, or yellow.
7. Code: For displaying the current signal time i.e. the time left for a green signal to turn yellow or a red signal to turn green or a yellow signal to turn red. The green time of the signals is set according to the algorithm, by taking into consideration the number of vehicles at the signal. The red signal times of the other signals are updated accordingly.
8. Generation of vehicles according to direction, lane, vehicle class, and whether it will turn or not all set by random variables. Distribution of vehicles among the 4 directions can be controlled. A new vehicle is generated and added to the simulation after every 0.75 seconds. 9. Code: For how the vehicles move, each class of vehicle has different speed, there is a gap between 2 vehicles, if a car is following a bus, then its speed is reduced so that id does not crash into the bus.
9. Code: For how they react to traffic signals i.e. stop for yellow and red, move for green. If they have passed the stop line, then continue to move if the signal turns yellow.
10. Code: For displaying the number of vehicles that have crossed the signal.
11. Code: For displaying the time elapsed since the start of the simulation.
12. Code: For updating the time elapsed as simulation progresses and exiting when the time elapsed equals the desired simulation time, then printing the data that will be used for comparison and analysis.
13. To make the simulation closer to reality, even though there are just 2 lanes in the image, we add another lane to the left of this which has only bikes, which is generally the case in many cities.
14. Vehicles turning and crossing the intersection in the simulation to make it more realistic.

5.6 Performance Analysis

1. Initially, all signals are loaded with default values, only the red signal time of the second signal is set according to green time and yellow time of first signal.
2. The leftmost column shows the status of the signal i.e. red, yellow, or green, followed by the traffic signal number, and the current red, yellow, and green timers of the signal. Here, traffic signal 1 i.e. TS 1 changes from green to yellow. As the yellow timer counts down, the results of the vehicle detection algorithm are calculated and a green time of 9 seconds is returned for

TS 2. As this value is less than the minimum green time of 10, the green signal time of TS 2 is set to 10 seconds. When the yellow time of TS 1 reaches 0, TS 1 turns red and TS 2 turns green, and the countdown continues. The red signal time of TS 3 is also updated as the sum of yellow and green times of TS 2 which is 5+10=15.

3. After a complete cycle, again, TS 1 changes from green to yellow. As the yellow timer counts down, the results of the vehicle detection algorithm are processed and a green time of 25 seconds is calculated for TS 2. As this value is more than the minimum green time and less than maximum green time, the green signal time of TS 2 is set to 25 seconds. When the yellow time of TS 1 reaches 0, TS 1 turns red and TS 2 turns green, and the countdown continues. The red signal time of TS 3 is also updated as the sum of yellow and green times of TS 2 which is 5+25=30.

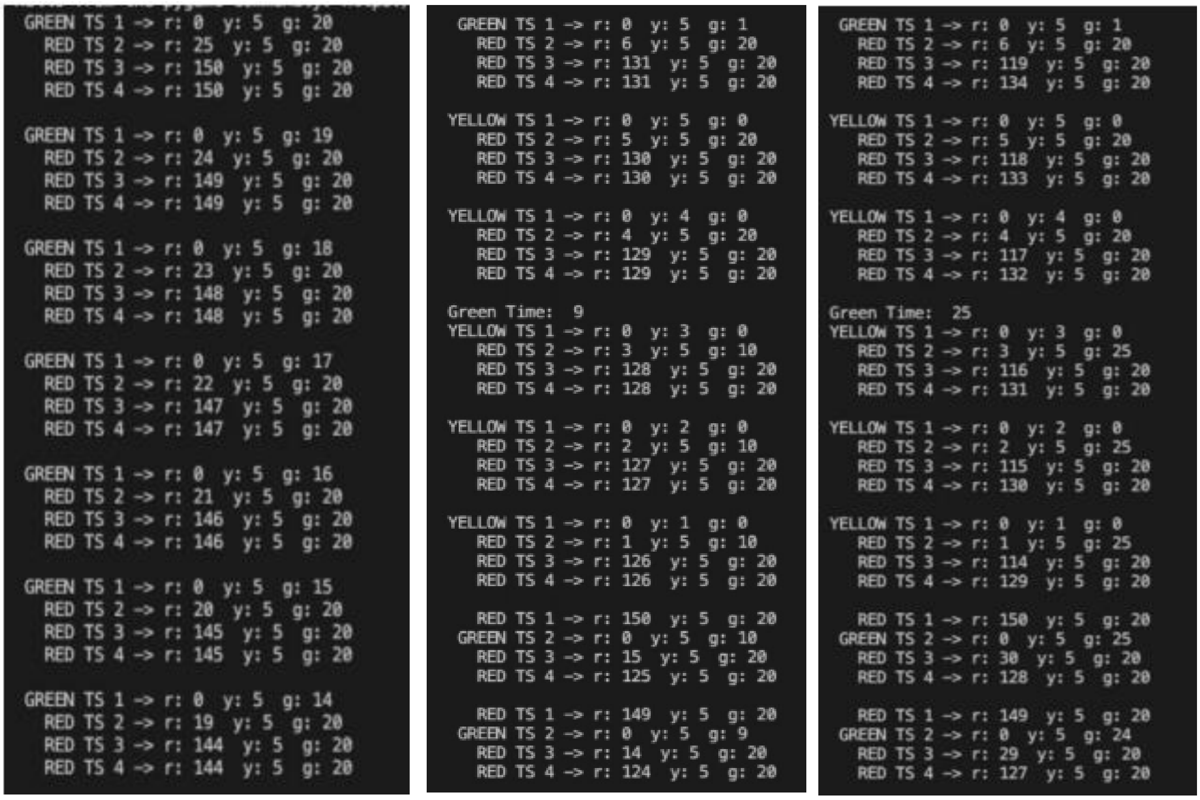

Figure 8: Output Images

5.7 Summary

The python code will be running and adaptive traffic control system will start after processing the stored data. The camera will start capturing vehicle activities and start recognizing and adjusting the timer for better performance.

6. PROJECT OUTCOME AND APPLICABILITY

6.1 Outline

In terms of applicability, adaptive traffic control systems can be applied in a variety of settings, including urban, suburban, and rural areas, to improve traffic flow, enhance safety, and promote sustainability. The systems can be used on roads, highways, and intersections, and can be integrated with other transportation systems, such as public transit, to provide a comprehensive and integrated approach to transportation management.

6.2 Key Implementations and Outline of the System

1. Improved Traffic Flow: An adaptive traffic control system can improve traffic flow by optimizing signal timings, reducing congestion, and increasing the capacity of roads and intersections. This can result in reduced travel times, reduced emissions, and increased efficiency.
2. Enhanced Traffic Safety: An adaptive traffic control system can improve traffic safety by detecting dangerous situations, such as pedestrian jaywalking or vehicles ignoring red lights, and alerting operators to take action. Additionally, the system can improve safety by optimizing signal timings and reducing congestion, reducing the likelihood of accidents and collisions.
3. Improved Environmental Sustainability: An adaptive traffic control system can reduce emissions and improve environmental sustainability by reducing congestion, optimizing signal timings, and promoting alternative modes of transportation, such as public transit and active transportation.
4. Increased System Reliability: An adaptive traffic control system can increase the reliability of the transportation system by using real-time data and decision-making algorithms to respond to changing traffic conditions, reducing the impact of incidents and unexpected events.

6.3 Significant Project Outcomes

The significant project outcomes of an adaptive traffic control system can include:

- Optimized signal timings: The system can use real-time data and decision-making algorithms to optimize signal timings and reduce congestion, resulting in improved traffic flow and reduced travel times.
- Enhanced traffic safety: The system can detect and alert operators of dangerous situations, such as pedestrian jaywalking or vehicles ignoring red lights, and can improve safety by optimizing signal timings and reducing congestion.
- Increased system efficiency: The system can increase the efficiency of the transportation system by using real-time data and decision-making algorithms to respond to changing traffic conditions and reduce the impact of incidents and unexpected events.

- Improved environmental sustainability: The system can reduce emissions and improve environmental sustainability by reducing congestion, optimizing signal timings, and promoting alternative modes of transportation, such as public transit and active transportation.
- Enhanced transportation management: The system can support the development of more sustainable and efficient transportation systems by providing real-time data and decision-making capabilities to transportation managers.
- Improved user experience: The system can improve the user experience by reducing travel times, improving safety, and promoting alternative modes of transportation, resulting in a more convenient and efficient transportation system.

6.4 Project Applicability on real World application

An adaptive traffic control system can have real-world applications in various transportation settings, including urban, suburban, and rural areas, to improve traffic flow, enhance safety, and promote sustainability. Some specific examples of the real-world applicability of such a system include:

- Urban Intersections: In urban areas, adaptive traffic control systems can be used to optimize signal timings and reduce congestion at intersections, improving traffic flow and enhancing safety.
- Highways: On highways, adaptive traffic control systems can be used to manage lane assignments and optimize signal timings, reducing congestion and improving safety.
- Rural Roads: In rural areas, adaptive traffic control systems can be used to manage signal timings and reduce congestion on rural roads, improving traffic flow and enhancing safety.
- Public Transportation: An adaptive traffic control system can be integrated with public transportation systems, such as buses and trains, to improve the efficiency and reliability of these systems and enhance the overall transportation experience.
- Intelligent Transportation Systems: An adaptive traffic control system can be integrated with other intelligent transportation systems, such as intelligent transportation management systems, to provide a comprehensive and integrated approach to transportation management.

6.5 Inference

An adaptive traffic control system can provide numerous benefits and outcomes, including improved traffic flow, enhanced safety, improved environmental sustainability, and increased system reliability. The systems can be applied in a variety of settings to improve transportation management and support the development of more sustainable and efficient transportation systems. In conclusion, an adaptive traffic control system can provide numerous significant project outcomes, including optimized signal timings, enhanced safety, increased efficiency, improved environmental sustainability, enhanced transportation management, and improved user experience. These outcomes can contribute to the development of more sustainable and efficient transportation systems and support the overall goal of improving transportation management. The real-world applications in a variety of transportation settings, including urban intersections, highways, rural roads, public transportation, and intelligent transportation systems. By improving traffic flow, enhancing safety, and promoting sustainability, the systems can support the development of more efficient and sustainable transportation systems and improve the overall transportation experience.

7. CONCLUSIONS

7.1 Outline

In conclusion, an adaptive traffic control system is a powerful tool for managing and improving transportation systems. The system can use real-time data and decision-making algorithms to optimize signal timings, reduce congestion, enhance safety, and promote sustainability. The investigation of related work revealed several different approaches and methods for implementing an adaptive traffic control system, each with its own pros and cons. Additionally, the investigation revealed several key issues and observations that need to be addressed to ensure the successful implementation of an adaptive traffic control system.

The significant project outcomes of an adaptive traffic control system include optimized signal timings, enhanced safety, increased efficiency, improved environmental sustainability, enhanced transportation management, and improved user experience. The real-world applicability of such a system includes urban intersections, highways, rural roads, public transportation, and intelligent transportation systems.

In conclusion, an adaptive traffic control system can play a critical role in improving transportation management and promoting sustainable transportation systems. Further research and development in this area can help to advance the implementation and use of these systems and contribute to the overall goal of improving transportation management.

7.2 Limitation/Constraints of the System

Like any other system, an adaptive traffic control system also has certain limitations and constraints that need to be considered. Some of the major limitations and constraints of such a system include:

- Cost: Implementing an adaptive traffic control system can be expensive due to the cost of installing and maintaining the necessary hardware and software, as well as the cost of training personnel to operate the system.
- Technical Complexity: The technical complexity of an adaptive traffic control system can pose a challenge, particularly in terms of integrating the system with existing transportation infrastructure and ensuring its compatibility with other systems.
- Data Collection and Accuracy: The accuracy and reliability of the data collected by the system are critical to its success. Factors such as the availability of data, the accuracy of the data, and the ability to process the data in real-time can all impact the performance of the system.
- Implementation Time: Implementing an adaptive traffic control system can take a significant amount of time, particularly due to the need to install and integrate the necessary hardware and software with existing transportation infrastructure.

- Maintenance and Upkeep: Maintaining and updating an adaptive traffic control system can be challenging, particularly in terms of ensuring that the hardware and software remain compatible and up-to-date.
- Public Acceptance: The success of an adaptive traffic control system can be influenced by public acceptance and understanding of the system and its benefits. Ensuring public awareness and understanding of the system and its benefits can help to promote its use and acceptance.

7.3 Future Enhancements

The development of adaptive traffic control systems is an ongoing process, and there is still significant room for improvement and enhancement. Some of the future enhancements that could be made to the system include:

- Advanced Data Analytics: The integration of advanced data analytics techniques, such as machine learning and artificial intelligence, can improve the accuracy and efficiency of the system and support real-time decision-making.
- Improved Integration: Improving the integration of the adaptive traffic control system with other transportation systems, such as public transportation systems, intelligent transportation systems, and traffic management systems, can enhance the overall performance and efficiency of the system.
- User-centered Design: Incorporating a user-centered design approach can help to ensure that the system is designed to meet the needs and preferences of users, enhancing its usability and promoting its acceptance and use.
- Intelligent Vehicle Technology: Integrating intelligent vehicle technology, such as connected and autonomous vehicles, can help to improve the performance and efficiency of the system and enhance the overall transportation experience.
- Sustainability: Incorporating sustainability considerations into the design and operation of the system can help to promote environmentally sustainable transportation practices and reduce the environmental impact of transportation.
- Dynamic Traffic Management: Developing dynamic traffic management strategies that can respond to changing traffic conditions in real-time can improve the efficiency and effectiveness of the system and enhance the overall transportation experience.

In conclusion, there are several potential future enhancements that can be made to adaptive traffic control systems, including advanced data analytics, improved integration, user-centered design, intelligent vehicle technology, sustainability, and dynamic traffic management. These enhancements can help to improve the performance and efficiency of the system and contribute to the overall goal of promoting sustainable and efficient transportation systems.

7.4 Inference

The Project experience was tremendous as we learned the core of vision algorithms and different programming techniques of VS-code. We learned how can a problem be simplified into smaller tasks and can be achieved successfully.

Appendix A

Group	Keyword	Meaning/Function
Database	**SQL**	It is a standardized programming language that is used to manage relational databases and perform various operations on the data in them.
Accuracy	**YOLO**	You Only Look Once can be used in an adaptive traffic control system to improve the accuracy and efficiency of object detection in real-time traffic scenes.
Developer Kit	**CMake**	CMake is used to control the software compilation process using simple platform and compiler independent configuration files, and generate native make files and workspaces that can be used in the compiler environment of your choice.
Library	**Pygame**	Pygame is a free and open-source library for creating video games using the Python programming language. It provides a simple and easy-to-use interface for creating 2D games and animations, making it accessible to beginners and experienced programmers alike.
Programming Language	**Python**	Python can be used on a server to create web applications.

Appendix B

Group	Keyword	Meaning/Function
Package	**time**	The time module in Python provides functions for working with time-related data.
Package	**sys**	The sys module in Python provides access to some variables and functions that are used or maintained by the Python interpreter.
Image	**PNG**	PNG is short for Portable Network Graphic, a type of raster image file. It's particularly popular file type with web designers because it can handle graphics with transparent or semi-transparent backgrounds.
Images	**JPG**	The JPG image file type, typically pronounced jay-peg, was developed by the Joint Photographic Experts Group (JPEG) in 1992.

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E-signature by Supervisor