A Project Report on

"Artificially Intelligent Traffic Management System"

SUBMITTED TO THE SAVITRIBAI PHULE UNIVERSITY, PUNE
IN THE PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE

OF

BACHELOR OF ENGINEERING (COMPUTER ENGINEERING)
(Academic Year: 2021-22)

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Under the guidance of

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Certificate

This is to Certify that the project report entitles

"Artificially Intelligent Traffic Management System"

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are bonafide students of this institute and the work has been carried out by them under the guidance of Mr. Ravindra Aher and it is approved for the partial fulfillment of the requirement of Savitribai Phule Pune University for the award of the degree of Bachelor of Engineering (Computer Engineering).

Project Guide	H.O.D	Principal
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Date: / /

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Abstract

Congestion of traffic in urban areas and smart cities is one of the major issues with increasing population in metropolitan areas. Traffic jams are not only a cause of delay and inconvenience in day to day life but also a major source of noise and air pollution. Modern approaches to deal with this issue range from complicated software handling dozens of traffic signals throughout an entire city to simpler single-intersection solutions. However these can be costly, difficult to implement and may require a lot of manual monitoring.

In this project, we propose a traffic management system which uses concepts from artificial intelligence and graph theory to control and optimize traffic flow. Our aim is to optimize traffic flow on a small to medium scale in a manner which adapts to the real time changes in traffic.

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Chapter 1

Introduction

This chapter briefly explains the need for an adaptive traffic management system and an overview of our implementation.

1.1 Overview

Traffic congestion is becoming one of the critical issues in cities with increasing population and number of vehicles. They not only cause problems like delays and stress to drivers but also cause secondary problems like increasing fuel consumption, transportation costs and pollution.

The causes of congestion can be divided into two categories, recurring and non recurring congestion. Recurring congestion can be expected to occur at the same time every weekday as a result of high volumes of commuter traffic traveling on roadways that are at or near their carrying capacity. Non-recurring congestion occurs as a result of an unexpected or non-typical event. Some causes of non-recurring congestion include: vehicular crashes, vehicle breakdowns, roadway construction, inclimate weather, and additional traffic resulting from special events. While non-recurring congestion can be unpredictable and difficult to treat, recurring congestion can be reduced by increasing road capacity or with the help of adaptive traffic control systems.

There are several existing standardized solutions for adaptive traffic control such as SCOOT, SCAT, etc. which have been implemented in many major metropolitan cities. However, most suburban and urban areas use conventional traffic control systems such as manual traffic control or non adaptive automated traffic control. Manual control consists of an on-site traffic official guiding vehicles. Non adaptive automated traffic control refers to the use of fixed timers in traffic signals. Wide implementation of standardized adaptive traffic control is not possible due to lack of feasibility since it requires manual labor and installation of new sensors. Therefore a more feasible solution which reuses existing infrastructure is required.

We propose an Artificially Intelligent Traffic Management System which uses existing CCTV feed and API data if needed to optimize traffic control over small to medium scale road networks. We use an artificially intelligent agent or model to handle the complexity of day to day traffic in real-time. Furthermore, simulations will be performed to demonstrate and test the model.

1.2 Summary

In this chapter we have discussed the need for an intelligent traffic management system and also discussed a brief overview of our project.

Chapter 2

Literature Survey

In this chapter we will see the various studies and research conducted on key concepts which are essential to create and understand our proposed system.

2.1 You Only Look Once: Unified, Real-Time Object Detection, Joseph Redmon, et al. [1]

Object detection comprises locating specific types of objects in an image or video. The output of a typical object detection algorithm consists of bounding box coordinates and a label of the object. YOLO (You Only Look Once) model consists of an extremely fast unified architecture for object detection. It makes use of a single neural network for predicting bounding boxes and class probabilities from a full image in a single evaluation. Hence, making it ideal for object detection in real time applications.

2.2 Traffic Congestion Detection from Camera Images using Deep Convolution Neural Networks, Pranamesh Chakraborty, et al. [2]

Recent improvements in computer vision algorithms have led to closed-circuit television (CCTV) cameras emerging as an important data source for determining the state of traffic congestion. To detect congestion in a traffic CCTV footage YOLO, a state-of-the-art real-time object detection algorithm is used. In the above mentioned paper, several object detection techniques were tested for congestion detection out of which YOLO showed the most promising results.

2.3 Smart Control of Traffic Light Using Artificial Intelligence, Mihir M. Gandhi, et al. [3]

Traffic signal timing plays an important role in controlling flow and efficiency of traffic. The above system makes use of vehicle count obtained from CCTV footage and uses it to optimize green signal timing for each lane to optimize traffic flow at a single intersection. Our aim is to create a similar system and extend the scope of optimization to multiple adjacent intersections.

2.4 Comparison of Current Practical Adaptive Traffic Control Systems, Hongyun Chen, et al. [4]

Existing Adaptive Traffic Control Systems (ACTS) such as SCOOT, SCAT, OPAC, RHODES, etc. are being adapted by major cities in developed and developing countries. They can cover up to hundreds (OPAC) to even thousands (SCOOT, SCAT) of intersections. However, their implementation includes installation of additional sensors and can lead to very heavy costs which isn't feasible for smaller cities. Additionally, these systems do not take into consideration challenges such as power failure, non lane following traffic and mixed traffic which are common in Indian roads.

The aforementioned systems provide key algorithmic insights for developing a more feasible ACTS model. Furthermore, usage of existing inputs such as CCTV needs to be emphasized over installation of new sensors in order to help reduce costs.

2.5 Summary

In this chapter, we reviewed research done on key concepts such as object detection and implementation of artificial intelligence with traffic signals which are essential to our proposed system. We also studied existing solutions, their inner workings as well as their advantages and disadvantages.

Chapter 3

Problem Definition

This chapter discusses the drawbacks of current systems implemented in suburban and urban areas and also defines the need and overall scope of an artificially intelligent traffic management system.

3.1 Need For Artificially Intelligent Traffic Management Systems

Traffic congestion is becoming a critical issue with increasing population and automobiles in cities. The conventional systems which were suitable at the time of their installation may not be suitable in the present time due to the rising number of vehicles. Furthermore, upgrading these systems to the standards used in major metropolitan cities is often not feasible due to several factors such as manual labor and installation of new sensors. Owing to these factors, the majority of intersections make use of either manual control which includes traffic police officials guiding vehicles or non adaptive automatic control, which includes the use of fixed timers. In most scenarios these solutions may not be at par with the unpredictable rate of traffic flow. Hence, an intelligent, adaptive and feasible solution is needed.

3.2 Additional Features

Additionally, the following points must be kept in mind while developing or optimizing an automated traffic controlling system:

- Ensuring necessary fall backs in case of disconnection or power cuts.
- Ensuring signal times are between a maximum and minimum limit to avoid starvation.
- Indian traffic is not lane following and has a high amount of mixed traffic. System must be able to withstand these challenges.
- The system must make use of existing sensors and avoid installation of newer sensors in order to maintain feasibility.
- The system must be scalable within budget and it should be able to handle an increasing number of vehicles.
- Additional features such as incident detection, report generation and assistance for emergency or VIP vehicles are desirable.

3.3 Summary

In this chapter we discussed the need of artificially intelligent traffic management systems and the various points which must be kept in mind while developing said system.

Chapter 4

Analysis

This chapter describes the project plan adopted and determines the requirement analysis. We have implemented the project on the basis of Agile model and Model View view-model.

4.1 Project Plan

4.1.1 Project Plan for semester I

The following Table 4.1 describes the project plan for semester I. It describes the various activities and accountability of the developers for the respective modules. Following are the major activities carried out in this plan :

- Identifying the functional requirements.
- Designing of the Framework.
- Studying the necessary development tools and technologies.

Phase	Activity	Start Date	End Date	Group Members
1	Selection of Project Topic	22-08-2021	25-08-2021	Team
1	Functional Requirement Specification(FRS)	29-08-2021	09-09-2021	Team
1	Design Prototype	11-09-2021	21-09-2021	Team
1	Set Theory and Math Model	23-09-2021	06-10-2021	Saquib, Giwil
1	UML Diagram Prototype	23-09-2021	03-10-2021	Vrushabh, Rutuja
1	Project Problem Statement using NP Complete	08-10-2021	19-10-2021	Saquib, Giwil
1	UML Diagram in StarUML	05-10-2021	22-10-2021	Team
1	Paper Presentation	05-11-2021	05-11-2021	Team
1	Software Requirement Specification	6-11-2021	10-11-2021	Team
1	Test Plan	11-11-2021	15-11-2021	Vrushabh, Rutuja

Table 4.1: Planner and Progress Report I for AITMS

4.1.2 Project Plan for semester II

TODO: Project Plan for semester II

4.2 Requirement Analysis

4.2.1 Necessary Functions

- Deliver a reusable piece of code.
- Build an application and
- Deployment of application built onto the Windows.

4.2.2 Desirable Functions

- Assistance to emergency and VIP vehicles.
- Traffic incident detection.
- Real-time Traffic Congestion Detection.
- Real-time Statistics.

4.3 Summary

In this chapter we described the implementation details of the project plan for Semester I and Semester II. We also studied the necessary functions and the desirable functions of Artificially Intelligent Traffic Management System.

Chapter 5

Design

This chapter describes the Software Requirement Specification (SRS) to be implemented for Artificially Intelligent Traffic Management System. It also explains the architecture of the system and external interface requirements. We have also described the Risk assessment strategy and the Data Flow Diagram which explains the flow of the project.

5.1 Software Requirement Specifications

The Software Requirement Specification describes the scope of the project, operating environment, user characteristics, design and constraints. It also elaborates the system architecture of the Artificially Intelligent Traffic Management System.

5.1.1 Project Scope

The main purpose of developing the Artificially Intelligent Traffic Management System is for the welfare of the public and reduce the pollution caused by traffic congestion. The issue of transportation is one of the most problematic issues in the country, and in the world at large. In an age where a person has a private car, and especially in countries where there is a failing public transport system, traffic jams and the countless accidents that accompany road congestion harm the economic, political aspect and social in both the public and private sectors. the transportation systems used by transportation agencies around the world are not adapted to modern transportation - these are systems designed decades ago, when the amount of cars on the roads was much smaller than

today, and the transportation nodes were relatively simple. today, innovative technologies for computerized transportation management are in use, but these turned out to be extremely expensive, and due to budget shortages and even many cuts in the transportation budget, transportation agencies are often forced to give up these systems and stick with the old systems.countries such as Australia, Singapore, and a number of U.S. states have adopted transportation management technologies on a massive scale (for example, GLIDE, SCATS - these are huge economic investments, but they are prove themselves as highly prudent and effective investments. The purpose of the software is to enable the optimization of transportation traffic through the optimization of node activity transportation, and adjusting their mode of operation in real time to the transportation traffic at any given moment. The software is intuitive and accessible as much as possible, while maintaining accuracy, maximum detail, level of performance And high efficiency.
The scope of Artificially Intelligent Traffic Management System can be considered as a collection of reusable piece of code, style-sheets and include files that can be used by the developer for developing more advanced systems and also considering the following points :

- Warehousing of parametric data and reports to analyze periodic patterns and improve optimization using it (data science)
- Making AITMS compatible with each other so that neighboring solutions can work together providing another layer of optimization with added scalability

5.1.2 Operating Environment

Our proposed system will require an operating environment with appropriate version of windows OS, python, tensorflow and sufficient computation power through GPUs.

5.1.3 Design and Implementation Constraints

The key restriction here will be to verify the validity of the report,which is not always feasible.Security threats may be involved.

- **Memory:** Minimum 16GB RAM
- **CPU:** Intel Core i5 - 8300H or equivalent\higher.

- **GPU:** Nvidia GTX 1050ti or equivalent\higher.
- **LAN for CCTV:** CCTV feed from intersections to the server room.
- **Operating System:** This application works on Windows.

5.1.4 Assumptions and Dependencies

The Framework is capable of allowing the developer to develop the more advanced application for Traffic Congestion Clearance. The Admin has a computer with graphic card, gets to monitor intersections and rest of the system is automated.

5.2 System Architecture

Our overall architecture can be viewed in the form of a 3 layer architecture consisting of physical intersection, intersection node and the optimizer.

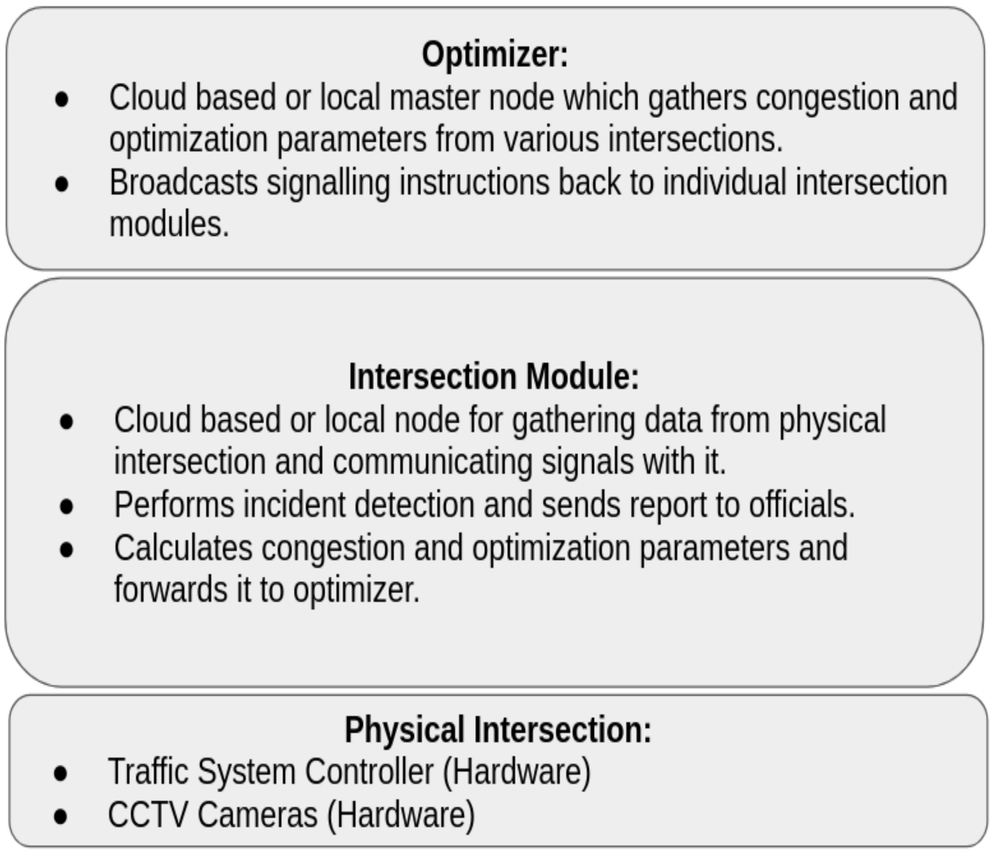

Figure 5.1: Layered form of System Architecture

The lowermost layer i.e. the physical intersection consists of the physical traffic signal controllers and CCTV cameras. This layer contains the pre-existing infrastructure used for controlling traffic. The traffic signal controller must provide an interface to obtain and control its state. Furthermore, real-time CCTV footage must be made available to our model.

The intermediate layer consists of intersection nodes (software). Each intersection node represents a single traffic intersection. Intersection nodes serve the following primary functions:

- Collecting CCTV footage and other data from physical intersection layer and APIs (if required by optimizer).
- Obtaining optimizer parameters from the collected raw data. For example, obtaining vehicle count from CCTV footage using YOLO. The intersection node then forwards this data to the optimizer.
- Intersection nodes also receive timing signals as outputs from the optimizer, their task is to then interface these signals onto the controller.

Aside from the above functions, the intersection nodes can also be used to perform extra tasks such as incident detection and sending reports on traffic incidents and congestion to traffic officials. It must be noted that since intersection nodes are services in execution, they can be executed over cloud or locally depending on feasibility. Depending on availability of computation power and hardware setup, a single computing device can hold multiple intersection nodes as well.

The uppermost layer consists of the optimizer. The optimizer is the master node which receives the required data from all the intersection nodes and executes the optimization algorithm. The optimization algorithm gives the signal timing details as output in terms of green signal time which is broadcasted back to the respective intersection nodes.

We have shortlisted several optimization algorithms which can be applied depending on their performances on a simulation consisting of a specific map. It should also be noted that different optimization algorithms may be suited for different maps.

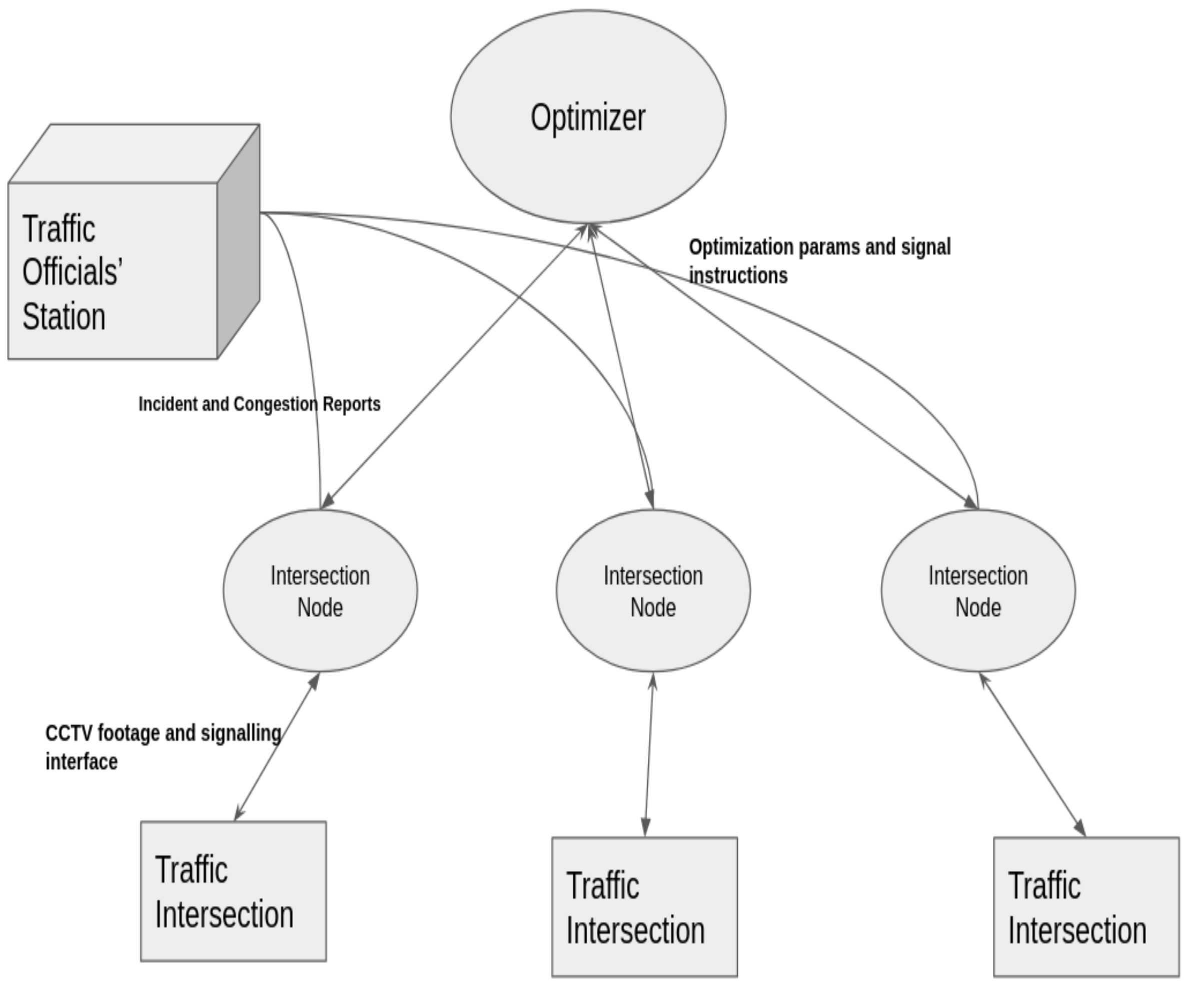

Figure 5.2: System Architecture Illustration

5.3 Software System Attribute

- **Reliability:** The traffic management system should be reliable with necessary fallbacks in case of technical failuers.
- **Maintainability:** The Artificially Intelligent Traffic Management System shall be well documented and easy for developers to improve on

5.4 Summary

In this chapter we studied the system architecture, operating environment and the software attributes which describe the scope of the project.

Chapter 6

Modeling

This chapter includes the various modeling techniques which describes the various users of the Artificially Intelligent Traffic Management System. It also describes the functionality of the different features of the Artificially Intelligent Traffic Management System.

6.1 Use Case Diagram

A use case diagram is a type of behavioral diagram defined by the UML created from a use case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals represented as use case and any dependencies between those use cases.

Four modeling elements make up the use case diagram; these are:

- **Actors:** Actors refer to a type of users, users are people who use the system. In this case traffic officers are the users of the framework and application
- **Use cases:** A use case defines behavioral features of a system. Each use case is named using a verb phrase that express a goal of the system. The name may appear inside or outside the ellipse.
- **Associations:** An association is a relationship between an actor and a use case. The relationship is represented by a line between an actor and a use case.

- **The include relationship:** It is analogous to a call between objects. One use case requires some type of behavior which is fully defined in another use case.
- **The extend relationship:** It is intended for adding parts to existing use cases as well as for modeling optional system services

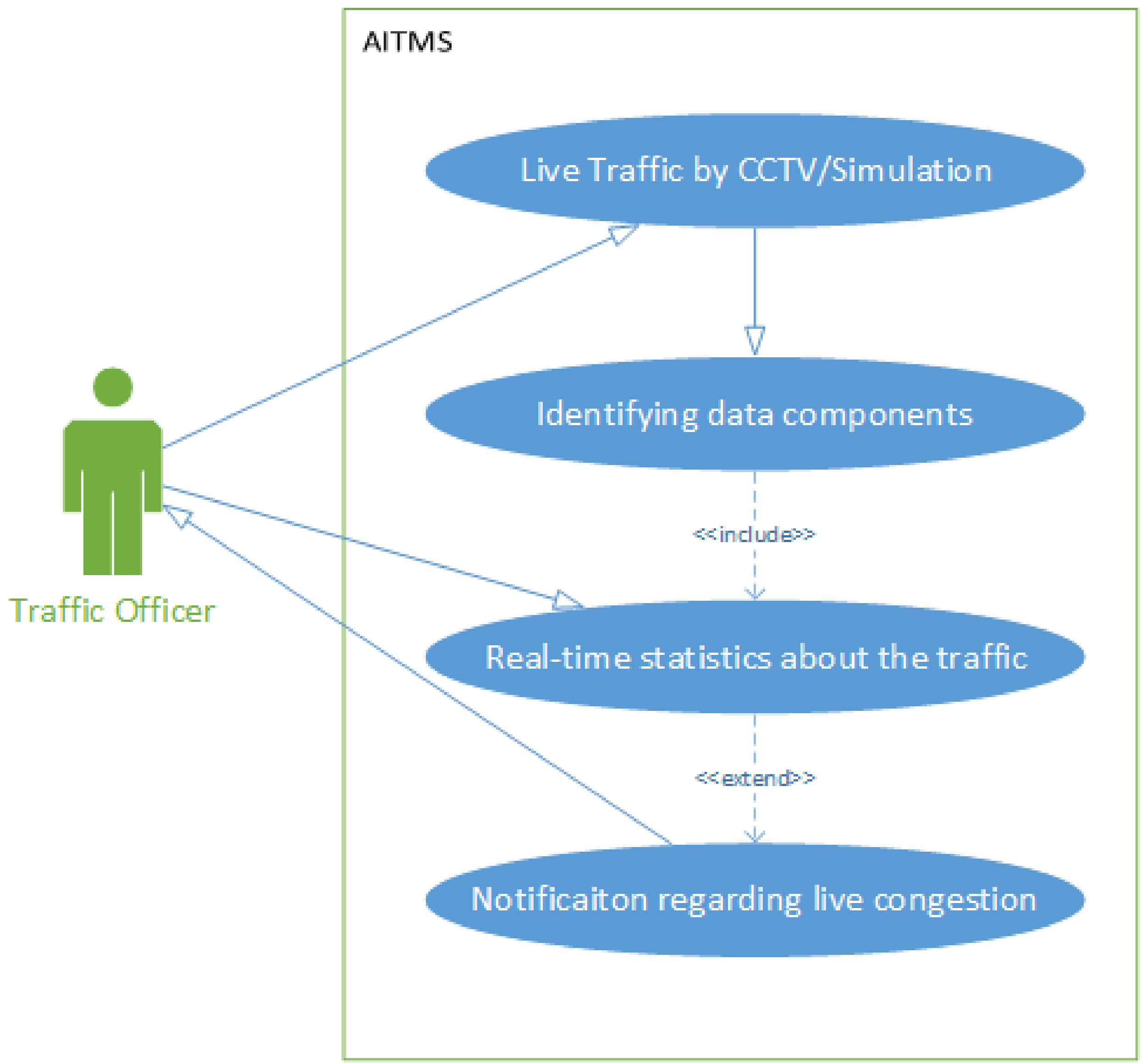

Figure 6.1: Use Case Diagram

6.2 Activity Diagram

Use cases show what your system should do. Activity diagrams allow you to specify how your system will accomplish its goals. Activity diagrams show high-level actions chained together to represent a process occurring in your system. An activity diagram is essentially a flowchart, showing flow of control from activity to activity. Unlike a traditional flowchart, an activity diagram shows concurrency as well as branches of control. Activity diagrams focus on the dynamic flow of a system.

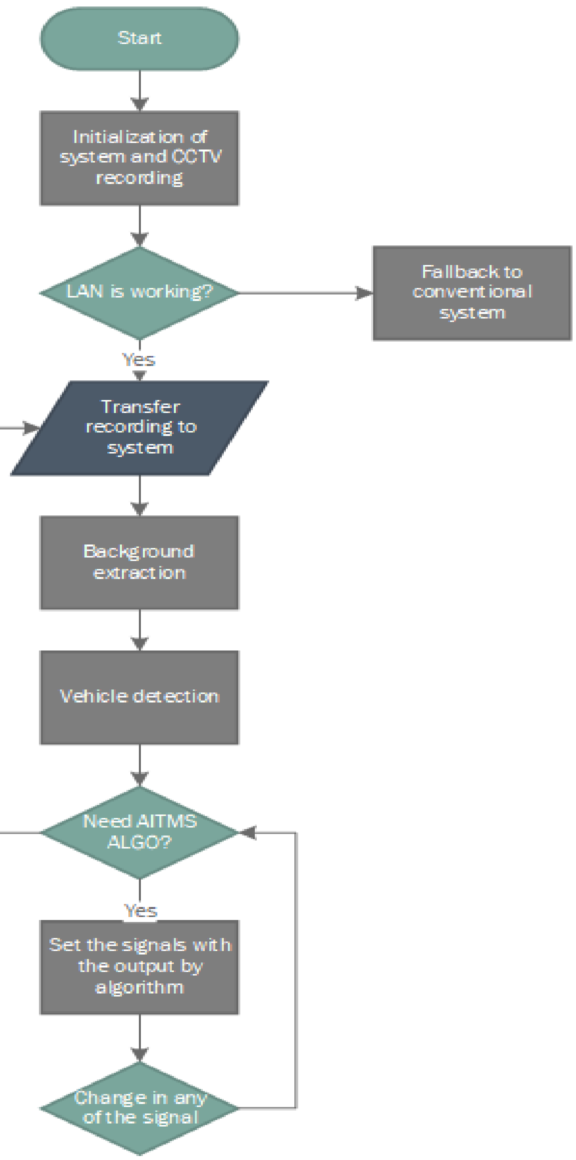

Figure 6.2: Use Case Diagram

6.3 Summary

Thus we saw the various modeling techniques used for the design of Artificially Intelligent Traffic Management System.

Chapter 7

Technical Specifications

In this chapter discuss the hardware and software requirements of our proposed Artificially Intelligent Traffic Management System.

7.0.1 Hardware Requirements

- Intel Core i5 8300H or equivalent/higher
- 16GB RAM for application development
- Min. 16 GB Space in Hard Disk

7.0.2 Software Requirements

- Visual Studio 2019
- Unity 2020.3
- Python 3.7 or higher
- YOLO 3.0 or higher
- TensorFlow 2.0 or higher
- GIMP and Photoshop

7.1 Summary

In this chapter we discussed the various hardware and software requirements of the project.

Chapter 8

Future Scope

Scalability is an essential feature for traffic management systems in current age. As the number of vehicles and roads increases for a particular locality, it's traffic management system must be able to handle the changes in maps and traffic flow. Keeping this in mind, our proposed system provides the following future possibilities:

- Warehousing of parametric data and reports to analyze periodic patterns and improve optimization using data collected over use. This gives the opportunity to use data science concepts to improve existing traffic management systems and even other roadway infrastructure.
- The ability to connect multiple AITMS will greatly improve scalabbility and optimization. If nieghboring solutions can work together, providing an additional layer of optimization using their combined data becomes possible.
- Improving on library of optimization algorithms. Since, different algorithms may suit different maps, having a variety of algorithms in our toolkit becomes helpful.
- Integration of additional functionalities such as incident detection, manual control, etc.

Chapter 9

Conclusion

Our proposed system will be able to minimize congestion and will be able to report various statistics regarding congestion and traffic incidents in real time. The system also provides sufficient scope for scalability and additional functionalities which will help cope with rising number of vehicles and roads. Furthermore, our aim in the coming phases will be to perform simulations of various optimization algorithms in order to validate our system for real life implementation.

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