Faculty of Computers and
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Intelligent Transportation System Based on Internet of Things

A Thesis submitted to the Department of Information System,
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DEDICATION

I dedicate this work to the soul of my lovely uncle Mohammed and the soul of my beautiful auntie Madeha.

ACKNOWLEDGEMENTS

Firstly, I would want to thank God for his many and ongoing gifts, and I hope that God will help me to continue the journey and offer my best that I have in my job and my life. Words cannot describe how thankful I am to my parents, so I dedicate this work to them. They always support me in all my life, not only my studies. I like to thank My Sister, My Brother, and his wife for their support.

My faithful husband, I wholeheartedly appreciate everything you have done for me. Exceptional thanks to my daughters as they are the reason of my importance in life. I cannot thank Dr. Hatem Mohammed Abdul Kader and Dr. Diaa Salama enough for the opportunities they provided, and for having faith in me.

Finally, I am grateful to Dr Ljubica Kazifor giving me positive energy and the right bits of advice with love.

Thank you

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LIST OF PUBLICATIONS

[1] D. S. Abdul Minaam, H. M. Abdul Kader, E. Mahmoud, " Monitoring and Detection the Cognition Roots Using Quad Copter," International Journal of Electronics and Information Engineering, vol. 9, no. 2, pp. 81-90, Dec. 2018.

[2] E. Mahmoud, H. M. Abdul Kader, D. S. Abdul Minaam, "Fuzzy Knowledge Base System for Floating Car Data on SUMO "29th International Conference on Computer Theory & Application (ICCTA), pp.38-42, 2019.

[3] E. Mahmoud, H. M. Abdul Kader, D. S. Abdul Minaam," Spatial-Temporal Information System for Studying the Relation Between Vehicles Emissions and Fuel Consumption using SUMO," 9th International Conference on ICT in our lives ***Data Science Shaping the Future*** Bibliotheca Alexandrina,2019.

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LIST OF ABBREVIATIONS

The Third Generation of Cellular Networks	**3G**
Analytic Hierarchy Process	**AHP**
Advanced Traffic Management System	**ATMS**
methane	**CH4**
Congestion avoidance througH a traffIc classification MEchanism and a Re-routing Algorithm	**CHIMERA**
carbon monoxide	**CO**
carbon dioxide	**CO2**
COperative Traffic congestion detECtion	**CoTEC**
Dynamic Shortest Path	**DSP**
Floating Car Data	**FCD**
Fuzzy logic expert system	**FLES**
General Public License	**GPL**
hydrocarbons	**HC**
Internet of Things	**IoT**
Internet Protocol	**IP**
Intelligent Roadway Information System	**IRIS**
An Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions	**iTETRIS**
Intelligent Transportation System	**ITS**
k-Nearest Neighbor	**KNN**
Local Area Network	**LAN**
Micro-ElectroMechanical Systems	**MEMS**
nitrous oxide	**N2O**
Near Field Communication	**NFC**
nitrogen oxides	**NOx**
origin-Destination	**OD**
particulate matter	**PM**
Radio Frequency Identification	**RFID**
Random k Shortest Paths	**RkSP**
Roads Sides Unites	**RSU**
Simulation of Urban Mobility	**SUMO**
Traffic Analysis Zone	**TAZ**
Transportation Problems	**TP**
Traffic Control Interface	**Traci**

Wide-Area Networks	**WAN**
wireless sensor networks	**WSN**
World Wide web	**WWW**
Extensible Markup Language	**XML**

Chapter 1

Introduction

Transportation linked to all parts of our life. Where we depend on it in daily life matters, it is an essential factor in the economic and social renaissance of the country. Millions of people, merchandise, machines, liquids, tools, and money transferred from one place to another by transportation. The Transportation Problems (TP) is the popular name given to an entire class of issues in which traffic and transportation are fundamental. The general parameters of TP are Resources, locations, and transportation modes [1].

The resources are those things that can be shipped from sources to destinations. Examples of various remedies are devices, people, payload, machines, liquids, energy, merchandise, and money.

Locations are the places where we go to or came from like bus stations, seaports, homes, schools, universities and refueling depots airports.

Transportation modes are the form of conveyance resources to locations. Transportation modes examples are trucks, vehicles, trains, ships, motorcycles, and others. This thesis presents land transportation problems as it serves a vast category of people. The land transportation conveys resources over long, medium, and short good ways from places to different places utilizing the vehicles, trains, motorcycles or comparable methods for land transportation.

Land transportation causes traffic jams, environmental, and noise pollution. Traffic jams cause harmful effects on society and individuals. Air pollution from vehicles, transports, and trucks, especially ground-level ozone and the particulate issue, can exacerbate respiratory maladies and trigger asthma assaults [2].

Over the most recent years, there was a developing enthusiasm for taking care of traffic issues by giving great approaches based on the Internet of Things (IoT) [3]. Also, monitoring traffic to detect environmental pollution, which caused by vehicle exhaust using the integration of Geographical Information System (GIS), Electrochemical Toxic Gas Sensors, Wireless Sensor Networks (WSN), and the use of a Radio Frequency Identification (RFID) [4]. Also, Vehicle exhaust causes two kinds of pollution, environmental pollution, and noise pollution. Environmental pollution is the measure of gases coming out of the vehicle, for example, methane (CH_4), hydrocarbons (HC), carbon dioxide (CO_2), carbon monoxide (CO), nitrous oxide (N_2O), nitrogen oxides (NO_x), and particulate matter (PM) [5]. Noise emission is the sound produced by vehicles on the road, especially in times of congestion. Monitoring all that kind of pollution and exhaust is not an easy try.

Sensor systems are thick remote systems of light, minimal effort sensors, which gather and disperse essential information [6]. Remote sensor systems encourage checking and controlling of physical situations from remote areas with better exactness. At the point when remote sensors organize advancements are coordinated with GIS innovation, various zones of a city can be observed, and vehicles with high emissions can be found right away.

This thesis proposes a traffic monitoring system, which monitors the transportation modes and air pollution from vehicles' exhausts. A proposed model uses integration between SUMO and Traffic Control Interface (TraCI). SUMO used to simulate traffic and TraCI provides great grained control over vehicles on the network [7] [8]. Not only that but also a proposed model offers a fuzzy logic expert system, which supports decision-makers (General Traffic Authority) with reports contains traffic states and arrival possibilities with confidence variables.

1.1 Problem Statement

With the expansion of the population and the massive number of transportations, despite that, there is difficulty in discovering appropriate methods for transport. Also, routes full of industrial bumps, shipping, and traffic causes a lot of problems, either the ordinary user or institutions or government. Also, the problems of internet of things in traffic are the difficulty of collecting data from the car without overlapping each other. Transportation and traffic problems are listed below:

1. Difficulty monitoring traffic and obtaining real-time data of the transportation system using.
2. Difficulty in determining the appropriate way, especially at peak time.
3. Difficulty in identifying road obstacles.
4. Difficulty in identifying the enormous exhaust of vehicles and their causes.
5. Difficulty in determining the relationship between fuel consumption and vehicle emissions.

1.2 Thesis objectives

The objective of this thesis is to turn the transportation system to an intelligent system by making full use of the Internet of Things in Vehicles to provideto monitoring the traffic and Managing its data by the following:

1. Easy access and handling of vehicle data on the roads.
2. Monitor and Simulate the road network of a determined area using SUMO.
3. Apply vehicles on the given network and prop up the trip directions with cars.
4. Manage the SUMO network using TraCI.
5. Get reports from the SUMO about all the cars on the transportation network like car speed, locations, auto exhaust, and others of car behavior.

6. Get the amount of exhaust like $CO2$, CO, HC, and other types of emissions and compare them with fuel consumption.
7. Support General Traffic Authority with reports on the behavior of vehicles where they can determine the traffic situation.
8. Provide users with the final traffic situation and help them in the final decision about their trip.

Finally, provide a GIS map with the full display of the traffic movements, thus avoiding the problems of fake notifications of crowding or not.

1.3 Thesis Contribution

The contributions in this proposed model focused on providing a solution to traffic problems differently than before. The most important contribution of this thesis is to make a visual map of the full traffic flow and to know all the vehicles data, which helps in extracting more accurate results of congestion or not.

1.4 Structure of the thesis

The rest of this thesis is organized as follows:

- **Chapter 2:** gives the Literature Review, which provides an overview of traffic problems in general. It discusses different solutions for solving traffic and transportation problems. Moreover, it gives various techniques to solve the traffic problem. Furthermore, it provides a fuzzy logic concept in traffic problems. At long last, it examines the principal traffic issues identified with the existing techniques in this thesis.
- **Chapter 3:** presents an overview of the Internet of Things technique, it's architecture, and its applications.
- **Chapter 4**: presents a proposed framework, which incorporates the fundamental clarification of our system. Additionally, it shows and

explains in detail the used techniques of how to simulate the traffic network, how to get data from cars in the SUMO network and apply a fuzzy expert system. Moreover, it provides the basic concepts and the steps required for the proposed model.

- **Chapter 5**: presents Experimental Results for our proposed system, that includes the floating car data, auto exhaust data, and trips paths through the edges of the network gotten from SUMO also results of the fuzzy expert system.
- **Chapter 6**: draw the Conclusions and Future works, which conclude the thesis and discusses future works in the field of traffic and transportation.

Chapter 2

Literature Review

In this section, we discuss the different approaches in managing traffic systems, such as reducing congestion and pollution in urban areas. Also, we elucidate the various directions that our method is related to.

2.1 Traffic control strategies

In the real world, there are many schemes created to manage traffic [9], [10]. They have utilized various strategies to control the traffic stream, which described below.

2.1.1 Traditional traffic control system:

This is the least complicated and most straightforward way of managing traffic flow, which includes a traffic policeman in this way. In this strategy, a traffic cop stands on each cross edges of the road and controls the traffic flow using the signal board.

In the event of increasing traffic density, at that point, the traffic police will give a signal to the driver of the vehicle, whether driving or stopping. He can also identify emergency vehicles on the road and provide the priority to the lane where the emergency vehicle passes. Moreover, in numerous crises, he will get confounded and gets incapable of dealing with the traffic flow.

2.1.2 Automatic traffic controlling:

We found that the automated system came to wipe out the most shortcoming of the traditional method. A programmed traffic sign strategy was suggested [11]. This framework incorporates straightforward three shading traffic signals that are red, green, and yellow. In general, every lane in the rout 120 seconds of green light is on. However, in some areas of the urban where traffic is less, in that crossing point, green light planning is under 120 Seconds.

This system can't see and arrange the emergency vehicle, ordinary vehicle, and rescue vehicle the same way. So, there are probabilities of delays in emergency organizations. An example is the delay of ambulances to reach the hospital in case of traffic congestion.

2.1.3 Intelligent traffic management system based on image processing:

This technique is depending on cameras [12]. It helps in defining the edges of the routes, lanes, and estimating the density of traffic on the paths. Additionally, there is another method of collecting data about traffic is Quadcopter, which records video film about the specified area [13]. Video film secured by the camera is broke down by a PC contribute request to distinguish objects (for example, vehicle, truck, and so on.) on the street. Distinctive object discovery methods are being utilized nowadays. Cameras are likewise valuable in the location of infringement of transit regulations. Sometimes this approach isn't productive. Because of the camera can't cover large spaces during the massive flow of traffic. Parking lot, and during natural effects such as rain and wind, the picture taken by the camera is not clear.

2.1.4 Intelligent Traffic Management & controlling System using IoT Technologies:

In this system, the emergency vehicle is outfitted wireless antennas transmitter. Additionally, the traffic signal pole is equipped with wireless receiver antennas. At the point when the emergency vehicle is drawing close to the intersected edges. It will send a sign to the traffic signal in the lane, and this antennas receiver sends it to the fundamental control framework. At that point, the control framework will ascertain the rough measure of time for the green sign where crisis vehicle is moving and keeping red light to an outstanding path. At that point, the car will pass effectively [14]. This system proficiently controls traffic streams and gives answers for emergency vehicles. It utilizes sensors, load cells, and so on for gathering vehicle density on the street. But this system cannot handle any type of vehicle except for emergency vehicles.

2.1.5 Intelligent Roadway Information System (IRIS):

IRIS is an open-source Advanced Traffic Management System (ATMS) schema created by the Minnesota Department of Transportation. It is utilized by transport and traffic departments to observe also, oversee interstate and roadway traffic. In previous schemes, the framework did not give any traffic data and was utilized distinctly to follow the traffic blockage. However, IRIS will provide ongoing data on parkway conditions to distinguish traffic occurrences, deal with the progression of traffic, and communicate explorer data [12]. IRIS uses the General Public License (GPL). Advanced Traffic Management System (ATMS) is a programming device. ATMS diminishes trip times, augment roadway limit, increases roadway limit, and for the most part, provides more secure routes. ATMS additionally furnishes administrators with brought together access and control to various kinds of roadway gadgets as opposed to working different frameworks. ATMS made of a few exclusive programming arrangements that are costly to gain [14]. The repetitive upkeep costs have likewise been expanding.

2.2 Traffic Simulation

Because of the problems that have emerged in the previous strategies. Moreover, the high interest in finding solutions for traffic problems. Also, IoT costs a significant spending plan to cover an enormous territory. So many researchers have resorted to thinking about the simulation of traffic on the simulation program. For example, Axel et al. [15] address the issue of application-centric mobility-oriented evaluation of VANETs. VANETs impact vehicle development during runtime by proposing TraCI, which provides the control of portability properties of each vehicle simulated by the SUMO. It additionally, makes a standard API for controlling a SUMO. So, a street traffic simulator can be combined with a network simulator or whatever other simulator systems that necessities to control the street traffic. Also, Marie et al. [16] make a realistic simulation of a small region of Europarc indirect in the town of Creteil, France. It thinks that it is hard to work with accurate information. So, simulate a zone of 1:1km2 around the Europarc Roundabout utilizing OpenStreetMap and apply it to, which causes contrasts between the real-data and the simulated model. Laura et al. [17] manufacture iTETRIS ("An Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions"). iTETRIS defines the condition of traffic in the city of Bologna. It is relying upon reenacting the territory on VISSIM and imports the system to SUMO and gets information from a region of Bologna. But it needs to take control of the traffic of Bologna. Karl et al. [18] give a layout of observing traffic framework courses of action of the state Upper Austria, including distinctive data sources from a determined taxi, and salvage vehicle associations, similarly as by the Austrian roadway authority. They likewise use speed tests and traffic counters to produce traffic simulation. The framework utilizes SUMO for giving traffic information on streets where constant traffic data is inaccessible. Lara et al. [19] assemble Luxembourg SUMO Traffic (LuST). LuST is a schema that gives sensible versatility to mobility in an average size city. This system relies upon open information about the traffic attributes over the ongoing seven years and utilizations SUMO to fabricate a real system closer to the guide, which was gotten from OpenStreetMap.

2.3 The Fuzzy logic traffic problems

Another technique in solving traffic problems is to think in it as a fuzzy logic system. Amrita et al. [20] give another definition of utilizing fuzzy logic with transportation. Likewise, it examines a few utilizations of Fuzzy Logic in transport arrangements. It supposes trip distribution, trip generation, the third phase of transport arranging named as the modular split. Modular split is planned to know which transportation modes are utilized by how many numbers of individuals, Route decision lastly, and final assignment of Traffic. Amir et al. [21] introduce a claiming traffic technique utilizing a fuzzy logic framework. He relies upon gather information about the traffic, avenues, number of vehicles, and Combines rules, which comprised of four restrictive explanations associated with 'AND.'

The Analytic Hierarchy Process (AHP) method was utilized to gauge the standardized loads of the variables. At long last, get reports for decision-makers, which help in improving the systems.

2.4 Embedded system using IoT

In addition to all the previous solutions, there is another approach to thinking about solving transportation and traffic problems. In [22] we found that Menon et al. propose a structure to comprehend the plausibility of actualizing Internet of Things in transport transportation framework in Singapore to assist shopper with realizing the appearance time of the transport dependent on the speed of traffic which relies upon more than the sensor in one truck. The examination was meant to discover the possibility of utilizing of Internet of things in the transport transportation framework in Singapore and to approve whether it improves the customer experience. The plan proposed by us has exploited the favorable circumstances given by IoT by providing continuous information to the purchasers for each transport course. Through the Impact examination and Competitive investigation with one of the most utilized transport versatile applications Iris NextBus in Singapore, it was discovered that IoT application whenever executed would exceed NextBus in practically every one of the parameters. These parameters incorporate time the board, efficient transport productivity the executives, transport swarm the board, and in the number of alternatives being offered to clients. It would consider every one of the segments of the general public was fulfilling their changing needs. Also, Souza et al. [23] suggest CHIMERA (Congestion avoidance througH a traffIc classification MEchanism and a Re-routing Algorithm) in light of applying sensors in the zone of traffic which collaborates like street-side units and vehicles. CHIMERA made of three primary techniques; the first system is the Road system and correspondence model, which separates the street with sensors that present correspondence models to help in gathering street information.

The second methodology is Data preparation and congestion identification. CHIMERA utilizes the k-Nearest Neighbor algorithm (KNN) to group congestion levels on streets. CHIMERA uses the average street speed and the concentration of vehicles in the road as info parameters. The yield of the calculation is the traffic condition. The third methodology is Re-routing and traffic adjusting. Re-routing calculation works under the limits forced by the Roads Sides Unites (RSU) inclusion. CHIMERA ascertains elective courses by utilizing the K-Shortest Path calculation dependent on street loads. CHIMERA may allot various ways to various vehicles, therefore playing out a stack balance transversely over elective form.

On the other hand, we find that Bauza et al. [24] presents CoTEC (COperative Traffic congestion detECtion), a novel helpful procedure dependent on Vehicle-to-Vehicle (V2V) correspondences which apply sensors in vehicles to have the option to distinguish street traffic cognizance. CoTEC utilizes messages to advise all vehicles about traffic conditions and identifies a potential blockage condition locally in every car. Along these lines, after distinguishing an automobile overload, every vehicle communicates its estimation about the car influx and, at that point, with all estimates, vehicles cooperatively recognize and portray the street traffic blockage. In any case, the component utilized to identify the traffic condition can cause an over-burden in the system because of the occasional reference point messages and the neighborhood estimations dispersed by all vehicles. Moreover, despite having the option to recognize clog, no instrument to limit or control the congested driving conditions is introduced. Furthermore, CoTEC was proposed to work only on highway situations.

Additionally, Brennand et al. [25] execute a dispensed Intelligent Transportation System (ITS) for recognizing and controlling clogs. To this end, RSUs are dispersed over the city to guarantee all out overcrowding inclusion of the district. Furthermore, each RSU is answerable for overseeing congestion just in the zone secured by its correspondence range. In this way, vehicles can connect with a few RSUs along with their routes. Another researcher Pan et al. [26] propose a centralized framework to get, progressively, the vehicle geographic position, speed, and heading to distinguish traffic jam. Once recognized, vehicles are re-directed, dependent on two distinct algorithms. Firstly, Dynamic Shortest Path (DSP), which traces vehicles utilizing the shortest path, which additionally has the least, voyaged time. Be that as it may, one weakness of this algorithm is the likelihood to move the congestion to another spot — secondly, The Random k Shortest Paths (RkSP). RkSP is a calculation, which arbitrarily picks a road among k shortest path roads. The objective of this algorithm is to avert switching overcrowding from one spot then onto the next by adjusting the re-directed traffic among a few paths. This plan does not actualize a continuous system to recognize overcrowding as it happens, just distinguishing it during the following re-directing stage.

Xavier et al. [27] purpose comparative study and execution assessment of different areas discovering methods for mobile following and its application for considering traffic densities in roadways and sidelong streets. Also, Hasan Omar Al-Sakran [28] proposes a comparative study and execution assessment of different areas discovering methods for mobile following and its application for considering traffic densities in roadways and sidelong streets.

Ming Chen [29] presents a thesis, which displayed the methodologies techniques used to set sign planning for evacuation to move individuals out from an imperiled region as fast as could be expected under the circumstances to evade setbacks.

P. Shahane et al. [30] present a model, which senses and monitors the emission of carbon dioxide CO2 and knows his percentage by comparing it with the allowable rate in their country and telling the driver of the car and the informal communities and car enterprises about the gas emitted by the vehicle to take the necessary precautions.

G.Arun Francis et al. [31] present a model, which senses and monitors the emission of carbon monoxide CO, hydrocarbons (HC), and nitrogen oxides (NOx). The system uses the controller to proceed with the data to the vehicle driver.

Finally, various traffic problems were presented, and techniques were used to solve some of the traffic problems. There are a lot of suggestions like using IoT, image processing, simulating traffic, and supposed solutions using the fuzzy logic system.

All the previous work, depending on IoT, rely on putting a wireless sensor in some of the vehicles and make wireless sensors network on roads. Or simulate traffic with supposed data, not real data, and depend on solving traffic by suggesting an alternative route, which may affect the traffic jam later.

Because of the different methods of dealing with the traffic problem, it was difficult to compare these methods, and this is also due to the difference in the comparison factors and elements, so it was excited to create a system that integrates more than one method to get a proposed model of this thesis like in (Table 2.1).

Table 2. 1 Comparison between different techniques and a proposed model

Techniques / factors	iTETRIS	DEVELOPMENT OF A FUZZY EXPERT SYSTEM	Real Time Monitoring of CO2 Emissions in Vehicles Using Cognitive IOT	Proposed Model
SUMO	YES	NO	NO	YES
IOT (Sensor)	NO	NO	YES	YES
Fuzzy system	NO	YES	NO	YES
Measure CO2	NO	NO	YES	YES
Measure CO, HC, NOx	NO	NO	NO	YES
Define Cognition	YES	NO	NO	YES
Get Relation between vehicles and it's data	NO	YES	NO	YES

Chapter 3

INTERNET OF THINGS

The Internet of Things (IoT) is characterized as a worldview in which objects furnished with sensors, actuators, and processors speak with one another to fill a significant need. Another definition of The Internet of Things (IoT) is the system of physical items or "things" installed with gadgets, programming, sensors, and system network, which empowers these objects to gather and trade information [32][33].

IoT is undoubtedly not a solitary innovation; instead, it is an agglomeration of different advancements that work together side by side (Figure 3.1).

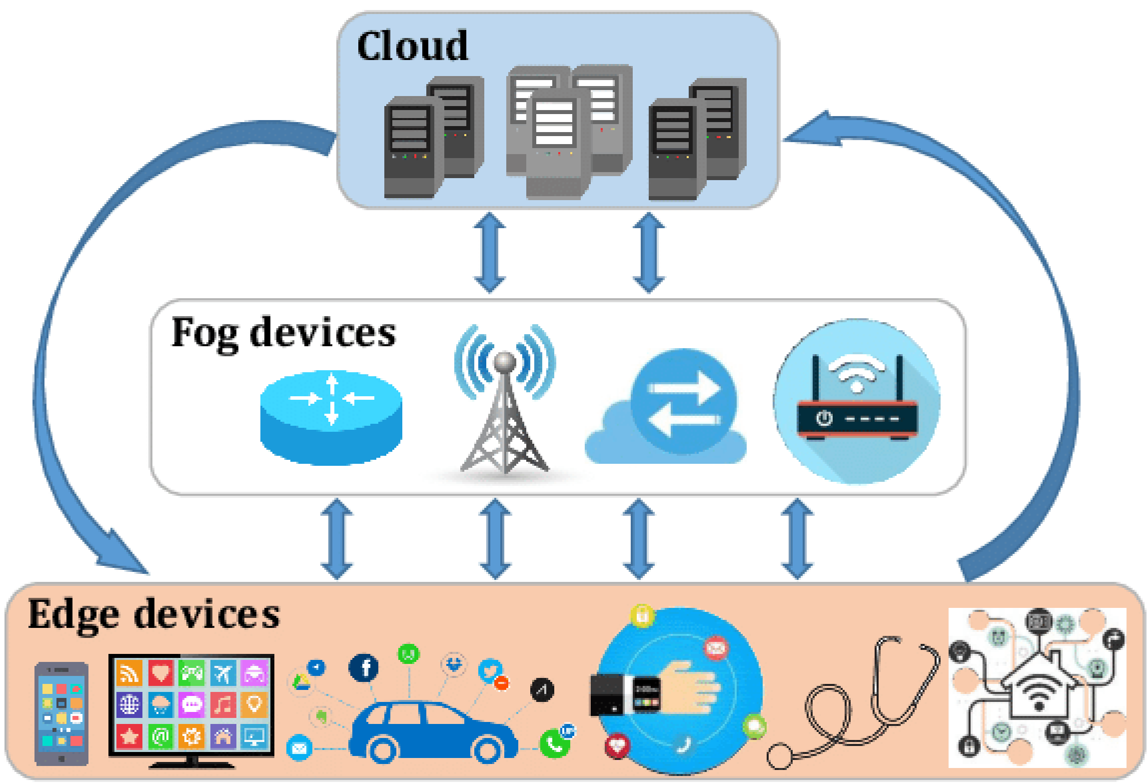


Figure 3. 1 IoT overview [34]

3.1 Internet of Things: Background

The Internet of Things, as an idea, was not authoritatively named until 1999. By the year 2013, the Internet of Things had advanced into a framework utilizing multiple advanced technologies, starting from the Internet to remote correspondence and Micro-Electro**m**echanical Systems (MEMS) to embedded systems [35]., the Internet of Things comprises any device with an on / off change associated with the Internet. This incorporates almost anything, from mobile phones to building maintenance to the plane's jet engine. Medical devices, such as implanting a heart monitor or a vital transceiver in an animal farm, can transfer data over a network and be members of the Internet of Things.

Kevin Ashton trusted Radio Frequency Identification (RFID) was essential for the Internet of Things. He finished up if all gadgets were "labeled," PCs could oversee, track, and stock them. Somewhat, the labeling of things has been accomplished through advancements, for example, computerized watermarking, standardized tags, and QR codes. Stock control is one of the clearer favorable circumstances of the Internet of Things.

The IoT condition likewise takes into consideration interfacing gadgets with constrained memory, force, and CPU. (Figure 3.2) shows how various parts and clients are interconnected in an IoT worldview.

Moreover, if the items are exceptionally addressable and associated with the web, at that point, the data about them can course through a similar convention that interfaces our PCs to the internet. Since these items can detect nature and impart, they have become instruments for getting intricacy, and may frequently empower autonomic reactions to testing situations without human mediation.

Since the internet of things is based upon the capacity to remarkably recognize associated internet objects, the addressable space must be sufficiently enormous to suit the uniquely allocated IP-addresses to the various gadgets. The first internet protocol IPv4 utilizes 32-bit addresses. This was a sensible structure when IPv4 was proposed. With an expanding number of devices being associated with the internet, and with each requiring its IP-address for full peer-to-peer communication and functionality, the accessible IP-addresses are hard to find. Starting in 2008, the number of associated web devices surpassed the total number of individuals on the planet. Luckily, the new IPv6 convention, which is being received, has 128-bit addressability. This is probably going to settle the addressability bottleneck being looked at by the internet of things problem.

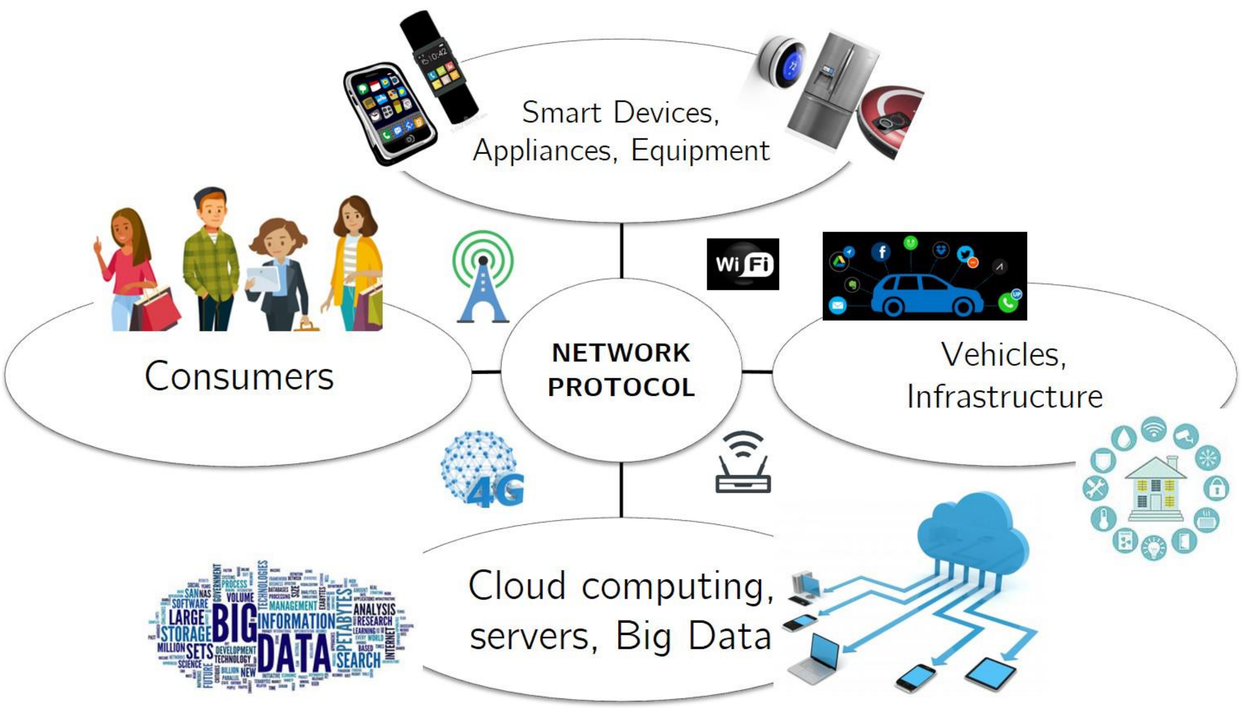
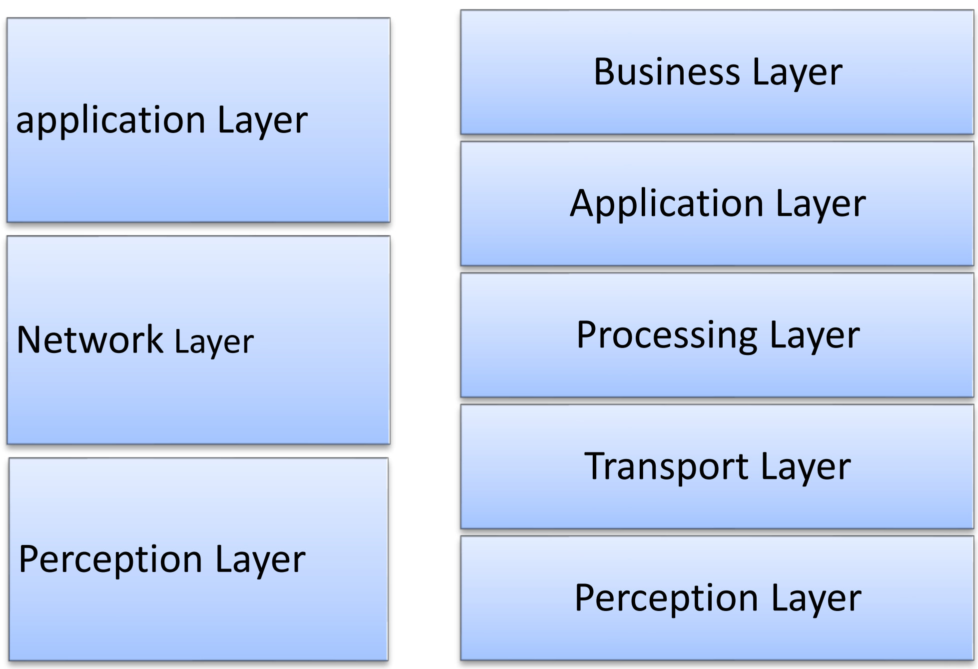


Figure 3. 2 IoT Environment [36]

3.2 Internet of Things: Architecture

There is no single accord on engineering for IoT, which is generally concurred. Various researchers have proposed different designs. Three-Layer and Five-Layer Architectures. The essential architecture is a three-layer architecture [37-40], as presented in (Figure 3.3).The three-layer architecture characterizes the fundamental thought of the Internet of Things; however, it isn't adequate for inquiring about on IoT because examination frequently centers around more delicate parts of the Internet of Things.



(a) Three Layer (b) Five Layer

Figure 3. 3 IoT Architecture

Three-layer architecture (Figure 3.3) has three layers, namely, the perception, network, and application layers:

- **The perception Layer:** is the physical layer, which has sensors for detecting and assembling data about the environment. It identifies some physical parameters or distinguishes other smart items in the environment. In this work, the perception layer presented in vehicles in the transportation network.

- **The network layer:** is liable for interfacing with other intelligent things, network gadgets, and servers. Its highlights are additionally utilized for transmitting and handling sensor information.
- **The application layer**: is responsible for providing application-specific utilities to the user. It identifies the various applications through which the Internet of Things can be deployed, for example, smart cities, smart homes, smart transportation, and smart health [38].

The Five layers of architecture (Figure 3.3) consists of perception, transport, processing, application, and business layers. The job of the application and perception layers is equivalent to the architecture with three layers [39]. We state the function of the remaining three layers:

- **The transport layer**: moves the sensor data from the perception layer to the processing layer and the other way around through network, for example, 3G, wireless, LAN, RFID, Bluetooth, and NFC.
- **The processing layer**: is otherwise called the middleware layer. It stores analyze and form large measures of information that originates from the transport layer.

  It can oversee and give a different arrangement of administrations to the lower layers. It utilizes numerous advancements, for example, distributed computing, cloud computing, and big data handling modules [40].
- **The business layer**: it deals with the entire IoT framework, including applications, business and benefit models, and clients' protection.

3.3 Internet of Things: How IoT Works

According to [41] much the same as Internet has changed how we work and speak with one another, by interfacing us through the World Wide Web (WWW), IoT additionally plans to take this connectivity to another level by associating numerous devices at a time to the internet herewith simplify man to machine and machine to machine interactions. there are four main components of IoT, which inform us how IoT works, which are sensors/Devices, connectivity, data processing, and user interface see (Figure 3.4).

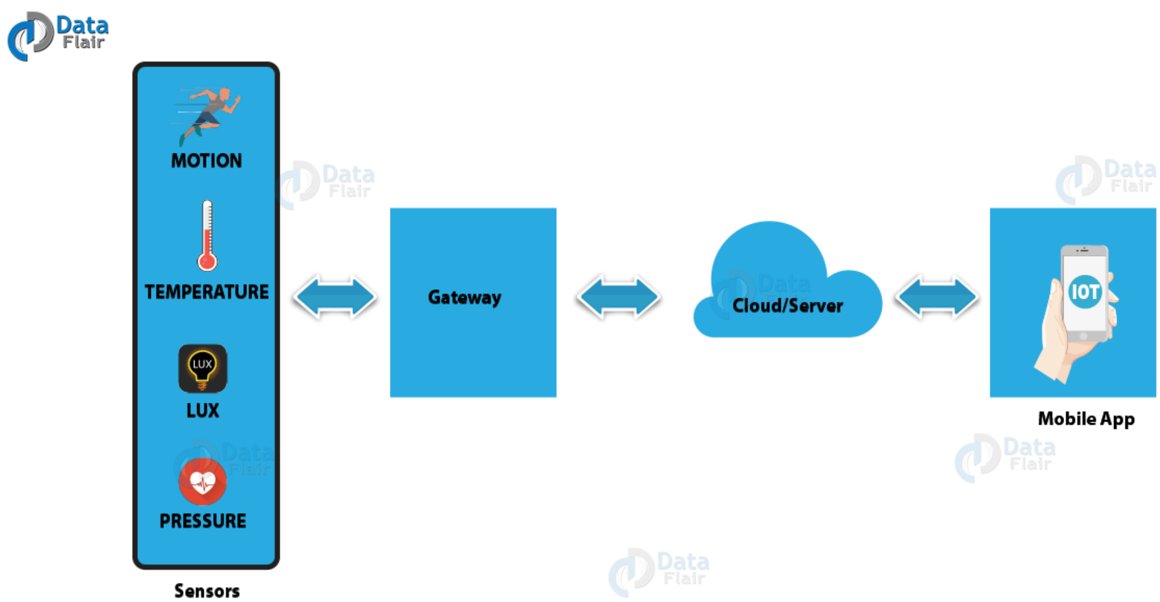


Figure 3. 4 How IoT Works [41]

3.3.1 Sensors/Devices

To start with, sensors help in gathering exact moment data from the encompassing environment. All of this collected data can have different degrees of complexities ranging from a simple temperature checking sensor or a multiple full video feed.

A device may have various sensors that can package together to accomplish something beyond sense things. For instance, our mobile is a device, which has different sensors, for example, camera, accelerometer, GPS; however, our mobile does not sense things [42].

The most primitive step will consistently stay to pick and gather data from the encompassing environment, be it an independent sensor or various devices see (Figure 3.5).

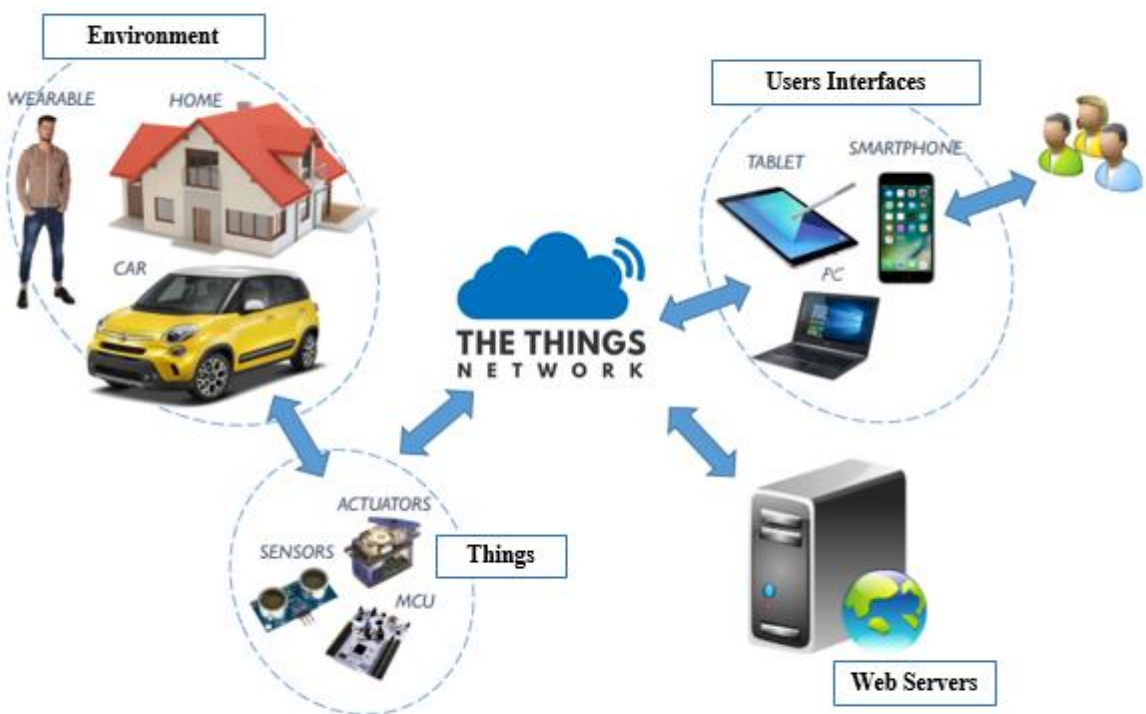


Figure 3. 5 IoT- Sensors/Devices [42]

3.3.2 Connectivity

The gathered data is sent to a cloud infrastructure; however, it needs a mean for transport. The sensors may be connected to the cloud through different ways of correspondence and transports, for example, satellite network, cellular networks, Wi-Fi, Wide-area networks (WAN), Bluetooth, low wide area network and some more.

Each alternative we pick has a few determinations and exchange offs between power utilization, bandwidth, and range. In this way, choosing the best connectivity choice in the IoT framework is significant [42].

3.3.3 Data Processing

As soon as the data is gathered, and it puts on the cloud, the software performs preparing and processing on the obtained data.

This matter ranges from something straightforward, such as checking that the temperature reading on devices such as air conditioning or heaters falls within an acceptable range. It can sometimes also be complicated, like identifying objects from videos (such as intruders in a house) using computer vision. However, there may be a situation when user interaction is required; example- what if when the temperature is unsuitable or if there is a foreigner in a house? Here the user comes to the image [41]. Figure 3.6 shows how the gathered data is processed.

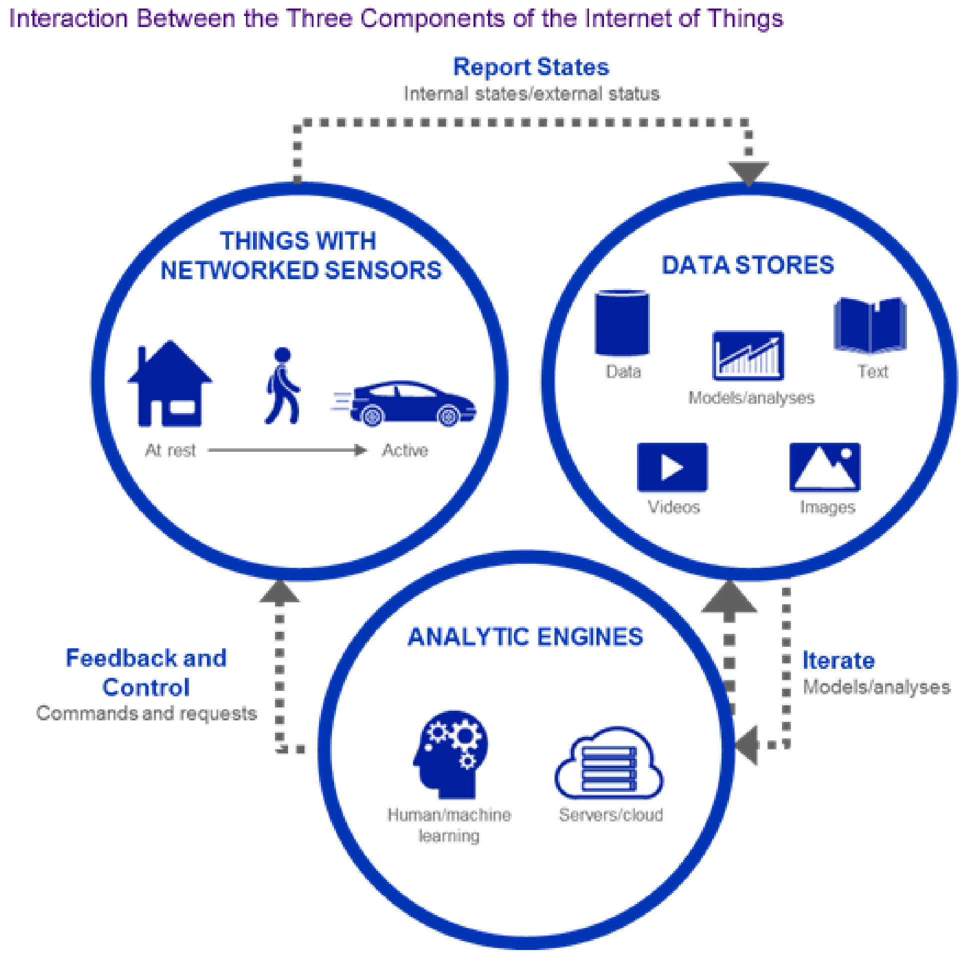


Figure 3. 6 IoT- Data Processing [41]

3.3.4 User Interface

Th e information should be made accessible to the end-user. This can accomplish by activating alerts on their mobiles or telling through writings or messages.

Moreover, a client may likewise have an interface through which they can effectively monitor their IoT framework. For instance, a client has a camera introduced in his home, and he may check the video accounts and every one of the feeds through a web server.

3.4 Internet of Things: Applications

IoT has many applications, but this thesis will cover the most popular IoT Applications with uses. So, in the following, let's explore them one by one:

3.4.1 Smart City

The smart city, like the name proposes, is an exceptionally enormous development and ranges a wide assortment of utilization cases, from distributing water to monitoring the environment, waste management, traffic management, and urban security. The motivation why it is so well known is that it attempts to remove the problems and discomfort of individuals who live in urban areas. IoT solutions offered in the Smart City zone solve different city-related issues involving traffic, decrease air and clamor contamination and help make urban communities more secure [44].

Figure 3. 7 IoT Application- Smart City

3.4.2 Smart Home

whatever point we think of IoT system, the most significant and productive application that stands out every time is Smart Home, which ranking as the most noteworthy IOT application on all channels [45].

The quantity of individuals searching for smart homes expands each month, with around 60,000 individuals and growing. Another identifies the thing is that the database of smart homes for IoT Analytics incorporates 256 organizations and new companies. More organizations are presently actively being associated with smart homes than different comparable applications in the field of IoT. (Figure 3.8) shows a visualization of a smart home.

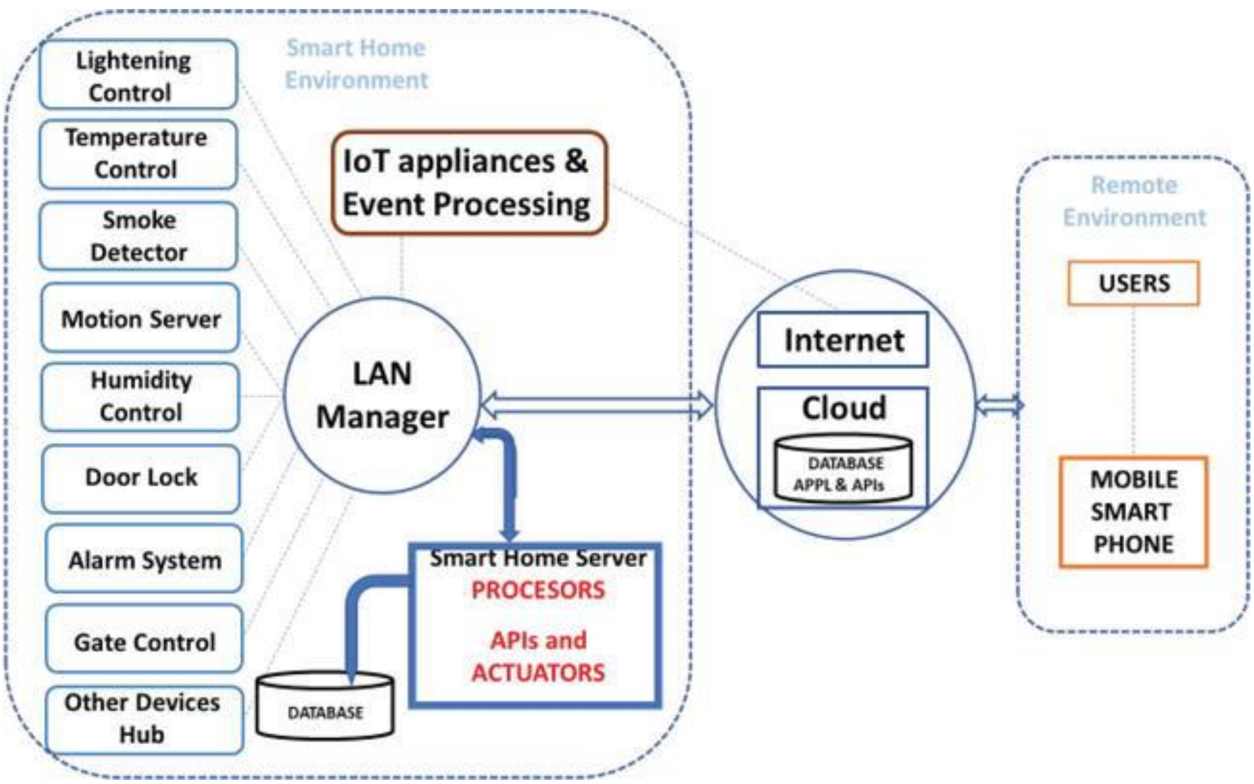


Figure 3. 8 IoT application - Smart Home [45]

3.4.3 Wearable

Much the same as smart homes, wearables stay a hotly debated issue too among potential IoT applications. Consistently every year, clients all over the globe wait for the arrival of Apple's smart watch. Aside from this, there are a lot of other wearable devices that make our life simple, for example, the Sony Smart B Trainer, or LookSee wrist trinket, the Myo sign control.

3.4.4 Smart Grid

Smart grids (Figure 3.9) is another territory of utilization that sticks out. A smart grid fundamentally promises to extricate data on the practices of customers and power providers in a robotized style to improve the proficiency, financial aspects, and dependability of power dispersion. 41,000 months to month Google searches is a demonstration of this current idea's ubiquity [46].

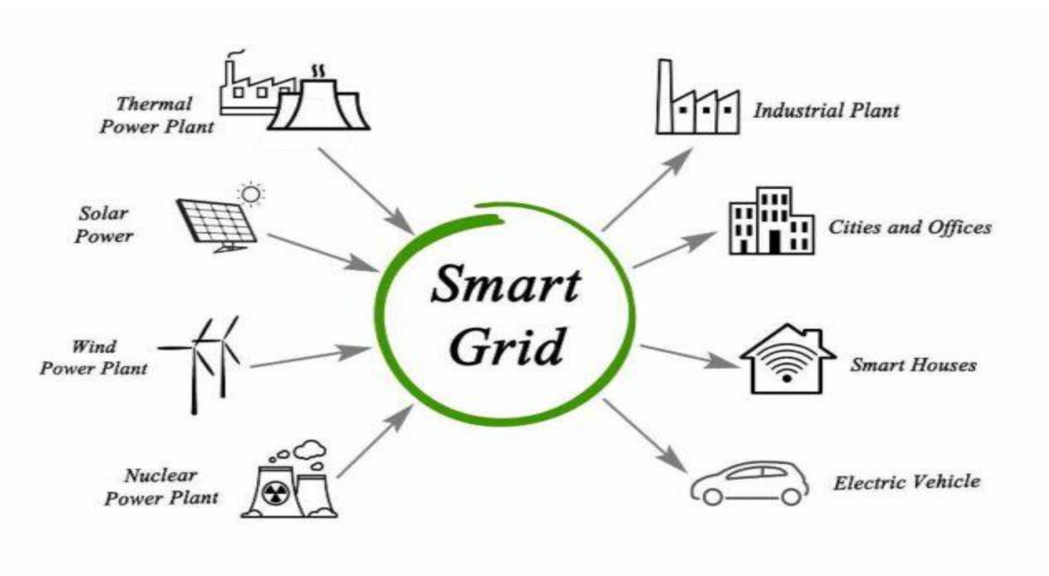


Figure 3. 9 IoT Application - Smart Grid [46]

3.4.5 Industrial Internet

One approach to think about the Industrial Internet is, as associating machines and gadgets in ventures, for example, power age, oil, gas, and medicinal services. It is additionally utilized in circumstances where spontaneous personal time and framework disappointments can bring about dangerous situations. A framework installed with the IoT will, in general, incorporate gadgets, for example, wellness groups for heart observing or savvy home apparatuses. These frameworks are useful and can give usability; however, they are not solid since they don't regularly make crisis circumstances if the downtime was to happen [41].

3.4.6 Connected Vehicle

Connected vehicle innovation is a great and vast system of different sensors, reception apparatuses, implanted programming, and advances that aid correspondence to explore in our mind-boggling world. It has the obligation of settling on choices with consistency, exactness, and speed. It likewise must be dependable. These prerequisites will turn out to be considerably increasingly essential when people surrender the control of the controlling haggle to the self-governing or mechanized vehicles that are by and large effectively tried on our expressways at this moment. (Figure 3.10) shows vehicle with various sensors, which help in gathering different data [47].

Figure 3. 10 Connected Vehicle [47]

3.4.7 Digital Health

IoT has different applications in healthcare, which are from remote checking equipment to progress and smart sensors to gear reconciliation. It can improve how doctors convey the mind and keep patients protected and reliable. Medicinal services IoT can enable patients to invest more energy interfacing with their primary care physicians by which it can help tolerant commitment and fulfillment [41].

Figure 3. 11 IoT Application - Digital Health [41]

3.4.8 Smart Retail

Retailers have begun receiving IoT arrangements and utilizing IoT inserted frameworks over various applications that improve store activities, for example, expanding buys, diminishing burglary, empowering stock administration, and upgrading the buyer's shopping experience. Through IoT, physical retailers can go up against online challengers all the more unequivocally. They can recapture their lost piece of the overall industry and draw in purchasers into the store along these lines making it more straightforward for them to purchase more while setting aside cash.

3.4.9 Smart Supply Chain

Supply chains have just been getting more brilliant for two or three years. Offering answers for issues like following of products while they are out and about or in travel or helping providers trade stock data are a portion of the essential contributions. With an IoT empowered framework, industrial facility hardware that contains implanted sensors imparts information about various parameters, for example, weight, temperature, and use of the machine. The IoT framework can likewise process work processes and change gear settings to streamline execution [48].

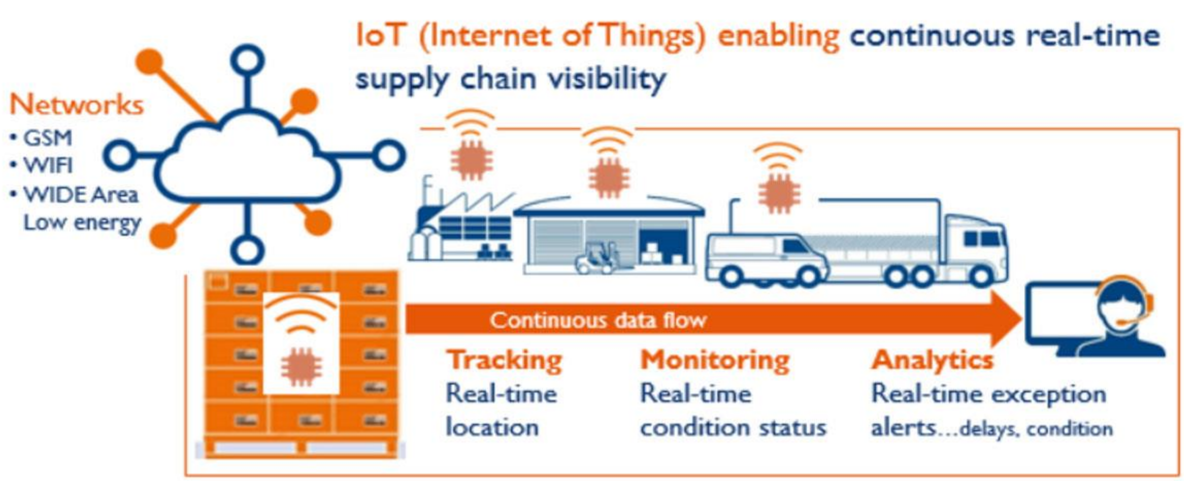


Figure 3. 12 IoT Application - Smart Supply Chain [48]

3.4.10 Smart Farming

Smart Farming is a frequently disregarded IoT application. Be that as it may, because the quantity of cultivating activities are typically remote and the massive number of domesticated animals that ranchers take a shot at, all of this can be checked by the Internet of Things and can likewise upset how ranchers work. In any case, this thought is yet to arrive at an enormous scale consideration. By and by, despite everything, it stays to be one of the IoT applications that ought not to be disparaged. Brilliant cultivating can turn into a significant application field specifically in the horticultural item sending out nations [49].

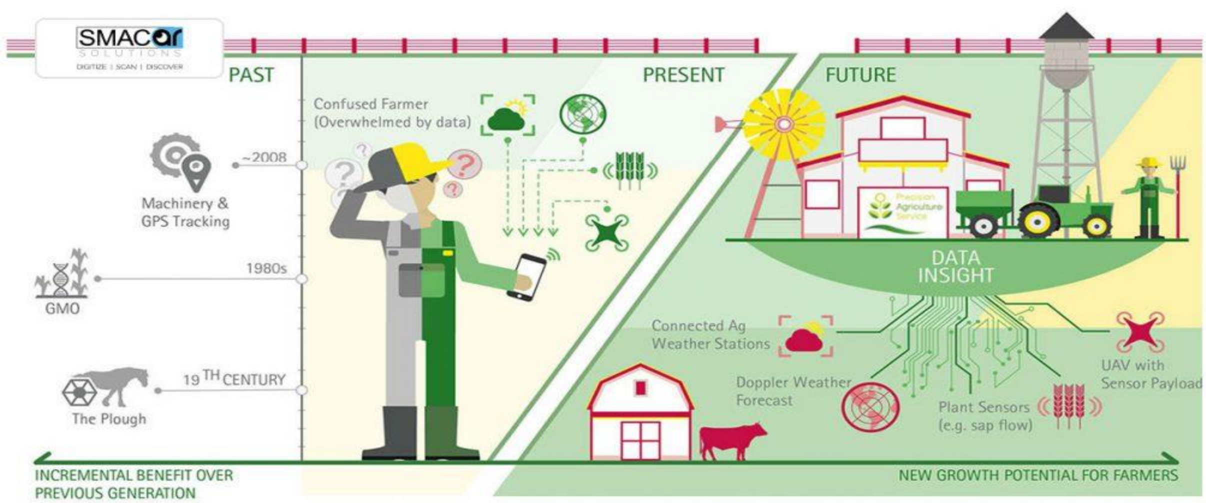


Figure 3. 13 IoT Application - Smart Farming [49]

3.5 Internet of Things: IoT Environmental Monitoring Application

This application contains a lot of separate applications. Parts of them are most important to the subject of the thesis, which is monitoring vehicles and monitor air pollution (Figure 3.14) presents four various applications of monitoring environment:

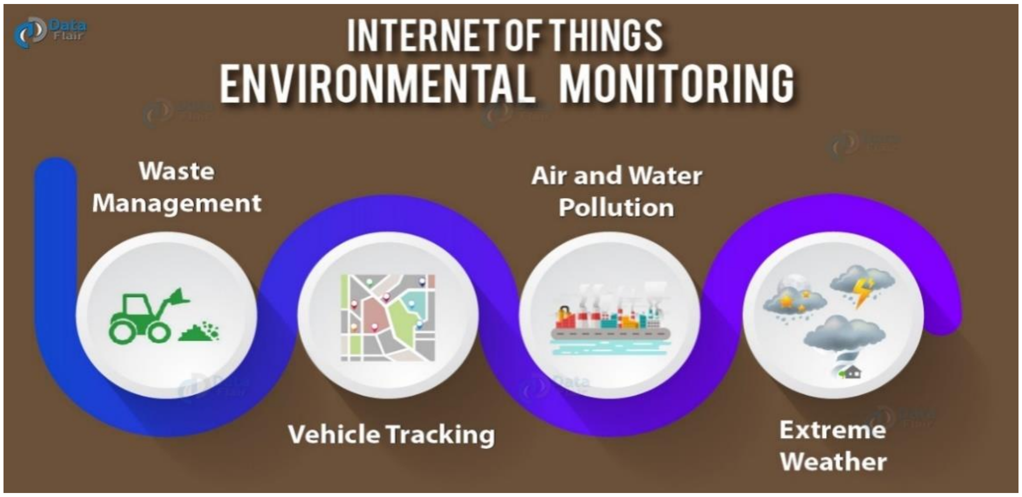


Figure 3. 14 Environmental Monitoring [41]

3.5.1 Waste Management

The issue of waste management (Figure 3.15) is extremely critical in active urban communities because of two reasons; first, the expense of service and second the problem of storage of accumulating trash. To save and utilize competitive environmental advantages, points of interest, a more profound infiltration of data and correspondences innovations arrangements in this field will be required.

For instance, smart waste compartments help recognize the degree of burden the trucks convey and consider a streamlining of the gatherer trucks course, which like this can decrease the expense of waste assortment and improve the nature of reusing. To use and utilize such smart waste management benefits, the IoT will associate these intelligent waste containers, to a control focus where an advancement software will process the data and decide the ideal administration and course the authority truck bought to follow [41].

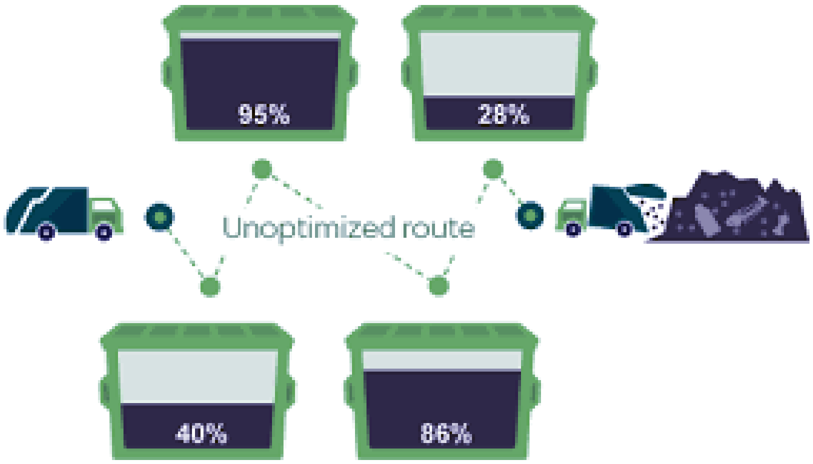


Figure 3. 15 Smart Waste Management [41]

3.5.2 vehicle tracking

The vehicle tracking making easy utilize of routs sensors and intelligent display systems that help drivers to locate the best route for parking in the city. The advantages of this administration are numerous; for example, quicker the vehicle takes to find a leaving space implies lesser CO outflow from the car, lower traffic issues, and at last, more joyful citizens. The IoT foundation can legitimately coordinate the vehicle parking facility.

Moreover, similar to we examined before, by utilizing correspondence advancements, for example, Near Field Communication (NFC) or Radio Frequency identifiers (RFID) see (Figure 3.16) [41], we can comprehend the electronic affirmation arrangement of stopping and find spaces saved for occupants or debilitated people, along these lines offering a superior help to inhabitants that can utilize those openings and as an effective instrument to recognize any infringement rapidly (Figure 3.17).

Figure 3. 16 Vehicle Tracking [41]

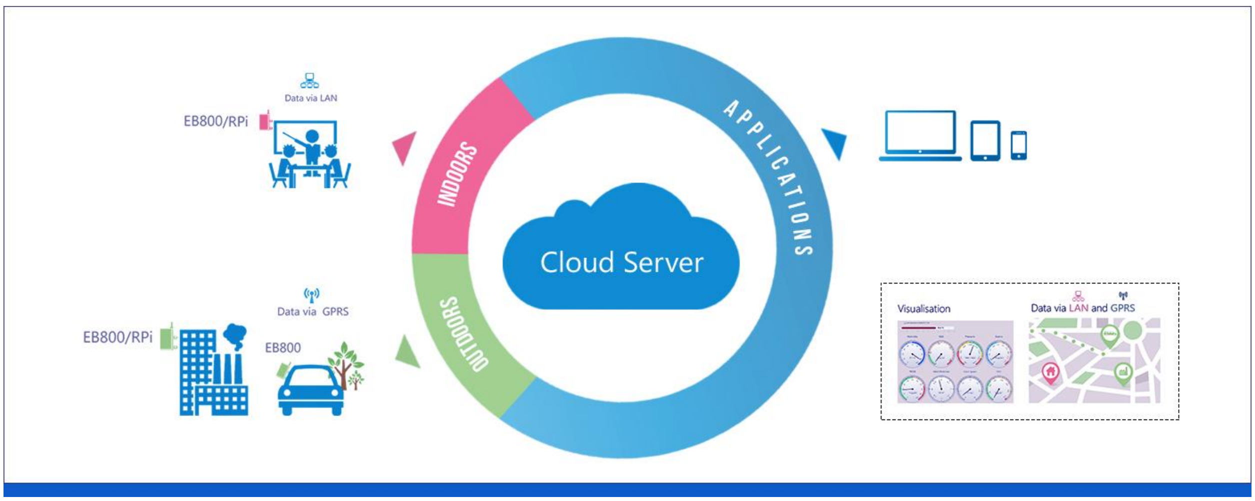


Figure 3. 17 How Vehicle Tracking is made?

3.5.3 Monitor Environmental Pollution

The monitoring technique, at present, is used for air and water safety, mostly manual labor, along with some advanced tools and lab handling procedures. Through IoT frameworks, the requirement for manual labor is decreased. Thus, frequent sampling is permitted, expanding the scope of monitoring and sampling, allowing sophisticated testing on location, and giving reactions to identification frameworks. This forestalls any further pollution of water bodies and other standard assets and related fiascos [50].

3.5.4 Extreme Weather

sturdy, propelled frameworks at present utilized for weather forecasting allow in-depth monitoring. However, they experience the ill effects of using expansive instruments, for example, radar and satellites. These instruments that are being used for little subtleties come up short on the precise, focusing on the potential for brilliant innovation [41].

Presently, through the new IoT propels, the IoT system guarantees more data that fine-grain, better adaptability, and exactness. Viable climate gauging strategies require high detail just as adaptability in instrument type, range, and arrangement. This outcomes in early reactions to forestall death toll and property through the first location.

Chapter 4

A Proposed Framework

This chapter discusses the strategies for a proposed model and how we have gotten it. It goes to monitor and work on traffic as a simulated world and provides an expert system to produce reports for decision-makers. The simulator presents another method for monitoring, controlling, and dealing with the transport on the network. Using SUMO and TraCI, we can get data about the vehicles on the network. Like the least and the most extreme speed for each car out and about, exhaust proportion of every vehicle and which path on the system that the vehicle takes. Also, the expert system utilizing (exsys corvid) tool gives various proposals for various instances of routes trips.

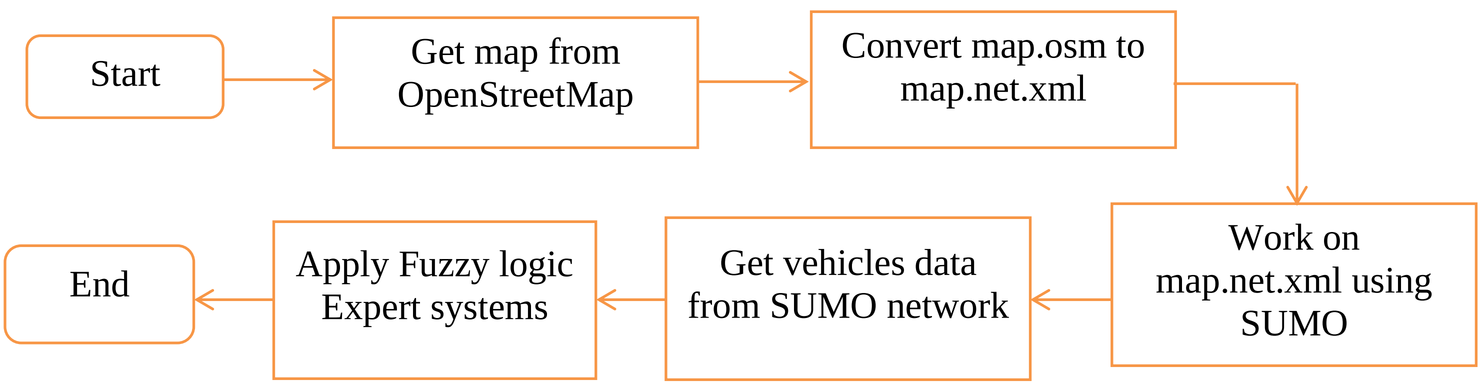


Figure 4. 1 Proposed System Overview

4.1 A Proposed model Steps:

The proposed technique discusses the implementation of a real network of the traffic system. There are three main aspects: traffic simulator, Real network with real data about transportation, and fuzzy expert system, as shown in (Figure 4.1).

Step 1: Start.

Step 2: Get the map.osm (input).

Step 3: Use Netconvert tool to get network.net.xml.

Step 4: Use built-in python scripts randomtrips.py to create trips on the network.

Step 5: Output network.rou.xml.

Step 6: Create a config file network.sumocfg.

Step 7: Display network on SUMO.

Step 8: Create TAZ and (OD) files (inputs to sumo).

Step 9: Output od2trip.xml.

Step 10: Apply daurouter algo.

Step 11: Get Floating Car Data (FCD).

Step12: Apply Fuzzy Expert System on FCD.

Step 13: Get emission output ex: co2, co, hc, nox, fuel, electricity, and noise.

Step 14: Extract reports.

Algorithm 4. 1 The steps of a proposed model

Also (Algorithm 4.1) describes the steps of a proposed model starting from the loading of the map from OpenStreetMap through the transformation into a network to work on it by adding trips and extracting vehicle data for these trips ending by applying the fuzzy logic expert system on it.

4.2.1 Traffic simulator

SUMO (Simulation of Urban Mobility) is an open-source little traffic recreation bundle that is broadly utilized in numerous transportation and vehicular systems administration ventures [51]. In SUMO, vehicle development is generally mimicked using line approaches, and single autos are moved between such lines. Likewise, SUMO offers extraordinary grained power over vehicles on the system through the Traffic Control Interface (TraCI). TraCI is a strategy for interlinking street traffic and system test systems. It permits us to observe the lead of vehicles during simulation runtime. TraCI empowers us to recuperate esteems, for instance, vehicle speed and fuel use, and to deal with their states, for example, speed and path changes. SUMO models driving practices for all purposes with the objective that control any gigantic level of vehicle flow. Heading would be executed in a way that agrees to extreme physical limitations to avoid the accident or running the red lights. SUMO utilizes its NETCONVERT [52] instrument to import the OSM guide and convert it to the system and remember saving the highlights of the streets, for example, organize structures, street levels, and assessed speeds.

4.2.1.1 NETCONVERT

It is a tool, which imports advanced street systems from various sources and produced a network that can be utilized by different instruments from the bundle.

It is a command-line application. It supposes at least one parameter the blend of the name of the document type to import as parameter name and the name of the record to import as parameter esteem. We use the command *"Netconvert –osm -files map.osm -o banha.net.xml."* to get the desired network to SUMO (Figure 4.2).

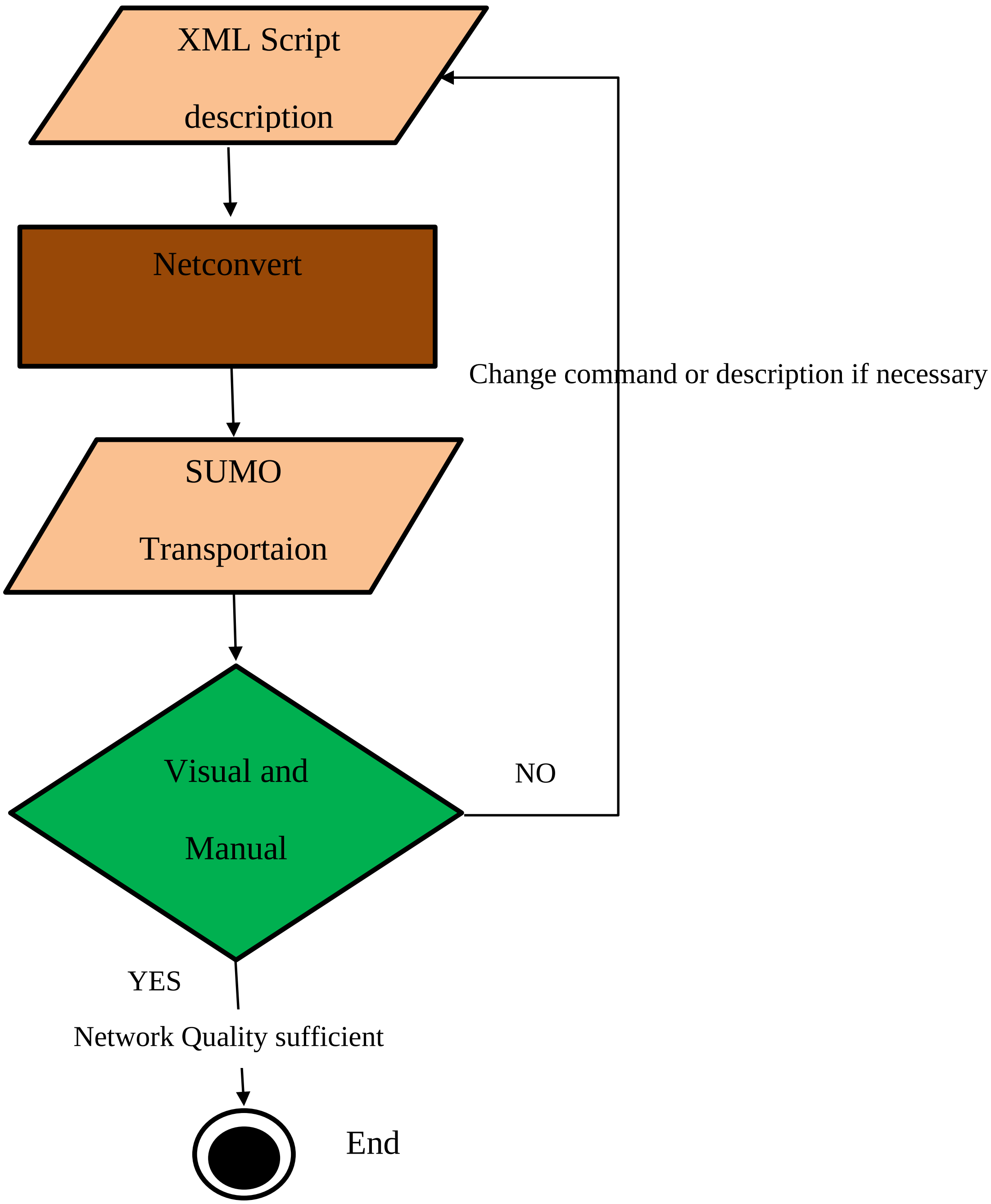


Figure 4. 2 WorkFlow of SUMO Network Import

4.2.1.2 Create Trips

After converting the map to the desired network, we apply the built-in python script "randomtrip.py" [53]. It creates a set of random trips for a given network. The output is put away in an XML (Extensible Markup Language) record.

In our model, we have to create our journeys to be enabled to restrict data to a small area. So, after defining the edges and lanes of our network, we decided to work on a small part of the map. So, we have to organize trips in that area by identifying the zone of work using TAZ and identify the sources and destinations of the vehicles in that zone by creating origin-Destination (OD) Matrix (Figure 4.3).

4.2.1.3 Traffic Analysis Zone (TAZ)

TAZ configuration [54] is dependent on a smoothed thickness surface of geocoded travel request information. The calculation plans to limit the loss of data while moving from a constant portrayal of the starting point and goal of each outing. To their discrete representations through zones, and spotlights on the exchange off between the measurable exactness, geological mistake, and the level of intra-zonal excursions of the subsequent origin-Destination (OD) grid.in the traffic analysis zone we define the worked edges in our proposed model. In (Table 4.1), the first column expresses an ID for each edge where the second column is the name of each edge as it is in the transportation network in SUMO. The proposed model is based on five edges, of which vehicles move through them.

Table 4. 1 traffic analysis zone

Taz id	Edges
1	-271661553#1
2	-433695808
3	271661554#3
4	433696434
5	271661554#2

4.2.1.4 Origin-Destination (OD)

OD [55] is a file, which expects the matrix to be coded as measures of vehicles that drive from one region or (TAZ) to another inside a specific period. Since the produced outings must be beginning and end at edges, OD2TRIPS requires a mapping of TAZ to edges. OD2TRIPS imports O/D-grids and parts them into single-vehicle trips. Also, OD2TRIPS maps traffic that is characterized by OD file zones onto the edges of a network. The OD matrix identifies the source and direction based on the TAZ file and the number of vehicles in this zone. In (Table 4.2), for example, on the first row, we define that from the first edge to the fourth one there are fifty vehicles are moving through the network depending on real collected data.

Table 4. 2 Matrix Of OD

Source edge id	Destination edge id	Number of vehicles
1	4	50
4	1	40
1	2	30
2	1	25
1	3	20
3	1	15

4.2.1.5 DUAROUTER

It is an algorithm that imports different demand definitions, computes vehicle routes that may be used by SUMO using shortest path computation. The input of this phase consists of the network on SUMO (.net.xml file) and a configuration file that defines the input and output of the trip, which contains the TAZ file and OD matrix.

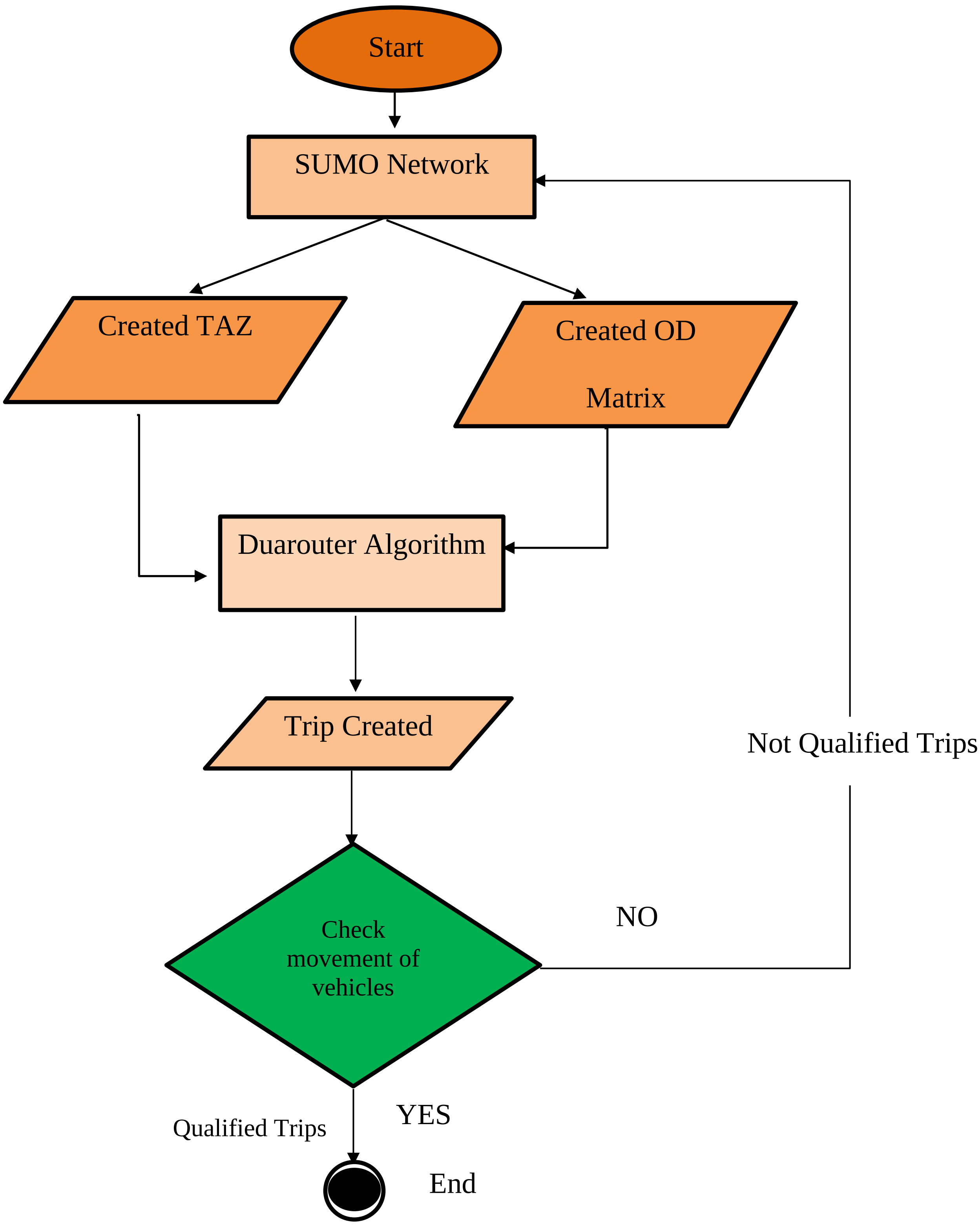


Figure 4. 3 Create Trips through the transportation

4.2.1.6 Floating Car Data (FCD)

The technique for Floating Car Data (FCD) [56] [57] is probably the least expensive strategy to give constant or close to ongoing traffic data. The approach has gotten progressively reasonable with the multiplication of advanced mobile phones and with the current foundation of the remote system. Even though not different giving more than one of the traffic stream parameters, estimating the adequacy of using FCD, we get the time of movement of each vehicle, speed, and GPS location (Figure 4.4).

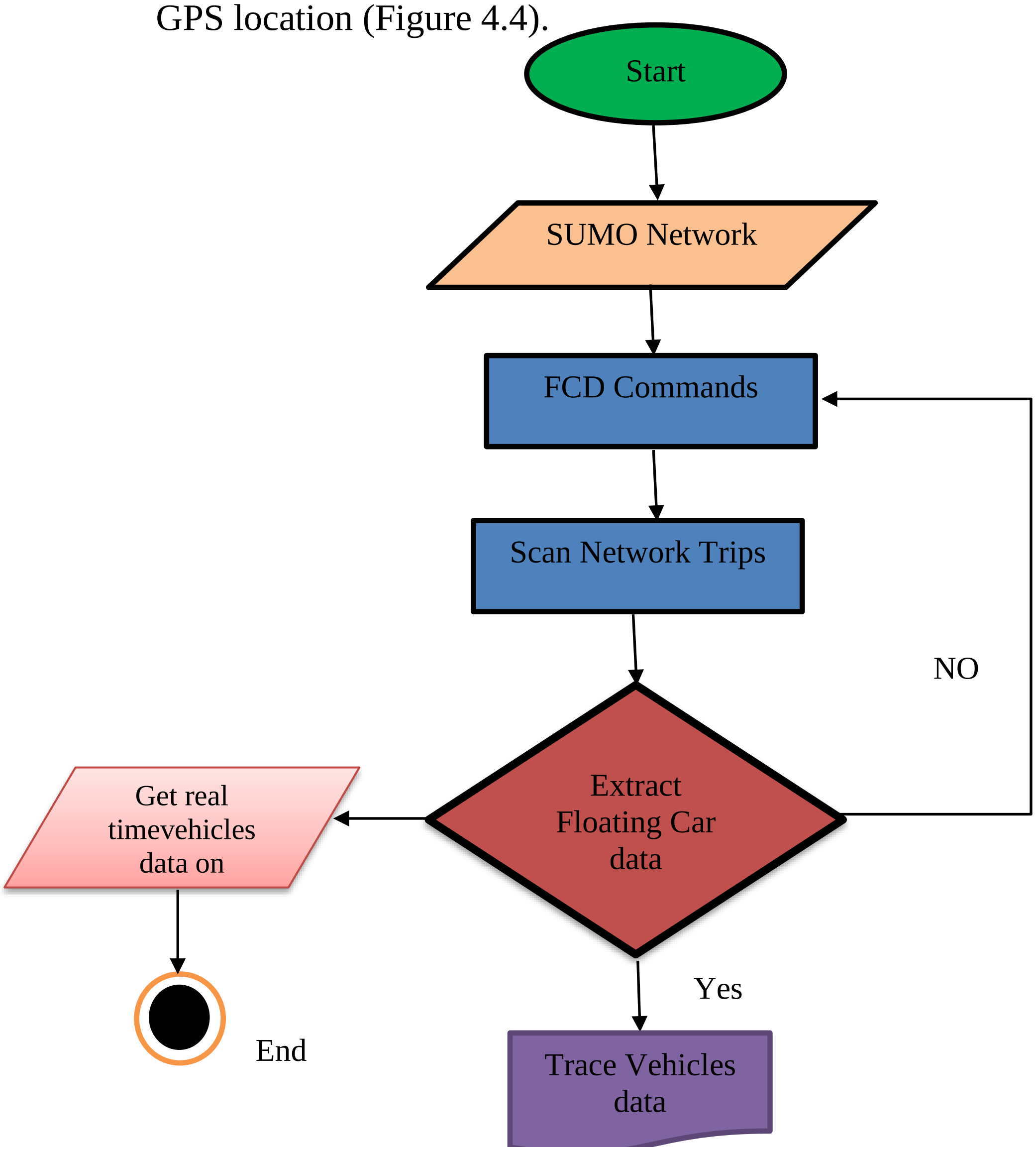


Figure 4. 4 Steps of getting FCD

4.2.1.7 Emission Output

Emission output [58] helps in define the exhaust out each vehicle like the amount of co2, co, Nox, fuel, electricity, noise, emitted by the car in the actual simulation step (Figure 4.5).

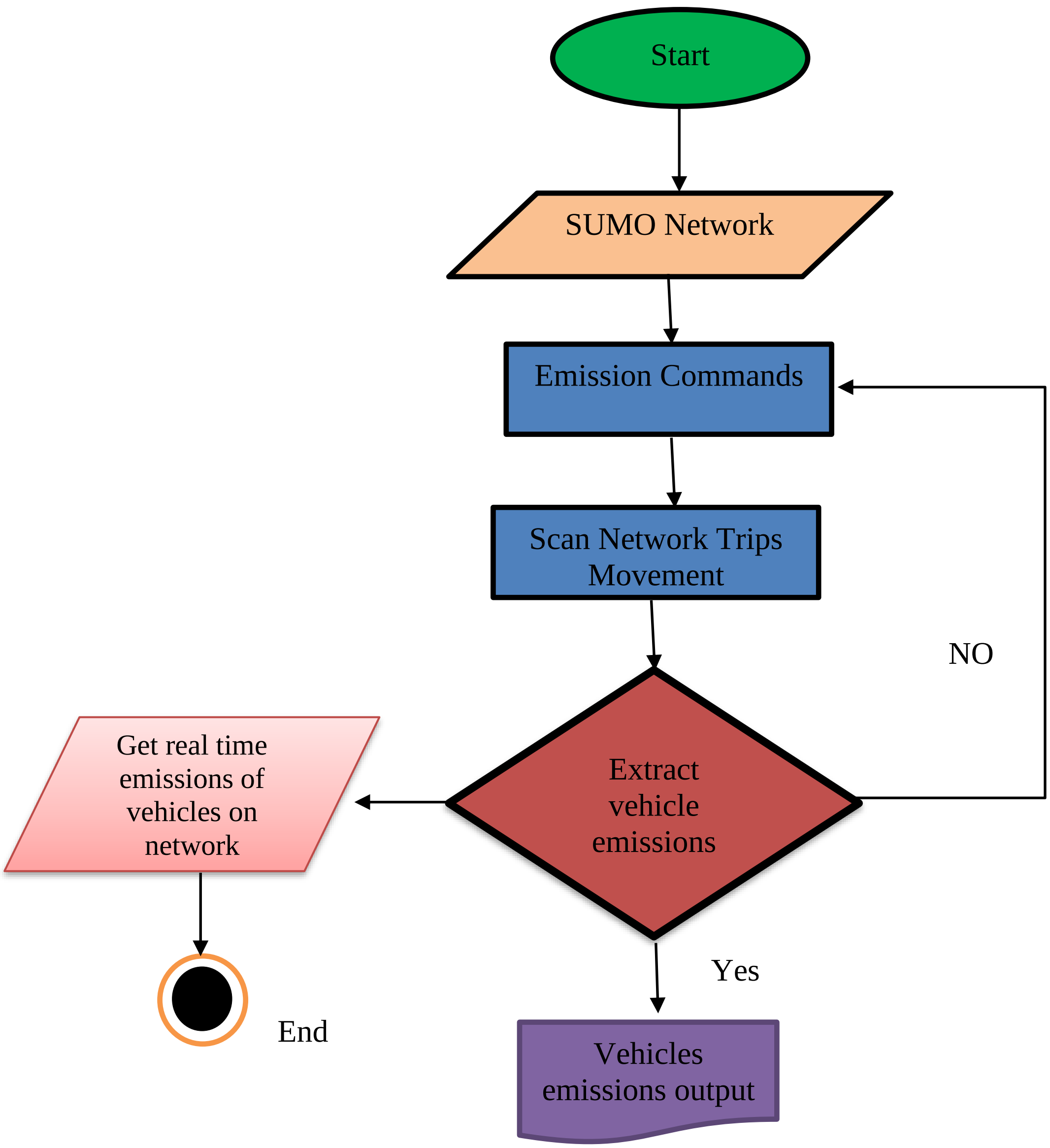


Figure 4. 5 Steps of getting vehicle's emissions

4.2.2 Real network with real data about transportation

Working on traffic simulation requires data and a road network. To simulate traffic and transportation models, we can work with not actual data. And assume the number of vehicles, its data, and their routes from edge to the other on the network, yet we deal with a real street arrange imported from OpenStreetMap (OSM). To get the OSM map, we go to the site https://www.openstreetmap.org. After that, select the desired area and export the map to be downloaded in our pc (Figure 4.6) (a & b). After that, the utilization of the Netconvert command is used to change over to the SUMO system to be able to work with it (Figure 4.7) (a & b). Keeping in mind that it maintains the infrastructure of the defined area

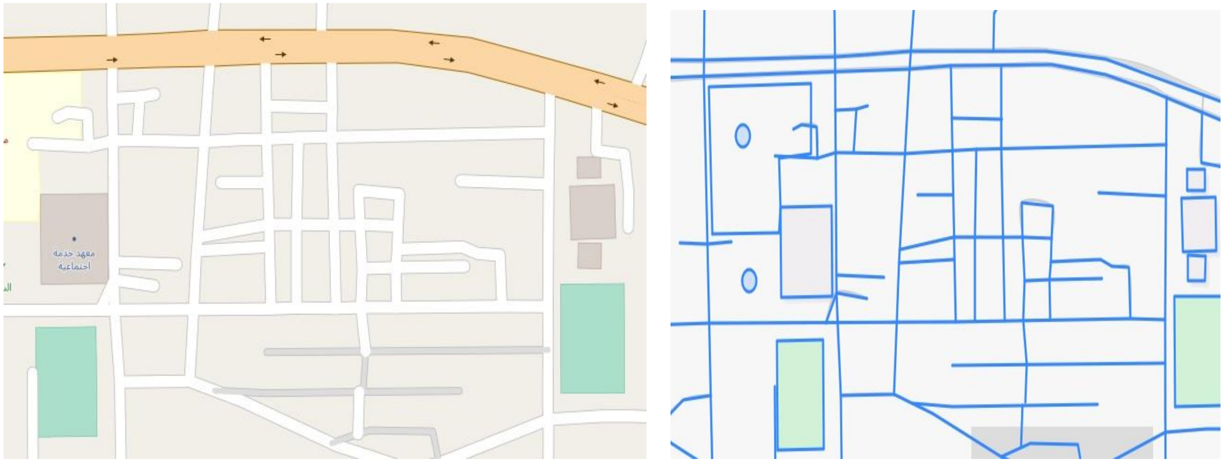


Figure 4. 6 (a) benha map from OSM (b) transport layer of benha from OSM

Figure 4.6 (a) shows the shape of the map on the OpenStreetMap site, which we were exported from the site. Where Figure 4.6 (b)shows another shape of the map on the OpenStreetMap site, which expresses the transportation layer.

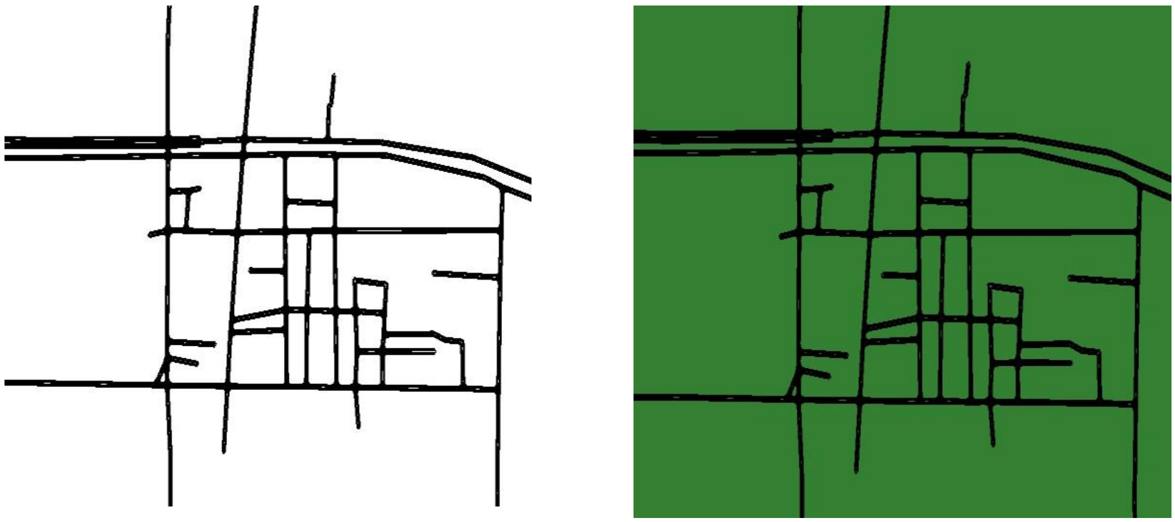


Figure 4. 7 (a) standard sumo network (b) real-world sumo network

Figure 4.7 (a) represents the standard shape of the network, which was obtained through the converting of the OSM map. Where (Figure 4.7) (b) is a real-world view.

To allow sensible traffic on the sumo street arrange, we need an original dataset about the district we were imported from OpenStreetMap. Unfortunately, there are no datasets about the locale we take a shot at. Along these lines, we use Quadcopter to accumulate data about the region, like the number of vehicles in the gathered streets in the system and the time of traffic conditions. We take about Quadcopter in **chapter 2 (section 2.2.3).**

Figure 4.8 explains the steps of knowing and registering the number of cars and their traffic condition throughout the day, as well as knowing their itinerary so that we have real data that we put on the SUMO.

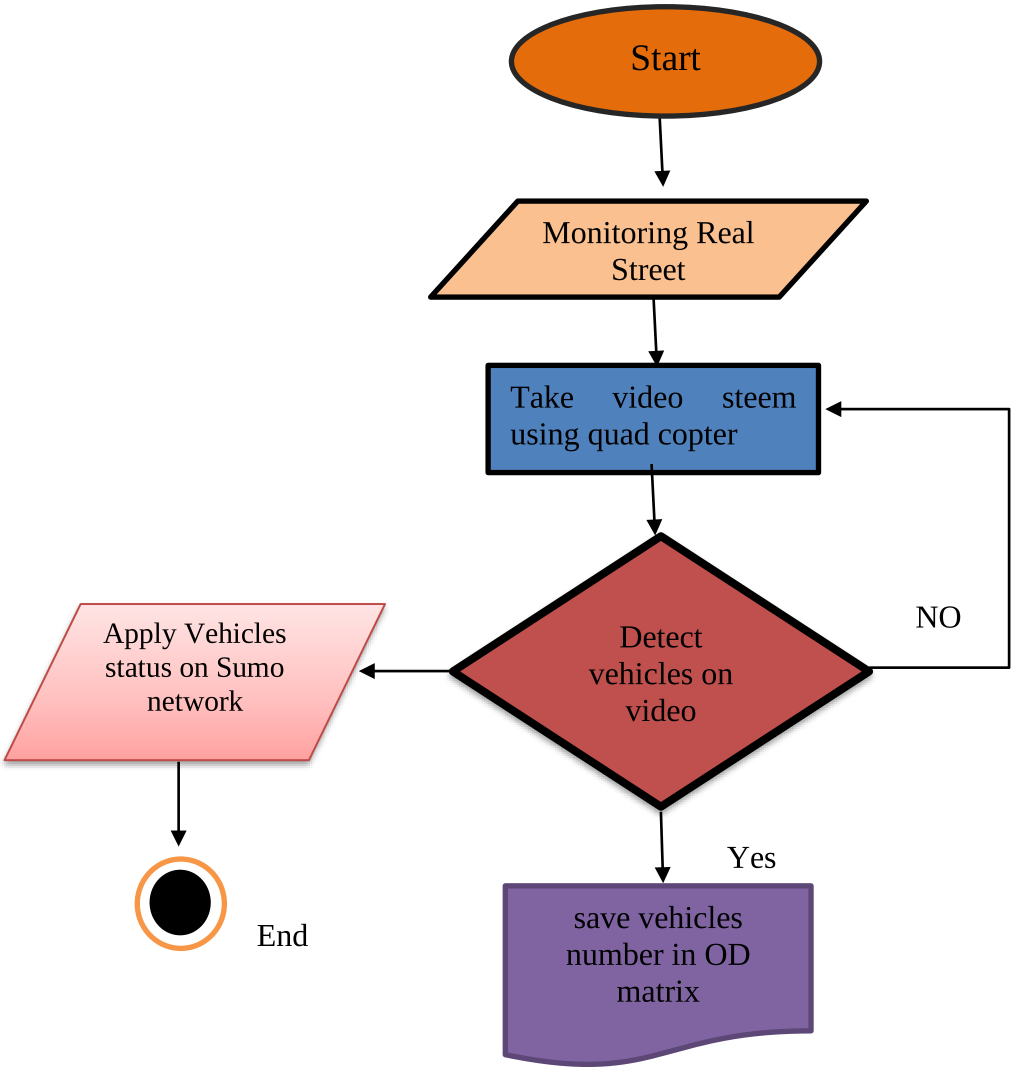


Figure 4. 8 Steps of record real data on SUMO

4.2.3 Fuzzy expert system

After we get the routes network of veritable traffic zone using SUMO. In like manner, distinguish and monitor the traffic conditions around there using Quadcopter. We have two options either get reports for decision-makers or develop the management of traffic by TraCI and SUMO. This thesis applies an expert system, which works on data and analysis to extract reports [59]. An expert system resembles a PC application, and this application is an Artificial Intelligence (AI) application. The job of an expert system is to reenact the human decisions in necessary leadership forms. The fuzzy logic expert system is a blend of input/output guidelines rules and decisions that they are used to organize assurances and information against the given standards. A fuzzy logic expert system, as a rule, utilizes IF_THEN rules to think and make a decision on the procedures. In light of the proximity of helplessness and imprecision in the more critical piece of PC designing fields, fuzzy logic is a useful strategy for working up a pro structure. In this proposition, we use exsys corvid apparatus as a specialist framework device. In this thesis, we separate the factors (variables) that are being given to the corvid device into:

- Static factors like the source, destination, taken road, and the user's status.
- Numeric factors like the number of cars in the streets, cars' velocity, time of trip and amount of gas in the car tank.
- Confidential factors are the variables that fuzzy logic is depended on like traffic conditions and favorite roads for cars in the network.

Finally, after getting the OSM and convert it to the SUMO net, the proposed model depends upon the yield of SUMO as an input of the fuzzy expert system. It transforms the XML output Sheets from SUMO to a bit of the rule and offers them to the corvid expert system tool to get the perfect decision.

The possible result of this fuzzy structure relies on the benchmarks made on the corvid device. In fuzzy logic, we use IF-THEN rules, which IF part relies on clients given information and THEN brief decisions using the fuzzy expert system, in our approach. In (Figure 4.9) we dedicate the form of the rules which it will be followed, providing the best cases, and gives the program the possibility to modify the confidence variables based on the input variables each time.

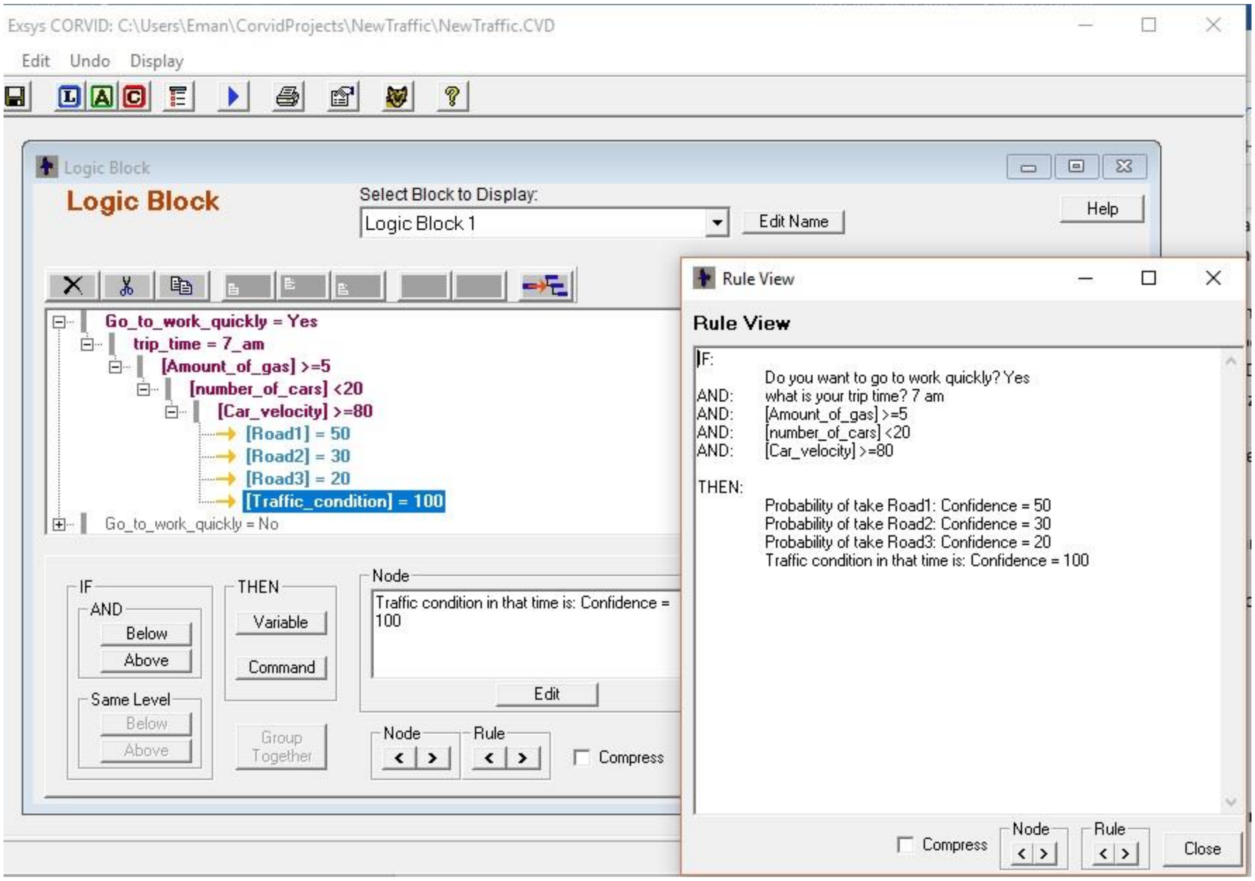


Figure 4. 9 an example of the logic rule used in fuzzy logic expert system

In (Figure 4.10) discuss the primary function of a proposed system. It explains the state of the traffic network based on the time, as we can determine the appropriate path for each user based on its inputs and what is monitored on the network at the time of path request. In the flowchart, we find that the number of vehicles (NV) affects the traffic condition and the arrival time. The following equation describes how NV is calculated, where RL is Route Length, VL is vehicle length, and 2 is the normal space between a vehicle and other.

$$NV = {}^{RL}/_{VL} + 2$$

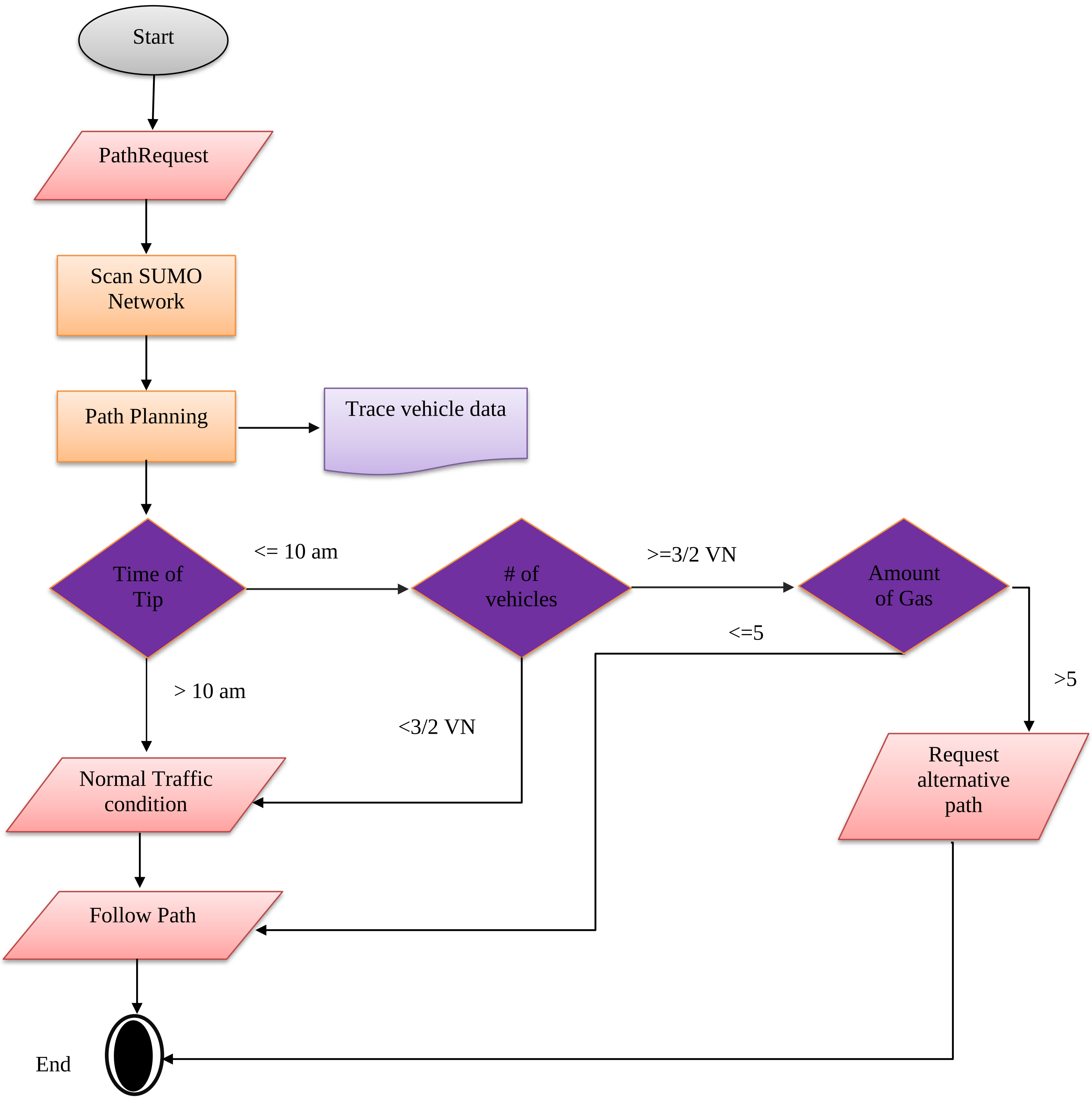


Figure 4. 10 Flowchart of the main functions of the proposed system

Chapter 5

Experimental Results

In this chapter, we will display and discuss the results of the proposed model. The results are two parts — results related to the monitoring system and results related to the expert system.

5.1 Monitoring System

Monitoring results were shown by the SUMO simulator, where (Figure 5.1) indicates the presence of a proposed model transportation network. It also displays the edges that are working, which have surrounded by traffic lights. The data that was loaded for this network are listed in (Table 5.1).

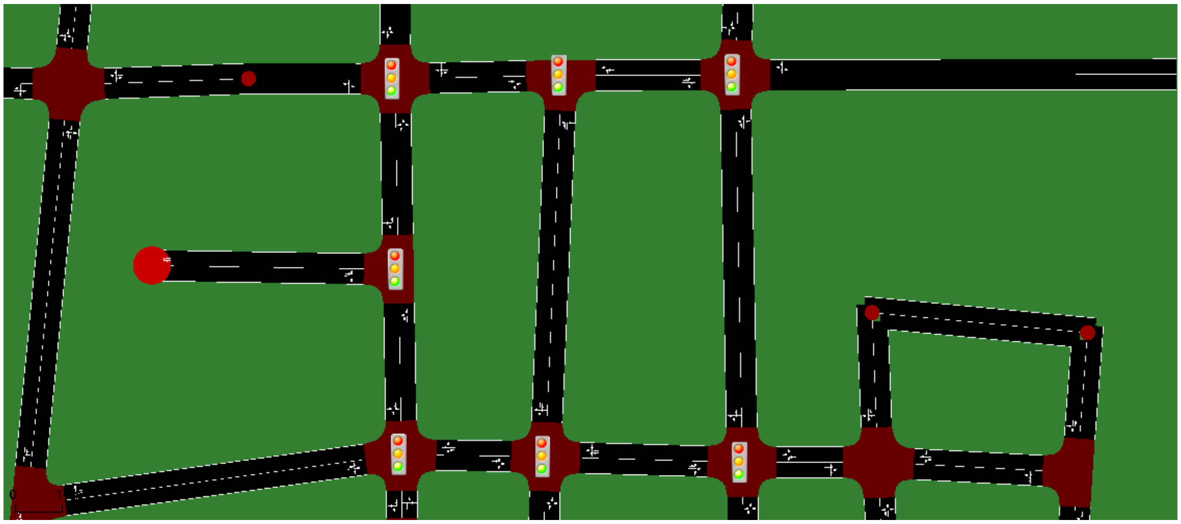


Figure 5. 1 Transportation Network used for Monitoring

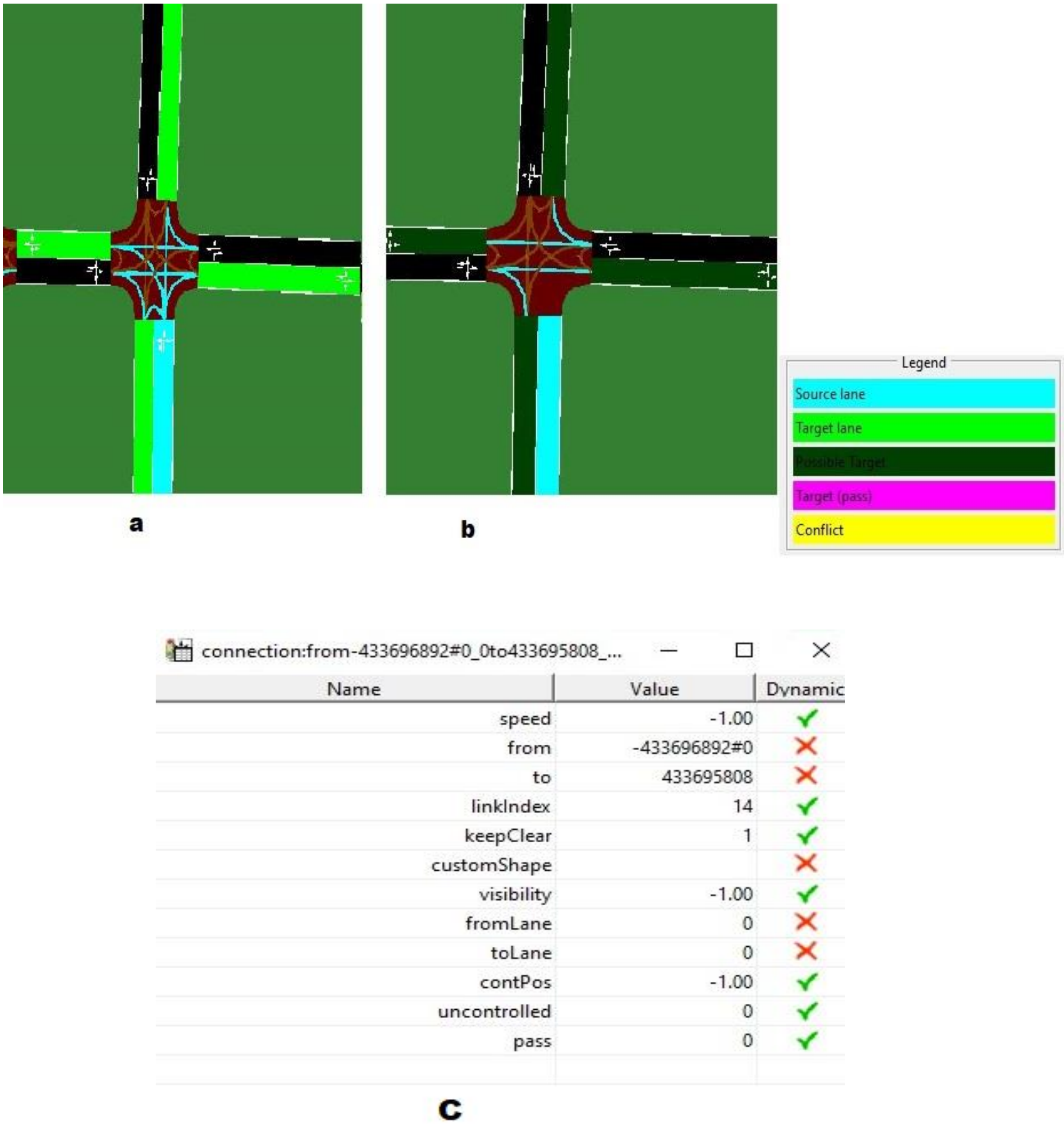
Figure 5.1 shows that there are five light signals activated at the beginning or end of the activated edges to work on SUMO network.

Table 5. 1 Scenario description for the transportation network of a proposed model

Time of loading transportation network	320 MS
Total number of loaded nodes	64
Total number of typed loaded	32
Total number of edges loaded	163
Total number of Traffic light used	7

5.1.1 Monitoring Nodes (Connection between edges)

After importing the transportation network, one of the monitoring functions is to know the connection between the edges. For example (Figure 5.2) (a, b), it shows the definition of the source lane and the destination or target lane (Possible path). (Figure 5.2) (a) define the possibilities of the moving from the source lane to target lane, wherein (Figure 5.2) (b) establishes only the source, and the possible lane may be reached from the source in that net junction. In (Figure 5.2) (C) describes the parameter of the connection between the source lane to the corresponding target lane. And this is useful to determine the movement of vehicles through the network. Also, when recommending paths for the vehicle's requests.



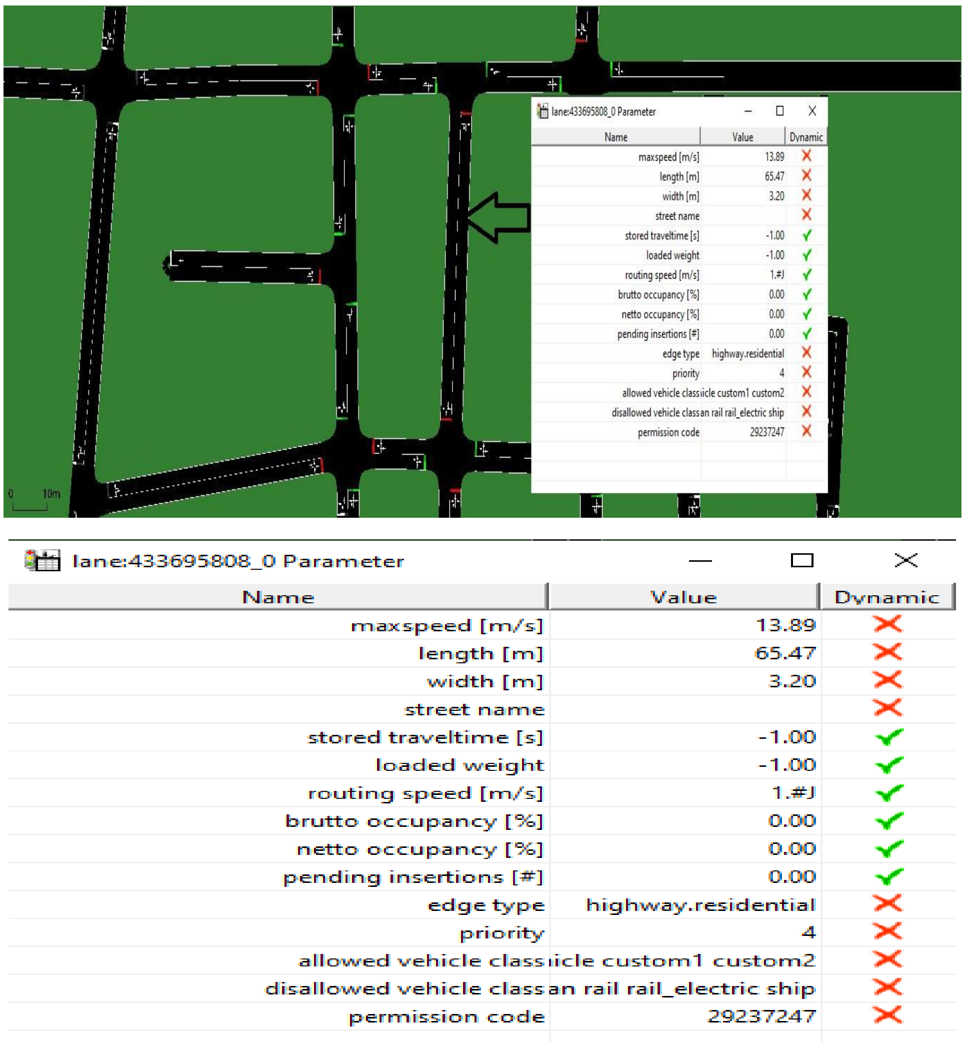
Name	Value	Dynamic
speed	-1.00	✓
from	-433696892#0	✗
to	433695808	✗
linkIndex	14	✓
keepClear	1	✓
customShape		✗
visibility	-1.00	✓
fromLane	0	✗
toLane	0	✗
contPos	-1.00	✓
uncontrolled	0	✓
pass	0	✓

Figure 5. 2 Representation of an intersection with nodes/edges in SUMO

5.1.2 Monitoring edges

Each edge of the network may be consisting of one lane, two lanes or more. A transportation network of a proposed model monitors edges with one lane and two lanes. In (Figure 5.3), the monitoring system presents the data related to the selected edgy before starting the movement of the vehicles. The parameter is more used in a proposed model is the length of the lane as it used to detect the congestion of the lanes.

Moreover, the lane width can be used to calculate if the lane can seat two cars side by side or no.


lane:433695808_0 Parameter

Name	Value	Dynamic
maxspeed [m/s]	13.89	✗
length [m]	65.47	✗
width [m]	3.20	✗
street name		✗
stored traveltime [s]	-1.00	✓
loaded weight	-1.00	✓
routing speed [m/s]	1.#J	✓
brutto occupancy [%]	0.00	✓
netto occupancy [%]	0.00	✓
pending insertions [#]	0.00	✓
edge type	highway.residential	✗
priority	4	✗
allowed vehicle class	ıicle custom1 custom2	✗
disallowed vehicle class	an rail rail_electric ship	✗
permission code	29237247	✗

Figure 5. 3 Scenario description of the edgy definition

In (Figure 5.4), the graph displays the ratio between the speed of the vehicles and the time of their presence on this edge in the first 100 seconds of observation. The graph shows that in the first 40 seconds, there are not any vehicles to go through this lane. then the movement started within the edge with one vehicle per second 41 until the time reached the second 81, which shows that there are two vehicles were moving on the same edge with different speeds, and by 84 seconds, the lane contains one vehicle until the end of the first 100 seconds. This, in turn, shows the state of this lane along the day and the speeds through it, so it helps in making the decision. if this lane is available for other vehicles or not.

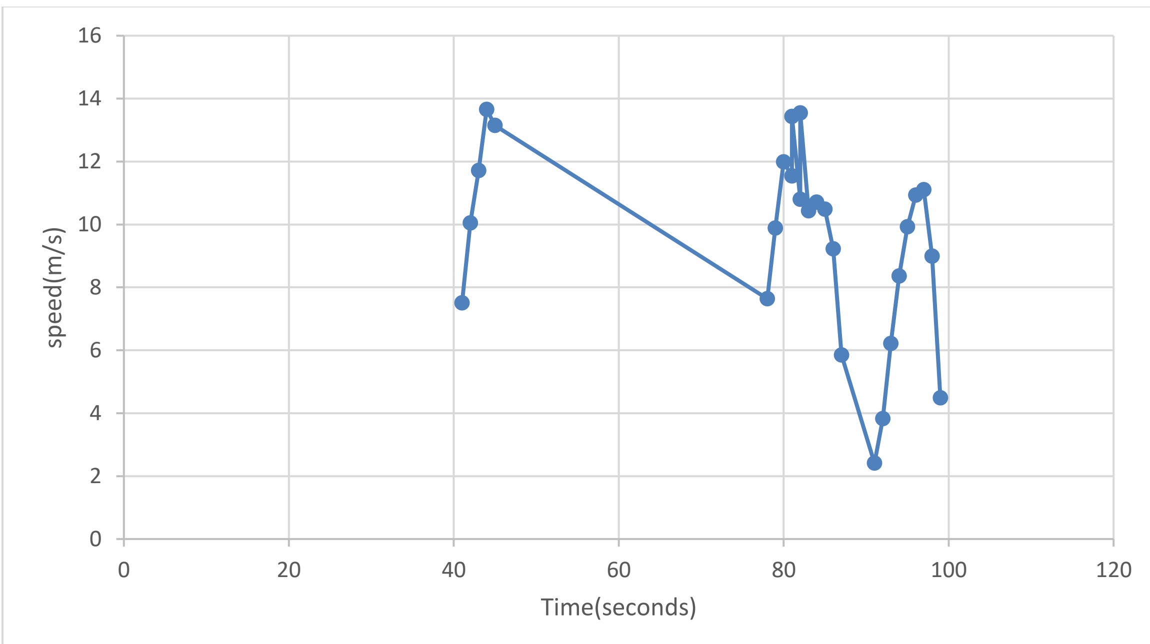


Figure 5. 4 presents the first 100 seconds of actions in lane #433695808

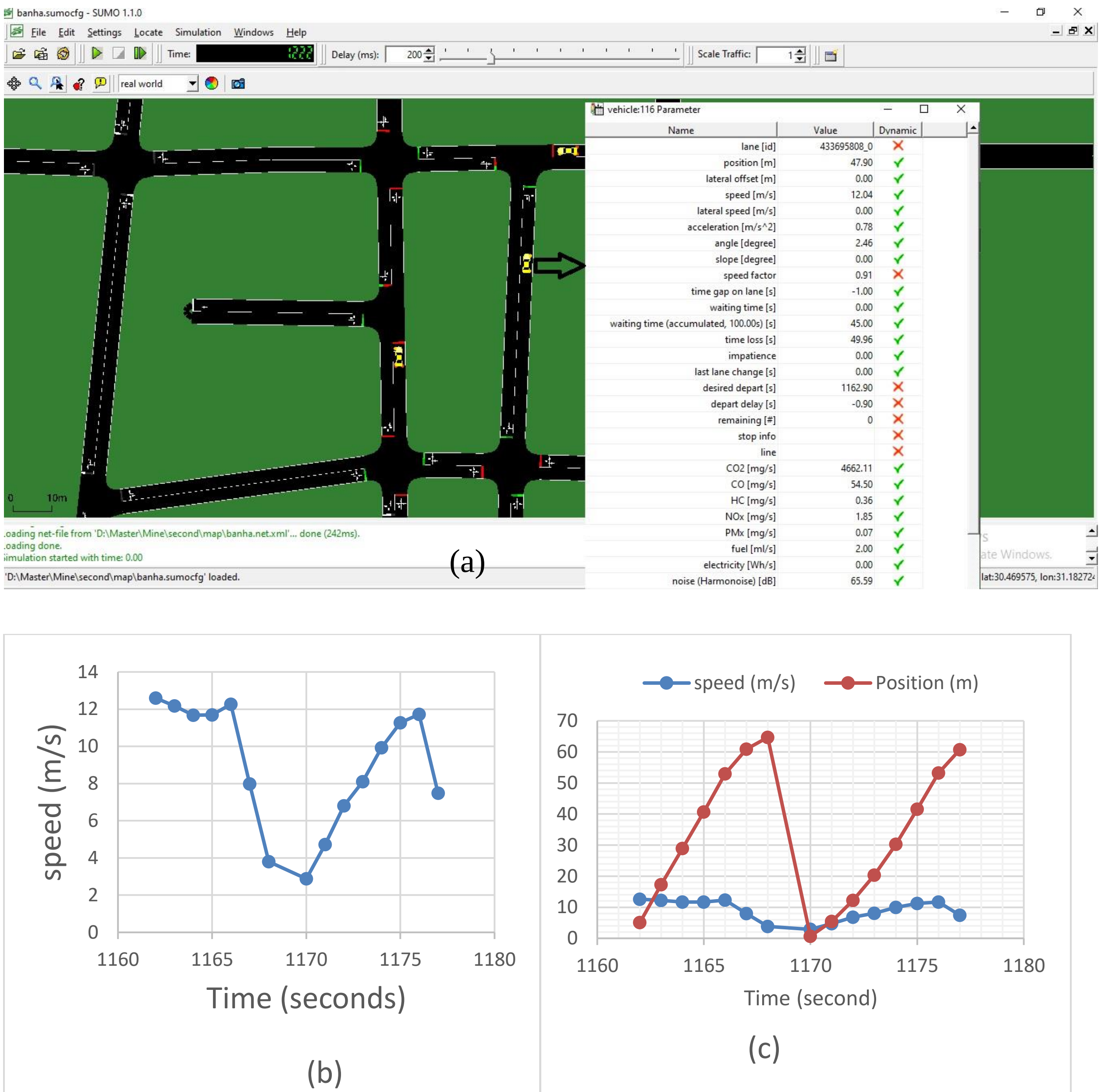


Figure 5. 5 The average of car movement concerning its speed, position, and time of move at the same edge after the 1000 seconds of monitoring

In (Figure 5.5), we still observe the same edge after 1000 seconds of monitoring where (Figure 5.5) (a) shows a moving vehicle on the edge and its parameter data at that specific location of the edge. However (Figure 5.5) (b) explains a study of the relationship between the speed of a car, its movement time, and the extent of time's effect on movement based on what was monitored in the system. It shows that at the beginning of the time the speed was high, which is the beginning of the vehicle entering to the first lane of the edge- took its permitted speed- and then started to decline, due to its entry on a red traffic light, which means the rate decreases to what is like stopping.

Moreover, when the signal is opened, and the vehicle passes the speed starts to increase along the second lane and then decreases as the vehicle leaves the lane to change its direction. Additionally, (Figure 5.5) (c) defines the relation between the speed and the position of the vehicle on edge over the time of its trip. It shows the position of the vehicle on this edge, as the position of the vehicle changes along the path, then the car changes the lane in the same edge to take the opposite lane, which carries similar positions to that in the opposite lane.

5.1.3 Monitoring traffic lights

One of the most critical elements affecting the movement of vehicles, it works to regulate the flow of routes by three red, green, and yellow colors (Figure 5.6) (a). Where (Figure 5.6) (b) is a static monitor define the time of each phase of the sign and (Figure 5.6) (c) is a dynamic monitor define the stages of the sign after starting the system. This dynamic screen monitors the status of the traffic light in the event of this screen stops. The administrator can know that there is a problem with this signal, so he performs the appropriate procedures. Every traffic light in the transportation network has its unique name, which helps to know where the problems are in.

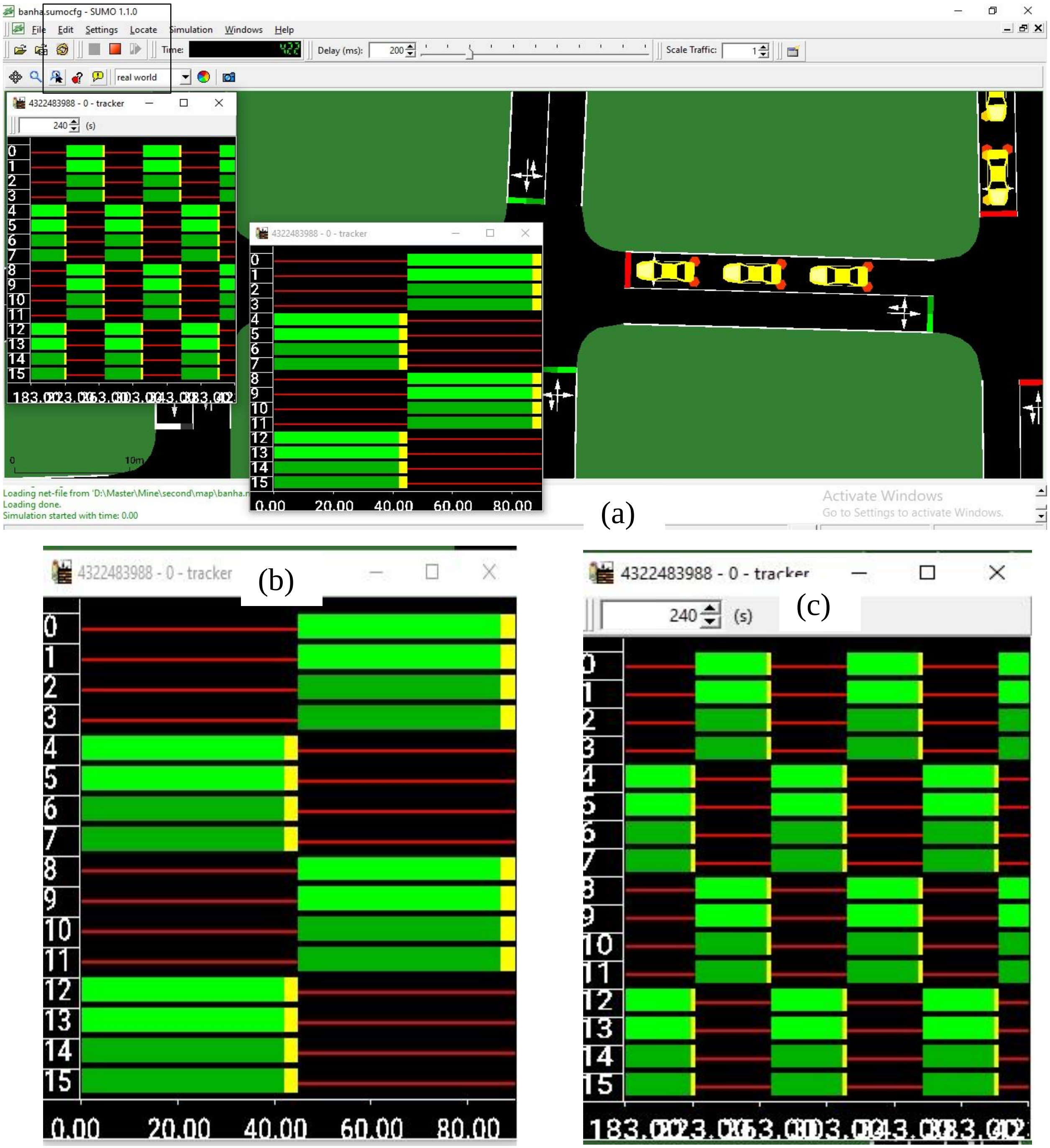


Figure 5. 6 Traffic light management system

5.1.4 Monitoring vehicles

Vehicles are the primary and vital component of the traffic control process, as they are the leading cause of congestion. Therefore, the following will display the results of monitoring the movement of vehicles and knowing their directions.

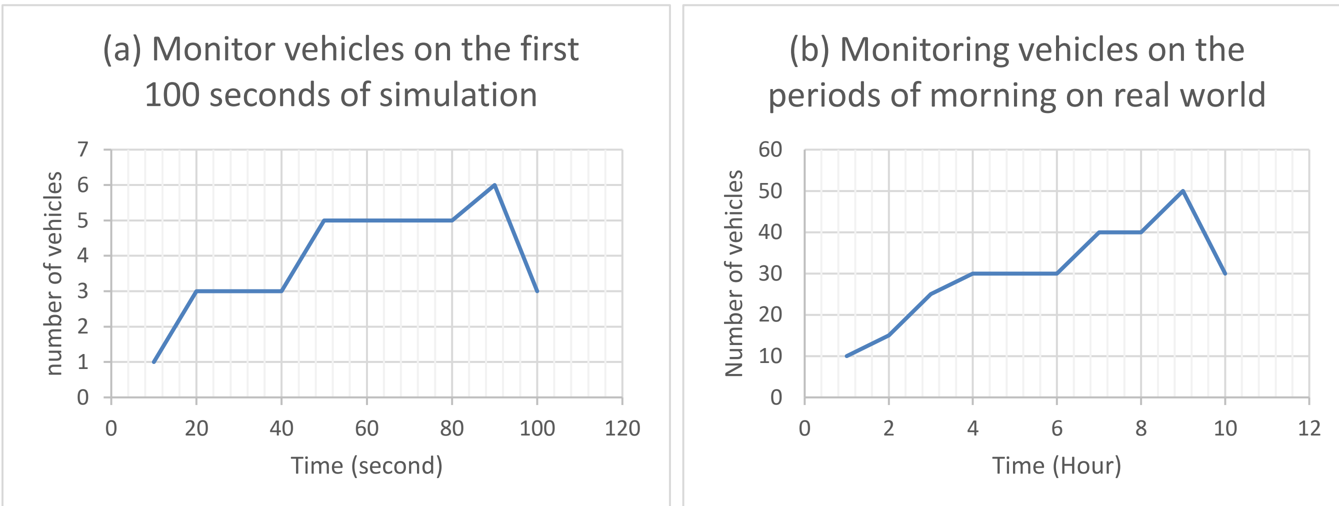


Figure 5. 7 Comparison between monitoring traffic on real and simulated world

Before presenting the SUMO results, we find that (Figure 5.7) shows a comparison between the movement of cars on the simulator and in real world, which indicates the extent of similarity between reality and simulation, and this makes us able to use the simulator to follow the movement and use its results and benefit from them. Besides (Figure 5.7) (a) we note the number of vehicles and the time of observation on the simulator. (Figure 5.7) (b) represents ten periods, as the SUMO representation, starting from 6.30 am to 4 pm, whereas the data collection place is the same as the place taken for simulation.

In the following, a discussion of the observed vehicles on the SUMO simulation.

5.1.4.1 Monitoring Speed

the system begins to detect the vehicles' speeds on the transportation network, which describe each vehicle's state. (Figure 5.8) (a) shows the movements of three cars on the first 25 seconds of monitoring. While (Figure 5.8) (b) shows the average speed observed on the map in the first 25 seconds of monitoring.

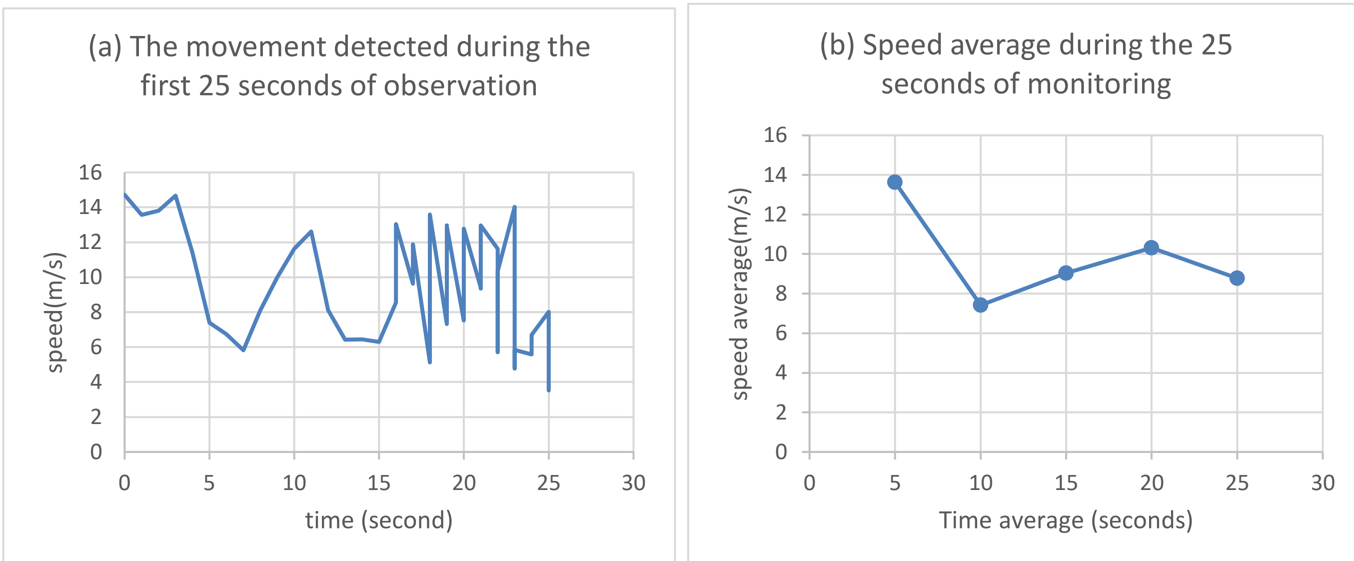


Figure 5. 8 The movement caught during the first 25 seconds of observation

The results of this observation are useful in determining the traffic condition as the high speed indicates excellent traffic, while the low speed expresses a crowded traffic condition.

5.1.4.2 Monitor vehicles Data

The system can trace every car on the transportation network and get real-time spatial data. Also, the system can detect the auto industry data recorded on each vehicle (Figure 5.9). The vehicles used in this system are all of the same default type to comply with all the rules in the expert system as a whole without changing a rule or another according to the difference in type and model of the car, such as gasoline consumption.

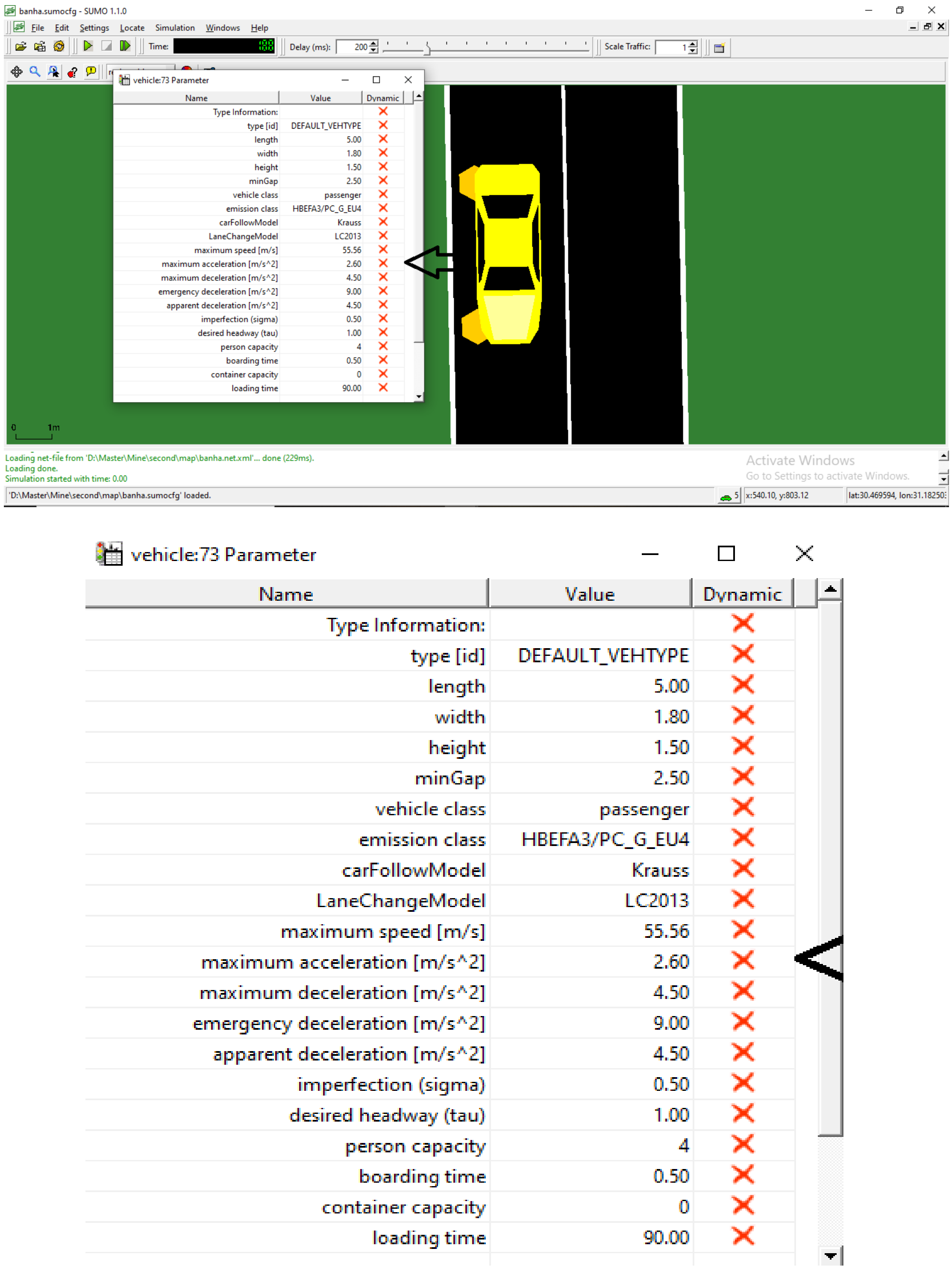


Figure 5. 9 detecting of vehicle manufacture data

Moreover, the system provides a monitoring screen for each vehicle with dynamic data, which changed every second like the monitor in (Figure 5.10).

vehicle:73 Parameter

Name	Value	Dynamic
lane [id]	-271661553#1_0	✗
position [m]	26.14	✓
lateral offset [m]	0.00	✓
speed [m/s]	10.78	✓
lateral speed [m/s]	0.00	✓
acceleration [m/s^2]	0.51	✓
angle [degree]	178.93	✓
slope [degree]	0.00	✓
speed factor	0.86	✗
time gap on lane [s]	1.60	✓
waiting time [s]	0.00	✓
waiting time (accumulated, 100.00s) [s]	0.00	✓
time loss [s]	0.23	✓
impatience	0.00	✓
last lane change [s]	0.00	✓
desired depart [s]	186.01	✗
depart delay [s]	-0.01	✗
remaining [#]	0	✗
stop info		✗
line		✗
CO2 [mg/s]	3576.65	✓
CO [mg/s]	42.41	✓
HC [mg/s]	0.27	✓
NOx [mg/s]	1.37	✓
PMx [mg/s]	0.05	✓
fuel [ml/s]	1.54	✓
electricity [Wh/s]	0.00	✓
noise (Harmonoise) [dB]	63.90	✓
devices		✗
persons	0	✓
containers	0	✓

Figure 5. 10 Monitoring screen for vehicle number 73

The data gathered by the system is useful in calculating the traffic conditions. For example, the length of the vehicle is used in calculating the states of each lane using the length of the lane, as explained in **Chapter 4 section (4.2.3).**

5.1.4.3 Monitor vehicles Path

Trace vehicle is one of the provided function by a proposed model like in (Figure 5.11). It shows the vehicle's itinerary is demonstrated from start to finish, and this is indicated in the yellow in the figure. While the green track shows the best lanes, the car can take to reach its goal. Every time the vehicle finishes from a lane, the green color disappears to the end of the trip

Figure 5. 11 Trace vehicle through defining its path

5.1.4.4 Monitor vehicles Emissions

The results are not vehicles exhaust, but also, we can dedicate the fuel consumption relationship with the amount of pollution and the speed relationship with the noise emission. All results shown relate to one vehicle on its trip from edge to another edge on the network.

(Figure 5.12) (a) shows that there is not any emission from the vehicle at the beginning of the movement. While after some time, the car starts to extract emissions, which indicated in (Figure 5.12) (b).

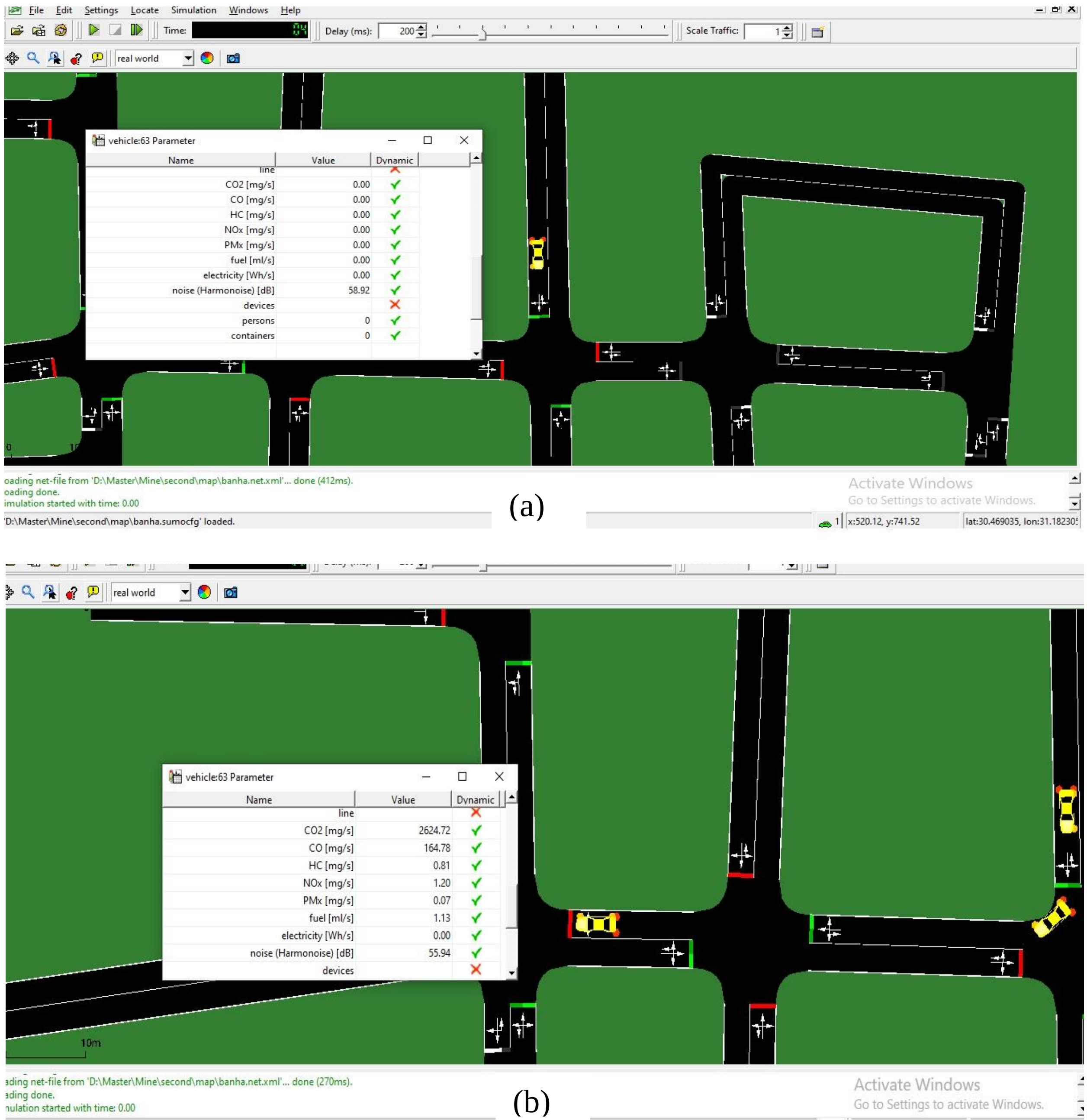


Figure 5. 12 real time vehicle emissions

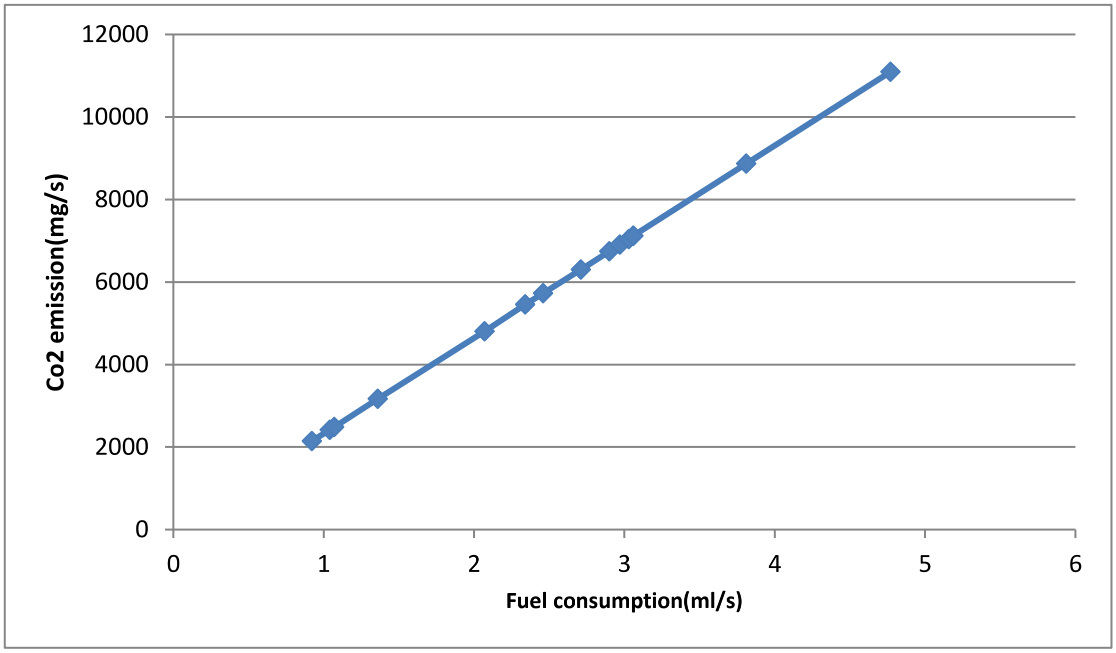


Figure 5. 13 Fuel Consumption Vs. CO2 emission

Figure 5.13 study the relationships between Vehicles Emissions and Fuel Consumption. It also shows the percentage of carbon dioxide (CO_2) exhaust in exchange for fuel consumption, through which it is advised to follow up on the use of gasoline while walking to avoid increasing the exhaust rate.

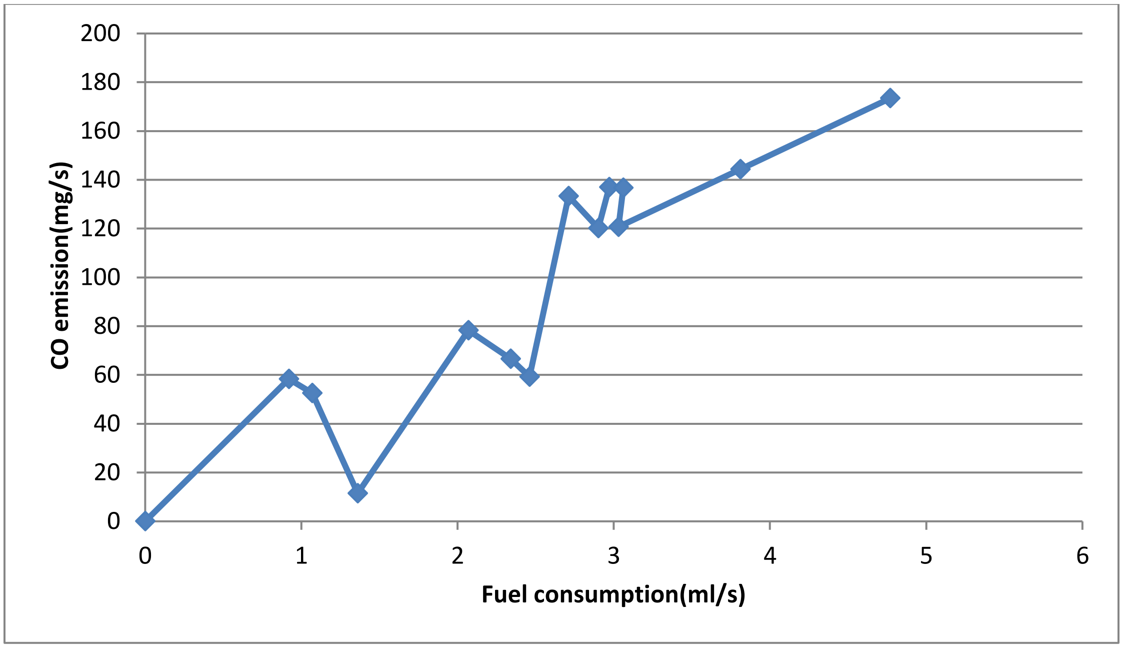


Figure 5. 14 Fuel Consumption Vs. CO emission

Figure 5.14 defines the relationship between fuel consumption and carbon monoxide (CO), where (Figure 5.15) presents the ratio of hydrocarbons (HC) exhaust; moreover, (Figure 5.16) clarifies the nitrogen oxides (NOx) exhaust, and finally (Figure 5.20) shows all exhaust from the vehicle through its trip vs. its fuel consumption.

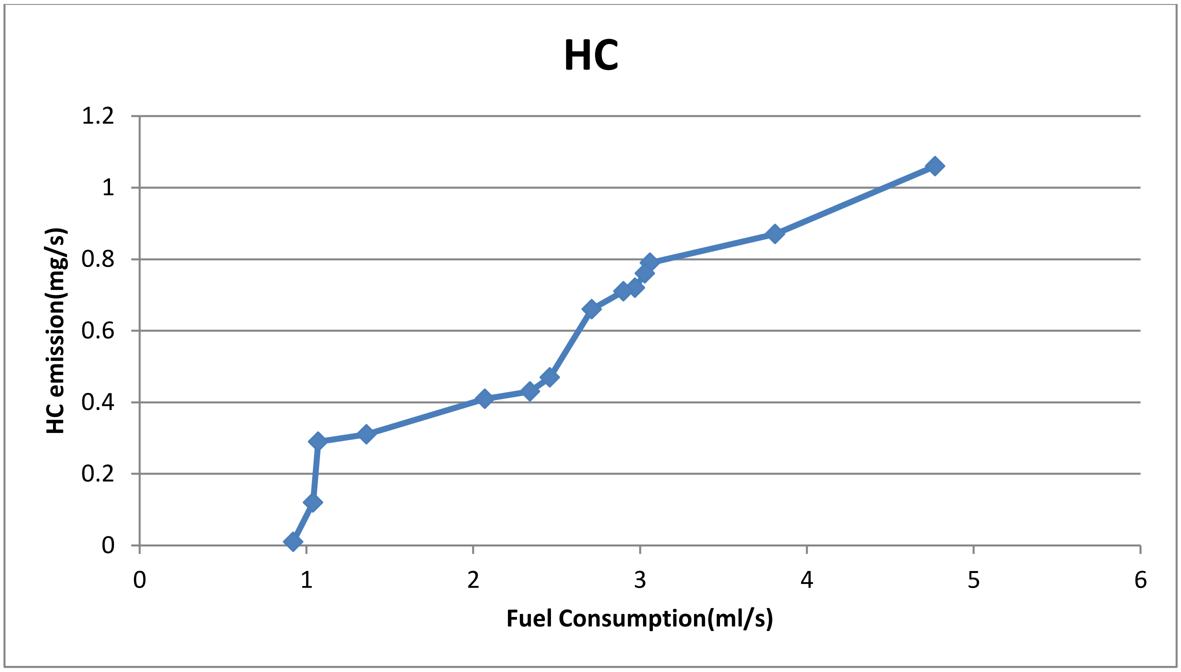


Figure 5. 15 Fuel Consumption Vs. HC emission

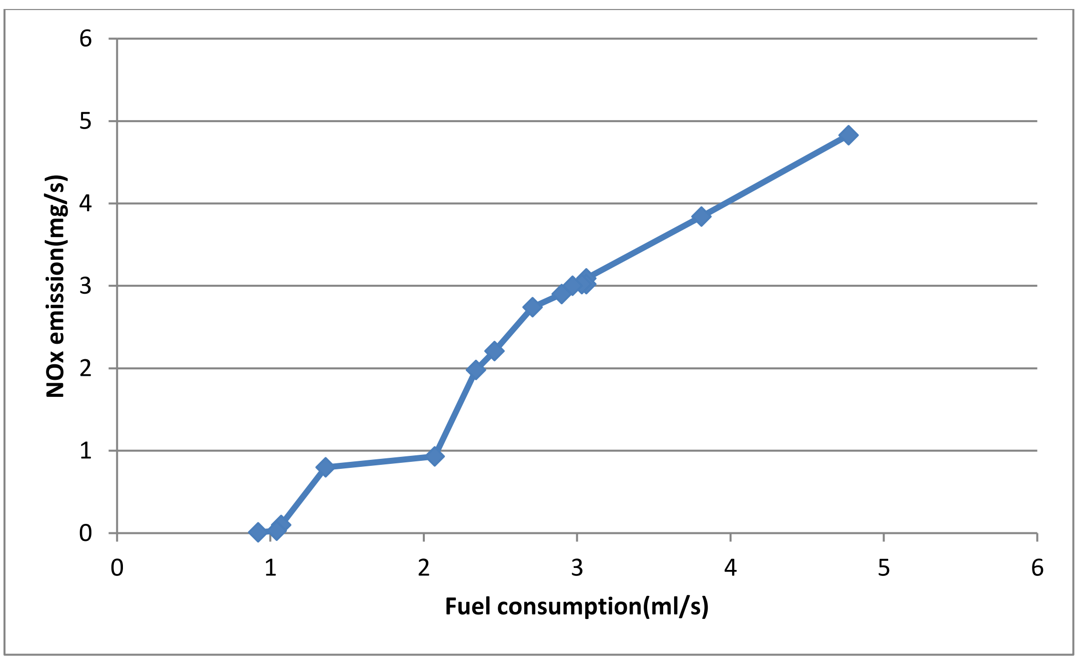


Figure 5. 16 Fuel Consumption Vs. NOx emission

Figure 5.17 shows the relationship between the car’s speed and fuel consumption, which shows that the car’s speed begins to increase with increased use of fuel until the car reaches a fixed speed amount in which consumption increases at a lower rate from the beginning, and then the fuel consumption increases with a slight change in the car’s speed, which indicates the presence of a factor affecting the vehicle's speed at the new lane on the network.

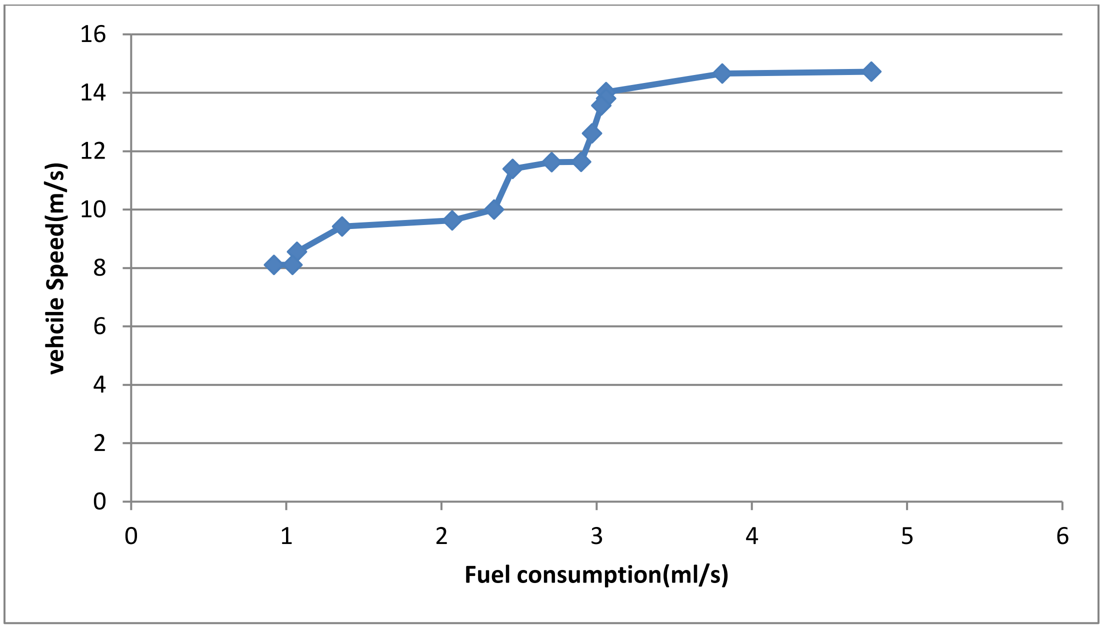


Figure 5. 17 Fuel Consumption Vs. Vehicle speed

Additionally, Figure 5.18 describes the change in the car’s location during the trip and the extent of the increased noise pollution emitted by it. The drawing shows an increase in noise emission during the trip, which indicates the possibility of stopping the road during the journey, which suggests the presence of congestion in the places of increased noise pollution.

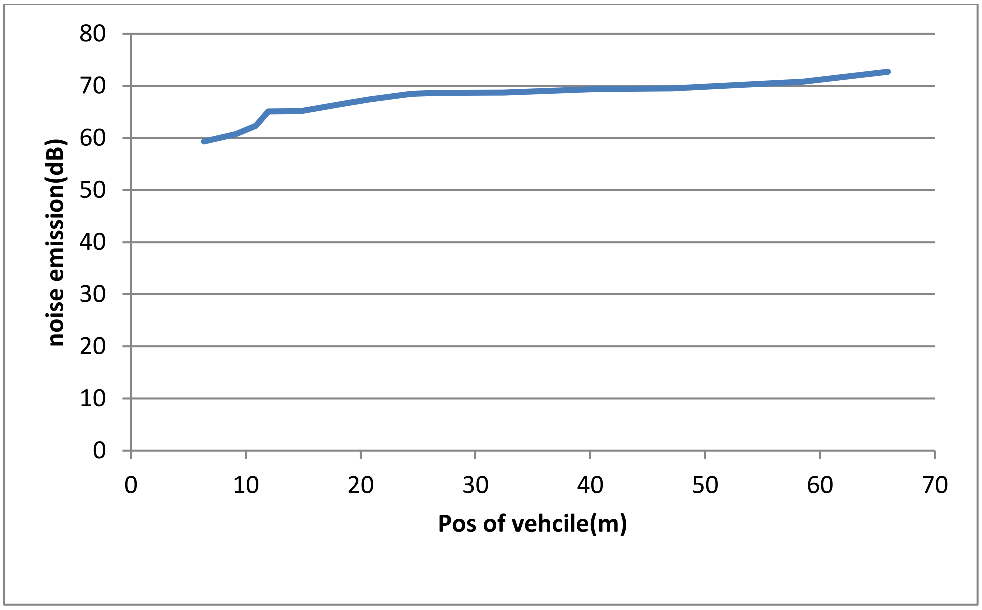


Figure 5. 18 Position of Vehicle Vs. Noise emission

Moreover, Figure 5.19 proves the authenticity of the previous figure when progress at the time of the trip has the potential for the road to be locked by congestion, which increases noise emission.

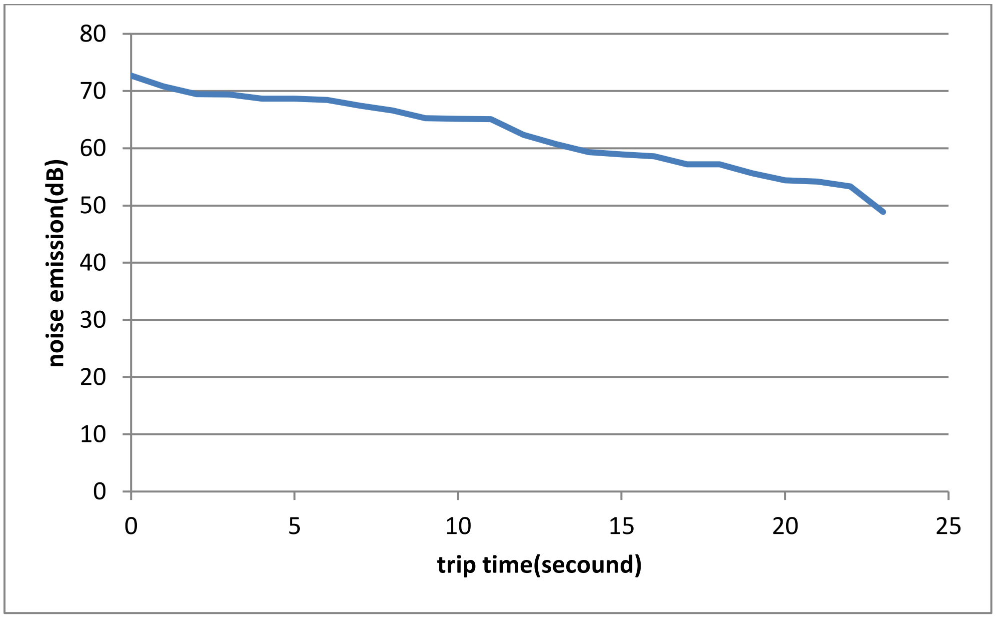


Figure 5. 19 Trip time Vs. Noise emission

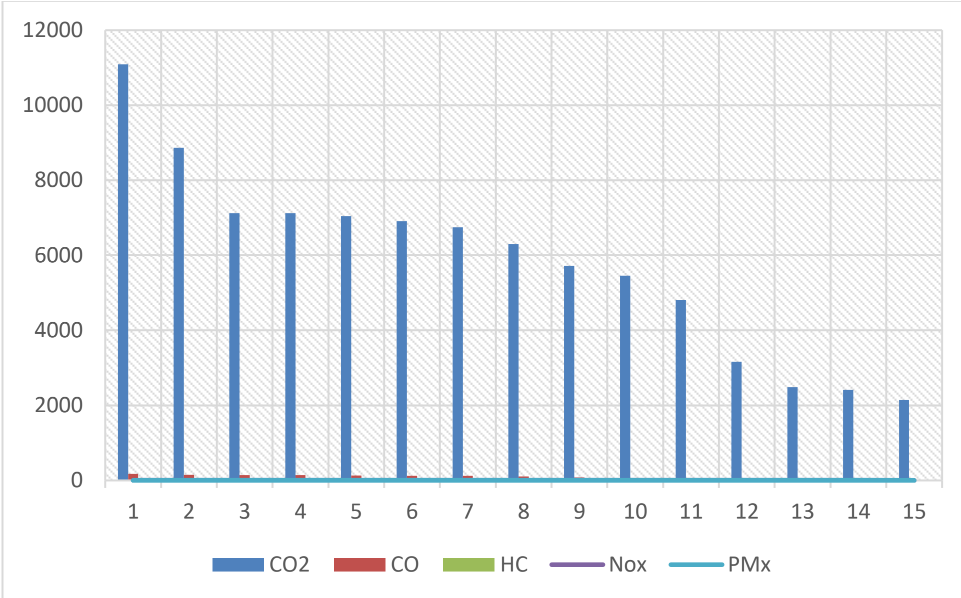


Figure 5. 20 Total vehicle emissions

5.2 Fuzzy Logic Expert System results

What could happen if I had some variables that might affect the trip?! Factors like if a user is in a hurry or not, time of the trip, amount of gas in the car, number of vehicles in the taken road and their velocity and the most critical factor, and it is the traffic condition in the time of the trip.

In this stage, we discuss the accessibility through the main road, and alternative paths where the first road is the main and the alternative routes are Road 2, Road 3, and Road 4. in standard cases Road 1, is the best chosen followed by Road 2, Road 3, and Road 4 which has the least probability in standard case and high probability in emergency cases.

By using the exsys corvid tool, we use the confidence variable to know if this is the best road or not. A road with high confidence is the best.

Traffic Conditions are : Normal flow

Amount of Gas 5.0

Do you need to go to work/home quickly? Yes

Trip time 8.0

number of car 30.0

car velocity 50.0

Go to home/work via Road 1= Conf=200.0

Go to home/work via Road 2= Conf=55.0

Go to home/work via Road 3= Conf=35.0

Go to home/work via Road 4 Conf=10.0

Figure 5. 21 sample result shows that Road 1 is the best

Figure 5.21 shows that in the normal flow of cars, the best road is Road 1 Even if the amount of gasoline in the car is small because it is the shortest road and the least consumption of gas.

After working on some of the real data of vehicles and by using the SUMO we find that the relation between the car velocity and trips time after the 10 am, which is shown in (Figure 5.22) that the velocity started with the minimum at that period of the day then increase.

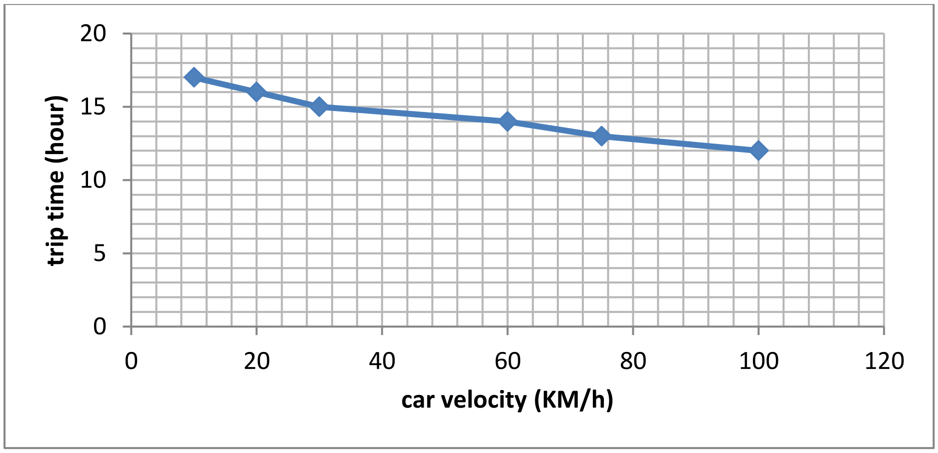


Figure 5. 22 Fuzzy knowledge system on real data

Chapter 6

Conclusion and Future Work

6.1 Conclusion

This thesis presented a novel method of working on traffic and transportation as an intelligent technique. In our system, we tried to work with real data but on a simulation program so that we can retrieve information about transportation. We had been able in our new system to create a network of a real area, provided trips on this network, and also determined the direction of trips on the network and the number of vehicles on each trip.

In our system, we were able to get information that was hard to get from the real traffic world especially for a large number of vehicles. We could extract data about the directions of the trips from the source to the destination passing through other edges to the end. Moreover, our system traced data of each vehicle on the network and got data like GPS, speed, time, and so on, which we called Floating Car Data (FCD).

Additionally, we got emissions of the vehicles in the actual simulation step, lane change files, and raw vehicle position dumper.

The other part of our system was related to the expert system, where we created a fuzzy logic expert system depending on the data was extracted from the simulation steps. The outputs of this (Fuzzy Logic Expert System) FLES were reports, which helped users and decision-makers.

6.2 Future work

In the future work we intend to work on:

- The management of oversees traffic and transportation utilizing SUMO and TraCI to build up the algorithms of vehicles' developments.
- We are thinking about how to analyze all extracted data from SUMO to get more and more useful reports.
- Distinguish problems on the roads, such as industrial pumps, drilling, accidents, and any other issues.
- Focus on the relation between noise emission and the speed of the vehicles.
- Apply a fuzzy system on different types and models of vehicles.

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ملخص الرسالة

الطرق والنقل والمرور مجموعة متنوعة من أكبر المشكلات في المجتمع التي يواجهها صانعو القرار. الطرق المدمرة المليئة بالمطبات الصناعية تؤدي إلى مشاكل في السيارات وأيضًا وقوع العديد من الحوادث والكثير من الخسائر المادية والمعنوية. أيضًا ، تؤدي سعة الطريق الضيقة إلى زيادة عدد السيارات في مساحة أقل من المساحة المفروضة. بالإضافة إلى ذلك ، أعمال التطوير وبناء الجسور على الطرق العامة دون إنشاء طرق بديلة ، والتي تسبب الكثير من الازدحام المروري والحوادث. تشير هذه المشكلات إلى عدم وجود تفكير منطقي ومنهجي لحل مشكلات الطرق.

علاوة على ذلك ، زيادة عدد السكان والافتقار إلى فرص العمل ، مما يؤدي بالعديد من الشباب إلى شراء السيارات أو سيارات الأجرة. لخلق فرص عمل لهم دون الأخذ بعين الاعتبار العدد المتزايد من المركبات التي تتسبب بالتالي في اختناقات مرورية. بالإضافة إلى كل ما سبق ، يعد ازدحام المرور في ساعة الذروة مشكلة لا مثيل لها.

كل النقاط ، كما ذكر أعلاه ، تسبب مشاكل للمجتمع والأفراد. تهدر الطرق المزدحمة الوقت وغالبًا ما تتسبب في وفاة بعض المرضى الذين يتم نقلهم بواسطة سيارات الإسعاف التي تقيد وصولها إلى المستشفى بسبب الاختناقات المرورية. أيضًا ، يعد عادم السيارة من أكثر الآثار خطورة على البيئة بشكل عام والأفراد بشكل خاص. لحل جميع هذه المشكلات ، يتعين علينا الحصول على بيانات حقيقية حول البنية التحتية للمنطقة المحددة والبيانات الفعلية حول الطرق وحالات المرور. ومع ذلك ، هذه ليست محاولة محتملة لأنه لا توجد مجموعات بيانات حول البنية التحتية أو المركبات. الحلول الأخرى هي توفير أجهزة استشعار على جوانب الطرق ، وأجهزة استشعار في السيارات ، وتطبيقات الهاتف المحمول ، كما أنه من الصعب حفظ كل هذه الأنواع من أجهزة الاستشعار في الطرق والمركبات. إذن هذه الأطروحة تقدم حلولاً من خلال محاكاة الطرق

والسيارات وسلوكياتها على الطرق على) SUMO محاكاة الحركة الحضرية). ليس هذا فقط ولكن أيضًا تقديم نظام خبير منطقي (FLES) لإنتاج تقارير لصناع القرار.

كلية الحاسبات والذكاء الاصطناعى

جامعــة بنهــا

نظام النقل الذكى على أساس إنترنت الأشياء

رسالة

مقدمة إلى قسم نظم معلومات كلية الحاسبات والذكاء الاصطناعي جامعة بنهــا

كجزء من متطلبات الحصول على درجة الماجستير في نظم المعلومات

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