Design of Route Finding for Addis Ababa City

Name of candidate: Moti Bacha

A Thesis submitted to the Department of Computer Science and Engineering

School of Electrical Engineering and Computing

Presented in partial fulfillment of the requirement for the Degree of Masters of Science in Computer Science and Engineering

Office of Graduate Studies

Adama Science and Technology University (ASTU)

June 22, 2020

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Declaration

I hereby declare that this MSc thesis is my original work and has not been presented as a partial degree requirement for a degree in any other university, and that all sources of materials used for the thesis have been full acknowledged.

Name: Moti Bacha

Signature: ____

This thesis has been submitted for examination with my approval as thesis advisor.

Name: Mohammed Wazih Ahmad (Ph.D.)

Signature: ____

Date of Submission**: 06/22/2020 G.C**

Approval of Board of Examiners

We, the members of the board of examiners of the final open defense by Moti Bacha have read his/her thesis entitled "**Design of Route Finding for Addis Ababa City**" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Computer Science and Engineering.

______________________	________________	______________
Supervisor/Advisor	Signature	Date
______________________	________________	______________
Chairperson	Signature	Date
______________________	________________	______________
Internal Examiner	Signature	Date
______________________	________________	______________
External Examiner	Signature	Date

Acknowledgment

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GIS = Geographic Information System

ITS =Intelligent Transport System

KML =Keyhole Markup Language

TSM = Transportation System Management

RDBMS =Relational Database Management System

RFID = Radio Frequency Identification

SDCS = Speed detection camera system

DRIP = Dynamic Route Information Panels

GPS =Global Positioning System

YOLO = You Only Look Once

R-CNN = Regional-based convolutional neural networks

CPU = Central Processing Unit

GPU = Graphical Processing Unit

CUDA = Compute Unified Device Architecture

C = Consistence

ATIS = Advanced Traveler Information System

VMS = Voice Messaging System

NLP = Natural language processing

Abstract

Addis Ababa, the administrative and financial capital of Ethiopia is experiencing continued growth and change. Enabling change is more complex and has many results that need to be optimized and balanced by promoting sustainable growth. Road traffic congestion is a major problem in urban area of both developing and developed countries. The traffic congestion is often intensified by drivers habitually following the same routes and there is no information about status of the road. Route finder information, optimum vehicle routing system that takes traffic density into system can be a possible solution to this problem. Theoretically, if the driver keeps the same driving mode, the shortest path will cost the shortest time, but in reality, the traffic environment is complex and the driving speed is variable thus the shortest path is probably not the fastest path. The normal expectation of route choice is that a path between an origin and a destination will be selected (in advance) so as to minimize the distance and/or time required. Less often discussed are the decisions that motorists make while driving about which roads to use as a result of their own perceptions of the traffic situation. The effect of traffic congestion on the study area are delay movement, accident, inability to forecast travel time, fuel consumption, road rage and environmental pollution. Shortest or quickest best route analysis is one of the many web mapping service currently available. For route finding determining shortest distance and traffic congestion are the big problem of Addis Ababa city because of that identifying traffic congestion are the best solution. For the traffic management, vehicles detection is the critical step. In this research we have designed quickest route to destination for Addis Ababa city and also able to detect objects with accuracy by 97.47%

Keyword: Object Detection, traffic congestion, route finder, YOLOV3 algorithm

CHAPTER ONE

1. Introduction

Addis Ababa, the administrative and financial capital of Ethiopia, is experiencing continued growth and change. It is also home to the African Union, the Economic Commission for Africa and other international organizations. For administration purposes, Addis Ababa is divided into 10 sub-city. Hence, Addis Ababa has a significant involvement to the economic, social and political sector development of the country. Over the past years, the city of Addis Ababa has witnessed an amazing expansion of the city size. Located at hear of the country with a population of 6-7 million and the roads of Addis Ababa cover around 2,200 km. With the economic growth, the number of motor vehicles has increased rapidly for the last decades, especially in Addis Ababa city. One of the major transportation problems is route finding. With the considerable and complicated road network of a modern city or country, finding a route to travel from one place to another is not a simple task. Critical problems in metropolitan cities are the ever-increasing traffic congestion. Congestion may be defined as the condition where a vehicle covers little distance and moves slowly due to the high concentration of vehicles that are beyond the holding capacity of the road. The rapid growth of the number of cars on the roads has created a plethora of challenges for road traffic management authorities such as traffic congestion, an increasing number of accidents; air pollution and fuel consumption. Road traffic congestion is a major issue in most Addis Ababa cities [**1**]. There is a common agreement that traffic congestion is one of the biggest problems in everyday modern life and creates several costs. The main findings of this research are depending on the source and destination determine shortest time and heaviest traffic jam. It is recognized that the shortest distance does not always provide the best solution due to extra time consumed as a result of traffic conditions along the way. Moreover, this research demonstrated how a decision-maker should choose the best routes to deliver a destination based on the criteria and constraints presented in this research. The congestion, safety, and environmental problems has increased to such an extent that it has become increasingly difficult to navigate due to the combined effects of rapid motorization and urbanization. With the development of the Intelligent Transport System (ITS) and Geographic Information System (GIS), the increasingly intensive demand for route guidance systems in real-time has coincided with the increasing growth of roads in the real world. **[19]**GIS is the tool that can manage and maintain road data efficiently. The main characteristics of the Geographic Information System (GIS) that differentiate it from other information systems are its spatial data and geo-statistical analyses. Such analytical functions usually present the best solutions to the users of GIS. The integration of these analyses with high visualization capabilities lead GIS to be widely used in the decision-making process. A GIS (Geographic Information System) is about the scientific investigation of geography. It is searching computer hardware, software, and geographic data together to capture, display, investigate, analyze and manage of geographic information**[2**].The goal of Intelligent Transport System (ITS) is to apply Information Technology concepts, Communication Networks, Internet and other technologies to Transport Management System (TMS) to improve travel time, safety, reliability, passenger convenience and mitigating traffic congestion. GIS technology is appropriate for a variety of usages including resource management, land surveying, and traffic planning. Traffic uses GIS technology to solve problems, find solutions for traffic congestion, delivering better services distribution, and making good decisions. Also, GIS technology has been implemented in service management for displaying large volumes of diverse data pertinent to various local and regional planning activities. A route guidance system helps to tackle many of the transportation problems by minimizing congestion and ensuring uniform utilization of the road network. For this purpose modeling of real road networks into digital map format is necessary that requires a large amount of preprocessing time and human effort **[3],[7],[8]**.This paper presents Route Finder, a system of providing real-time traffic density mapping on the driver's smartphone using an in-vehicle module built using inexpensive components that communicate with the existing mobile telephone network, to enable the driver to choose the short distance or least congested route to the desired destination. With the help of the Internet and accompanying tools, creating and publishing online interactive maps has become easier and rich with options. For example, a city guide web site can use maps to show the location of restaurants, museums, and art venues. These days, one of the most popular uses of web mapping is delivering map base local information. Good examples of such kinds of web mapping services include Google Maps, Yahoo Maps, Bing map, and Google earth to mention few **[5], [6]** and **[10].** To determine traffic congestion three levels (options) are available in this point. Those are:-crowded road (traffic jam), less crowded and free road depending on the number of car.

- ♣ **Traffic Jam**: there are many number of cars and almost all of them run very slowly
- ♣ **Less crowded**: there are a many number of vehicles and most of the vehicles run at half speed
- ♣ **Free road**: there are a minimum number of vehicles and the vehicles run at normal speed

In **[17]**,another study relied on GIS to identify deficient facilities (i.e., tolerable, moderate, moderate to heavy and heavy road deficiencies) in the vital area within Riyadh's ring road by incorporating the link volumes resulting from the travel demand forecasting into the network attribute table in GIS. The shortest path and travel time allocation of major activity centers analyses are also investigated. Also demonstrate the importance of Geographic Information System (GIS) as a support tool in developing policies for the organization, management, and promotion of transport efficiency in Almada, a Portuguese city. When we check traffic congestion the methodology that are traffic counting, travel time and vehicle speed are the most important. Sensing type loop detectors are installed along the route and the signal system is capable of providing data about the free, slow and traffic jam back to the traffic estimation system. Also, since many urban transportation networks are operating at near capacity, they are especially vulnerable to congestion occurring as the result of unplanned incidents such as accidents and infrastructure failures (e.g., bridge closings, construction).GPS provides autonomous geo-spatial positioning and navigation service. GPS is available to all anywhere and any weather condition without any controls. After the prediction of traffic state through GPS, the system suggests the alternate route to the user by using various algorithms **[2][4].** The alternate route must be least congested, shortest distance, minimal delay path. Once the user enters the destination, the navigation service will show the shortest path from the location of the user to the destination. In this paper we present Route Finder, a system that uses standard communication signals from a mobile phone network and a digital map to determine the optimum route to reach a destination. For the future purpose, we have designed Route Finder that helps a user to compute the cost-optimal path inefficient way. It helps us to find better paths to travel from source to destination.

1.1. The motivation of the study

In Addis Ababa, the number of vehicles increases day to day leads to denser urban mobility (Table 1: Causes of traffic congestion). In the city especially, every day in the morning and every day in the afternoon the road is crowded by cars. The number of cars increment on the road leads to the narrow road, a gap of information about another route is available or not and driver use of the same route. To minimize this problem one solution is to use route finder by understanding traffic congestion. But the problem is no new system related to the route finding task is adapted in the city. To minimize road crowded, air pollution and fuel-efficient ride, proposed identifying traffic congestion is one of the best solutions; because it solves the problem of drivers on the crowded roads. Route Finder shows the locations of vehicles in all possible routes from origin to destination, to enable the driver to choose the route with the shortest distance and traffic congestion **[3].**

1.2. Statement of the problem

There is a big problem in both accessibility and availability of information about how a person could navigate from one place to another and what the condition to reach the desired destination is. Traffic congestion has been one of the fundamental problems faced by modern cities since the wide usage of automobiles. The ultimate solution is usually to ask people nearby for information. The reliability of this information is limited to the availability of the person to ask from and also on that person's knowledge and the willingness to share the information plus the level of accuracy of the information. The small road capacity is also one of the contributing factors. As the number of private cars increases greatly over the years, traffic congestion occurs when the needed road capacity is not fulfilled.There are many reasons behind this problem among which the common reasons are poor traffic management, cars changing lane and unplanned stoppage. Route finding in case of traffic congestion is an on-going and old problem unless managed properly signs of improvement in cities. It has detrimental impacts on the economy, health, and environment as evidenced by delays, which may result in late arrival for employment, meetings, and education, resulting in lost business, disciplinary action or other personal losses. Wasted fuel increases air pollution and carbon dioxide emissions contributing to global warming, health and environmental problems owing to increased idling. Traffic jam comes with stress and frustrations which may lead to accidents. Finally, Blocked traffic may interfere with the passage of emergency vehicles traveling to their destinations where they are urgently needed. Building new roads to address the congestion problem is not the only solution other methods using current technology are needed to better manage traffic. Technology will provide a platform for visualization of historical and real-time traffic data which is currently missing. The provision of accurate travel time information to the public is critical as they can make an informed decision in terms of which alternatives routes to use and what is the most appropriate day of the week and time to travel.

There is no web map business location service. Besides there is no web service that advises online users which streets that they can use to travel from a given point to a given point in time and check the roads are free or not. Using web-based service facilitates the daily life of mankind and reduces the cost of obtaining information. Tourists, guests, travelers, and the likes yearn for local information like the location of things and the best route from a point to point as they come into new places. Hence, Web-based services that deliver information that can be consumed by the above-mentioned groups of people are of paramount importance and plays a pivotal role in providing the basic set of the technological solution. A problem statement always expresses the words that will be used to keep the effort on tracking things out to represent a solvable problem with the existing system (Linus, 2014). Below are the problems with the existing system. Those are:

- Time consume when the roads are traffic congestion
- No information about the status of the roads are free or not

1.2.1 Research Questions

These problems motivate us to carries out this research work. The above defined and explained problems summarized in the following research questions:

RQ1:- What is the main benefit of designing Route finding system in Addis Ababa city?

RQ2:- What might be the root cause of the traffic congestion and how to solve it?

RQ3:- Which methods have been used to analyze object detection of car counting and how detection evaluation can be improved?

1.3. Contribution of the Study

The main contribution of in this study is developing route finding for Addis Ababa city in case of traffic congestion. This research work is to provide a system that will minimize the challenges associated with the current manual system of finding the Shortest or quickest best route to reach the destination. The people who are not familiar with the driving environment, and want to reach their destinations in the shortest time without confusion. It is necessary to provide a route plan which will cost the fewest time. Theoretically, if the driver keeps the same driving mode, the shortest path will cost the shortest time. In this study, the fixed factors which will impact the speed of vehicles are turnings, schools, hospitals, traffic lights, and residential area. We set different weights to different factors. Besides the factors mentioned above, we also set a user-controlled factor, which stands by the sites of traffic jams, accidents, and temporary construction on the road.

1.4. The objective of the Study

1.4.1 General objective

The general objective of this research are to develop a design of route finding for Addis Ababa City

1.4.2 Specific Objective

- Determine street traffic information dynamically in case of traffic congestion
- Prepare a dataset of vehicle images for object detection
- Implementing car detection and counting
- Evaluate the proposed architecture

1.5 Research Methodology

To achieve the objectives of this research, different methodologies were employed. The detail of the research methodology is explained in Chapter 3. To achieve the objective of this research work the following processes are involved:-

1.5.1 Analysis of Existing System

To avoid the rapid growth of the number of cars on the roads has created a excess of challenges for road traffic management authorities such as traffic congestion, an increasing number of accidents; air pollution and fuel consumption associated with the last minute some drivers look forward to making route-finding before the actual time of travel.

1.5.2 Methods of Data collection

For using methods of data collection deeply in chapter 3.Some methods are questionaries, identifying existing system problems, and online materials. To acquire the needed knowledge, both secondary and primary (documented and undocumented) sources of knowledge are used. Primary knowledge is gathered from Addis Ababa city Transport Authority and Traffic Police commission directorate. The secondary sources of knowledge are collected by using document analysis. Interview (both structured and unstructured) is used to collect tacit knowledge from the domain experts. Also, analyzing elicitation methods are to be used to purify the collected knowledge. The acquired knowledge is refined with the consultation of the experts. Moreover, secondary sources of knowledge are gathered from the internet, papers related to in this research

1.5.3 Hardware, Software and Programming Tools

Different hardware, software and programming tools are used to design and implement the proposed architecture.

Hardware tool

- ✓ Laptop**:** The laptop computer is used for finalizing my thesis

Software tool

- ✓ Design tool: drawio
- ✓ Data Annotation Tools: Labelimg
- ✓ Editing tool: MS-Word 2013.

Programming tool

- ♣ YOLOV3 tiny
- ♣ Darknet19
- ♣ Python
- ♣ Opencv
- ♣ Google colab

1.5.5 Evaluation Methods and Tools

During the interface design process, usability evaluation has an important role that includes an interactive cycle of designing, prototyping, and evaluation. It has been used by different methods and tools to evaluate the system. And the overall system performance was evaluated by taking the average performance of the object detector. A Darknet evaluation tool from AlexeyAB was used to evaluate the object detection model performances. It was evaluated with three different threshold values and thereby the mAP, precision, and recall of the model was calculated. Finally, the threshold value which shows the best accuracy was taken as a parameter of this model.

The following diagram is a general idea of the methodology

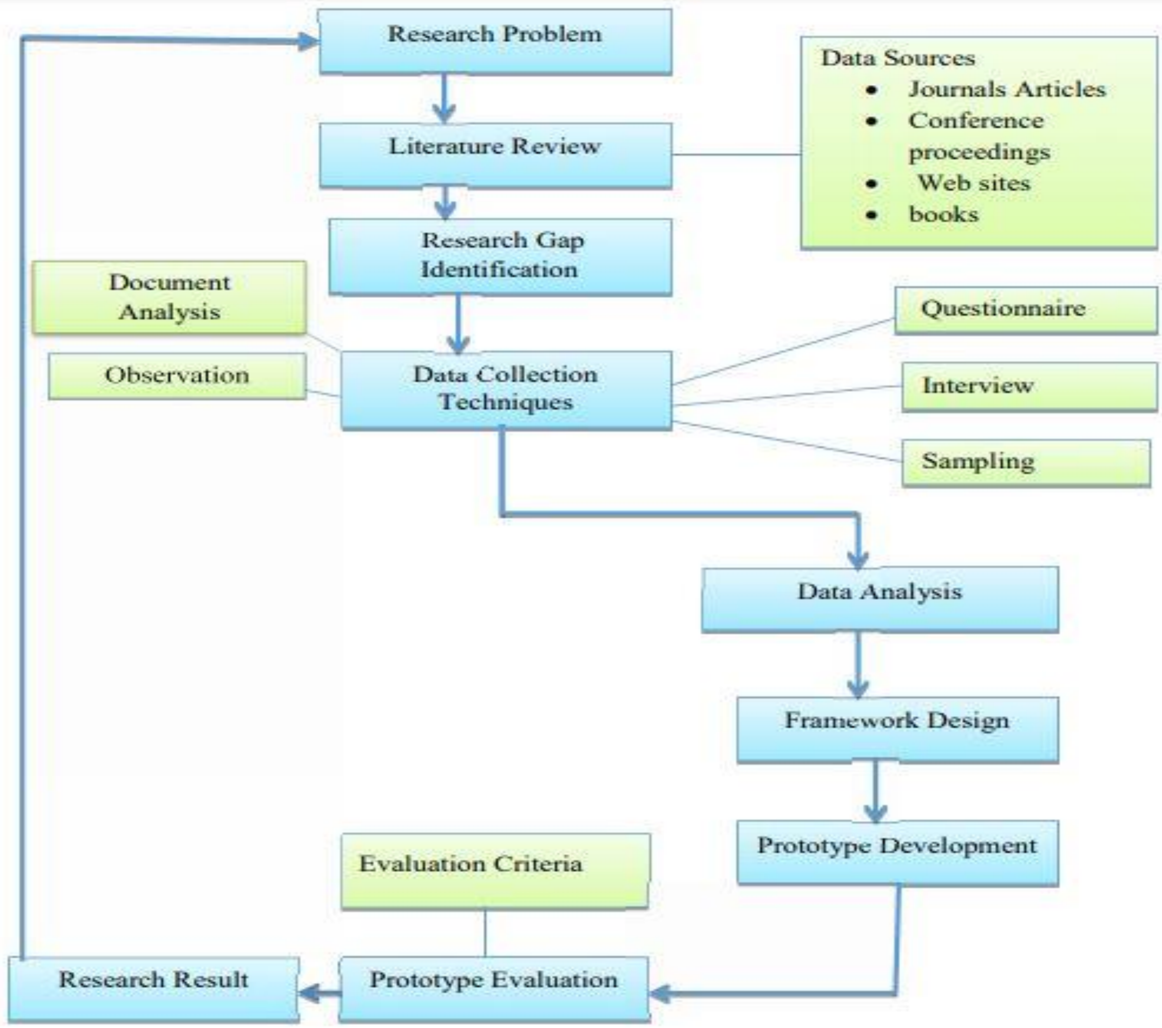

Figure 1: Research process

1.6. Significance of the Study

Traffic congestion has a direct effect on our quality of life since most people suffer from the daily inconvenience of traffic pollution, traffic delay, and traffic costs. It includes considerable costs for the community and a great deal of effort is devoted to every large city to reduce the negative impact of this phenomenon. The results of the current research will help to formulate policy recommendations to improve the traffic system in Addis Ababa City, to obtain peaceful, comfortable, sustainable and economical traffic system. This research document might have significant value in terms of the following aspects:

- The outcome of this study overcome the problems related to route finding
- It also provides information to understand the traffic congestion and route guidance to suggest possible solutions to enhance more important for users

1.7 Scope of the Study

The research is constrained by the fact that all streets in Addis Ababa City, as it holds to all other Ethiopian cities, are not properly named. Some are known by local names and others are known by their name was given by the responsible authority. For example, the street that spans from Meskal Square to Bole International Air Port is locally known as Bole Road, while its official name is Africa Avenue. Besides, it is very difficult to precisely determine the starting and ending points of a given street. These aforementioned points made it difficult to communicate with users the result of route analysis in a common and standardized way. To cope with the problems, the streets were named using common ground references starting and ending that signifies the starting and ending point of the street. One of the expected functionality of the system is to deliver optimal driving route information between two points by considering real-time land traffic reality. But this research is constrained by the fact that real-time traffic information service is some existent [14]. The scope of in this research is to make the user feasible or easy to identify the shortest distance and traffic jams. But the main point of my thesis are more focus on how to understand traffic congestion (traffic jam) by using object detection and counting because of shortest distances are available online like from Google map, yahoo maps and etc.

1.8. Limitation of the study

This study comes across to limitations on a different phase of the research process. Since there is a lack of other studies for comparison of object detection for traffic congestion. Many factors have limited this study, some of these factors are:

- Lack of well-organized information among the route
- Difficulty in gaining access to information pertaining to the study.
- Due to lack of time didn’t include integrate shortest distance (Google map) with traffic congestion of the road.
- Illiteracy and ignorance on the part of the respondents was another factor that hindered progress of the study.

1.9. Application of the Result

The basic idea of this research is to help drivers to find the best path of the road in case of traffic congestion. The aim is to overcome in previous traditional system to generate fast and accurate results. The advantages of the proposed solution for route finding are listed below:

- Use the time, cost and fuel consumption without confusion
- Easy finding the quickest route
- Considering traffic congestion

1.10. Organization of the Thesis

This thesis is organized into seven chapters. **Chapter one** describes an overview of the study, background information, statements of the problem, motivation, objectives, scope and limitation, and application of the study. **Chapter two** presents about literature review. It includes an overview of the shortest path, route finding, traffic congestion, and related works. **Chapter three** discusses the research methodology which includes route-finding methods, data collection method, design proposed framework method, the framework implementation method, and the prototype evaluation method. **Chapter four** discusses the proposed framework design and describes each proposed framework components. **Chapter five** describes the implementation of the proposed framework. **Chapter six** presents results, evaluation, and discussion of the framework based on the prototype implementations. **Chapter seven** consists of a conclusion, recommendation and identifies future works for further research direction on this research topic.

CHAPTER TWO

2. Literature Review and Related work

2.1 Geographic Information System (GIS)

In general, GIS may be defined as a computer-based information system, which attempts to capture, store, manipulate, analyze and display spatially referenced and associated tabular attribute data, for solving complex research, planning, and management problems [17]. The geographical information system is also called a geographic information system or geospatial information system. It is an information system capable of integrating, storing, editing, analyzing, sharing, and displaying geographically referenced information. In a more generic sense, GIS is a software tool that allows users to create interactive queries, analyze the spatial information, edit data, maps, and present the results of all these operations. GIS technology is becoming an essential tool to combine various maps and remote sensing information to generate various models, which are used in a real-time environment. The geographical information system is the science utilizing geographic concepts, applications, and systems. Moreover, some of the powerful statistical analyses software provides a service to connect to GIS, which makes it possible for running complicated statistical models, and directly view the results of the model diagrammatically in GIS. It has its strength in providing visual and logical capabilities to precisely model and represent spatial features. GIS has flexibility in modeling spatial objects to appropriately satisfy the specific requirement of the user or application which makes it very interesting. GIS provides tools and applications for spatial data manipulation, spatial data query and analysis, and map operations [33].

Ogunbodede E. F. explained that GIS is a tool that can be used to sustain an endurable flow of traffic in an urban environment, provided it is built on a properly designed database, which must also be amenable to constant updating.

Ammar Alazab et.al examined the value of real-time traffic information gathered through Geographic Information System for achieving an optimal vehicle routing within a dynamically stochastic transportation network. These features will help users and vehicle drivers in improving their service levels and productivity as the Web application enables them to interactively find the optimal path to reach the destinations**.**

Mukti Advani et.al developed a GIS-based model to minimize travel distance and travel time of users. Constrains taken into consideration were impedance for intersections, type of road and speed. It is reported that GIS is a useful tool for getting solutions to such complex problems very accurately and rapidly.

2.1.1 Components of GIS

A Geographic Information System (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information and disseminating primary or derived information in the form of reports, maps and graphical displays. GIS technology integrates common database operations, such as query and statistical analysis, with the unique visualization and geographic analysis benefits offered by maps.

A working GIS integrates these five key components: hardware, software, data, people, and methods.

Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are (a) a database management system (DBMS) (b) tools for the input and manipulation of geographic information (c) tools that support geographic query, analysis, and visualization (d) a graphical user interface (GUI) for easy access to tools. GIS software is either commercial software or software developed on the Open Source domain, which is available for free. However, the commercial software is copyright protected, can be expensive and is available in terms number of licensees. Currently available commercial GIS software includes:

Arc/Info: ESRI launched the first version of ARC/INFO - which it claims as "the very first modern GIS. The name refers to its architecture as a geographic information system composed of: geographic input, processing, and output tools ("ARC") and a complementary, but separate database ("INFO")

ArcGIS: geographic information system (**GIS**) for working with maps and geographic information maintained by the Environmental Systems Research Institute (Esri). It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database.

Intergraph: It provides enterprise engineering and geospatially powered software to businesses, governments, and organizations around the world

MapInfo: MapInfo is a software for analyzing geographic data. It is a software for Geographic Information System (GIS).

Hardware

Hardware is the computer on which a GIS operates. Today, GIS runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Data

The most important component of a GIS is the data. Geographic data or spatial data and related tabular data can be collected in-house or bought from a commercial data provider. Spatial data can be in the form of a map/remotely-sensed data such as satellite imagery and aerial photography. Tabular data can be in the form attribute data that is in some way related to spatial data. The data that a GIS operates on consists of any data bearing a definable relationship to space, including any data about things and events that occur in nature. At one time this consisted of hard-copy data, like traditional cartographic maps, surveyor's logs, demographic statistics, geographic reports, and descriptions from the field. Advances in spatial data collection, classification, and accuracy have allowed more and more standard digital base-maps to become available at different scales.

Users/People

GIS technology is of limited value without the users who manage the system and to develop plans for applying it. GIS users range from technical specialists who design and maintain the system to those who use it to help them do their everyday work. These users are largely interested in the results of the analyses and may have no interest or knowledge of the methods of analysis. The user-friendly interface of the GIS software allows the nontechnical users to have easy access to GIS analytical capabilities without needing to know detailed software commands. A simple User Interface (UI) can consist of menus and pull-down graphic windows so that the user can perform the required analysis with a few key presses without needing to learn specific commands in detail.

Methods

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

The database information (attribute data) is tied to spatial data (feature layers). An example of this would be schools. The actual location of the schools is the spatial data. Additional data such as the school name, school ID, and school type would make up the attribute data. It is the partnership of these two data types that enables GIS to be such an effective problem solving tool. By querying the database associated to the layers, the GIS allows users to perform "why" and "what if" scenarios and creates a resulting map depicting a visual analysis.

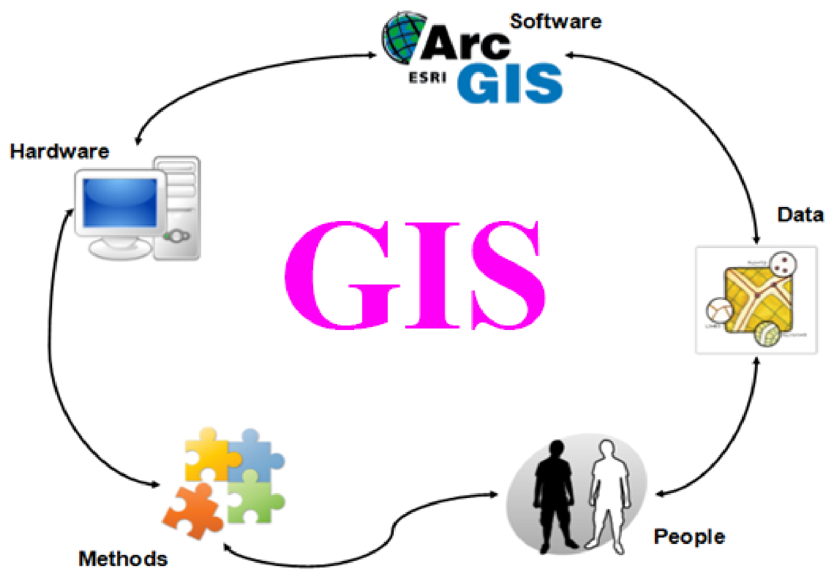

Figure 2: Components of GIS

2.2 Intelligent Transport System (ITS)

To understand fully the advantage and benefit of search techniques, we must first understand the commercial environment where these techniques are applied. ITS integrated application of advanced technologies using electronics, computers, communications and sensing devices in transportation system in order to improve efficiency and safety. Intelligent Transport Systems (ITS) are those that utilize the technologies and engineering concepts to enhance the capabilities of the transportation system. Many route-finding systems are in development worldwide. It is the name given to the application of computer and communications technologies to manage transport problems. In a rapidly changing society, the emphasis on road technology improvements to assist in road management has been identified. As ITS technologies are advancing, they have enabled the collection of data or intelligence which provides relevant and timely information to road managers and users. To fully appreciate the merits of a search technique it is important to understand the commercial environment in which these techniques are implemented. Many route finding systems are currently in development worldwide and the majority form part of much larger systems to manage and operate the road network more efficiently. These management infrastructures are known as Intelligent Transport Systems (ITS) and vary in complexity and size. These systems fall into two main categories centralized and decentralized systems [58].

Centralized ITS systems are linked to an information center which collates and processes traffic and network information. Typically a driver requests a particular route from onboard electronics. The route is then relayed to a central location that carries out all the processing of the route.

De-centralized ITS systems on the other hand offer information to the driver which is computed onboard using local information sources. Typically such systems contain road network information on optical storage devices and electronics to feed a GPS. The Auckland based company Talon Technologies is developing a decentralized routing system; this work forms part of their research effort [59].

Benefits of Intelligent transport system

- Secure, safe and comfortable movement of road users
- Reduce:- Delay and congestion
  - Travel time
  - Waiting times at signal
  - Queue length at signals
  - Fuel consumption
  - Air pollution
- Increase convenience and road user satisfaction
- Parking information, guidance and alerts to drivers

2.3 Deep Learning

Deep Learning has proficiently solved some problems that have been challenged Artificial Intelligence as its performance surely is exceptional in many fields **[50].**An amazing incremental improvement in deep learning and becoming the most preferable algorithm in different applications such as self-driving cars, virtual tasks**,** humanoids, NLP and image processing, medical care, etc. **[51]** So**,** nearly every industry is going to be affected by deep learning play a big role in it. Therefore**,** there is a possibility that one day a human being may be replaced by a highly autonomous robot. The majority of modern deep learning architectures are based on Artificial

Neural Networks (ANNs) and use multiple layers of nonlinear processing units for feature extraction and transformation. The output of previous layers is an input for its next successive layers. What they learn forms a hierarchy of concepts where each level learns to transform its input data into a slightly more abstract and composite representation **[52].**

2.3.1 Deep Learning-Based Object Detection

At present, a deep learning model has been widely adopted in the whole field of computer vision, including general object detection and domain-specific object detection. Most of the state-of-the-art object detectors utilize deep learning networks as their backbone and detection network to extract features from input images (or videos), classification, and localization respectively **[53] .**Interpreting the object localization can be done in various ways, including creating a bounding box around the object or marking every pixel in the image which contains the object (called segmentation) **[54].** So, the goal of object detection is to recognize instances of a predefined set of object classes (e.g. {objects, cars, bikes, animals}) and describe the locations of each detected object in the image using a bounding box **[55].**

2.4 An Overview of Route Finding

Route finding is the process of finding the optimum path through a network from one chosen location to another. The most familiar examples of route finding are the journey planning features found on in-car satellite navigation systems and travel websites. In such cases, the network in question is normally a public road network, and the optimum path is the route between a given source and a destination that takes the least amount of time or covers the shortest distance and determine traffic congestion. For route finding, considerable research has been done on identifying and quantifying the general rules governing human route-finding behavior. It can be described from two aspects: route preference, and route finding process. For route preference, several findings had let to a general framework called pyramidal (or hierarchical) route structure [24]. It states that a driver starting from his point of departure will first take lower-level roads in the network to reach the higher-level roads as quickly as possible, and will then try to stay there as long as possible. Only when the driver is close to his destination he will then use intermediate and lower-level roads to reach his place. Speed and convenience are perceived to be the primary considerations for route selection. “Shortest route” is thus interpreted to mean the most convenient route with the shortest travel time. The main aim of the developed system is to minimize the number of re-computation for finding the shortest route and alternate route. This leads to less memory consumption and less wastage of resources resulting in minimized response time [21]. A route is said to be convenient when there is minimal directional between major and minor roads. Such a route may not be the shortest one. Intuitively, however, it would seem that for many situations, it is fairly close to the optimal solution.

For route finding, Pailhous**[25]** has shown that almost a complete route-finding behavior of experienced car drivers can be described by three search strategies. First, if the destination is part of the basic network of major roads, then go to it by the shortest possible route. Second, if the destination is not in the basic network and the neighborhood is (visually) familiar, then go to the point in the basic network which is the closest to the destination and from there go to the destination making use of the visual attributes. Third, if the destination is not in the basic network and the neighborhood is not (visually) familiar, then go to the point in the basic network which is closest to the destination and proceed further by minimizing the angle between the present direction of travel and the calculated direction to the destination. Transport planners are interested in motorists' route choices for a variety of reasons, as described in chapter one. Some authors seek to explain how motorists determine the route they follow in terms of factors such as time, distance, delay and costs of travel. Models have been developed to explain this process and how the choice of route can be used to manage traffic and enhance the performance of the network by encouraging drivers to divert from congested links.

Bajaj and Gupta have suggested using RFID technology to transmit the location information, after determining it through an in-vehicle GPS receiver **[4].**

Most researchers have restricted themselves to identify their locations, and displaying only their positions on a digital map. The objective is to provide vehicle tracking for security purposes. We wish to provide the locations of all the vehicles on the route, and our objective is to determine the least-cost path to a driver's intended destination, accounting for traffic densities on the possible routes. Performing route-finding techniques on a large graph slow down the processing of any algorithm. To increase the efficiency of these algorithm researchers do manual modeling and preprocessing of graphs [30]. This requires too much of preprocessing time, human effort and manual working. To minimize this computation time, the proposed system not only models and process the road network automatically but also provide different route finder options as follows:

- Shortest Route Finder (Based on constraints such as time, distance or traffic, etc.)

- Alternate Route Finder (In case, there is a change in the topology of the shortest path)
- Facility-Based Route Finder (In case, there is a route based on facilities such as hospital, business center, police station, etc.)

2.5 Route Guidance

Route Guidance is an essential component of the Intelligent Transport System (ITS) and Traveler Information System (TIS) which provides road condition, traffic information and travel recommendations to the driver to help them make better travel decisions. Route guidance can be provided to a driver on demand by information center (Centralized ITS) or can be computed by the individual drivers (De-centralized System). Route Guidance can be divided into following major categories of guidance, descriptive or prescriptive, static or dynamic, reactive or predictive and system optimal or user optimal **[34].** Route Guidance Information System (RGIS) takes help of route guidance that can provide guidance to all the drivers at the same time or can provide guidance to an individual driver based on the road network conditions.

2.6 Route choice

Transport planners are interested in motorists' route choices for a variety of reasons. Some authors seek to explain how motorists determine the route they follow in terms of factors such as time, distance, delay and costs of travel. In more recent years, researchers have been particularly interested in the role that the provision of information (in particular ATIS, such as VMS), plays in determining route choices (e.g. Abdel-aty et al 1993; Polydoropoulou, Ben-Akiva&Kaysi 1994; Dia 2002; Furusawa, Woolley &Yue 2004). Models have been developed to explain this process (Ben-Akiva, de Palma &Kaysi 1991) and how the choice of route can be used to manage traffic and enhance the performance of the network by encouraging drivers to divert from congested links. Satellite navigation systems have been used in recent years to obtain a more accurate picture of drivers' route choices than is available from diaries or using stated preference techniques. The problem of route choice faced by an automobile driver is very complex. First, there can be a large number of possible alternative routes through the road network from origins to destinations, and complex patterns of overlap typically exist between the various route alternatives[9] [24].

2.7 Method chosen to develop a route choice

[25]Wang et al the increasing number of vehicles on roads has complicated the said congestion problem. In today's era of smartphones, a multitude of positioning technologies has come over that can be utilized to better resolve the congestion issue.

These personal devices serve in several ways; for example, connecting to Information Traffic System (ITS) and searching the latest real-time traffic information by using GPS. In this context, the traveling network of roads and traffic infrastructure potentially increase complexity. As per Wang et al, lack of traffic information exchange and route guidance lead to waste of time and energy (due to the uncertainty about traffic). Although travel time, cost, distance, traffic jams and so on are vital elements in the route choice process, they are not the first actions related to route choice to be considered in the trip making. Before these factors come into play, and after the decision has been made that a trip is to be made, a decision will be made (or a habit invoked) that determines the framework to be used to determine the route – that is, travelers must decide whether they will use their judgment or that of a third party. This may help explain how the traveler behaves during the trip. A route may be known before the traveler sets out (planned or as a result of experience) or develop as the trip progresses. Trip characteristics include trip purpose, time and location, flexibility in arrival time, availability of alternative routes, traffic conditions, and traffic information that influence travelers' decisions both before the trip and en-route **[24].**

A route known in advance may be:

- specified by a third party;
- Already known to the traveler;
- planned by the traveler using the sources of information available;
- Computers generated from a database of route information.

Routes specified by a third party include bus routes, routes that company drivers are required to follow and routes. A traveler who knows the area through which the route passes may already have a good knowledge of alternate routes because of experience gained through trial and error. If the traveler does not know the area, they may want to plan their trip.

A route may develop as the trip progresses:

- a known route may be disrupted by incidents experienced (or information received) en-route, or
- a diversion may be required from a known route to bypass anticipated delays based on information received (e.g. ATIS or traveler observations);
- It may be generated by random turnings or following other motorists.

As the trip proceeds, there may be disruptions (e.g. the motorist (or a passenger) may recall an errand which must be completed in the course of the trip, or the motorist may take a wrong turning).

Alternatively, the motorist may see or hear something which suggests that there will be a disruption to their trip (e.g. congestion) if they continue on the route they are currently using.

Once it has been decided whose judgment for devising a route will be used, factors such as minimizing delay or distance can be used to guide subsequent actions, by, for example, selecting the most appropriate of several known routes. Yet route choice research has an additional use; to assess the amount of excess travel, caused directly from route selection criteria, to estimate the potential time and cost savings for both the public and the private sectors. **[13]**Shortest path analysis is an essential precursor to many GIS traffic applications. Has worked on this and explored the use of fast shortest path algorithm on extensive road networks. Has evaluated the possibilities of optimization, in which the optimum routes, travel time, travel distance and cost for defined paths and the optimum paths were determined for few transport services. Congested road is a typical example of environmental quality deterioration caused by the collective outcome of individual route choice decisions.

2.8 What is Traffic (Traffic Congestion)

Traffic can be defined as the movement of pedestrians and goods along a route, and in the 21-century the biggest problem and challenge for the traffic engineer is often imbalance between the amount of traffic and the capacity of the route, leading to congestions.

The European Conference of Ministers of Transport (ECMT) (2007), traffic congestion is caused by a number numerous factors such as; poor pavements, too many vehicles and motorcycle, land use patterns, employment patterns, income levels, car ownership trend, infrastructure investment, regional economic dynamics, tourism, poor land use integration among other factors. In the transportation realm, congestion usually relates to an excess of vehicles on a portion of a roadway at a particular time resulting in slower speeds, sometimes much slower, than normal or "free flow" speeds. Congestion often means stopped or stop-and-go traffic, it is one of the main reasons for immensely increasing transportation costs due to wasted time and extra full. It is measured by travail time and capacity of roads (Cambridge systematic, Inc. & Texas Transportation Institute). Traffic congestion is an extremely annoying feature of road transport. It consumes substantial amounts of valuable time, creates difficulties for scheduling and on-time deliveries, and thus reduces the potential advantages of road transport. Congestion typically occurs at times of high travel demand or as a consequence of accidents or other non-recurring incidents that temporarily reduce a road's capacity. It is associated with external costs in the sense that an additional driver on a road forces everyone else using this same road at the same time to adapt to the higher traffic volume by lowering driving speeds, so other drivers need more time to cover a given distance. (Schrage, 2006).

The work in this research tries to minimize the number of re-computations needed for computing the shortest route, traffic jam or alternate route from source to destination. To achieve this goal we have Design of GIS based route finding that does not require any preprocessing of the real road network as many of the systems do **[18].**

For instant, The Federal Highway Administration (FHWA) defines traffic congestion as: "the level at which transportation system performance is no longer acceptable due to traffic interference". Traffic congestions **[20]** is not a new phenomenon. Roman history recorded that the streets of Rome were so clogged with traffic that at least one emperor was forced to issue a proclamation threatening the death penalty to those whose chariots and cars blocked the way. Based on this the definition is divided as congestion and unacceptable congestion and it is defined as:

- Congestion is travel time or delays over that normally incurred under light or free-flow travel conditions.
- Unacceptable congestion is travel time or delay over an agreed-upon norm.

Traffic congestion refers to incremental delays and vehicle operating costs caused by interactions among vehicles, particularly as traffic volumes approach roadway capacity (Todd Litman) **[21].**

Traffic congestion may be recurrent and nonrecurring. Recurrent Traffic Congestion that was happened in a particular section of the road during a particular time of day, when traffic flow in a roadway exceeds its capacity (Abraham, n.d, Sarah & Michael, 2003, & Littman, 2009). Recurring congestion includes congestion due to bottlenecks, traffic signals, and persistent higher demand, etc. and they are predictable. Recurrent congestion occurs at the same place at the same time every weekday or weekend. It is a capacity problem and is logically combated with raising roadway capacity. Non- Recurrent Traffic Congestion that was happened due to special or random events, that temporary increased demand or reduces capacity on a road segment. Such events as weather, road construction, and accidents (Abraham, n.d, Sarah &Michael, 2003, & Litman, 2009).

2.8.1 Cause of traffic congestion

The traffic congestion is a situation on road networks when physical uses of the road by vehicles increases. Moreover, 70 percent of trips in Dhaka are short trips; most of them are less than two kilometers **[22].** In basis of a survey on Ireland based company named Bus Eireann, is losing €18 million annually only because of their improper adjustment of timetables due to the increased traffic congestion **[23].** Congestion is creating immense prohibitive situations in all developing countries. It occurs when the road network is no longer capable to accommodate the volume of movements that used by them and it is characterized by slow speed, long trip timing and high vehicular queuing.

- Increasing growing population in Addis Ababa cities rapidly growing the population by birth and migration facing unexpected congestion on road. Better facilities like- communication system, medical facilities, educational institution leads to heavy traffic.
- Improper planning Addis Ababa is one of the oldest city within Ethiopia, so proper planning was not done that time and in modern times growing urbanization leads to worst.
- Forced occupier the retailer forcedly set up their business along main city road or bus road and pavements causing narrowing the road.

Figure 3: Occupancy by business shops on the road

- Random parking the illegal and random parking on the main road is common habits of drivers and riders, causing unexpected congestion any time.
- Irregular public transport Irregularity of public transport courage people to depend on private vehicles.

Figure 4: Traffic Jam

- ✓ Increasing rent within short distance of public transport is one of the reason to depend on private vehicles.

The following table are cause of traffic congestion

No.	**Factors**	**Causes Described**
1	Social & Economic factors	• Rising population number together with the rural-urban migration • Unplanned land use which result unidirectional traffic flow especially at pick hours • Increased car ownership in line with the improved living standard
2	Road factors	• Smaller number of lane & Narrow road • Lack of side walk which result occupation of traffic lanes by pedestrians • Distressed pavement which result in a reduced travel speed • Uncontrolled traffic Intersections

3	Vehicle factors	• Size of vehicle • Age of vehicles
4	Human factors	• Perception of drivers • Perception of pedestrians
5	Accident	• The severity, number and location of accident

Table 1: Causes of traffic congestion

There are some more serious social effects of congestion on the environment are listed here

1. Congestion means just a waste of valuable time and health. The time wasted in congestion could effectively be used in doing some productive work
2. The sudden stop and go driving pattern in the congestion leads to more fuel consumption in the city and thereby increasing the pollution level in the city by emitting more carbon into the environment.
3. The slow speed of vehicles in the traffic jams also leads to the emission of the oxides of nitrogen and some hydrocarbons which is a major culprit of a term known as photochemical smog.
4. Traffic congestion causes the noise of a high level (more than 90 dB) which causes the environment unpleasant.

According to research done by Cambridge Systematic, Inc., 2004 with Texas Transportation Institute Traffic Congestion has several root causes that can be broken down into two main categories and summarized the finding in below Figure

A. Too much traffic for the available physical capacity to handle:

Bottlenecks: - Bottlenecks are perhaps the most common cause of congestion. They result from the convergence of a greater number of lanes in the upstream roadways than are available in the downstream roadways. Bottlenecks delay is typically found in hours of peak flow where the number of lanes converging on a roadway, bridge or a tunnel exceeds the number of lanes these facilities have.

B. Traffic-influencing events:

- Traffic Incidents such As Crashes And Vehicle Breakdowns;
- Work Zones;
- Bad Weather;
- Special Events; And
- Poorly Timed Traffic Signals.

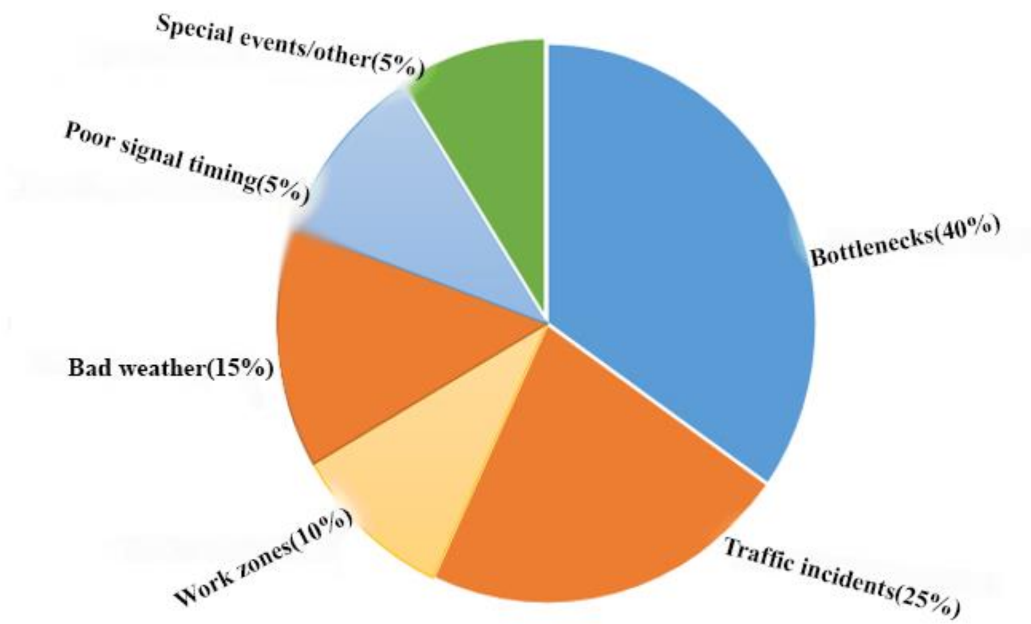

Figure 5: Source of Traffic Congestion [25]

A common form mathematical model for traffic congestion is as follows

$$\mathbf{Y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + \ldots\ldots\ldots\ldots\ldots\ldots + a_nx_n}$$

Where,

Y is traffic parameter. $\mathbf{a_0}$ is constant.

X1, X2, X3 ----Xn are the variables affecting the road traffic.

a2, a3-----------an are the coefficients to be determined adopting multiple linear regression method

Equation 1: Traffic congestion

Anithaselvasofia et. al., (2013) talks about traffic congestion, which is a condition on road networks that occurs by slower, and increased vehicular queuing. To study the effect of the TSM measures, one needs to have a clear view of the flow patterns, location as well as **existing road network**. GIS can be effectively used to analyze the problems associated with transportation. An attempt was made to find solutions to reduce traffic congestion using SPSS16 and to identify and rectifying the problems using a GIS-based model **[25].**

The growth of traffic congestion on many streets and highways is a major concern to travelers, administrators, merchants, developers, and the community at large. Its detrimental impacts in terms of longer journey times, higher fuel consumption, increased emissions of air pollutants, greater transport, and other affected costs, and changing investment decisions are increasingly recognized and felt across the country. Congestion reduces the effective accessibility of residents, activities, and jobs, resulting in lost opportunities for both the public and business.

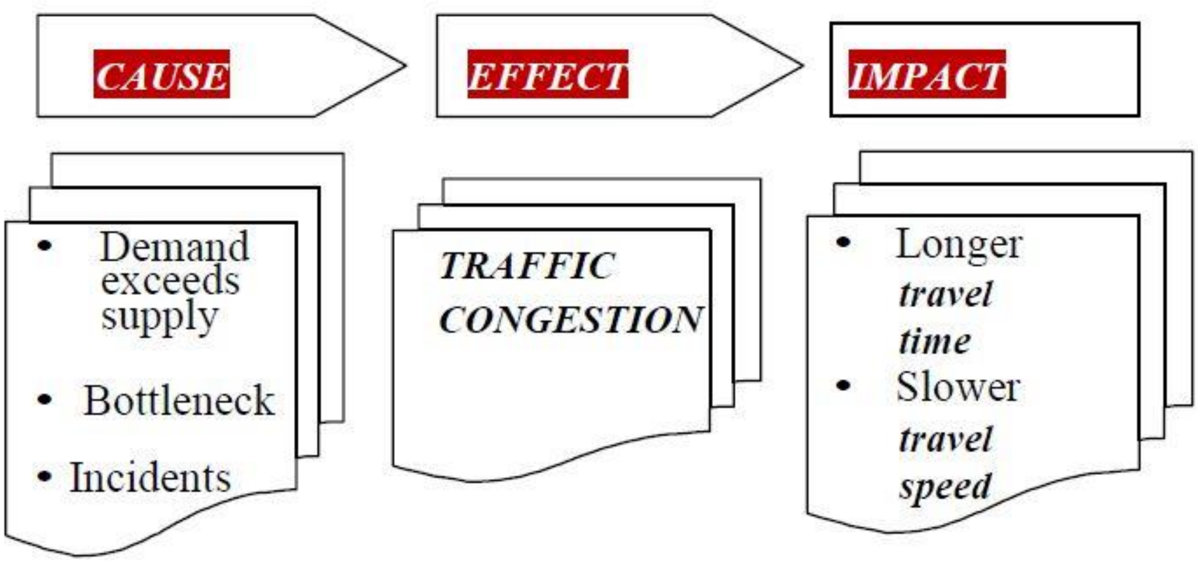

Figure 6: Conceptual frame work of Congestion Cause and Impact [32]

The data collected from Addis Ababa transport bureau indicate that there are various arterial roads and roundabouts identified as major congested areas in all the ten sub-city under the city's administration (see table below). And as indicated in the report there are 55 major congested areas in all the ten sub-city and 36% of the identified congested areas and roundabouts have no identified alternative routes to be used as an alternative solution to the problem.

S.No	Sub City	Congested area and roundabout in number	Cause for congestion
1	Akaki kality	3	Too narrow roads
2	Nifasilk Lafto	7	Too narrow roads, road side parking
3	Yeka	3	Unavailability of alternative roads, road side parking
4	Kolfe keranyo	3	Unavailability of alternative roads
5	Lideta	4	Road expansion and development work, unavailability of alternative road
6	Kirkos	8	Operators not using the available alternative roads
7	Gullele	12	Poor road condition, unavailability of traffic signs, increased number of bus stations, too narrow road, unavailability of sufficient pedestrian walkway
8	Addis Ketema	3	Too narrow road and roundabout, road side parking
9	Arada	8	Road side parking
10	Bole	4	Entering and exiting of heavy trucks in the area, too narrow road , tax terminals with too many vehicles at a time
Total congested Area			55

Source: Addis Ababa Transport Bureau

Table 2: Number of Congested area in the city and the causes of congestion

2.9 Routing problem

The most important problem of dynamic routing is solved by the information updating system and the route finding system. These two subsystems together form the routing system. The function of the route finding system will be clear: we are building a system to route vehicles. The reason why we need the timetable updating system is the following. The route finding system needs information about the state of the network. A static route-finding system could use a fixed set of data, but we will use a dynamic route finding system that needs dynamic data.

Those data are provided by the timetable updating system. The information can be the load of the parts of the network but a more direct and therefore more practical type of information is the time it takes to cover a road. The route finding system uses the information in the timetable to compute the shortest routes for the drivers. When the driver requests route information, the route finding system sends this information back to the driver.

2.10 Routing Algorithms

Routing means searching for what path to take while a routing algorithm searches for the optimum path between an origin and a destination. For example, given scattered cities that are linked to each other through a complicated road network such that there is more than one alternative route from one city to another and motorist just wants to know the cheapest or the quickest route between any two of those cities. This is an example of a network problem in which optimum routes need to be computed. In the context of this research, the following routing algorithms were considered:

- Dijkstra shortest Path algorithm
- A* search algorithm.
- YOLOv3 algorithm

Network analysis in GIS assists indetermination and making of choices with regard to optimum route, finding nearest social amenities and service points. Sanjeev et al. remarks that GIS route finding modules and heuristic algorithms are employed in search for the best solutions to optimum path problem. These routing algorithms could be further customized to address problems of selecting a route to a given destination in intelligent transport systems. An optimum route search for destination is the most important goal in network analysis. Minimum travelling times or distances are used in definition of the optimum route. According to Mainali et al., sometimes the user may not always be interested in the minimum time or distance given in the shortest route but may prefer using certain routes even if it means adding to the cost of travel [45]. In this research, route computations for user selected origin and destination stations required an implementation of a routing algorithm. A brief discussion of three of the most widely used routing algorithms is given in this report. Those are Dijkstra's, A* search and yolov3 algorithms.

2.10.1 Dijkstra's Algorithm

Dijkstra's shortest path algorithm computes the lowest cost path from one node to all others in a network graph composed of weighted edges [43, 44]. For example, the weighted edges can be thought of as interconnected road network and the nodes as cities. Dijkstra's algorithm is an exact algorithm but does not guarantee that realistic deadlines will be met.

How Dijkstra's Algorithm Works

Beginning at a start node, the algorithm sets the cost to this source as 0 and to all other existing and unvisited nodes as infinity. The algorithm then proceeds to look for adjacent nodes that are connected to the source node. It updates the visited nodes to new value which is the sum of the value of previously visited node and weight of the adjacency from this previous node to the current node. The current node is then set as visited and the algorithm searches for any other existing unvisited nodes connected to the current node and the value at the visited nodes is updated. When the value of adjacent edge plus node value becomes less than the value of adjacent node, the adjacent node is changed to this value. The algorithm continues until all existing nodes are marked as visited and their values updated. The value of the nodes that the algorithm returns denotes the least cost of the travel from start node to that node [44].

The algorithm maintains two sets of vertices S and D. Set S contains all vertices for which we know that the value d[v] is already the cost of the shortest path and set D contains all other vertices. Set S initially starts empty, and in each step one vertex is moved from D to S. This vertex is chosen as the vertex with lowest value of d[u]. When a vertex u is moved to S, the algorithm relaxes every outgoing edge (u, v).

In **Dijkstra Algorithm F (n) = g (n)** Where,

g (n) represents the cost of the path from the starting point to the vertex n

2.10.2 A* search Algorithm

This is another routing algorithm that utilizes priority queue in the computation of least cost paths. It is an improvement of the efficiency of the dijkstra's algorithm. If a chosen path contains higher cost than another visited path segment, it leaves the former in preference to the later until the destination is reached. It uses the following concept [46]:

$$\mathbf{F\ (n) = g\ (n) + h\ (n)}$$

Where:

g (n) - Distance from start to current node.

H (n) - Estimated distance from current node to destination node created using a heuristic function

f (n) - Current estimated shortest path.

Equation 2: A* algorithm

The heuristic function **h'(n)** is an arbitrary function and the better its estimate the better the accuracy of the least cost path solution [46].

A* uses an estimator or heuristic function in estimation of the shortest path between source and destination nodes. According to Sanjeev et al. A* algorithm performs better than Dijkstra algorithm.

Suppose, for verification purpose we have a route 1_2_3_4_5_6_7_8_9_10 stored in database table as a shortest route between source node "1" and destination node "10" then for all subset of cardinality 2 of set {2, 3, 4, 5, 6, 7, 8, 9} where number denotes source or destination nodes, we don't need to either compute route from algorithm nor we have to compute routes to be stored in the database table. Therefore, by storing a route with "n" nodes, we can save the space required for storing **(n*(n-1))** routes.

Comparison between Dijkstra's and A* algorithms in road networks

Comparison of A* and Dijkstra's both the algorithms find the shortest distance between two nodes. Now, we would try to implement A star and Dijkstra's on distributed system and compare them on running time and try and show that A star is a better than Dijkstra's. First of all let us cite the major differences between the two.

Parameters	**A* algorithm**	**Dijkstra algorithm**
Search algorithm	Best first search	Greedy best first search
Time complexity	Time complexity is O(nlogn),n is the number of nodes	The time complexity is O(ElogV)
Heuristics function	Heuristic function, F(n) = g(n) + h(n),where g(n) represents the cost of the path from the starting point the vertex n H(n) represents the heuristic estimated cost from vertex n to the g	Heuristic function, F(n) = g(n),where G(n) represents the cost of the path from the starting point the vertex n

Table 3: Comparison of A* and Dijkstra algorithm

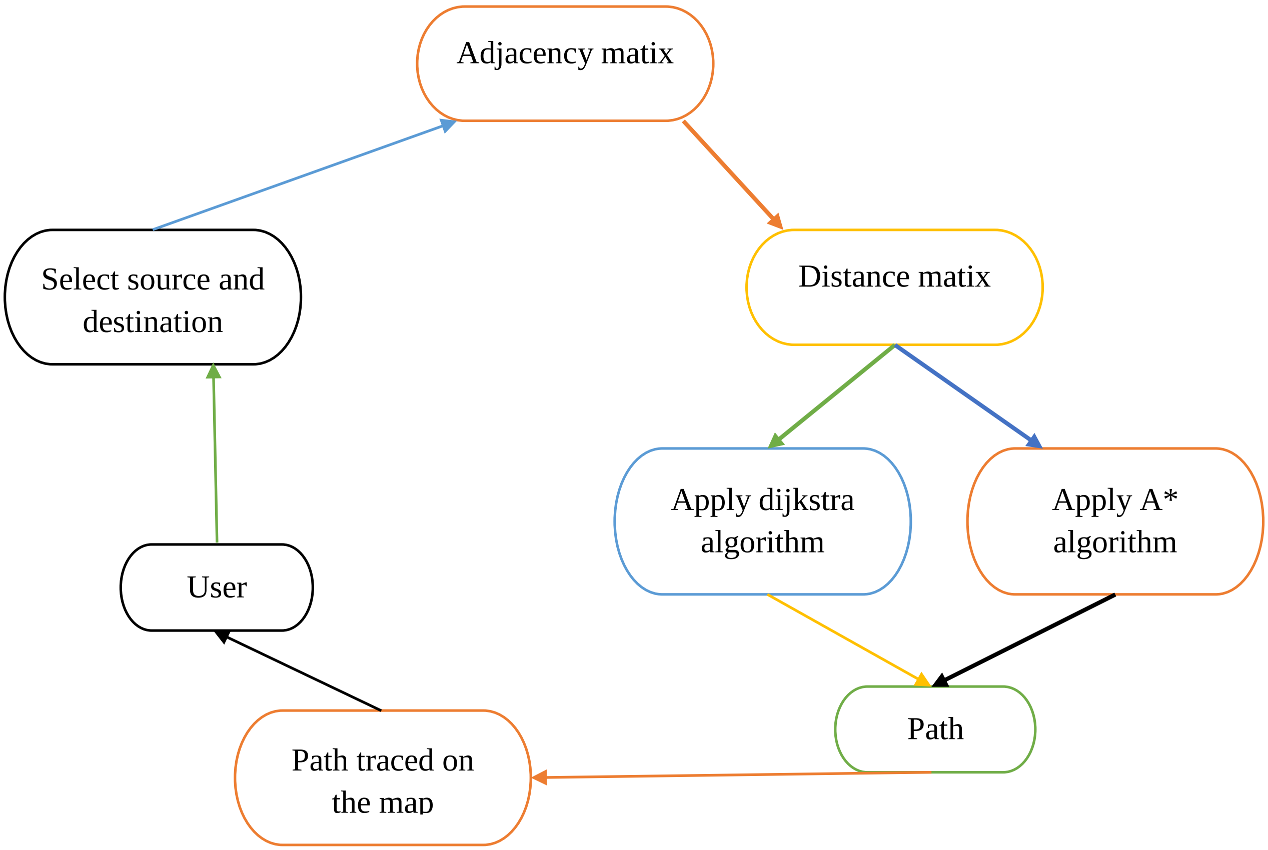

Figure 7: Flow diagram of A* and Dijkstra algorithm

2.10.3 YoloV3 Algorithm

You Only Look Once or more popularly known as YOLO is one of the fastest real-time object detection algorithm (45 frames per seconds) as compared to R-CNN family (R-CNN, Fast R-CNN, Faster R-CNN, etc.)The R-CNN family of algorithms uses regions to localize the objects in images which means the model is applied to multiple regions and high scoring regions of the image are considered as object detected. But YOLO follows a completely different approach. Instead of selecting some regions, it applies a neural network to the entire image to predict bounding boxes and their probabilities.

2.11 Congestion Measures

Traffic congestion is an unavoidable part of modern-day life. To understand the nature of congestion and to control its growth, a system for measuring the severity of traffic congestion is needed. In some countries, for example, as in the study of **[30][31]** found out that the main parameters used to define the traffic congestion levels are time, speed, volume, service level, and the cycles of traffic signal that the motorists have to wait. Our work would focus only on the interpretation of vehicle velocity since our work needs to determine the congestion levels with minimal parameters. Vehicle velocity could be collected by almost all types of sensors. This made it easier, broader and more versatile for the model to be used.

Traffic congestion can be measured based on roadway volume to capacity ratios (V/C). A V/C less than 0.85 is considered under-capacity, 0.85 to 0.95 is considered near capacity, 0.95 to 1.0 is considered at capacity, and over 1.0 is considered over-capacity or simply use Level-of-Service (LOS) ratings, a grade from A the best to F worst. Also, Congestion is a non-linear function, so as a road approaches its maximum capacity, small changes in traffic volumes can cause proportionately larger changes in congestion delays (Victoria Transport Policy Institute, 2013). On the other hand Lomax, 1997 suggested measures related to travel time, delay and speed are more flexible and useful for a wide range of analysis and also it is easily understandable by the professionals and the public. Further congestion measures can be explained by indexes like travel time index, delay rate index, delay ratio. Some of the congestion measures are summarized in the table below.

Travel Rate	**Travel Rate (minutes /km)** $= \dfrac{\textbf{Travel Time(minutes)}}{\textbf{Segment Length(miles)}} = \dfrac{\textbf{60}}{\textbf{\textit{Average Speed}(\textit{mph})}}$
Delay Rate	**Delay Rate (minutes /km) = Actual Travel Rate(mpm) – Acceptable Travel Rate(mpm)**
Total Segment Delay	Total Segment Delay (vehicle - minutes) = [Actual Travel Time (minutes) –Acceptable Travel time (minutes)] * vehicle volume (vehicles)
Relative Delay Rate	Relative Delay Rate = $\dfrac{\textbf{Delay Rate}}{\textbf{Acceptable Travel Rate}}$
Delay Ratio	Delay Ratio = $\dfrac{\textbf{Delay Rate}}{\textbf{Actual Travel Rate}}$
Congestion Travel	Congested Travel=Sum of all (vehicle - miles) [Congested Segment Length(miles) *Traffic Volume(vehicle)]

Source: NCHRP Report 398 “Quantifying Congestion” by Lomax et.al, 1997.

Table 4: Summary of Congestion Measures

Jenks et.al, 2008 suggested that it is important to know the four components of congestion namely; duration, extent, intensity, and reliability to measure congestion easily. Duration is the amount of time congestion affects the travel system. Extent described by estimating the number of people or vehicle affected by congestion. Intensity shows the severity of congestion that affects travel and Reliability described as the variation in the other three components.

Summary of literature Survey

Title of the paper	Description
[11] Robust and Adaptive traffic surveillance system for urban intersection on embedded platform	The paper presents a real time traffic monitoring system that makes use of image processing algorithm to detect and estimate the count of vehicles using motion detection approach
[35] Real time integrated CCTV using face and pedestrian detection image processing algorithm for automatic traffic transitions	Integration of face detection and pedestrian. When pedestrians are detected, it adds extra seconds to the red light and the signal changes back to normal after sometime
[38] Review of the CCTV techniques for vehicular traffic management	CCTV's can lessen the traffic problems. By treating video imaging having parameters of traffic, desired information is noted, such as traffic composition,speed,shapes and types of vehicles,breakig of traffic rules or accidents
[40] An algorithm for full coverage real time traffic density calculation on roads	An algorithm is proposed that will increase the coverage area to the entire road. It will also assess the incoming and outgoing traffic
[41] Recognition of car makes and models from a single camera image	This paper recognizes car models from a single image captured by a camera. Due to various configuration of traffic cameras, a traffic image may be captured in different viewpoints and lighting conditions the image quality varies in resolution and color depth

[56] SDCS using image processing techniques on video streams	A SDCS is applicable as a radar alternatives. SDCS uses several image processing techniques on video stream in online captured from single camera. It uses a hybrid algorithm based on combining an adaptive background subtraction technique with a three frame differencing algorithm
[57] Adaptive traffic control system using raspberry pi	Implement an artificial density traffic control system using image processing and raspberry pi

Table 5: Literature Review

2.12 Related Work

Many prior works have been done related to hierarchical routing where either traffic networks are divided into several smaller and less complex networks by introducing a hierarchy or the given road network is divided into a multiple-layer hierarchy. Algorithms based on the concept of hierarchical abstraction make use of the knowledge about the road network to reduce search and provide near-optimal solutions. An alternate approach to forming multiple levels of abstraction for route finding was proposed by Timpf et al**. [39].** They proposed a conceptual model with three levels of abstraction named planning, instructional and driver levels based on human spatial reasoning. In this approach, an object may be present in all the three levels but with different levels of detail. In this research, we have divided the road networks into three levels of specification ranging from highways to mini roads.

Summary of Related Work

Author	Title	Proposed Idea	Techniques	Limitation
Abdul khalik	Traffic congestion in urban roads network using GIS technology	Reduce traffic congestion, air pollution and enhancing safety in many indesterized and commercial country ITS	Traffic counting ,travel time and vehicle speed analysis	Poorly planned in urban areas and inefficient in their operating capacity
Rewadkar	Traffic estimation and least congested alternative route finding using GPS	Predict the traffic state of road by using GPS	Automated vehicle identification system, video cameras, inductive loops, radar based sensors, floating cars using GPS receiver	There is no key performance
Akhilesh et al	An approach for web based GIS route finder system	Determine shortest path and alternative path	Counting vehicle	Single algorithm slow for finding any response

Table 6: Summary of related work

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Overview

Based on the research objectives and questions stated in the introduction chapter, the method of the research is discussed in this chapter. The methods of data collection, data preparation, and data analysis are also discussed. Generally, the research is focused on the data and methods required to analyze and evaluate the nature (shortest path finding, accessibility, and effectiveness) of the existing route-finding network structure of the study area using different techniques. The method used when collecting, processing and analyzing the gathered information can be either quantitative or qualitative research method. Quantitative research methods: collect numerical data (data in the form of numbers) and analyze it using statistical methods. Observation, direct field measurements and secondary data were the main sources of quantitative data. Qualitative research methods: collect qualitative data (data in the form of text, images, sounds) drawn from observations, interviews and documentary evidence, and analyze it using qualitative data analysis method [42]. Qualitative methods tend to be more appropriate in the early stages of research and for theory building. Quantitative methods tend to be more appropriate when theory is well developed and for purposes of theory testing and refinement. In practice, no research method is entirely qualitative or quantitative. For example, a survey may collect qualitative as well as quantitative data using open-ended questions; an experiment may include observations of participant behavior as well as measures of response time and accuracy; a case study may incorporate quantitative data (e.g. system usage statistics) as well as qualitative data (e.g. interviews with users). This research tries to understand the shortest distance and traffic jam using selected evaluation tools listed in the research objective in Addis Ababa city with the current condition and give some suggestions for concerned bodies. A researcher requires several data gathering tools or techniques which vary in complexity, design, interpretation, and administration; each technique is suitable to get a certain type of information. Data collection techniques such as interviews, questionnaires, direct observation, and document analysis have been used to get a different type of information. The data collected from public service provider organizations and another sector

3.2 Data Types and sources

Multiple data sources were used to investigate the different dimensions of the research objective. Both primary and secondary sources were explored to collect the required data. The type and the availability of data are evaluated before the commencement of the fieldwork.

Primary Data: - The primary data was collected by visiting relevant offices and observations, experiments, questionnaire, and interviews with Addis Ababa City Road and Transport Authority and experts were conducted for capturing their experience on the current practice of road network analysts.

Secondary Data: - The secondary data was collected from the city and sub-city administration and traffic police as well as from published and unpublished materials. Besides Government publications, websites, books, journal articles, internal records and research papers written on the issues and the internet are also considered for the study.

3.3 Research Design

The research design is to provide for the collection of relevant evidence with optimum effort, time and expenditure [36]. This study incorporates qualitative and quantitative methods of research. Qualitative research objective is used to get an enhanced understanding through truthful reporting, firsthand experience, and citations of actual conversations [37]. The quantitative research was used to see the number of people who would like use the new model or think it is a good idea (California State University, 2012).Collecting relevant data needs a strategic plan; otherwise, the research result may be incorrect. The outline of the research design has been illustrated in Figure below. The research problem and the objectives were stated above are followed by the literature review. Next, the identification of data required to deal with and solve the problem was regarded. Primary data were acquired from field data collection; whereas, secondary data were acquired from different documents available at the office of the Subject Company and different kinds of literature. Finally, the conclusion was formulated and recommendations forwarded based on the results of the analysis for the development of improvement strategies.

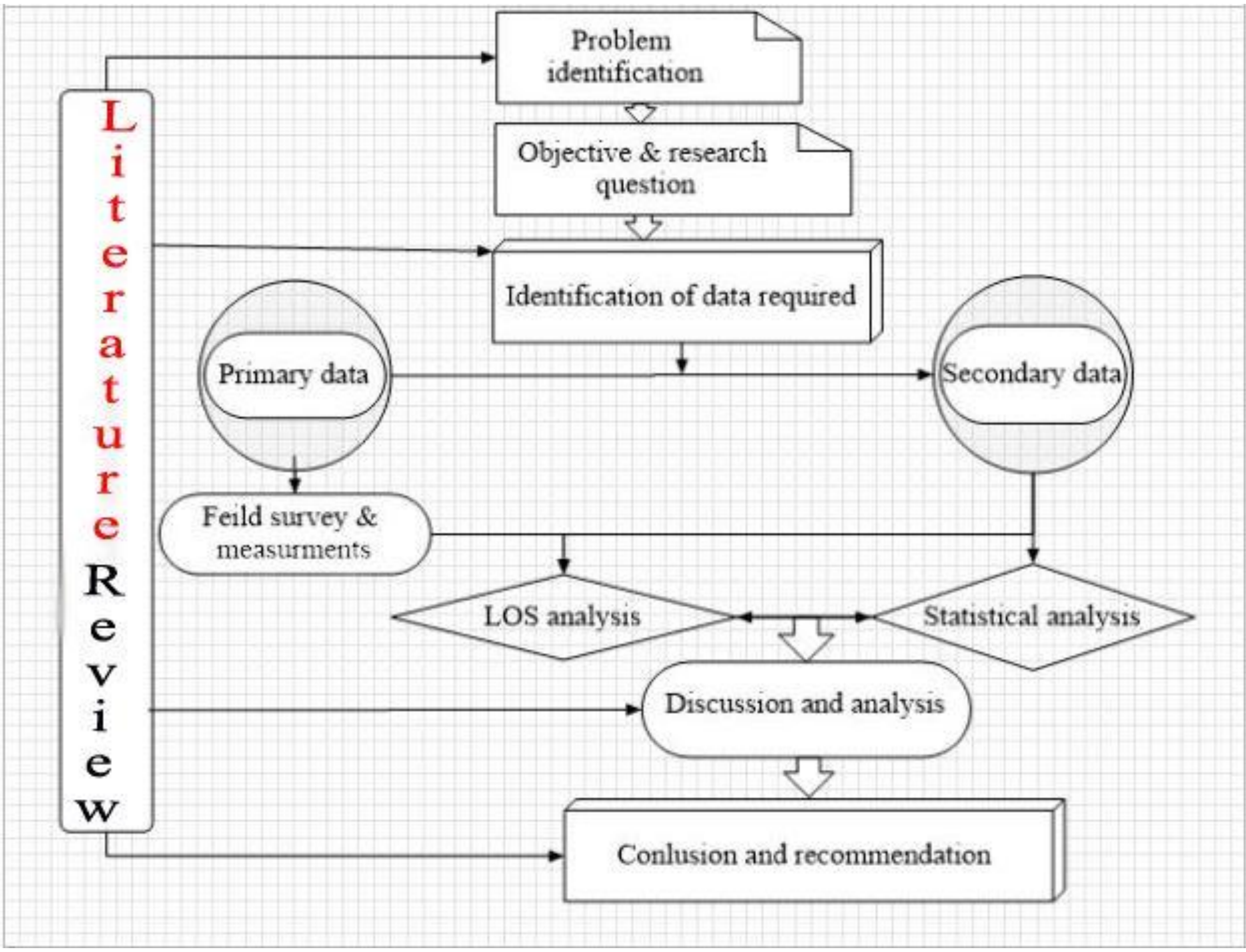

Figure 8: Research Design

To do the automatic search, the most relevant electronic sources used are:

1. IEEE Explorer
2. ACM digital library
3. Springer Link
4. Google Scholar
5. Science Direct

3.4 Data Collection Techniques

The research method used for this research is qualitative and quantitative methods which include interviews, questionnaires, direct observation, and document analysis in the organizations and Google map/satellite images. The goal is to receive qualified survey data from users to request source and destination and possibly identify methods to receive the best route. Several data collection techniques are used parallel to crosscheck data for validity and also use as a compliment.

3.4.1. Interview/Discussion

Interview is Primary data source which is one of the methods used for data collection in which it gives a chance of asking different questions. This is conducted by applying the method of dramaturgy. This has helped to create conversation with persons found in concerned governmental bodies without creating the feeling that they are being interviewed. Interviewing the organization staff allows to understand and analyze the existing situations and it helps to design the solution desirably and to solve the problem and also discussion is conducted by applying the method of dramaturgy. This method has helped to understand how relevance is this issue i.e. performance evaluation.

3.4.2. Direct Observations

The researcher observed different problems that reduce driver's satisfaction by moving to different areas in Addis Ababa city. Direct observation was very easy to realize the situation. It is possible to look at all issues in the residents. This method is highly preferred to the researcher to understand the problems that exist in the community. Before the observation is conducted the observation checklist is prepared. As a resident and researcher in the city, it was convenient to use the technique of participant-observation by observing the current route-finding system in the city and the assessment of transport planning for the city. In which it has an advantage of Directness, Diversity, Flexibility, and Provision of a permanent record and Applicability. The data collected through observation is used to cross-check the data collected from the questionnaire.

3.4.3. Document Analysis/Annals study/ historical record study

This data collection technique is used to get data from written documents such as the organization's rules and regulations, responsibilities, complaint and suggestion forms that have been used. By looking through the existing relevant documents or literature tried to analyze the issues related to the performance evaluation and route finding also how the current master road finding of the city developed.

3.4.4 Collected Data

From Addis Ababa Transport Office about

- Arrangement of taxi (bus) for Arada sub city

S.No	Source	Path	Destination	Distance(Km)	No.of car
1	Arat kilo		Buna Shay	5.3	2
2	Arat kilo		Bela	4.7	1
3	Arat kilo		Bole	7.6	35
4	Selassie	Kebena	Megenagna	4.1	13
5	Selassie	Megenagna	Kotobe	11.8	25
6	Sinima	Kasanchis	Megenagna	9.1	40
7	Sinima	Kebena	Megenagna	7.9	90
8	Sinima		Tele medhanalam	9.3	13
9	Turist		Ambassadar	2.4	9
10	Ayalew music		Adisu gebeya	3.3	4
11	Ayalew music		Dilber	5.1	2
12	Arada Bulding		Asko	8.9	26

13	Piazza		Addis sefer	9.7	25
14	Piazza		Mikily land	8.2	1
15	Piazza		Shogole mender 7	7.0	1
16	Piazza		Lukanda	4.7	2
17	Piazza		Atana tera	5	6
18	Shoa dabo		Karakore	11.2	31
19	Shoa dabo		Alem bank	13	15
20	Shoa dabo	Zenebewark	Ayertena	8.9	7
21	Churchil	Kera	Gofa	6.7	35
22	Churchil		Mekannisa	8.7	16
23	Churchil		Bole michael	7.3	10
24	Piazza		Bole	8.8	48
25	Piazza		Saris Abo	9.9	40
26	Georgis	Ferensay	Biret Dildiy	6.9	5
27	Arat kilo	Kazanchis	Megenagna l	7.2	15

28	Arat kilo	Sidist kilo	Biret Dildiy	5.5	6
29	Megenagna mezan	Kasanchis	piazza	8.4	55
30	Georgis total	Semen	Dilber	4.6	11
31	Megenagna	Diaspora	Piazza	7.9	10
32	Piazza	Paster	Winget	5.7	1
Total				219.6	600

Table 7: Code 1 Taxi Arrangement

From Addis Ababa Traffic police commission research documents about

- The number of vehicles in the sub city

Sub city	**Year**						
	<=2005	**<=2006**	**<=2007**	**<=2008**	**<=2009**	**<=2010**	**<=2011**
Addis Ketema	18479	18734	19158	20056	20903	23819	25555
Akaki kality	22400	23603	24068	27030	40710	47912	52595
Arada	30008	31379	34340	39017	43801	48337	50645

Bole	51369	54760	58251	61177	63783	69890	74374
Gulalle	7074	7132	7176	7226	7791	11324	14398
Kirkos	29657	34120	41300	49479	53462	58908	63488
Kolfe keranio	11468	11993	12212	12356	13601	18810	23050
Lideta	13625	14118	14253	14359	15598	20357	22827
Nifassilk lafto	21336	23480	23801	25965	37118	41625	45846
Yeka	15054	17183	19280	21408	22820	28355	32573

Table 8: Number of vehicles in Addis Ababa

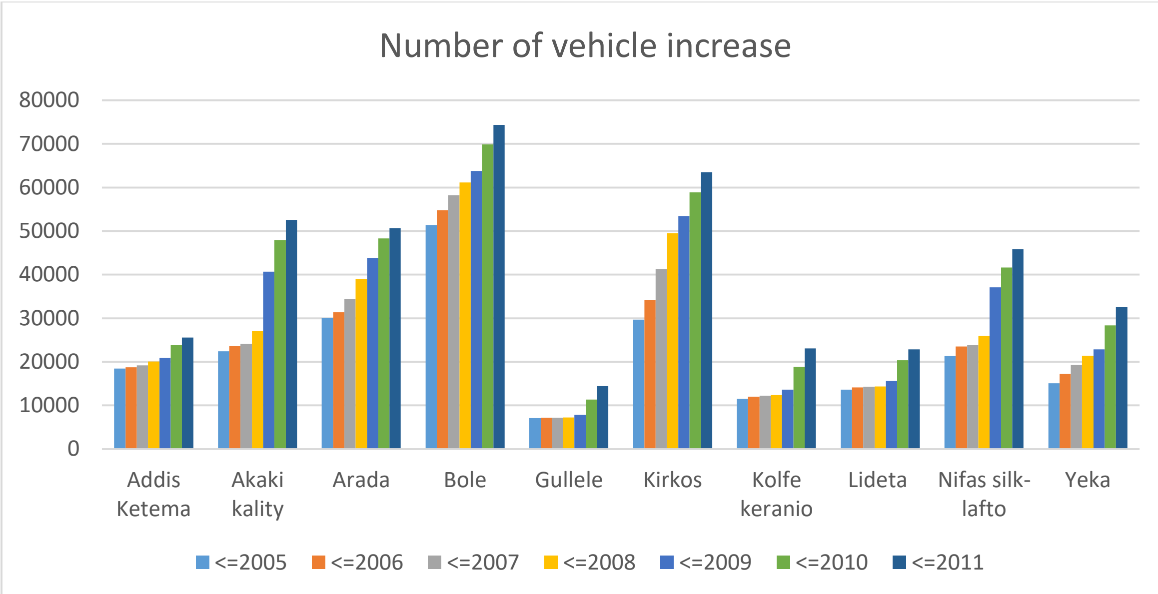

Chart: Number of vehicle

From Addis Ababa City Administration Bulletin about

- ✓ Area and population of the city

Most of the data are secondary data which were acquired through reviews in the institutions. However, some data was derived from primary sources and among them was through unstructured interviews. This collected data used directly or indirectly for the results and analysis part of the research.

3.5 Data Analysis

Qualitative data analyzed with thematic analysis which is widely-used qualitative data analysis method and quantitative data via descriptive statistics. In analyzing the data collected, the following descriptive-analytical methods were used. This method of analysis was chosen based on the nature of the research: an evaluation of the existing route-finding system and respective challenges using ideal management practices of traffic as the standard. These methods helped facilitate reporting on and evaluation of the practices within this sector. To give a better report on what is being done within the study area, a description of the research findings would be the best examination of the actual conditions in the sector; hence the descriptive analysis. Hence information collected through a review of documents and interviews is analyzed within the framework of the study objectives. Information obtained from the secondary and primary sources is used to make a descriptive analysis of the situation

CHAPTER FOUR

4. Proposed Solution for route finding

This chapter proposed an architectural solution for route finding for Addis Ababa City using different techniques. Research questions are defined to solve the problem mentioned inside the statement of the problem in this study. The proposed method provides the shortest distance, least-congested and minimum delay path to the driver when he/she starts from the source. We provide source location and destination location in the form of addresses or landmarks, but this form is not acceptable for processing. Based on the user inputs, the system estimates the distance and traffic on the route and suggests an alternate route to the user which is least congested and minimum delay path. This combined approach improves the performance of the proposed system in terms of accuracy depending on the evaluation method.

4.1 Route Finding System for shortest path and traffic jam

The proposed system is to use a web-based GIS with route-finding for Addis Ababa city database to provide functionalities of mapping shortest path finding, identifying traffic jams and minimum delay path and for analyzing spatial data. The system will have a user-friendly interface so that users with no GIS software skills could easily use the system. The system provides easy to use interfaces to enter the source and destination data, to view paths and traffic jam maps with Addis Ababa geo-features and route-finding statistics. This analysis can provide facts as a guide for different agencies to make some intervention measures and contribute to the reduction of the route-finding system occurring in the city. The Route finding system receives requests for routes from individual drivers. For each driver, the shortest route in time will be calculated and send back to the driver. This information depends on the time and the location of the vehicle. It consists of instruction at every crossing where to go next. The route information is updated at regular times. Routing is, of course, a very common problem and it is very dynamic. This means that the information is updated at a very high speed.

The Route finding system receives requests for routes from individual drivers. For each motorist, the shortest route in time will be calculated and send back to the motorist. This information depends on the time and the location of the vehicle. It consists of instruction at every crossing where to go next.

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4.2 System Architecture

The overall system architecture is shown below in Figure 16.The diagram shows the components and the interaction of various components in the proposed system. The mobile user and online user are also shown in the sketch. This diagram was meant just to show the components in brief. Detailed system architecture is shown in the final system architecture.

The conceptual system architecture is given in diagram. It consists of the following features:

- Graphical user interface where user interacts with the system.
- Routing algorithm: Dijkstra and A* shortest path algorithm and also use YOLOV3 algorithm for dynamic data
- Database (RDBMS).
- Google maps server connection to overlay KML on map to plot route data.

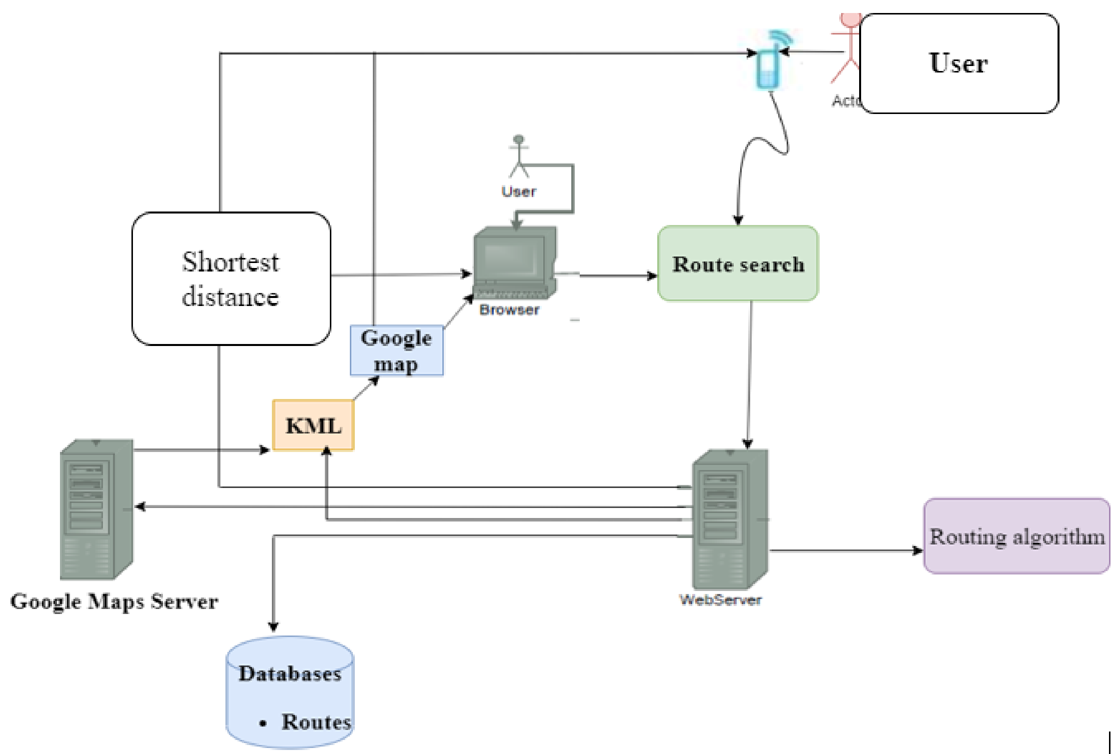


Figure 9: Proposed system architecture for shortest distance

Below are the pseudo code of Dijkstra algorithm

```
Dijkstra algorithm (source, destination)
Set adjacency matrix from graph G
s = source nod
g = destination node
bestnode = s
while bestnode ? g
for all successors of bestnode do
calculate the distance from s to these successors
end for
best_successors = successors with minimum distance from s
change bestnode with this current best_successors
display information
end while
```

Algorithm 1: Pseudocode for Dijkstra algorithm

4.3 Shortest Route Finder (Shortest Path)

Shortest Route Finder tries to sort the problem of finding Better Route between two vertices. Better Route may be defined as a route form vertex "i" to vertex "j" such that the sum of the cost of its constituent edges is minimized. In other way it is quickest way to travel between two vertices. But, these better routes are dependent on some constraints which make routes better for user, depending on their needs. These constraints may vary from travelling distance to time or to traffic congestion depending upon user's need of finding better route. Let d_{sd}, represent the distance between two nodes and assumed that each segment is known. The length of the branch (s, d) in the direction from node s to d need not be the same as traveling in the reverse direction, d to s. In this study, only the forward step is considered. If node s do not connect node j, the distance between the two is assumed infinite, or for the sake of digital computation, a very large number is assigned.

The problem for shortest route finder can be defined as follows:

Given:

1. A road network, G= (V, E) where V is the number of nodes or vertices and E is the number of edges

2. A Source "s" and a Destination "d"

Find:

- [**dist** (s, d)] or [**traffic congestion** (s, d)] **is minimum**, where dist and traffic congestion are network constraints

The network, below, is a sample for the three alternative routes from "Jolly bar (Arat kilo) to Siddist Kilo". The labels on the link are the distance in kilometers for the segment and the top number is the code for the nodes.

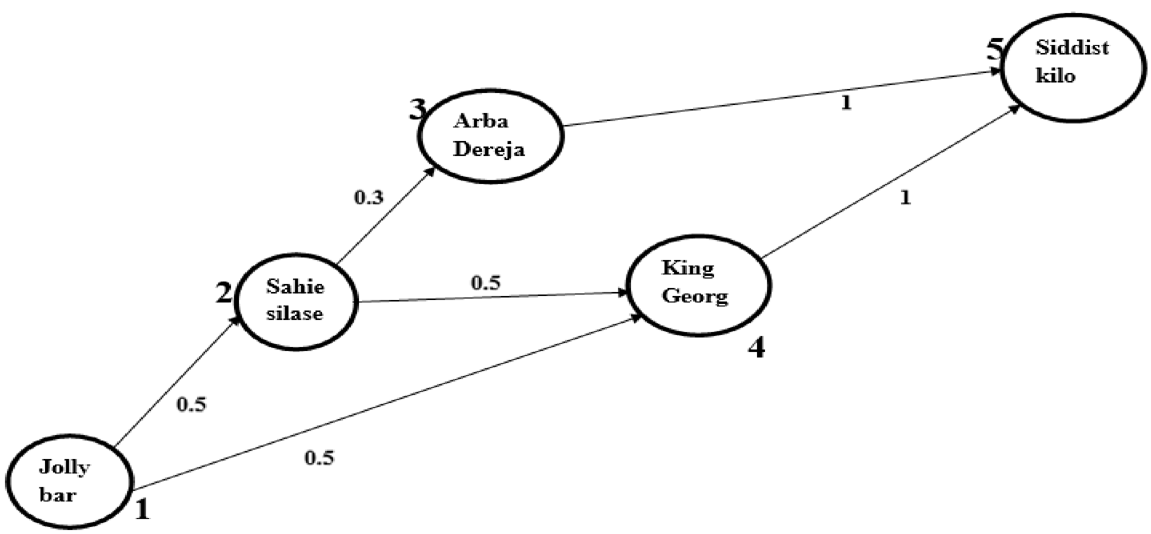


Figure 10: Determine for shortest path

Segments

1 – 4:"Joly bar to King George"
4 – 5:" king George to Siddist kilo" } Route 1

1 – 2:"Jolly bar to Sahie silase"
2 – 4:"Sahie to King George"
4 – 5:" King George to Siddist kilo" } Route 2

1 – 2:"Jolly bar to sahie silase"
2 – 3:" sahie silase to Arba Dereja" Route 3
3 – 5:" Arba Dereja to Siddist kilo"

Steps of Analysis:

We now represent the dynamic programming formulation and outline the algorithm solution. This approach has a distinct advantage of straightforward generation to the problem of finding the first best, second best, third best, in general the K^{th} best solution in the network.

For dij the distance between nodes i and j, djj = 0

U_i shortest distance from node i to the terminal node N. $U_N = 0$.

$$U_i^{K+1} = \min_{j \neq i} \left(d_{ij} + U_j^K + U_i^K \right), \quad i = 1, 2, \ldots N-1.$$

$$U_N^{K+1} = 0$$

Where

N= Terminal Node

i and j are nodes in the network.

K = number of link, K = N -1

$$U_i = \min k \, (U^K i)$$

Equation 3: Shortest distance

Below are the pseudo code of A* algorithm

A* algorithm (source, destination)

{

Enter Source and Destination

Check in Database, if any direct path stored,

If yes, Display the path and distance if no, Extract all path from Database and check whether if there is any sub path of same source and destination nodes

If yes, Display path and distance

If no, Compute Path on the basis of preferred algorithm and preferred constraint

{

Display path, distance and time

Check from all path in database whether this path is super path of any path

If yes, remove that path and insert this super path

If no, insert this path into database

}

}

Display information

Continue for other source and destination node

Algorithm 2: Pseudocode for A* algorithm

4.4 Dynamic Data

To route the traffic dynamically through a city we need dynamic data about the state of the traffic in the city. This can for example be directly from sensors in the road-surface. Such sensors can count vehicles and measure the speed of the vehicles. That information can be used to compute the time it takes to cover a part of the road. Another source can be the traffic information services. They can inform the system about congestion, diversions of the road, roadblocks and perhaps open bridges. And finally the vehicles themselves can provide the system with information about the path they followed and the time it took them to cover it. The current technology enables to fix the position of a vehicle with an accuracy of a few meters. That position can be communicated to the system along with the covered route. For our routing system we will at first only use the latter type of information as dynamic data. But of course the model is open for additional types of dynamic data. The information from the vehicles is handled by a separate part of the routing system, called the timetable updating system (below figure). This subsystem takes care that the information is processed for use by the YOLOV3 algorithm. This way one vehicle drives a certain route and sends its performance to the routing system. Another vehicle is able to use that information to choose the shortest route.

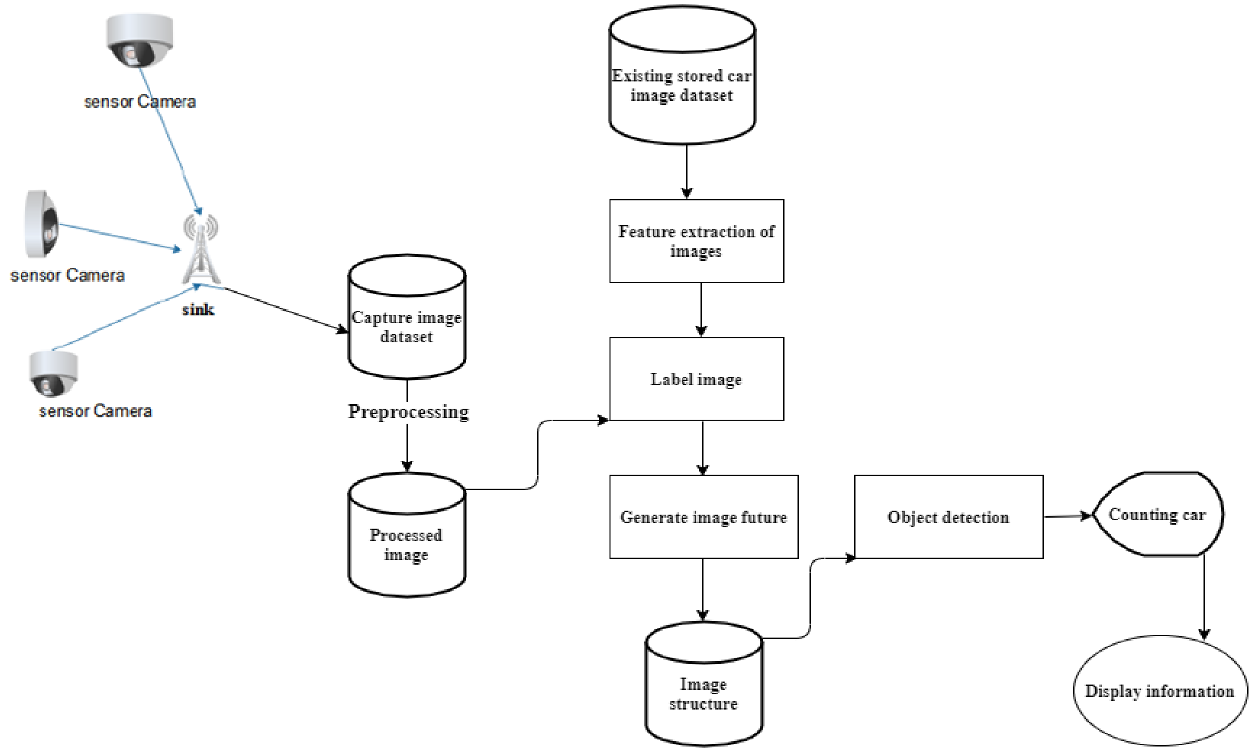


Figure 11: Proposed solution for traffic congestion

Pseudo code of proposed solution for traffic congestion

Input → image

Output → Information

Begin

Sense_ camera_ capture (image)

While **(**sensor_ transmitted (image) → **true)**

Process _the Image_ (visual _processing)

If process image&& dataset_ image → **true**

Car Count and Provide information

Else

Image _not_ occur

Algorithm 3: Object detection of traffic congestion

4.4.1 Dynamic Vehicle Routing System: Network Analysis

Road traffic is getting busier and busier each year. Everyone is familiar with traffic congestion in the city. And every one will admit that it is a problem that affects us both economically as well as mentally. It is very frustrating to end up in a traffic jam just when you were in a hurry. But it is even worse that a lot of people know in advance that every day they need twice as much time as the maximum allowed speed would make possible. Furthermore finding your way in an unknown city can be very difficult, even with a map, especially when you are alone. One of the reasons for congestions is that road capacity is not optimally used. Route information along the road is focused on the “shortest distance”. This information is static.

Dynamic route information could exploit the network capacity optimally. At this moment no system collects and provides dynamic route information for car drivers. This information could be presented at DRIP along the way. The goal of this system is to route the whole group of drivers in an optimal way.

To provide up-to-date, dynamic route information it is necessary to have access to a database of traffic congestion and up-to-date travel times. Travelers on the route may provide the necessary information themselves. At regular times they send their position to a central database. From that information, the time it takes to travel from A to B can be computed. So at the start, we have only static route information to provide the shortest routes, but once travelers are on their way, we get recent traveling data.

The next step is to compute the shortest route from A to B based on the existing dynamic route information. We have to realize that all the time the optimal route has to be computed, as soon as the travel times are refreshed. I have chosen the YOLOV3 algorithm for dynamic routing. After developing the system, it has to be tested, before it can be implemented in a real-world application. So it is necessary to design and implement a tested, simulation of the traffic in a city. An application called City consists of both the simulation environment for the traffic and the Control center, where parameter settings can be changed. The traffic in the simulation communicates with the Routing system. This way we simulate the communication of real vehicles with the Routing system.

The Routing system will consist of two subsystems. The first subsystem is the timetable updating system. This subsystem receives information about the traffic network in the city. This information is provided by the vehicles / Motorcycles driving through the selected nodes in the city. So the proposed system is self-contained. The second subsystem is the Route finding system. This system calculates the shortest routes, in the time frame, and the less probable road traffic jams occurrences for all the users based on the information in the table, and database with the travel times.

4.5 System Model

The work is divided into 4 parts. The first part is to process the video signal and image acquisition from fixed camera using python and opencv. The second part is the place where the image are stored. The third part is the object detection which is performed by enhancing features of the image. Finally, the last part is counting the number of cars/vehicles and display information. The following are block diagram of the proposed system is illustrated below

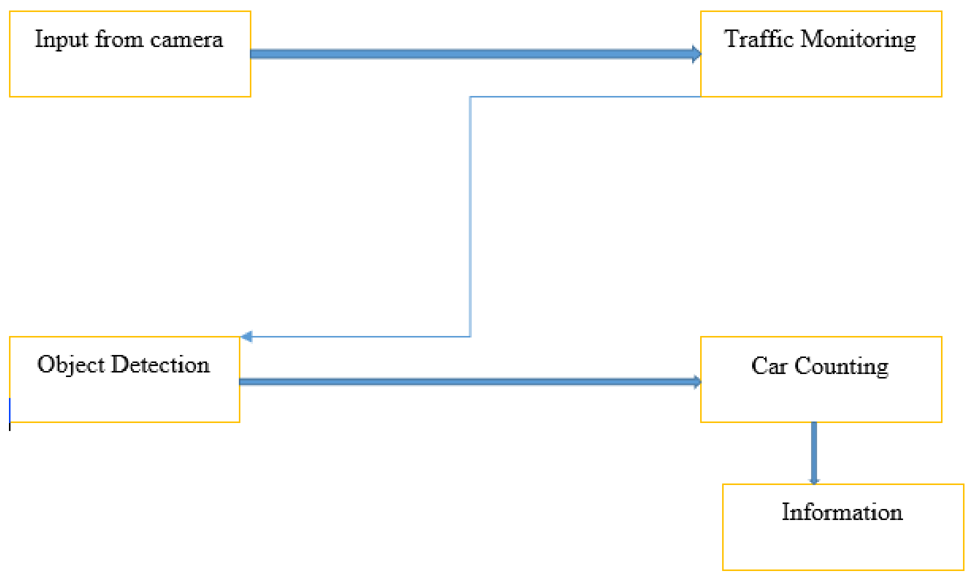


Figure 12: Block diagram of proposed model for traffic congestion

CHAPTER FIVE

5. Implementation of the Proposed Framework

5.1. Overview

This chapter describes the prototype implementation of the proposed framework by using the methodology discussed in chapter three. Also, implement the proposed solution in chapter four. Detail about the implementation of the proposed framework and further modules given in the following sections.

5.2 Implementation Environment

This study used several development tools and packages to implement the proposed solution, route finding. This study uses python programing language for implementing and experimenting with each proposed solution from the data preprocessing to the model building phase. Also, to evaluate the implemented proposed classifiers model. Python used because of its programming language of choice for developers, researcher and data scientists who need to work in machine learning models. Table 5.1 shows the list of tools and python packages with their version and description which is used in this study.

Tools	Version	Description
Labelimg		It has been used as a graphical image annotation tool, label object bounding boxes in images. Is a free, open source tool for graphically labeling images. It’s written in Python and uses QT for its graphical interface. It’s an easy, free way to label a few hundred images
Python	3.7	✓ Why? Python provides several packages for data manipulation that are easy to use and are supported by a large community of contributors. ✓ It has built-in libraries for scientific python as numpy ✓ Easy to learn, powerful programming language

Numpy		Array processing for number, strings, and objects. This study uses it for handling converting the text to numeric data for features and training and testing the model.
YOLOV3		Among a variety of object detection algorithms to tackle the problem of object detection, YOLO is relevant to its peculiarities and performances. As a real-time object detection need to use fast and performance detection algorithms, YOLO is preferable due to the fact that capable of performing detection in one go.
Darknet		**Darknet**: [48] is an open-source neural network framework written in C and CUDA. It is fast, easy to install, and supports CPU and GPU computation and serves as the basis for YOLO by extracting a feature and training on. In addition, Darknet-19, the backbone of YOLOv3 Tiny, is used to extract the features.
Google Collaboratory Cloud Service		The model is trained and tested using Google Colab. Since training a deep learning model takes a lot of time a GPU is required. Google Colab offers a 12 GB RAM with GPU and more than 135 GB storage space for free. All the image dataset is uploaded to Google Drive and then mounted with Google Colab to access the images while training and testing. And then, the Darknet framework was cloned from [49] git repository to Google Colab space and compiled. The compiled version was saved to Google Drive which could be accessed at any time for training and testing of the model.

Table 9: Tools for implementation

Working Environment

- Laptop
    - Operating system: Window 10
    - Processor: Intel® Core™ i5-5200U CPU @ 2.20GHz 2.20 GHz
    - Installed memory (RAM): 4.00 GB (3.71 GB usable)
    - System Type: 64-bit Operating System, x64-based Processor

5.3 Collecting and labeling dataset

I am collecting images by using online sources like google image from chrome browser then collecting and preprocessing images. After we collect the images we will need to annotate them. For YOLOv3, each image should have a corresponding text file with the same file name as that of the image in the same directory. And also labelling images by using labelimg tools software as below form

Training and Testing dataset

We can then randomly split the annotated images into train and test sets in the ratio of 8f5:15.

Content data/Darknet/train.txt → each row in the file should have the location of train dataset.

Content data/Darknet/test.txt →each row in the file should have the location of test dataset.

```
import os


path = '/content/darknet/img/'

imgList = os.listdir('Trainset')

print(imgList)

textFile = open('train.txt', 'w')

for img in imgList:
    imgPath = path + img + '\n'
    textFile.write(imgPath)
```

```
import os


path = '/content/darknet/img/'

imgList = os.listdir('Testset')

print(imgList)

textFile = open('test.txt', 'w')

for img in imgList:
    imgPath = path + img + '\n'
    textFile.write(imgPath)
```

5.4. Object Detection

An object detection algorithm should be used to interpret the exhibition environment by detecting the objects around the car. With the need for real-time object detection, one-step object detection architecture has been proposed, YOLOv3 Tiny. It calculates all bounding boxes across all classes for an image simultaneously. The detection of objects around the car should be fast enough so that the analyzes contexts based on the detection output. So, YOLOv3 Tiny is a very good choice for real-time object detection [47]. After the image is converted into frames by python segment of code, each frame is taken as an input to object detector sequentially.

5.3.1 Bounding Box and Class Prediction

The separate components in other state-of-the-art object detection algorithms are unified into a single network in YOLOv3 Tiny. In the first stage, the input frame is divided into an S x S grid. Then bounding boxes B and Confidence score C is defined in each grid cell. Each grid cell predicts conditional probabilities C, denoted as P (Class | Object) - if there is an object in the grid P(Object) = 1, Otherwise, P(Object)=0. The confidence refers to the accuracy the box predicts and the probability the objects are contained which defined as:

$$C = Pr\,(Object) * IOU_{pred}^{truth}$$

Where

IOU, intersection over union, represents a fraction between 0 and 1. IOU is referring to the intersection area between the predicted bounding box and the ground truth box.

Equation 4: Confidence of object detection

YOLOv3 Tiny predicts both bounding boxes and C conditional class probabilities for each grid cell simultaneously. The class-specific probability for each grid cell is defined as:

$$P(Class_i|Object) * P(Object) * IOU_{pred}^{truth} = P(Class_i) * IOU_{pred}^{truth}$$

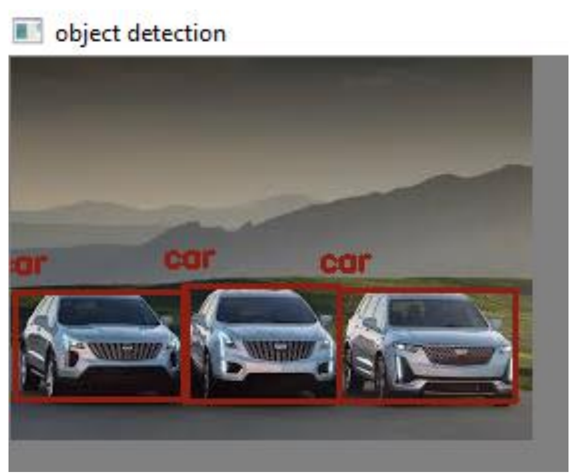
Equation 5: Class-specific probability for each grid cell

A. Normal image

B. Detected image

A. Normal image

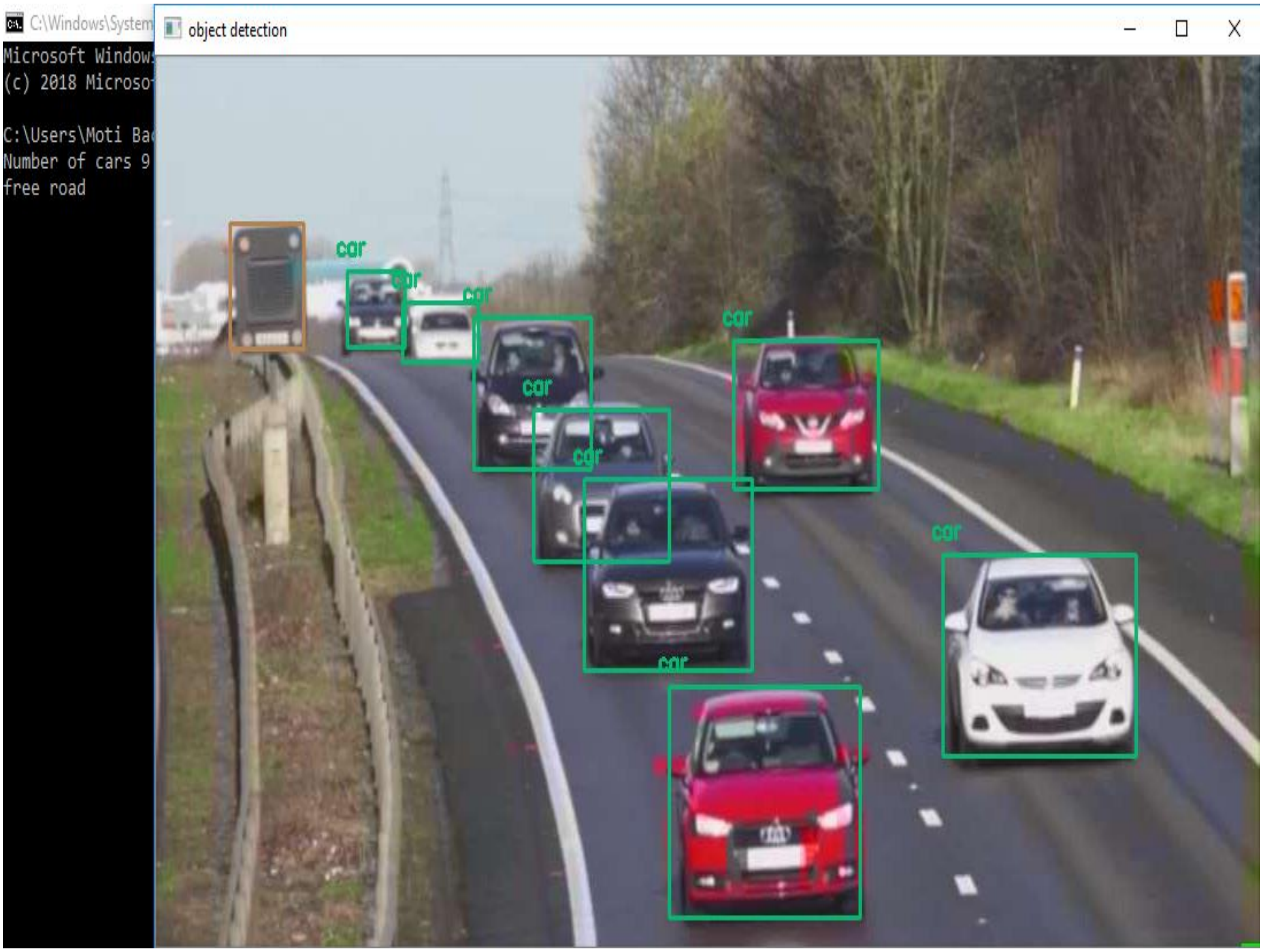
B. Detected image



A. Normal Image

B. Detected image

A) Normal image



B) Detected image

CHAPTER SIX

6. Results and discussion

6.1 Introduction

In this chapter, the evaluation of the developed system is presented and its outcome has been discussed. In the next section 6.2, the overall object detector its context analyzation performance are evaluated and their results are fatherly discussed.

6.2 Object Detection

The object detection algorithm (YOLOv3 Tiny) take an image from the scene as an input, and generates the probability and localize the objects. The dataset contains 1000 images from different sources. The images are taken at different background, scale, view, angle, and illumination to cover all possible scenario that detector may operate. Generally, around 1000 images were labeled for each sample of the objects.

The dataset has been divided into a training set and testing set with a ratio of 85 to 15 respectively. The training set contains 851 images and the test set contains 149 images. A segment of python code was used to select the test set randomly from the dataset. The image was capture and taken from Google image by using labelimg tool.

The **batch size** is set to 64 (64 images are used in one iteration). The batch is **subdivided** into 32 blocks (subdivision). The images of a block are running in parallel on the Google Colab GPU. Since weight updates fluctuate quite a bit among the batches, a parameter **momentum (momentum = 0.9)** is used to penalize large weight changes between iterations. Also, the large value of weights which will prone to overfitting problem is penalized by **decay** (decay = 0.0005).

At the beginning of the training process, the model starting with zero information and so the l**earning rate** needs to be high. It has been empirically found that the training speed tends to increase if the learning rate remains lower for a short time at the very beginning. This is controlled by the **warm-up (burn_in)** parameter. But as the neural network sees a lot of data, the weights need to change less aggressively (violently). In other points, the learning rate needs to be reduced over time. In the configuration file, this decrease in learning rate is accomplished by first specifying that the learning rate decreasing **policy** is **steps**. So, the learning rate starts from 0.001 and remains constant for 19200 iterations, and then it multiplied by **scales** to get the new learning rate after 19,200 and 21,600 iterations, and hence the learning is decreased less aggressively. The learning rate increases gradually from 0 to 0.001 by the 1000th batch. It would stay there till the 19,200th batch when it would again change to 0.0001. And then, when the training reaches on 21,600 batches, again it changed to 0.0001. Since the max batches reached 24000 and the loss is close to desired, the training is stopped and the learning rate has remained 0.0001.

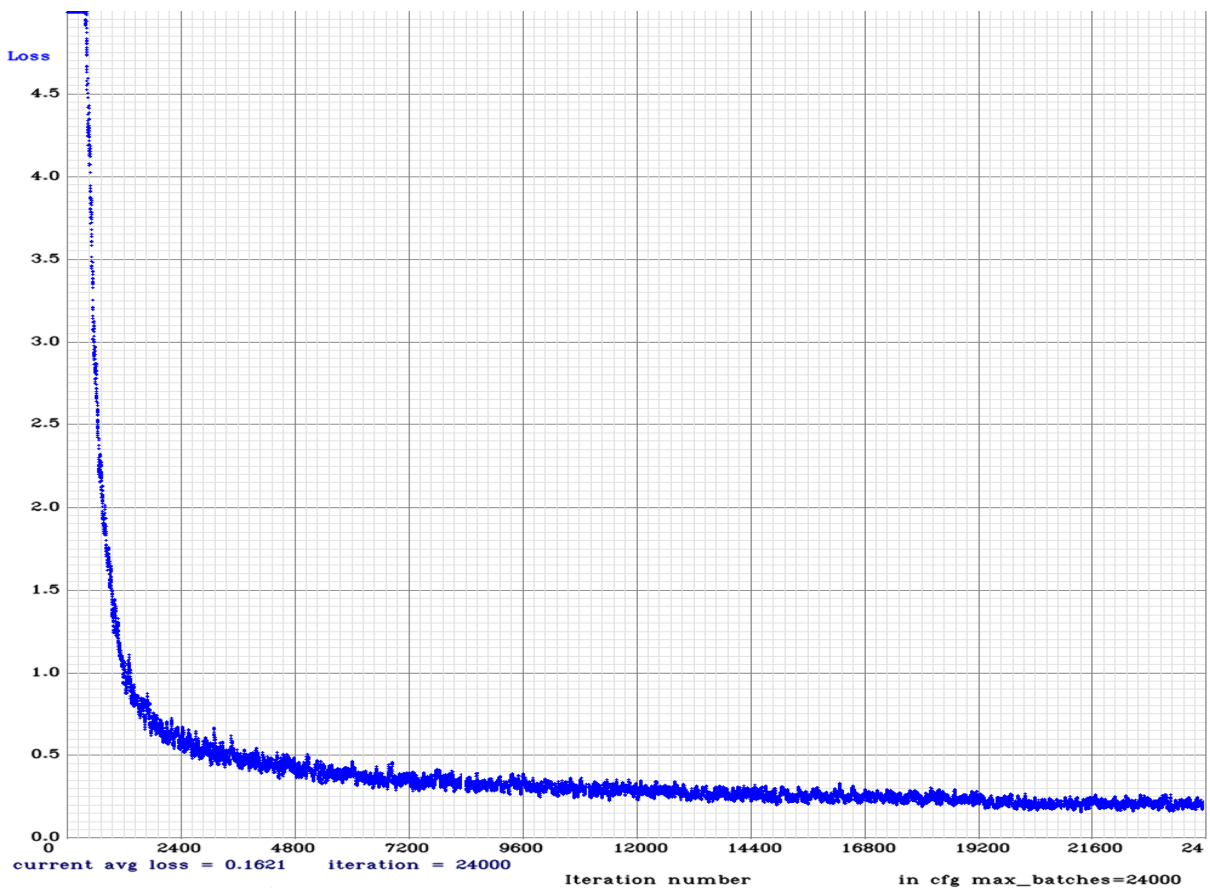


Figure 13:YOLOv3 Tiny: The Loss Curve

The box classifiers' classification and localization loss are 0.140484 and 0.021307 respectively which average of loss is 0.162147. And, Along with the loss, mAP (mean Average Precision) has been tested on the test set and hence the results are described in the figure below.

```
for thresh = 0.25, precision = 0.95, recall = 0.97, F1-score = 0.96
for thresh = 0.25, TP = 895, FP = 49, FN = 25, average IoU = 79.36 %

IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
mean average precision (mAP@0.50) = 0.974723, or 97.47 %
```

```
for thresh = 0.50, precision = 0.96, recall = 0.96, F1-score = 0.96
for thresh = 0.50, TP = 885, FP = 34, FN = 35, average IoU = 80.76 %

IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
mean average precision (mAP@0.50) = 0.974723, or 97.47 %
```

```
for thresh = 0.75, precision = 0.97, recall = 0.93, F1-score = 0.95
for thresh = 0.75, TP = 851, FP = 22, FN = 69, average IoU = 82.09 %

IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
mean average precision (mAP@0.50) = 0.974723, or 97.47 %
```

Figure 14: Model’s Evaluation Result in Precision, Recall, and mAP

CHAPTER SEVEN

7. Conclusion and Future work

This chapter contains recommendations for additional and useful tasks in the future. It covers important thoughts and ideas, which were not included in this study, due to time and scope restrictions.

7.1 Conclusion

One of the basic problems in route finding is to find the shortest and quickest route between two points in a road network in case of lack of information about traffic congestion and addressing mechanism for shortest distance. The emergence of traffic and subsequently traffic congestion in urban road networks are increasing worldwide with the growing number of vehicles, which results in excess delays, and reduced safety. The effect of traffic congestion to a shipper means longer travel times, decrease in vehicle utilization, decreased in fuel efficiency, higher cost of fleet operation, shrink in market coverage, higher cost of shipment.

In this research a methodology based on python language programming has been proposed. Python is very good library like numpy, matplotlib, scipy, and also Opencv which can help to object detection and count traffic. The YOLOv3 Tiny based object detector was trained on the darknet framework which is an open-source framework and written in C/CUDA and serves as the basis for YOLO. Due to increase in superhighway and traffic congestion, there is a huge amount of potential applications of vehicle detection and tracking on expressway and around the city. In this paper we have demonstrated vision based system for effective detection and counting of vehicles running on roads. Vehicle counting process accepts the images from single camera & detects the moving vehicles and counts them. The experiment of this study shows that the object detector performs very well and it archived much better accuracy.

7.2 Future Work

In this research can also be extended to include web mapping related services apart from the route find process by implementing an integrating interface (API) with other online services like Google map, yahoo maps and others to find shortest path for online services

The other future works includes GPS based data to be integrated into the system. This can be realtime traffic information monitoring scheme and linking it to the system. This will help to know peak times when the traffic is much congested thereby enabling less utilized road to be maximum utilized. It also includes study and generation of some good Consistent Anticipatory Route Guidance (CARG) algorithms. Future works also includes parallelizing the algorithms to run it on distributed machines to make computations much faster.

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Appendixes

Appendix A: Sample Code for Detection Model's Training Configuration

```
[net]

batch=64
subdivisions=8
# Training
# batch=64
# subdivisions=2
width=416
height=416
channels=3
momentum=0.9
decay=0.0005
angle=0
saturation = 1.5
exposure = 1.5
hue=.1

learning_rate=0.001
burn_in=1000
max_batches = 500200
policy=steps
steps=400000,450000
scales=.1,.1

[convolutional]
batch_normalize=1
filters=16
size=3
stride=1
pad=1
activation=leaky

[maxpool]
size=2
stride=2
```

```
[yolo]
mask = 3,4,5
anchors = 36, 55,  71,110, 188,190, 347,212, 263,294, 369,321
classes=1
num=6
jitter=.3
ignore_thresh = .7
truth_thresh = 1
random=1

[route]
layers = -4

[convolutional]
batch_normalize=1
filters=128
size=1
stride=1
pad=1
activation=leaky

[upsample]
stride=2

[route]
layers = -1, 8

[convolutional]
batch_normalize=1
filters=256
size=3
stride=1
pad=1
```

Appendix B: Python code for Object detection and car counting source code

```
############################################
# Object detection - YOLO - OpenCV
# Author : Moti Bacha

import cv2
import argparse
import numpy as np

ap = argparse.ArgumentParser()
ap.add_argument('-i', '--image', required=True,
                help = 'path to input image')
ap.add_argument('-c', '--config', required=True,
                help = 'path to yolo config file')
ap.add_argument('-w', '--weights', required=True,
                help = 'path to yolo pre-trained weights')
ap.add_argument('-cl', '--classes', required=True,
                help = 'path to text file containing class names')
args = ap.parse_args()


def get_output_layers(net):

    layer_names = net.getLayerNames()

    output_layers = [layer_names[i[0] - 1] for i in net.getUnconnectedOutLayers()]

    return output_layers


def draw_prediction(img, class_id, confidence, x, y, x_plus_w, y_plus_h):

    label = str(classes[class_id])

```

```
    color = COLORS[class_id]

    cv2.rectangle(img, (x,y), (x_plus_w,y_plus_h), color, 2)

    cv2.putText(img, label, (x-10,y-10), cv2.FONT_HERSHEY_SIMPLEX, 0.5, color, 2)


image = cv2.imread(args.image)

Width = image.shape[1]
Height = image.shape[0]
scale = 0.00392

classes = None

with open(args.classes, 'r') as f:
    classes = [line.strip() for line in f.readlines()]

COLORS = np.random.uniform(0, 255, size=(len(classes), 3))

net = cv2.dnn.readNet(args.weights, args.config)

blob = cv2.dnn.blobFromImage(image, scale, (416,416), (0,0,0), True, crop=False)

net.setInput(blob)

outs = net.forward(get_output_layers(net))

```

```
class_ids = []
confidences = []
boxes = []
conf_threshold = 0.5
nms_threshold = 0.4


for out in outs:
    for detection in out:
        scores = detection[5:]
        class_id = np.argmax(scores)
        confidence = scores[class_id]
        if confidence > 0.5:
            center_x = int(detection[0] * Width)
            center_y = int(detection[1] * Height)
            w = int(detection[2] * Width)
            h = int(detection[3] * Height)
            x = center_x - w / 2
            y = center_y - h / 2
            class_ids.append(class_id)
            confidences.append(float(confidence))
            boxes.append([x, y, w, h])


indices = cv2.dnn.NMSBoxes(boxes, confidences, conf_threshold, nms_threshold)
print("Number of cars",len(indices))
for i in indices:
    i = i[0]
    box = boxes[i]
    x = box[0]
    y = box[1]
    w = box[2]
    h = box[3]
    draw_prediction(image, class_ids[i], confidences[i], round(x), round(y), round(x+w), round(y+h))

cv2.imshow("object detection", image)
cv2.waitKey()

cv2.imwrite("object-detection.jpg", image)
cv2.destroyAllWindows()
```