# Modelling of Geodatabase for The Traffic Network Using Intelligent Transportation System (GIS-T): The Case of the City of Amman

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## Abstract

The infrastructure of road systems is weak in many developing countries, and in the emergency situations, there is an urgent need for the discovery of the nearby emergency facilities, finding the optimal route for these services, and avoiding traffic delays to reduce losses of lives and assets. In this paper, these problems were undertaken by building a geodatabase for the study area of Amman city, Jordan, and by adopting the Geographic Information System (GIS) with other applications, such as the Dijkstra algorithm for shortest path and nearest facility applications. In this paper, a specific area in Amman, with high traffic was selected to be analysed using GIS for Transportation Tools (GIS-T). This research has been conducted to help decision makers to discover the best way to plan transportation, investigate transportation needs, analyse travel demands, and monitor traffic flow, creating a new and efficient transportation system that will efficiently help in economic development of any country.

## Keywords

Geodatabase, Traffic, Intelligent Transportation System, GIS-T.

## Introduction

### 1. An Overview

Social and economic development of any society is directly affected by the level of transportation system structure which determines the quality of life in major cities (Indhoko et al, 2016). The increased number of population and vehicles in the world, which leads to increase pressure on the city's traffic, which mean a huge amount of rush hours for traffic systems (Zeng et al,2010). Transportation systems play a significant and important role in industrial and commercial growth through the improvement of urban infrastructure (Button al, 1995). The transportation systems consist of roads, freeways, railroads, seaports and water channels etc. It connects cities and towns and allows people from one location to communicate with others in different locations. A high-quality road system helps people easily to transport to their work locations and build up their life, lands etc. (Ndiwari, 2014).

Geographic Information Systems (GIS) are an exceptional kind of data framework that is utilized to input, maintain process, analyze, and visualize geospatial information and data to support decision making (Awange & Kiema, 2013).

Network analysis in geographic information system (GIS) offer high-quality decision support for clients concerned about shortest or best routes, discovering the closest facility and finding the service area (Delavar. et al. 2004). GIS for Transportation (GIS-T) refers to the principles and applications of applying geographic information technology to transportation problems (Didigwu, & Olajide 2015). GIS can be used as a decision support system in transportation field.

GIS-T is applied in a great part of the expansive extent of transportation and logistics, such as transportation safety investigation, travel demand analysis, traffic observation and control, intelligent transportation systems (ITS), routing and scheduling, and many other applications (Rodrigue, 2017). GIS-T studies can be classified into three classifications (Miller, Shaw 2015) as follows :-

- Data modeling: means by which transportation-related information in a GIS can be best represented to incorporate the requirements of different transportation applications.
- Analysis and demonstration: GIS gives a superior domain to experienced GIS-T clients to build up their own custom analysis methods and models.

- Applications: each GIS-T application will in general have its particular data and analysis necessities.

## 2. Research Objectives

- Review properties and techniques of urban network congestion for network flow modelling, and stressing the requirements for dynamic congestion forecasting.
- Design and implement geodatabase for GIS-T of a pilot study area of Amman city, to oversee relation between the transportation facilities and services, generally sorted out around different methods of travel for exact and dependable data exchange.
- Apply different network analyst and overlay examination using GIS-T functions such as ArcGIS 10.2.

## 3. Structure of the Paper

This paper has been formulated into six major parts. The first part is the introduction and contains an overview and research objectives. The second part is the literature review, the third part is about creation of the transportation data model for the city of Amman and contains the study area information, data availability, methods and the creating the geodatabase. The fourth part is the Transportation Network Analysis and contains an introduction, algorithm used in network analysis of GIS, transportation analysis. The fifth part is the conclusion and future work.

## Literature Review

(Obaidat and Bara'W 2012) Discussed the importance of integration of geographic information systems(GIS) and paver system to obtainan efficient pavement maintenance management system(PMMS), in Irbid city, Jordan.

GIS and paver system were integrated together and used for identifying,collecting, and displaying pavement conditions, and information pavement distresses were made sense of dependent on pavement record esteems registered by pavement condition file (PCI). A network analysis based on GIS for the roads network of the greater Cairo area was implemented in (Ahmed et. al., 2017) and distinguished the importance between best and shortest route algorithm, and it's significant effect to minimize the arrival time to desired location, this research tries to test the readiness to solve immediate response situation (fire response, police stations emergency response,health care emergency response etc..) through enhancing network analysis using capabilities of geographical information

systems (GIS). The obtained results shows a saving in travel time by 20% to 22%, depending on selecting the best route than the shortest route.

In the case study of (Gubara et. al., 2014), authers highlighted the importance of emergency support system for the reduction of disaster losses and the efficiency of improvement of emergency resources allocation based on utilizing geographical information systems(GIS).

(Naithani et. al., 2013) discussed the congestion pattern of Dehradun city, and analyzedthe traffic flows inorder to build a modeling network congestion routing to find the best alternative route for emergency cases. As a first step location, time and activity have been identified as primary content types of characterizing the situation of incident. Global positing system (GPS), geographical information system (GIS), and global system for mobile communication (GSM) are integrated together to provide the drivers with real-time positioning technique for optimal routing with minimum arrival time, and to determine the best route for hospitals ambulances management needs.

According to (Kong et. al., 2011) one of the main important application in GIS is the shortest path for ground transportation system based on Dijkstra algorithm, and the quick search for the shortest path considered as a top priority, it utilizes the technique for expanding node by node to get the shortest path tree which makes the beginning stage as it's root.

In the study of (Oo, H. 2019), about the GIS based fire emergency response system for Mandalay, the auther developed and implemented an effective fire response system supported by Dijkstra's algorithm, on a regional scale to tackle such emergency cases. The algorithm of this system can provide an optimal route that consumes less time.

(Khaing et. al., 2018) investigated the methodology and the importance of using GIS and Dijkstra's algorithm to calculate the shortest path of public transportation bus routes of Yangon city Myanmar. Dijkstra's algorithm based on GIS is implemented in this case study using free and open source technologies including open source GIS tool. The main goal of this study is to get the optimal route for any emergency case to reachthe nearest emergency service center.

(Phyo and Sein 2016) investigated the finding of ideal route, to support fire crisis services, and to arrive at the incident site in short time, the GIS based technology is applied to identify the fire incident location in short time to find the nearest fire station and calculate

the optimal route to travel to the incident site from fire station by avoiding closed and narrowed roads.Geographical databases (Geodatabase) contain information about population,commercial activities, industries, businesses, transport and services provided at urban level. Withsuch detailed data specialists can analyse and investigate to figure out the perfect comprehension and visualization of spatial phenomena, to identify clusters of services and to verify the correspondence between urban centers and high level of service( Borruso and Schoier 2004).

Aeronautical Reconnaissance Coverage Geographic Information System (ArcGIS) is used by organizations to produce, supervise, distribute, and investigate spatial data.

It offers a network-based spatial analysis tools for resolving compound routing problems. It utilizes a configurable transportation network data model, permiting organizations to correctly represent their exclusive network requirements. User can map routes for an whole task force, compute drive-times, find facilities and explain other network associated problems. (Scott and Janikas. 2010).

ArcGIS Network Analyst is an expansion for network-based spatial analysis for example routing, tour directions, and nearby facility, also its used for region service analysis. It permit users to form a realistic model network environment, traffic restrictions, speed limits, and traffic conditions, at different times of the day. (Elizabeth 2005).

## Creating Transportation Data Model For Amman City

### 1. The Study Area

Data required for the modeling should cover different aspects of traffic parameters, trafficvolume, speed, percentage of heavy vehicles, road surface, gradient, noise path and congestion through rush-hours (Jamrah & et. al., 2006). For the concerend area which is Amman city, the capital city of Jordan, it has several charactericteces such as rapid development, vast jamb in economy, quick increase in number of vehicles, and traffic noise pollution. This fact imposed to continuously look forward in finding the optimal traffic solutions to facilitate the life and economic style through urban and regional planning.

A specific area in Amman city shown in Figure 1, has been choosen to employ our network analysis, this area contains a heavy traffic density almost all day time, this area includes Zahran street starting from the sixeth, the seventh, and the eighth circle, with the surrounding roads.

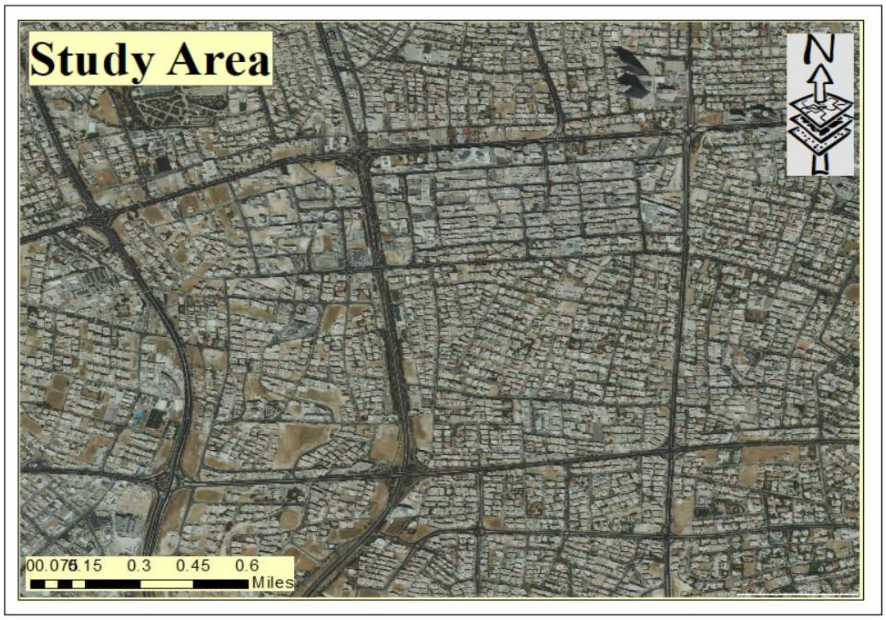


**Figure 1 Amman city study area**

Information required for network analysis, such as GIS layers for Amman city, roads, main features, buildings, contours lines, and sub districts was obtained from The Greater Amman Municipality, Department of Geographic Information Systems (GIS) in a suitable form to be processed. Other data have been captured by digitizing satellite imagery and available data from organizations.

Table 1 shows the types of data and all features used in the study, and the data sources.

**Table 1 The type of data used in the study and their source**

| Layer Name | Feature Kind | Source | Projection |
|---|---|---|---|
| Main Features | Vector | Amman Municipality | WGS_1984_UTM_Zone_36N |
| Roads | Vector | Amman Municipality | WGS_1984_UTM_Zone_36N |
| Contour Lines | Vector | Amman Municipality | WGS_1984_UTM_Zone_36N |
| Buildings | Vector | Amman Municipality | WGS_1984_UTM_Zone_36N |
| Sub districts | Vector | Amman Municipality | WGS_1984_UTM_Zone_36N |
| Index control | Vector | Amman Municipality | WGS_1984_UTM_Zone_36N |
| Amman Raster | Raster | Satellite Image Quick Birde | WGS_1984_UTM_Zone_36N |

## 2. Creating the GeoDatabase

Relational model is used as an approach to investigate the design and development of Geographical databases (Geodatabase). This model guarantee the independence between the logical level and the physical level to express view of geographical entities which still showing links to access and refer to them through both descriptive and geometrical

(Gargano and Nardelli 1990). The geodatabases have a three main Types of Dataset, as shown in Figure 6.

1. Table :- collection of rows each containing the same fields.feature classes.
2. Feature classes:- table containing point, line or polygon geometris for grograghic features. each row is feature.
3. Raster Datasets:-contains raster which represent continuos geographic phenomena)

## Creating Geodatabase in ArcGIS

Based on the database model of the study area (roads, buildings, contours, main Features, sub districts, index control), in ArcGIS the Geodatabase was created, and it has feature dataset, classes and tables as shown in Figure 2.

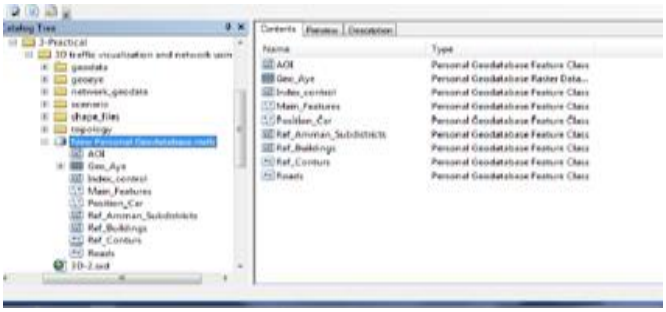

**Figure 2 The Geodatabase in ArcGIS-ArcMap**

## Creating Roads

Road features of the study area in Amman was created by digitizing the sateliite image as shown in Figure 3, the digitized roads contain all roads shape, names, types, functions, distance, shape length, speed limits, and elevations.

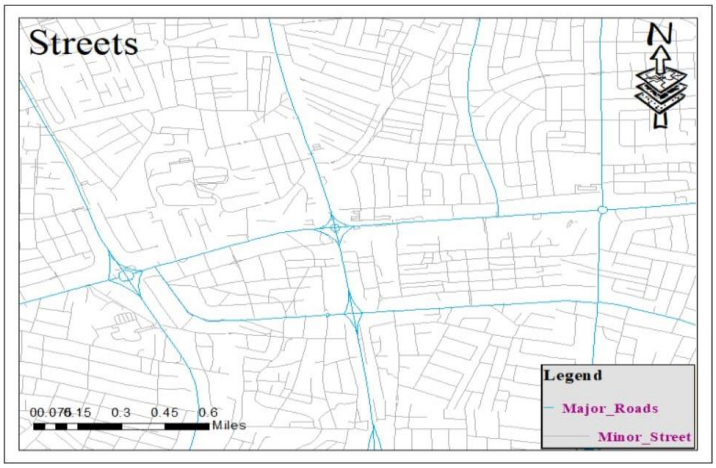


**Figure 3 Road feature of study area (Amman)**

## Creating Buildings

Building features of the study area(amman) was created by digitizing the satellite image as shown in Figure 4, the digitized building contain all buildings shape, number of floors, height, shape length, and shape area.

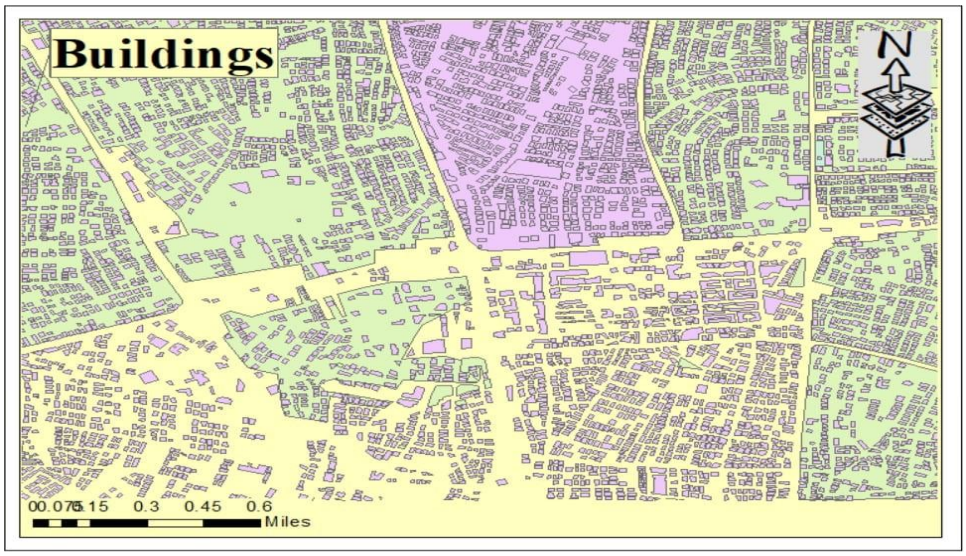


**Figure 4 Building feature of study area (Amman)**

## Creating Main Features

Main features at the study area in Amman, was created by digitizing the satellite imageas shown in Figure 5, the digitized main features contain all main features shape, name, type, and road name.

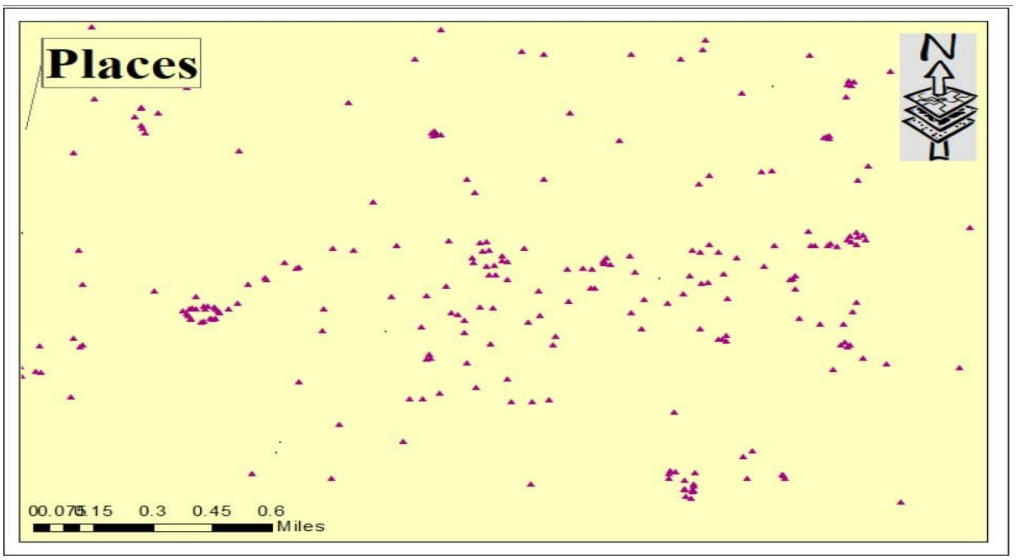


**Figure 5 Main features of study area (Amman)**

## Transportation Network Analysis

In any network and transportation analysis, computing the shortest path is one of the major tasks related to data analysis.One of the key problems in the network analysis is to specify the shortest path between two points within the network in order to help the drivers of an ambulances and/or fire cars to reach the needed destination within minimum time to save life and properties, it is necessary to apply an approach that is as efficient as possible through the implementation of Dijkstra algorithm,it was clear that this application is efficient enough as fastest approach to optimally solving 'one-to-one' shortest path problems.Dijkstraalgorithm can be improved by considering the advantages of network properties associated with GIS-Sourced data. Based on available data, two types of network analysis were done, the first one related to the shortest path. The second analysis is related to the closest facility approach which determine the path to the closest facility. The analysis was applied for network transportation roads in Amman greater area with the following constraint factors:

i. Speed limit
ii. Road function
iii. Level of road
iv. Obstacles

The two selected paths are shown in Figures(6,7,8,9).


**Figure 6 Case one showing the shortest path btween point 1and point 2**

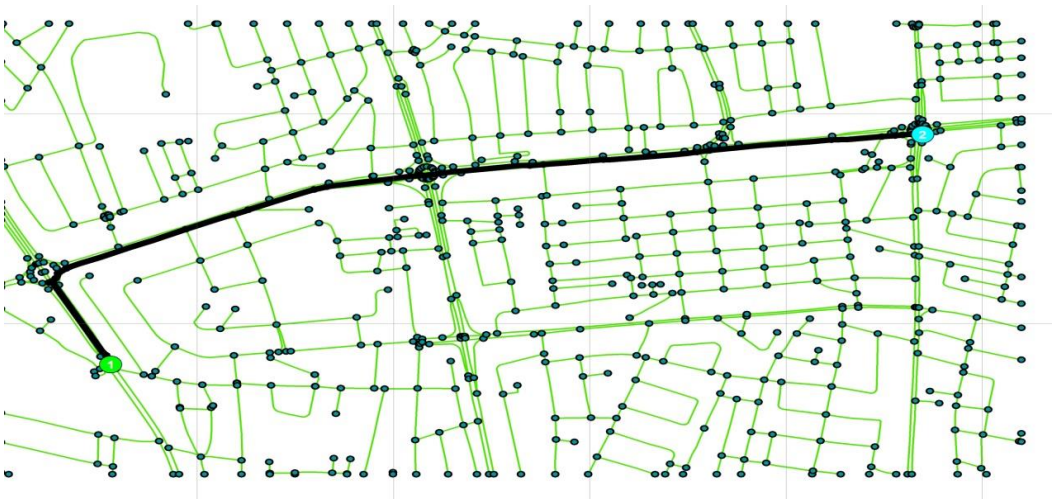

**Figure 7 Case two showing the shortest pathbtween point1and point 2**

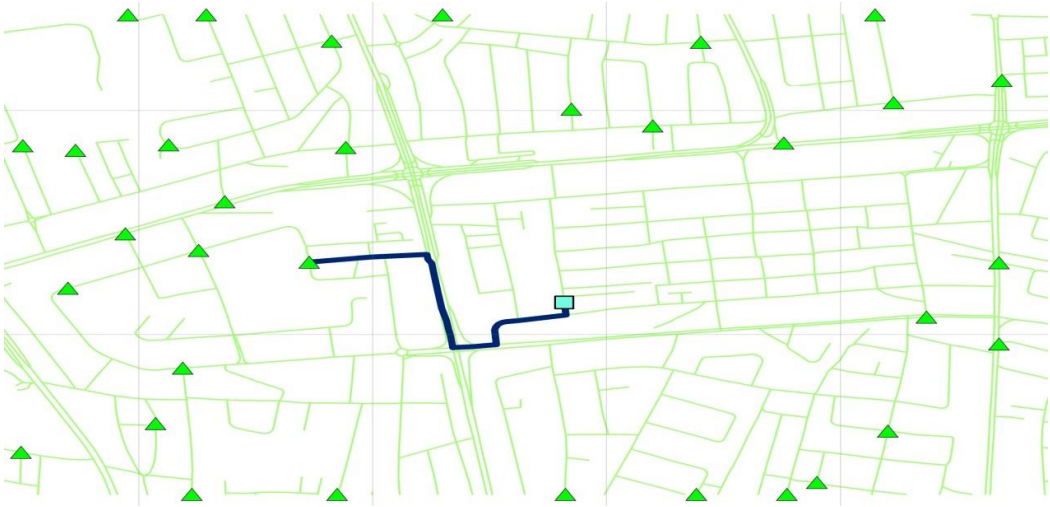

**Figure 8 Caseone showing the closest facility**

**Figure 9 Case three showing the closest facility**

The results provide the optimization route in terms of travel time for the shortest path, same results obtained for the closest facility.

The distance of route obtained from the shortest path analysis represent the accumulated lengths of the road segments over which agent will travel, and same as for the total time of route obtained which represent the accumulated time in minutes for each individual route segment over which the agent will travel, by using this analysis, the user may know the nearest needed facility according to his location and shortest path to arrive to destination.

## Conclusion

The main objective of our study focused on analyzing the transportation network in the selected area within Greater Amman Municipality in Jordan, creating and structuring a geodatabase related to that area, and the data was separated in the form of layers to simplify the analysis and provide better results,this analysis was based on Arc GIS to examine the outcome of shortest path and closest facility procedures in order to provide optimal solutions and serve the users of the traffic network.In future works, the researcher cango further to study of land suitability analysis including spatial multi-criteria decision making analysis, a technique for classifying spatial factors afficting transit oriented development (TOD) calculating factor scores to find a suitable area for land development.

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