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A Knowledge-based System for Developing Cognitive Map Based on Geographical Map

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Master Degree in
Computer Science

By

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إقرار تفويض

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Declaration

I do my hereby declare the present research work has been carried out by me under the supervision of Dr. Hussein H. Owaied, and this work has not been submitted elsewhere for any other degree, fellowship or any other similar title.

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إهداء

إلــى مــن علمتني الشعر قبل الفطام
إلى من أهدتني الوصـل دون الخصام
إلى من ربتني وليداً وسقتني من حنانها شهد المدام
لهـا مـا قدمت ومـا اقدم في الامــام
لحـــن حـــب ومــن الله الســـلام
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Abstract

This thesis presents a knowledge-based system for developing cognitive map from geographical map. The system consists of three parts; the user interface, the inference engine, and the knowledge base. The development of cognitive map processes ware based on the geographical map and the philosophy of human vision. These processes have been described in a set of mathematical algorithms and implemented as software modules. The mathematical algorithms have constituted the two parts, inference engine and the knowledge base of the knowledge-based system. This thesis introduces many applications for the system and gives an example that produces a very good result. The present thesis concentrates on the knowledge for only one layer of the geographical map and the future work will include the knowledge for multilayer.

الخلاصة

تقدم هذه الرسال نظام معرفة لبناء الخريطة الادراكية من الخريطة الجغرافية . النظام يحتوي على ثلاثة اجزاء: وسيلة الاتصال، محرك الاستدلال و قاعدة المعلافة. طور بناء الخريطة الادراكية بناءً على الخريطة الجغرافية و فلسفة النظر عند الانسان. وصفت عملية بناء الخريطة الادراكية بالتفصيل كمجموعة من الخوارزميات الرياضية و طبقت على هيئة وحدات برمجية ، ان الخوارزميات الرياضية شكلت على هيئة جزئين رئيسيين: محرك الاستدلال و قاعدة المعرفة.

قدمت هذه الرسالة عدة تطبيقات مع اعطاء امثلة اخرجت نتائج جيدة جداً و ركزت في الوقت الحاضر على المعرفة المستمدة من الخرائط ذات الطبقة الواحدة على ان يكون العمل المستقبلي مبني على الخرائط ذات الطبقات المتعددة .

Chapter One

1

Introduction

1. Introduction

Intelligent Agent can be used in many fields in our life, they can reduce the time and money consumed, they can reduce the risks especially in danger environments, in recent years intelligent agent were provided by sensor devices, cameras, wheels, motors and other components that allow agent to move from one location to other.

1.1 Overview

The Information Technology (IT) becomes the concept used by many people even though they are not professional in computer science, since all the societies deal with the use of electronic computers and computer software to convert, store, protect process, transmit, and securely retrieve information. (Owaied, 2008) presents the infrastructure of IT usually constructed by the international organizations which consists of the seven building blocks. These are:

1. People
2. Software
3. Information
4. Communication devices
5. Processing Machine
6. Storage Media
7. Input/output Devices

When the processing machine and communication devices technologies are combined together with multimedia technologies, the result is the most important combination for the development of software. This may include data management, networking, engineering computer hardware, database and software design, as well as the management and administration of entire systems. Information technology is starting to spread farther than the conventional personal computer and network technology, and more into integrations of other technologies such as the use of cell phones, televisions, automobiles, and more, which is increasing the demand for such jobs. Possibly the simplest, and least controversial, definition of Artificial Intelligence (AI) is the study of how to build and/or program computers in order that they can do the kind of things that minds can do (Shane O'Sullivan, 2003).

One problem with this definition is that it assumes that computers can do what minds do, i.e. diagnose, advise, and understand. This problem can be avoided by saying that AI is the development of computers whose observable performance has features, which, in humans, we would attribute to mental processes (Boden, M. A. 1990).

Many systems have been developed that are in line with the above definition, such as systems for medical diagnosis, Navigation and image recognition (Heckerman, D. 1986). However the holy grail of AI research is not merely to create systems that can carry out complex functions, but to create systems that comprehend what it is that they do (Boden, M. A. 1990). As the method of teaching often used with children states that: learn first, understand later. This means that in order to understand our environment we must first know it, this learning step is what this thesis is concerned with. Building a map of the environment an agent must operate in, is a method of organizing and validating the information then the agent can extrapolate using both its sensors and past information.

1.2 Geographic Information System (GIS)

During the recent years, the developments in the computer technology industry significantly contributed to the Geographical Information Systems (GIS) to be inside of our daily life. The development of Geographic Information Systems (GIS) is highly influenced by the progress of information technology (IT). The motivations for adopting new technologies are derived from the essential needs of GIS users and the GIS community (MING-HSIANG, 2001). Today's GIS is easier and more helpful to the user community. (A.Sengul, 2008) states that "The user profile of GIS can vary from a tourist who is seeking a destination by using navigation systems in a foreign city or an expert working on urban planning of governing a mega city". These examples can be increased with different examples for different professions and aims. The current usage of the systems shows us that GIS is highly recognized and information systems sophisticated projects with Geographical tools are highly ranked in the top list of decision makers. Developing computer technologies are progressively contributing to computerized information systems which have more use than they were ever before. The recent developments in the computer technology visualization are getting more important and getting more effective for the professionals who deal with the information systems.

The main technology components, geographic information systems (GIS), consist of software packages that are capable of integrating spatial and non-spatial data to yield the spatial information that is used in decision making or other purpose. They are computer-based equipment, procedures and techniques for manipulating spatial or map data. This is the common meaning of the term GIS.

1.3 Global Position System (GPS)

GPS is a satellite system used in navigation that allows us to determine our position 24 hours a day in any place on the globe in any kind of weather. It was conceived m 1960 by USAF but in 1974 other military services joined the effort and the project was renamed Navstar Global Positioning System (Kourtney C Nieboer, 2002).

GPS receivers can calculate a position on the earth by measuring the travel time of radio signals from the satellites to the receiver. The calculations depend on highly accurate clocks. The satellites have atomic clocks that are accurate to a nanosecond but due to cost, the clocks in most GPS receivers are not that accurate. Using three satellites, each measurement of time generates a sphere. Where these three spheres intersect is a point that indicates a place on the earth. The fourth satellite can then be used to eliminate any clock errors in the ground-based receiver. Even a small clock error can create a large error in location (Davis, 2005). The GPS “revolution” has had a major impact on soaring competition around the world. One significant change has been the development of recorders that can be used to verify flight track and turn point control. Equipped with a barometric altitude recording mechanism they can also be used to control starts and finishes.

1.4 Artificial Intelligent and the Cognitive Map

The concept of Artificial Intelligence has many definitions and the reason for that, A.I. is a concept considering how to build an Intelligence Machine (IM). The processes of building such machine related with many sciences, so we can define the A.I. as interdisciplinary of sciences and this is why there are many definitions. Therefore any given definition is a mirror of the background and professional of that scientist who defines the term A.I., such as either Computer Scientists, mathematicians, logicians, Psychologists, Biologists, neurologists, Engineers, Artists, Physicians, and so on.

In order to understand Artificial Intelligence concept, a clear and recent definition was mentioned by Owaied, Abu-A'ra (2007) state that “Artificial Intelligence is a concept of study and research for finding a relationships between cognitive science and computation theories in order to represent these relationships as data structures, search techniques, problem solving methods or representation forms for knowledge. The final goal of AI is to build an intelligent machine with another benefit which is better understanding of human thinking”. The previous definition was built on the fact that for a machine to be intelligent it should be smart and problem solver. Smartness can be defined as “everything gives pleasure and happiness to humans, through the facilities available in all sort of multimedia equipments”. On the other hand, the intelligent machine to be problem solver for unstructured and complex problem. Therefore the intelligent machine should be like the human where “humans usually solve algorithmic and non algorithmic problems and most problems are non algorithmic”. This capability is the most important and most of the pioneers of A.I. are concentrating on them like (Winston, 1992) and (Luger, 1999).

During the past decades there were many researchers who have done consigning the development of such machine; researches considering development of agents, researches considering development of Intelligent Agents and researches considering development of Humanoid Agents (James Kuffner et.al, 2003). Therefore the development of agent have been considered by many scientists such as psychologists, biosciences, and computer scientist's researches, going forward successfully with "Agentic Revolution" and how they can communicate with human. Navigation and manipulating of an environment became more vital problem and powerful matter; many researches focus on how agent can understand, interpret and represent environment in an efficient way.

(Owaied, Abu-A'ra & Farhan, 2010) discussed that building such machines should have certain capabilities such as “behaves like a human being, smart, problem solver of unstructured and complex problems as human does, understands languages, learner, and able to reason and analyze data and information, and so on”. For these capabilities to be reached, as Avron, (Paul & Edward 1990) declare, the machine “should have the facilities of recognition, analysis, deduction, and induction”. In this century, the researchers began to review the concept of Artificial Intelligence (A.I.) and they try to reinvent the concept of A.I. By going back to summer of 1956, the date of introducing the concept of A.I. and fixing the mistakes (Chandler D, 2009).

Since knowledge is the human brain soul, in order to solve problems and communicate with others, the needs of applying the human brain model on the intelligent agent increased by the demand of building an intelligent agent. The knowledge based system must be applied by covering one of its fields, i.e. receiving, thinking and storing knowledge.

As defined by (Stuart-Hamilton, 1995), Cognition is “The understanding, acquisition, and processing of knowledge, or, more loosely, thought processes”. However (Eysenck, 1990) defines the cognitive science “the interdisciplinary study of the acquisition and use of knowledge. It includes as contributing disciplines: artificial intelligence, psychology, linguistics, philosophy, anthropology, neuroscience, and education”

In order to understand the concept of cognitive mapping that is used during the concerned researches, Cognitive mapping as defined by (Downs & Stea, 1973) is “a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls, and decodes information about the relative locations and attributes of phenomena in their everyday spatial environment”.

The agent mapping project aims to give the abilities to the intelligent agent to read and gain knowledge from the geographical maps to build its own cognitive maps as knowledge-based system. This system mimics the human behavior when reading the geographical maps.

1.5 Problem Statement

Modeling a computational system based on any recourse of information such as geographical maps has become one of the most important problems in different science domains; maps may reflect the structure of an environment and may contain a lot of information needed to help the users with their wayfinding problem. Cognitively modeling these maps into digital environment will focus on the mental representation of this environments rather than the contents information of this environment’s map. Modeling Cognitive Mapping from Geographic Maps faces many problems such as:

1. Identifying the data and information required for development of cognitive maps from geographical maps.
2. The possibility of using geographical maps for building cognitive map for many different navigation systems.
3. Highlighting the relationships between the geographical maps and cognitive maps. These relationships can be represented in one of many ways in a digital environment replicated to affect the same result as the original document or file, it will be represented as either or any means of data, procedure, searching technique, or solving problems and decision-making.
4. Dealing with false information from geographic maps that could lead to probabilities of building incorrect cognitive maps for the building, so the problem is how to deal.
5. Simplifying and solving the difficulties that face the modeling cognitive map from geographical maps that can be used by mobile agent by using or constructing any needed algorithms that simplify the usage of a virtual environment to strengthen wayfinding in the real world.
6. Building dynamic application using the required information for creating cognitive map provided to agent that can give it the ability of determining the most suitable path in large scale area by determining two points (location and destination) as parameters.

1.6 Motivations

Wayfinding is one of the pillars we built on when navigating through an environment, without wayfinding, we are unable to make predictions for movement through an unfamiliar environment. Moreover, we may unable to determine which path we can use among routes in some environment. Cognitive mapping supports are needed to assist wayfinding in both virtual environment that will be discussed as in the case of some researches and applications like Geographical Information System (GIS), "GIS was first developed by government agencies and later by private industry as a powerful means to store, organize, and analyze data that can be described or modeled spatially or geographically" (Black, MacDonald, & Black, 1998). (Amira Sobeih, 2009) made a research for GIS in Egypt; she defined (GIS) as "a system for managing spatial data. In the strictest sense, it is a computer system capable of integrating, storing, editing, analyzing and displaying geographically-referenced information." And Car Navigation System (CNS) as defined by (Sinn Kim and Jong-Hwan Kim, 2001) is "A car navigation system which consists of several subsystems, such as a positioning system, a route guidance system, a communication system, and a user interface system." The main role of a car navigation system is to find the car position as precisely as possible.

Because of the importance of wayfinding and its strategies, cognitive map acts as a good solution for such problem, it can contribute in:

- Reduce traveling time and coast.
- Reduce the processing time of way finding.

1.7 Objectives

The objective of this research is modeling and developing a generic representation of how mobile agents can utilize geographic maps into cognitive map. It aims to provide some theoretical basis for important navigational system of human being and available systems. This research will study some psychological and geographical disciplines of the human being in order to present a model of human cognition for environment manipulation into a computer based application. However the objective of this research can be summarized into these points:

1. Modeling and developing a generic representation of how an agent can utilize geographic maps into cognitive map.
2. Provide some theoretical basis for important navigational system of human beings, and then how to translate these systems into computerized application.
3. Define some related concepts such as spatial knowledge, Navigation, Wayfinding, Landmark knowledge, procedural knowledge and others which are considered the basis of building cognitive map.
4. Increase the capability of the agent to deal with complex and large scale environment.

1.8 Contributions

The proposed knowledge base system can be used to develop cognitive map for any area that a human cannot reach such as a partially collapsed or abandoned mine shaft. Another application of the proposed system can be used for developing cognitive map according to the geographical military environment

The modeling of cognitive map from geographic maps can give many benefits for the societies, and cognitive map is becoming an increasingly important tool in environmental management such as retail, military, police, tourism and many other spheres of our daily lives. For example, if individual uses a computer or a cell phone, he/she has probably already used a GIS in some form without even realizing it. Therefore cognitive map can help people to find their proper way to reach any target position. More examples of this; in case of emergencies, it help the imbalances while carrying some patient to find the nearest hospital, also it can help tourists to find what hotels can they use, and for the police men they use the cognitive maps to reach the region where some trouble is happening. In other words; cognitive mapping can help any person to find any location and the path that goes to that location at any region.

However, most GIS software is usually very expensive or otherwise limits your freedom to copy, share and modify the software, but we have to remember the first four building blocks of IT infrastructure (section 1.1.1.): People, Software, Information and Communication devices, which are almost available in accrecent countries, and how people can invest their cleverness to produce the technology.

1.9 Study Boundaries

This work simulates modeling cognitive map based on geographical map has some limitations; the following listed points are to be considered through this work:

1. The study is based on an image map taken as a screen shot for some region in Amman city while implementing the simulation using VB 6.0, and it is limited to three areas (Um Al sommaq, Tla Al Ali and Khalda) while using Google Maps API V3.
2. The study uses landmarks symbols that simulate the landmarks used in the geographical maps while coding VB6.0. on the other hand it is limited to a (104) landmarks distributed on (15) types of Landmarks.

3. The study maintains the navigation over large-scale environment, but not indoor buildings.
4. The study should not maintain any secured areas like military areas, governmental or private areas, etc. Which do not authorize anyone to access, unless it has the authority to do so.

1.10 Thesis Structure

The thesis includes five chapters; the preceding chapter gave an introduction about this thesis. Chapter two is the literature survey and related work for the thesis, showing the related work regarding intelligent agent, intelligent agent mapping, analyzing geographical maps.

Chapter three introduces some ideas of image processing that might be required through this work, like the area of image processing and how to deal with geographical maps on computer monitors. Also this chapter introduces the types of knowledge that can be gained from the geographical maps.

However, chapter four goes within the implementation of the proposed methodology of the work, and it discusses the ability of building a knowledge base represent the knowledge obtained from geographical maps.

Chapter five discusses the conclusion and the future work of this thesis.

Algorithms were defined and written using the standard programming code (pseudo code), and were tested and proved using Visual Basic 6.0. and the website is implemented using MS Visual Studio 2010 using Java Script and XML editor.

Chapter Two

2

literature Survey & Related Work

2.1 Literature Survey

In this thesis study there are many research areas which are confined to the developing of cognitive map from geographical map, these research areas are; geographical maps, cognitive maps, intelligent agents, and intelligent agent mapping. In the following subsections are the study researches of the four areas.

2.1.1 Geographic maps

The idea of a "map" goes back into the farthest reaches of human history, predating even historical records (Wilford, 1982). The human in old centuries depended on stars and space galaxies to know their directions, and the geographical landmarks to positions. When most people think of maps, they think of geographical depictions (William M.K. Trochim 1999). The way in which problems like this are tackled by human beingss is characterized by psychologists as a cognitive process that is goal-directed and requires effort of the brain and concentration of attention (van Someren et al., 1994,).

The need of the maps was one of the most important issues facing human, therefore, geographic scientists since old years established many structures of maps, ancient maps were drown on animals skins or trees leaves. Modern maps use a special paper sheets technology. Both of old and modern maps are represented graphically to give or reflect the information about environments, geographic region, or even about the whole world, Until now we still explore maps to discover new areas, and we can make and update maps and their information whenever a change is made, with modern technology. Maps can be observed all the time and most of our map’s recourses is the maps which is sent by satellites (e.g. Google Earth). Recently too many definitions were raised by different scientists, (Corné P. J. M and Van Elzakker, 2004), geographic scientists, who suggested that "A map is an abstraction and simplification of geographic reality to scale, obtained by reducing the amount of information on geographic reality, translating it into graphic symbols and, usually, projecting it on a flat medium, the use of maps in the exploration of geographic data."

The National Geographic, as one of the famous institutes, defines the maps as "Maps are two-dimensional (flat) representations of three-dimensional spaces". They categorized the maps according to their use or concern. The following are he most important categories:

- Natural features, such as mountains, lakes, rivers, ocean, trees and so on.
- Political areas, such as city, state, and country borders.
- Scientific information, such as rainfall amounts or population numbers.
- Navigation features, such as roads, subway stops, and ocean depths.

People have been making maps for over 4,000 years, and they've come a long way. We used to rely on explorers to visit faraway places before a map could be made. We still have explorers that travel the Earth (and beyond) to discover and map new places, but now we can also make and update maps with information sent from satellites in space. According to national geographic web site all maps have five basic elements to help human understand them:

1. **Title** or **Name**, refers to which area the map belongs to.
2. **Orientation** (north, south, east, or west).
3. **Scale** to determine distance.
4. **Legend** that explains the shapes, colors, and symbols used.
5. **Grid** or **coordinates** that help show where the map fits into a larger global area.

2.1.2 Cognitive mapping

Every day people travel from point to point through their environments, they can learn and add more information about their environment every day. This information will enhance their spatial knowledge and mental representation of their environment. Individual can retrieve this information in a cognitive representation form to use them while, they can retrieve landmarks, routs and directions and use this variables to build cognitive map to decide how to travel from point to point. Therefore, the agent can encode and decode this information as a form of different types of data to utilize them cognitively as human do.

The term cognitive map is used to denote maps that are acquired and represented by human beings to simplify environment and spatial structures and to make geographic maps more readable by agent. The term ‘Cognitive map’ was first coined by Tolman (1948), who defined it as "a representation of the environment which indicated the routes, paths and environmental relationships that an animal uses in making decisions about where to move, many scientists are interested about how human can find his way and how human builds a spatial knowledge in his mind".

(Kelly, 1955) was one of scientists who put the initial steps for understanding the CM, Kelly suggests that “understanding how individuals organize their environments requires that subjects themselves define the relevant dimensions of that environment”.

Many definitions were written for cognitive mapping like Stephanie (1998), and (Yoichiro & Ronald, 2003). However Tolman (1948) defined it as “inferred the existence of cognitive maps by recording the spatial behavior of a maze-running rat who took a -short cut- to the final destination by running across the top of a maze instead of following a route through It”. But a very recent and accurate definition by (Yeap & Jefferies, 2001) was: “Cognitive mapping, the process by which one’s mental representation of the environment is acquired and manipulated”. In addition, it has been enhanced by many researchers gaining advantages from other fields like using finger print for places like Adriana & Roland. And some studies have been made to enhance a certain field on cognitive mapping like (Shrihari, Stefan, Viet & Roland, 2007). Others studied cognitive mapping on dynamic environments like (Dirk, Rudolph, Wolfram & Sebastian, 2003).

Since 1948 Tolman was the first scientist who defined the cognitive map, until nowadays, too many researches have been published discussing several problems that can be solved using the cognitive map and describing the importance of studying the cognitive map. The navigation and wayfinding through an environment captured the first grade of cognitive map domain especially with web based navigation systems and their applications like Google Earth, GIS, GPS and others.

One of the most common applications of cognitive map is the Fuzzy Cognitive Map (FCM) which acts as a perfect method of problem analysis and problem solving.

FCM is a directed graph with concepts (like policies, events etc.) as nodes and causalities as edges. It represents causal relationship between concepts. (W. B. Vasantha Kandasamy, Florentin S., 2009). The major advantage of fuzzy cognitive maps is that they can handle even incomplete or conflicting information (Voula C. G, Chrysostomos D. S, 2006).

2.1.3 Intelligent Agent

Intelligent Agent can be used in many fields in our life, that can reduce the time and money consumed, they can reduce the risks especially in danger environments, in recent years intelligent agent were provided by sensor devices, cameras, wheels, motors and other components that allow agent to move from location to other.

(Hachour O. 2009) introduced many definitions of agent, he claimed " An agent is a "device" that responds to sensory input by running a program automatically without human intervention”. Typically, an agent is endowed with some artificial intelligence so that it can react to different situations it may encounter.

The agent is referred to be all bodies that are modeled geometrically and are controllable via a motion plan. A agentic vehicle is an intelligent mobile machine capable of autonomous operations in structured and unstructured environment. It must be capable of sensing thinking and acting. The mobile agent is an appropriate tool for investigating optional artificial intelligence problems relating to world understanding and taking a suitable action, such as ,planning missions, avoiding obstacles, and fusing data from many sources.

Along the time, agent became dependable to assist human in problem solving in different domains, moreover agent researchers became being motivated to invoke agent with human navigation problems, and many researchers illustrate that intelligent agent can navigate any environment and build a cognitive map as human do. As agents are becoming more intelligent, they are also tending to be increasingly socially interactive (T. Fong, I. Nourbakhsh, K. Dautenhahn 2003).

(Khurshid, et al 2006) presented an application of agent as an interactive way of teaching by making synergistic formations. They proposed a group of agents that could arrange themselves on walls or ceiling of a room and make words or sentences or symbols with different or same colors. This kind of interactive teaching is especially helpful for kids.

(Hussein H. Owaied 2010) presents framework model of intelligent agent as knowledge-based system, detailed view of it architecture is shown in figure 2.1. This thesis is based on this view of Intelligent Agent.

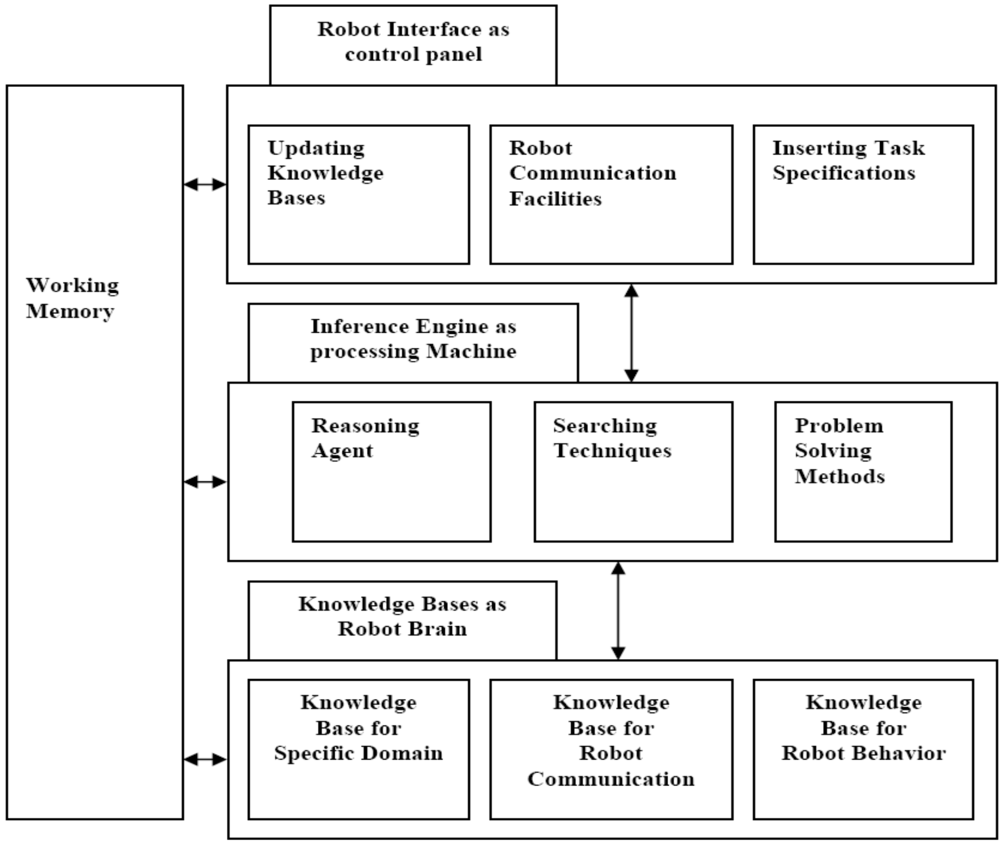


Figure (2.1) The Architecture of Intelligent Agent as Knowledge-Based System

2.1.4 Intelligent Agent mapping

Agentic mapping is the act of using an agent to create a map with which to navigate. Several applications require autonomous navigation, which means that the agent navigates and performs its task based on a program instead of a human. Autonomous agents must have some way of viewing or studying the environment around them and this motivates the need for maps with which to navigate and perform its task. “To make the agent most independent of human control, it must generate its own map in order to navigate”. (Robert G, 2007).

Mobile agents as universal technical system, which can provide mechanical activity, are one of the modern trends of the scientific researches in the field of agentics. The need for a mechatronic system to work in dynamic environment raises a high demand on the system adaptability.

(Anatoly S, 2006) describes the use of agent and claims that “These applications are oriented for in-door environment constructed by human and for external non-structured environment, where are widely used the landing, flying, space-oriented or under-water oriented agents”. There are important applications of mobile agents especially in the aggressive situations at dangerous environments or at environments where it is impossible for human to do their activities, for example, after the man-caused catastrophe, fire or terrorist acts.

One of the main tasks, which appeared during mobile agent (MR) navigation in the complex non-structured environments is the detection of the landmarks and path planning. Therefore, (Vidmantas M, 2006) states that “the methods for autonomous navigation become very important and an autonomous intelligent learning system are essential in order to achieve adaptability to new environment”.

2.2 Related Works

Maps can be used to provide navigational information and supplemented with additional detail about the objects in the environment, they become guides. There are many different sorts of map from the very detailed and realistic to the highly abstract and schematic. Maps are social things. They are there to inform and help people explore, understand and find their way through spaces. (Benyon & Höök, 1997).

A cognitive map, or mental map, is a map drawn by a person to record geographically his or her memories, ideas, and perspectives of a particular place. Cognitive mapping is a planning tool also used to determine desired future development. They are used to identify geographic areas of a community that people like, dislike, frequently visit, feel are important, travel through regularly, feel safe, and so on.

Cognitive Map is a tool, which can be used for modeling and simulation of complex systems (Khan M. and Quaddus M., 2002.), (Kosko, B, 1986.), it refers to an individual's ability to construct a mental representation of the geographical environment (Blades et al. 1999). This representation can be formed in more than one way. For example, an individual may cognitively form a mental representation through direct experience with the environment. In this process an individual visits an area and gradually builds up a knowledge base on places and routes in that environment. (Jacob and Luloff ,1995) term this process as "existential experience." Individuals may also develop cognitive maps through indirect means.

Despite the means used to construct these cognitive maps, the end result is a compendium of the larger environment that may include information and knowledge of areas and distances not actually visited or experienced. According to (Gilmartin, 1985), cognitive maps have the potential to significantly impact an individual's behavior, beliefs, and attitudes regarding places.

The application of cognitive mapping procedures to the study of recreation and tourism activities has been limited (Walmsley & Jenkins 1992). Yet as noted by (Downs and Stea, 1977) recreation and cognitive maps are inseparable. This is due to the connection between cognitive mapping and spatial behavior. Spatial behavior refers to patterns of movement that can be characterized by its origins, distances, destinations, directions, and frequencies of occurrence. Downs stated "All forms of recreation and travel have some form of environmental cognition because people must orient, traverse, and locate recreation destinations and attractions. Cognitive mapping allows recreation resource managers the opportunity to identify where users perceive the best recreation areas are located. (Samuel V. et al, 2004) emphasis that "It is important to understand these perceptions in order to manage intensive use areas appropriately in terms of maintenance, supervision, budgeting, and planning".

Designing a web based application that can give all information about environments that can offer all people needs and assist them to control their activity is nearly hard to construct. According to (D. Benyon ,2006) the navigation can be defined as "the process of picking up information from a variety of sources; they move through the information space to gather all the information that is required". There are many shades of opinion on exactly what activities constitute navigation. In an early review (Benyon & Höök, 1997) identified three different but related activities; they are:

- Object identification is concerned with understanding and classifying the objects in an environment.
- Exploration is concerned with finding out about a local environment and how that environment relates to other environments.
- Wayfinding is concerned with navigating towards a known destination.

In this context recently have been developed cognitive map using the blueprint map at Middle East University as M.Sc. thesis by (Al-Kazi, 2010). The thesis was concentrating on in door environment and the future work could be out door environment. Therefore in this thesis has been concentrating in the outdoor environment. The wayfinding is concerned with how people work out how to reach their destination. For (Downs and Stea .1973) and (Passini, 1984) the process involves four steps:

1. Orienting oneself in the environment,
2. Choosing the correct route,
3. Monitoring this route, and
4. Recognizing that the destination has been reached.

Each of these steps requires a certain design quality of the space. In order to orientate oneself in an environment it is necessary that the space has a series of unique, distinguishable characteristics and features. To do this people use a variety of aids such as signposts, maps and guides. They exploit landmarks in order to have something to aim for. Therefore, the design of proposed knowledge-based system is concentrating in these types of knowledge for building the cognitive map.

Chapter Three

Methodology Used

3. **Overview**

In general, data depicted on maps, and in fact maps themselves, are symbolic representations of geographic phenomena and the Earth's surface on a sheet of paper, or on a computer monitor, and data can be represented on maps by three basic elements: point, line, and landmark symbol.

- A point represents a geographic feature characterized by location. Its location can be represented by a single (x, y) coordinate pair.
- A line symbol represents a geographic feature characterized by linear dimension, but not area. In digital technology, a line is a sequence or stream of point coordinates with a node at each end (vector data) that symbolizes a linear feature such as a roads
- A landmark symbol represents a closed geographic surface feature, two-dimensional geometric region, characterized by location and attributes. Its location can be represented by (x, y) coordinate pair, while attributes can be name, category, etc.

3.1 Geographical Map

Geographical maps have been a critically important tool for human beings for hundreds of years as they explored, traveled, inhabited, fought over and planned the territories of the earth. In the whole world maps have become an essential part of the public, private and international levels.

Maps tell us where we are, they help us understand our surroundings, draw ideal routes from location to other. With knowledge maps can be a means for human beings to plan, build, develop and solve problems, with ignorance maps; conflict is created and life becomes hard. “Maps can convert the unknown into the known making it much easier for us to answer the question: What should we do?” (JACK DANGERMOND, 2008). Geographical mapping is about developing knowledge, skills and understanding what is related to people, places and environments at different scales overseas, and an appreciation of how places relate to each other over the wider world.

In recent years geographical maps have become more important and have been used in several sciences and have become as an essential tool for different applications like: Geographic (or geographical) Information System (GIS), Global Position System (GPS), Geo-information System, Spatial Information System (SIS), Land Information System (LIS), and Multi-purpose Cadastre.

The United Nations Geographical Information Working Group (UNGIWG) has been established in March 2000. The Map Collection houses of UNGIWG have over 80,000 maps, some 3,000 atlases, gazetteers, travel guides, cartographic and geographic reference works as well as digital cartographic products. Geographical mapping is about developing knowledge, skills and understanding what relates to people, places and environments at different scales overseas, and an appreciation of how places relate to each other and the wider world. Maps are an excellent means of visualizing and understanding geography, and the Beginners' Guide to UK Geography is accordingly supported by a range of reference maps. These can be downloaded directly by clicking on the appropriate link below. The maps may be reproduced free of charge in any format or medium for research, private study or internal circulation within an organization, subject to being reproduced accurately and not used in a misleading context.

3.2 Coordinate Grids

(Kourtney C Nieboer, 2002) proposed a good explanation for how to use the grid coordinate as the follows “a place on a map using letters and numbers called coordinates. The pattern of lines drawn on a map is used to uniquely identify every point. The UTMs (Universal Transverse Mercator: 11 U 703421m.E. 5662738m.N) and Latitude/Longitude (latitude/longitude: 42o4’ 55.2”N 114 o5’ 44.6” W) both are coordinate systems which can be used to uniquely identify points on a map. Latitudes/longitudes cover the entire surface of the earth while UTMs cover the area between 80 degrees South Latitude and 84 degrees North Latitude. Lat/longs are measured in degrees, minutes, seconds or degrees, minutes and tenths of minutes. UTMs are measured in meters. Both use the equator as the dividing line between north and south. Lat/longs use 0 degrees and 180 degrees for E/W reference and UTMs begin at 180 E/W and divide the world into 6 degree zones and are numbered 1-60. Each zone is split directly in two by a zone meridian from which the easting coordinates are measured and horizontally by the equator from which the northing coordinates are measured Therefore the advice for the users of GPS their receiver should support both systems (UTM and latitude/longitude) because these together cover the world.”

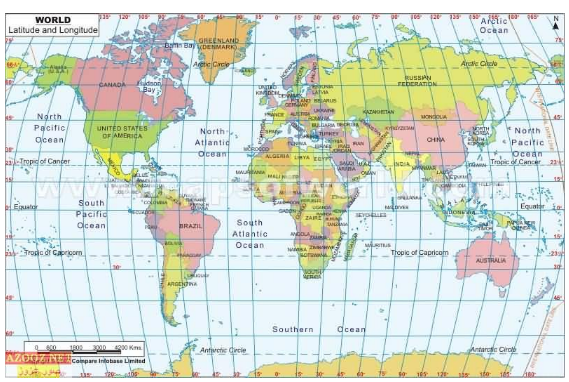


Figure (3.1) The Coordinate Grids of the word map

3.3 Scaling

In navigation, distance measurement is important. Actual distances between two points on a map can be obtained by taking measurements on the map and comparing them to the associated map scale, located at the bottom of maps. The actual traversal of the distance can be done by walking off the required number of steps if the hiker knows the length of their pace table (3.1) gives the most universal scaling measurements used in mapping systems. Conversely, a hiker with only a map, compass, and known starting point can keep track of their location by plotting on the map the azimuth of travel and distance traveled along that azimuth, beginning at the known starting location.

Application Levels	Scale	Detail
International	Depends on coverage	National boundaries, international motorway, related text.
National	1 : 8 000 0000	National boundaries, international motorways, state roads, city boundaries, related text.
City	1 : 250 000	Administrative boundaries, motorways and the state roads, railways, airports, related text.
County	1 : 25 000 - 1 : 50 000	POI (with symbols), motorways, state roads, arterial highways, land use (settlement or green area), related text.
District	1 : 5000 - 1 : 10 000	Land use (buildings, green area) POI, district and building block boundaries, all roads (all roads are represented by aerial symbols, and related text.

Table (3.1) Maps scaling details.

3.4 Spatial Knowledge Acquisition

There are many ways to acquire spatial knowledge of any environment, the fundamental distinction between sources of spatial knowledge is whether the information comes directly from the environment (primary) or from some other source (secondary) such as a map. An issue specific to secondary sources has to do with whether or not the source is used inside or outside of the actual environment. During way finding process, a person makes use of three kinds of knowledge to build up a cognitive map of the environment (Darken, R.P., & Peterson, B.2001), therefore the cognitive map can be built according to (Shemyakin, F.N, 1962) “as the progression from “landmark” to “route” to “survey” knowledge.”

3.5.1 Landmark knowledge

Landmark knowledge consists of visual attributes of an environment, including shape, size, names and locations. (Denis, 1997) states that “Landmarks are the static elements that may face anyone during movement through any environment" e.g. hospital, schools, post office, etc. These are important features in organizing the memory for spatial information and they are vital to route directions, and they clarify the features of the environment standing out of a multitude of spatial information perceivable by the senses.

3.4.2. Procedural Knowledge

Procedural knowledge is called rout knowledge by some researchers, such as (Thorndyke and Hayes-Roth 1982) who described it as “the sequences of actions required to follow a certain path or to traverse paths between different locations". This sequence of actions required information about an environment including directions and distances in addition to visional attributes, it allows people to solve problems quickly and efficiently. (Thomas Stüdeli, 2008) emphasizes that "procedural knowledge or route knowledge is encoded as a series of navigational steps required in following a particular route."

They employ various functions in route directions though the environment such as demarcating decision points determine direction at intersections, (e.g. “turn left at the restaurant”), confirming correct progression along the route (e.g. “continue past the school”), or providing a global bearing (e.g. “the sea is on your left and the mountains are on your right”).

Route maps in particular have gained much interest in recent years as an effective tool to convey route information. Maps convey meaning in graphic form, in a similar manner that descriptions convey meaning by words. However, Paul U. Lee (2002) said, "maps can provide richer and more veridical information of geographic space, employing relation-preserving mappings from the geographic sphere to a two-dimensional, bounded, and external medium.” Figure (3.3) is an example of road network describes routs in a map.

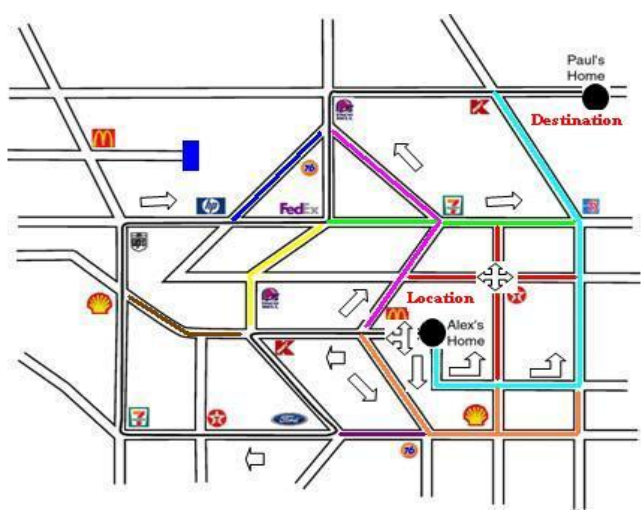


Figure (3.3) Rout map

3.5.3. Survey Knowledge

The survey knowledge can be described as the configurational or topological knowledge of an environment, consisting of object locations, inter-object distances and object orientations; it represents the highest level of spatial knowledge and has a hierarchical nature. Usually the survey knowledge takes the longest time to build up. It can estimate the distance and the time required to travel through a certain path considering all landmarks and orientation, it can be acquired by direct traveling and navigation an area (Thorndyke and Hayes-Roth 1982).

3.5.4. Methodology Used for Data Acquisition

The most important data used in the processing of the maps in GIS system are the metadata, and usually there are many methods have been used for the acquisition of this metadata.

Amman Secretariat is considered one of the most important providers for metadata, but it is good to describe in simple words how Amman Secretariat collects information about urban and the areas of Amman does. This is done by suing a device called GPS Cam, this is a camera that can be attached to a laptop which is connected to the Internet. This camera captures a video file while traveling by a car or any vehicle and scanning some area and it stores it on the hard disk, this video can be played on a special driver similar to media player, but has two screens, one to show the video file and the other one is to show the Google map which is synchronized with the recording process to give the exact point where the car is.

While running the video file, the Google Maps section gives the coordination of the point where the camera is located. This point is stored manually to the ArcGIS software and creating the deferent layers of geographic area.

Chapter Four

4

Proposed Model

4. Overview

Digital image processing is concerned primarily with extracting useful information from images. Ideally, this is done by computers, with little or no human intervention. Important examples of image processing fields are medicine, film and video production, photography, remote sensing, and security monitoring. These and other sources produce huge volumes of digital image data every day, more than could ever be examined manually.

4.1. Google Mapping and GIS

Geographical Information System (GIS) has been widely used in the fields of space or position concerning information processing, such as resource, environment, electric power, mapping, agriculture, traffic, telecom, city facility management, aviation and spaceflight, military affairs etc. If we make a deep analysis of the role that an expert plays in these tasks, we will find that the GIS software or platforms merely act as a kind of tool to store and display facts or data, and the analysis that these platforms could do maintains in a relative simple, direct and superficial level. That is to say any non-trivial or novel conclusion is made really by the operator of that software.

In 2005, Google Mapss (GM) has transformed the online mapping. No longer dependent on a simple and slow server-client relationship, Google Mapss uses a more interactive, tile-based system based on AJAX to present an online map that allows for highly interactive panning and zooming. In 2006, the GM application programmer Interface (API) was introduced. Maps have had a major impact on how spatial information is communicated. Examples are presented online using GM API that involves the mapping of point, lines, and area data. Both in-code GeoRSS data will be mapped. All examples use an HTML/JavaScript to link with Internet and XML/JavaScript interface to save spatial information (metadata) to the GM API.(Michael Peterson, Chair 2010)

Often we want to use a different marker than the default one. The API offers a simple way of doing this with the property `icon`. `Icon` takes either an URL pointing to an image or a `MarkerIcon` as its value. This icon is taken from Nicolas Mollet's map icon set.

4.2.Image Processing

Image processing is a rapidly growing area of computer science; its growth has been fueled by technological advances in digital imaging, computer processors and mass storage devices. Fields which traditionally used analog imaging are now switching to digital systems, for their edibility and affordability. This chapter presents the proposed model for creating the cognitive map using geographical map as a knowledge-based system. The model consists of many modules; they are used for gaining knowledge from the geographical maps, to build the cognitive map. These modules are complementary to each other and respectively are:

1. Architecture of proposed model.
2. Threshold Module
3. Road Extraction Module.
4. Skeleton
5. Localization.

5.1. Start Point

5.2. End Point

5.3. Nearest Point

6. Path Finding Module.
7. Shortest Path Module.
8. Orientation Module.
9. Producing Cognitive Map Module.

All these modules are produced as a simple project using MS Visual Basic 6.0 to implement the algorithms, and they will be reflected on a simple website using Google Maps API V3.

4.3.The Architecture of Proposed Model

Figure 4.1 presents the architecture of the proposed model of cognitive map as knowledge based system, which consists of the user interface, inference engine, database and the knowledge base. In the following subsections are the detailed descriptions of them.

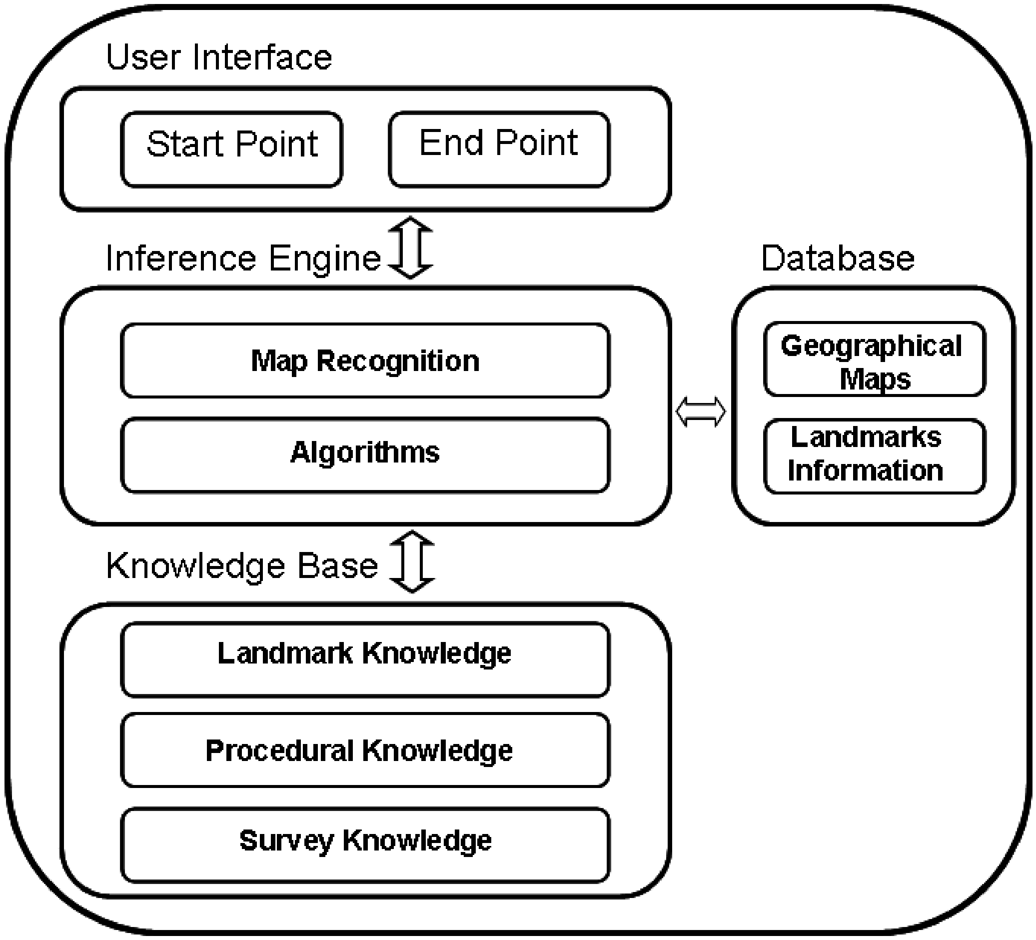


Figure (4.1) an overview of the proposed model

4.3.1. User Interface

This section is considered as the communication between the proposed knowledge-based system and the user of the system. The system will display a form that allows the user to enter the start point and the intended place to be reached. Figure 4.1 shows two rectangles, one called start point which is the location where the agent or the user is located. The other is called end point, which is the final destination that will be the agent or the user will reach. The data related to start point can be obtained as the following:

For VB project: the two points are gained from their (X,Y) coordination on the frame. And for Google Maps: the two points are gained from Google Maps API services.

4.3.2. Inference Engine

This section is considered as the brain of the cognitive map model, through this section several algorithms is generated like retrieving the required geographical map and the map symbols with their information from database, a part of this section is concerned of generating the image processing algorithms like thresholding, filling and thinning algorithms, and other parts are concerned with generating the calculation algorithms for estimating the localization of starting and end points until generating the shortest path between the two locations.

4.3.3. Database

Database section consists of geographical maps details, these details are the database, which contains the information of some area. There are several methods used to store the metadata, they can be stored as Excel sheet, XML file, Shape File, and others. Through this work the implementation of VB project, the database (metadata) will be simulated as artificial landmarks stored as an array of symbols that includes the symbol name, category, and dimensions to calculate the coordination, table (4.1) is a sample represents the data related to information of symbols. Moreover, implementing the website, metadata, will store as XML file can be readable by the Google Maps API. Figure (4.2) shows a sample metadata stored in XML file.

Name	Category	Dimension	
		Width	Height
Nadeem	School	65	70
Khaled	Hospital	63	72
Hanadi	Restaurant	75	65

Table (4.1) landmarks sample attributes

```
<Export_Output>
<ID>1</ID>
<EN_NAME>Islamic Bank \ Khalda</EN_NAME>
<LANDMRK_CO>9</LANDMRK_CO>
<Type>Bank</Type>
<Area_name>Tlaa Alali</Area_name>
<POINT_X>35.863276</POINT_X>
<POINT_Y>31.993938</POINT_Y>
<Category>Service</Category>
  <ICON_IMAGE>Bank.png</ICON_IMAGE>
</Export_Output>

<Export_Output>
<ID>2</ID>
<EN_NAME>Arab Bank \ Khalda</EN_NAME>
<LANDMRK_CO>9</LANDMRK_CO>
<Type>Bank</Type>
<Area_name>Khalda</Area_name>
<POINT_X>35.848762</POINT_X>
<POINT_Y>31.997138</POINT_Y>
<Category>Service</Category>
  <ICON_IMAGE>Bank.png</ICON_IMAGE>
</Export_Output>
<Export_Output>
```

Figure (4.2) metadata sample using XML

4.3.4. Knowledge base

Cognitive mapping is the primary theory of human spatial cognition proposed in the literature. Discussions focus on cognitive mapping as the spatial cognition process and cognitive maps as the organizational structure of spatial knowledge. These studies are based on theories of human spatial abilities (e.g., Mandler, 1988).

Cognitive map tasks are based on spatial knowledge gathered from the environment (Brown, 1932). (Thorndyke and Goldin, 1983) describe spatial knowledge in terms of three levels of information: landmark, procedural, and survey knowledge, where each level builds on previous levels. Landmark knowledge covers the perceptually salient objects (Golbeck, 1985) in the environment. Procedural knowledge (or route knowledge) encompasses information about the sequence of actions required to follow a particular route. Survey knowledge deals with topological information. Among the three levels of spatial knowledge, landmark knowledge is essential in human cognitive maps (Golbeck, 1985) and (Mandler, 1988).

Therefore the knowledge based of the proposed system has been implemented as a hybrid knowledge representation scheme of three types of knowledge representation forms which refer to the hierarchical organization of spatial knowledge as shown in figure (4.3) which consists of three types of knowledge, these are; landmark knowledge, procedural knowledge, and survey knowledge. The following subsection is a brief description of representations of the three types of knowledge as: landmark knowledge as declarative knowledge which is as a sets of facts, procedural knowledge as rules, and the survey knowledge as the blackboard.

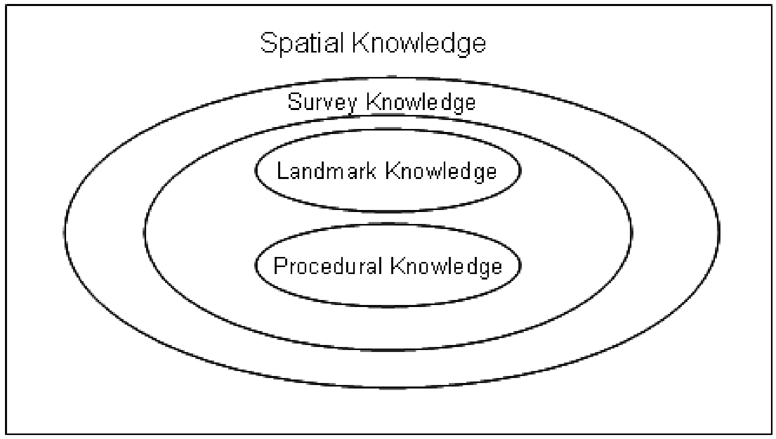


Figure (4.3) the hierarchical organization of spatial knowledge

This rule-based expert system consists of a main window system (expert part, user part, and application part), rule-based engine, and a database. This system is applicable to any interactive interpretation of GIS applications. The development of the application part is independent of the other parts in order to create independent object oriented components rather than coherent ones.

To build a rule base for some region or urban, first FCM must be constructed to clarify the relationship between landmarks, and how a landmark may influence other(s). This can be achieved based on the human being cognition. i.e. what may make a person pay attention while observing a map and searching for some landmark; this relationship can be given a value as a percentage represents the weight of the graph, while the landmarks represent the concept. Table (4.2) illustrates some values which represent the amount of strengthen for how a landmark influences other.

	Mll	**Res**	**Kin**	**Phm**	**Msq**	**Sch**	**Gas**	**Htl**	**Bnk**	**Hos**	**Ins**	**Mkt**	**Uni**	**Chr**	**Nur**
Mll	100	55	35	30	35	60	30	45	55	35	55	95	60	35	60
Res	55	100	45	45	55	55	75	65	80	55	30	30	45	55	55
Kin	50	45	100	35	60	95	60	35	35	60	75	45	80	60	90
Phm	60	35	60	100	35	60	40	55	55	85	60	35	55	45	60
Msq	40	55	55	35	100	55	30	60	60	30	55	30	45	70	35
Sch	30	60	80	55	30	100	40	45	55	45	75	60	70	50	85
Gas	45	65	55	60	45	35	100	70	75	35	35	40	35	60	35
Htl	35	75	50	45	35	55	80	100	90	30	55	30	55	40	55
Bnk	55	70	60	35	35	60	65	80	100	40	60	35	60	30	60
Hos	60	55	40	90	55	45	60	60	45	100	45	55	35	45	35
Ins	55	50	80	60	60	90	40	40	35	35	100	60	80	35	85
Mkt	85	35	45	55	60	40	30	30	35	55	45	100	45	55	60
Uni	35	55	65	35	40	75	60	60	55	60	65	35	100	50	70
Chr	40	60	45	55	56	55	40	60	60	35	60	55	45	100	60
Nur	25	30	70	60	60	75	30	55	40	50	70	60	65	30	100

Table (4.2) Estimated strength values between landmarks.

Now to construct the FCM, it is assumed that if the relationship strength value between landmarks is larger than or equal (65%), then the arc will appear on the graph. Table (4.3) highlights the main concepts (landmarks) which may influence or influenced by other landmark.

	Mll	Res	Kin	Phm	Msq	Sch	Gas	Htl	Bnk	Hos	Ins	Mkt	Uni	Chr	Nur
Mll	*100*	55	35	30	35	60	30	45	55	35	55	***95***	60	35	60
Res	55	***100***	45	45	55	55	***75***	***65***	***80***	55	30	30	45	55	55
Kin	50	45	***100***	35	60	***95***	60	35	35	60	***75***	45	***80***	60	***90***
Phm	60	35	60	***100***	35	60	40	55	55	***85***	60	35	55	45	60
Msq	40	55	55	35	***100***	55	30	60	60	30	55	30	45	***70***	35
Sch	30	60	***80***	55	30	***100***	40	45	55	45	***75***	60	***70***	50	***85***
Gas	45	***65***	55	60	45	35	***100***	***70***	***75***	35	35	40	35	60	35
Htl	35	***75***	50	45	35	55	***80***	***100***	***90***	30	55	30	55	40	55
Bnk	55	***70***	60	35	35	60	***65***	***80***	***100***	40	60	35	60	30	60
Hos	60	55	40	***90***	55	45	60	60	45	***100***	45	55	35	45	35
Ins	55	50	***80***	60	60	***90***	40	40	35	35	***100***	60	***80***	35	***85***
Mkt	***85***	35	45	55	60	40	30	30	35	55	45	***100***	45	55	60
Uni	35	55	***65***	35	40	***75***	60	60	55	60	***65***	35	***100***	50	***70***
Chr	40	60	45	55	56	55	40	60	60	35	60	55	45	***100***	60
Nur	25	30	***70***	60	60	***75***	30	55	40	50	***70***	60	***65***	30	***100***

Table (4.3) Highest influencin values between landmarks.

From the table above, it possible to conclude the relationship between landmarks, table (4.3) is derived to show the stinghten values of influencing which can be seperatered into two types: the *influencer* concepts which are the landmarks that can force other to appear on the map, and the value of stringthen is highlighted ***Bold,Italic*** font, and the *influenced by* conceptes which are the landmarks forced to appear on the map, and the values are hightlighted with **Blue,Underlined** font represent what landmark is influenced by other. Table (4.4) shows the sringthen values for all landmarks and what landmarks influence or is influenced by other landmarks.

	Mll	Res	Kin	Phm	Msq	Sch	Gas	Htl	Bnk	Hos	Ins	Mkt	Uni	Chr	Nur
Mll	***100***	55	35	30	35	60	30	45	55	35	55	***95***	60	35	60
Res	55	***100***	45	45	55	55	***75***	***65***	***80***	55	30	30	45	55	55
Kin	50	45	***100***	35	60	95	60	35	35	60	**75**	45	***80***	60	***90***
Phm	60	35	60	***100***	35	60	40	55	55	**85**	60	35	55	45	60
Msq	40	55	55	35	***100***	55	30	60	60	30	55	30	45	**70**	35
Sch	30	60	**80**	55	30	***100***	40	45	55	45	**75**	60	**70**	50	***85***
Gas	45	**65**	55	60	45	35	***100***	**70**	***75***	35	35	40	35	60	35
Htl	35	***75***	50	45	35	55	***80***	***100***	***90***	30	55	30	55	40	55
Bnk	55	**70**	60	35	35	60	**65**	**80**	***100***	40	60	35	60	30	60
Hos	60	55	40	***90***	55	45	60	60	45	***100***	45	55	35	45	35
Ins	55	50	***80***	60	60	***90***	40	40	35	35	***100***	60	***80***	35	***85***
Mkt	**85**	35	45	55	60	40	30	30	35	55	45	***100***	45	55	60
Uni	35	55	**65**	35	40	***75***	60	60	55	60	**65**	35	***100***	50	**70**
Chr	40	60	45	55	56	55	40	60	60	35	60	55	45	***100***	60
Nur	25	30	**70**	60	60	**75**	30	55	40	50	**70**	60	**65**	30	***100***

Table (4.4) Seperation influence values.

Based on the theory of intend and expectation of human being, it is notable that any two couple of landmarks will retreive each other, i.e, if user intends to search for some landmark, he will expect to see other related landmarks on the map which can be considered useful or worthy of attention. Table (4.5) shows an example of two landmarks and the values of influencing between them.

	Mll	Res	Kin	Phm	Msq	Sch	Gas	Htl	Bnk	Hos	Ins	Mkt	Uni	Chr	Nur
Mll	***100***	55	35	30	35	60	30	45	55	35	55	***95***	60	35	60
Res	55	***100***	45	45	55	55	***75***	***65***	***80***	55	30	30	45	55	55
Kin	50	45	***100***	35	60	**95**	60	35	35	60	**75**	45	***80***	60	***90***
Phm	60	35	60	***100***	35	60	40	55	55	**85**	60	35	55	45	60
Msq	40	55	55	35	***100***	55	30	60	60	30	55	30	45	**70**	35
Sch	30	60	**80**	55	30	***100***	40	45	55	45	**75**	60	**70**	50	***85***
Gas	45	**65**	55	60	45	35	***100***	**70**	***75***	35	35	40	35	60	35
Htl	35	***75***	50	45	35	55	***80***	***100***	***90***	30	55	30	55	40	55
Bnk	55	**70**	60	35	35	60	**65**	**80**	***100***	40	60	35	60	30	60
Hos	60	55	40	***90***	55	45	60	60	45	***100***	45	55	35	45	35
Ins	55	50	***80***	60	60	***90***	40	40	35	35	***100***	60	***80***	35	***85***
Mkt	**85**	35	45	55	60	40	30	30	35	55	45	***100***	45	55	60
Uni	35	55	**65**	35	40	***75***	60	60	55	60	**65**	35	***100***	50	**70**
Chr	40	60	45	55	56	55	40	60	60	35	60	55	45	***100***	60
Nur	25	30	**70**	60	60	**75**	30	55	40	50	**70**	60	**65**	30	***100***

Table (4.5) Example of influencer and infuenced landmarks.

For example: if user intends to find a (School), he will expect to find a (kindergarten by 95% and Nursery by 85%) in addition to the main arget (School by 100%). But on the other hand, if user intends to find a landmark of (kindergarten) he will expect to find only (Nursery) landmark by 90%.

Now it is possible to extract a FCM elements by using the influencers or the influenced as concepts and the values as arcs, to determaine the directions of the arcs, this work uses the highest values of influencing which are highlighted by red color. Table (4.6) represents the summary of relations between landmarks which will be used to buid the FCM.

	Mll	Res	Kin	Phm	Msq	Sch	Gas	Htl	Bnk	Hos	Ins	Mkt	Uni	Chr	Nur
Mll	**X**											**X**			
Res		**X**					**X**	**X**	**X**						
Kin			**X**			**X**					**X**		**X**		**X**
Phm				**X**						**X**					
Msq					**X**									**X**	
Sch			**X**			**X**					**X**		**X**		**X**
Gas		**X**					**X**	**X**	**X**						
Htl		**X**					**X**	**X**	**X**						
Bnk		**X**													
Hos				**X**						**X**					
Ins			**X**			**X**					**X**		**X**		**X**
Mkt	**X**											**X**			
Uni			**X**			**X**					**X**		**X**		**X**
Chr														**X**	
Nur			**X**			**X**					**X**		**X**		**X**

Table (4.6) Summary of relations between landmarks

FCM can be built either by using the influencers or the influences as concepts and the relations will be determined according to concept used. The next step is to build the FCM itself by filtering table as shown in table (4.7) to determine the elements of graph; this work will use the influencers as concepts to create the graph. Figure (4.4) represents the FCM using the influencers landmarks with abbreviated names shown in table (4.8) as concepts, and the highest values to determine the arcs and directions.

	Mll	Res	Kin	Phm	Msq	Sch	Gas	Htl	Bnk	Hos	Ins	Mkt	Uni	Chr	Nur
Mll	**X**											**X**			
Res		**X**					**X**		**X**						
Kin			**X**			**X**							**X**		**X**
Phm				**X**						**X**					
Msq					**X**									**X**	
Sch						**X**									**X**
Gas							**X**		**X**						
Htl		**X**					**X**	**X**	**X**						
Bnk							**X**	**X**	**X**						
Hos				**X**						**X**					
Ins			**X**			**X**					**X**		**X**		**X**
Mkt												**X**			
Uni						**X**							**X**		**X**
Chr														**X**	
Nur															**X**

Table (4.7) Filtered influencing values.

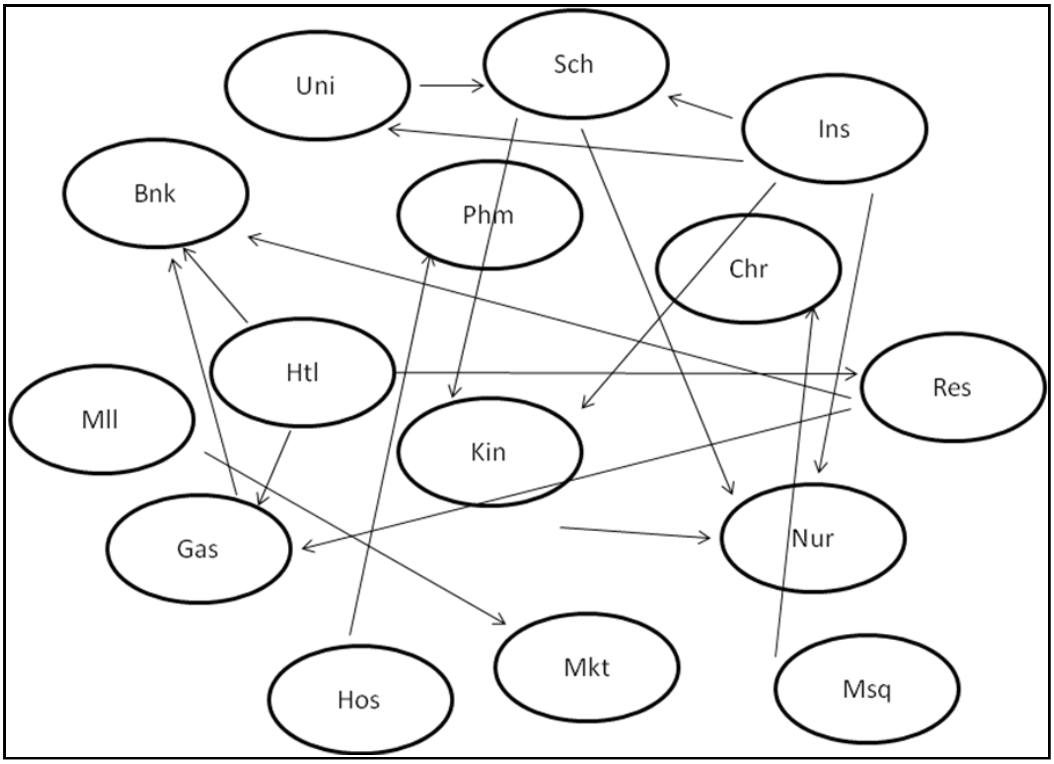


Figure (4.4) Fuzzy Cognitive Map produced

School	sch	Bank	Bnk	Mosque	Msq
Kindergarten	Kin	Mall	Mll	Church	Chr
Nursery	Nur	Market	Mkt	Hospital	Hos
University	Uni	Gas	Gas	Pharmacy	Phm
Institute	Ins	Restaurant	Res	Hotel	Htl

Table (4.8) List of abbreviations names used in FCM

To simplify the retrieving process, its preferred to categorize the landmarks into groups as shown in table(4.9),so the knowledge base can be implemented as set of rules based on (If-Then) structure as shown in figure (4.5).

		Shopping		Education					Health		Service				Religion	
		Mll	Mkt	Uni	Sch	Ins	Kin	Nur	Hos	Phm	Bnk	Res	Htl	Gas	Msq	Chr
Shopping	Mll	X	X													
	Mkt	X	X													
Education	Uni			X	X	X	X	X								
	Sch			X	X	X	X	X								
	Ins			X	X	X	X	X								
	Kin			X	X	X	X	X								

	Nur			**X**	**X**	**X**	**X**	**X**								
Health	Hos								**X**	**X**						
	Phm								**X**	**X**						
Service	Bnk										**X**	**X**	**X**	**X**		
	Res										**X**	**X**	**X**	**X**		
	Htl										**X**	**X**	**X**	**X**		
	Gas										**X**	**X**	**X**	**X**		
Religion	Msq														**X**	**X**
	Chr														**X**	**X**

Table (4.9) Categorizing landmarks.

If select (Mall) then retrieve (Mall, Market)
If select (University) then retrieve (University, School, kindergarten, Nursery, Institute)
If select (School) then retrieve (School, Nursery, University, kindergarten, Institute)
If select (Nursery) then retrieve Nursery, (kindergarten, University, School, Institute)
If select (Restaurant) then retrieve (Restaurant, Bank, Gas, hotel)
If select (Hotel) then retrieve (Hotel, Bank, Restaurant, Gas)
If select (Gas) then retrieve (Gas, Bank, Hotel Restaurant)
If select (Institute) then retrieve (Institute, University, School, kindergarten, Nursery)
If select (Hospital) then retrieve (Hospital, Pharmacy)
If select (Mosque) then retrieve (Mosque, Church)
If select (kindergarten) then retrieve (kindergarten, University, School, Nursery, Institute)
If select (Bank) then retrieve (Bank, Gas, Hotel Restaurant)
If select (Church) then retrieve (Church, Mosque)

Figure (4.5) basic rule to construct the relations

4.3.4.1. Landmark Knowledge as Declarative Representation

Landmark knowledge is the first level of spatial knowledge and is the most easily acquired (Darken & Peterson 2001). A person gains spatial knowledge of landmarks that are prominent visual objects in fixed locations (Werner et al. 2003). In urban environments these are usually large recognizable buildings or areas, which can be seen afar. When traveling in an urban environment, a person can navigate to a landmark without knowing the exact route to use, if he is able to keep track of the landmark (Boden, M. A. 1990).

Declarative knowledge in the spatial domain consists of features often referred to as landmarks and its attributes, which may exist in both the natural and built environments. In knowledge representation it is usually referred to declarative knowledge as the set facts. (Lynch, K. 1960) defined landmarks as" points of reference external to the observer that may vary widely in scale, such as buildings, mountains, signs, and parks, etc".

In real environments, landmark location is represented by its latitude and longitude, the attribute could be included with its name and category, each category can form a layer on the maps, for example; a map can be constructed to show the universities, restaurants, towers layer or any layer. The layers can be represented to stand alone or can be combined with other layer, so any of the layers can be added or removed as desired.

All of these landmarks must have a symbol according to its category, assigned by a unique name, and location (Latitude and Longitude). These readings can be obtained from several systems or software like ArcGIS, PALGrid and others, in addition to portable devices like electronic compass. For example, ArcGIS requires geographic coordinates, latitude/longitude in decimal-degree format, as seen in table (4.2) which produces the figure (4.3).

Usually the declarative knowledge (some times called data or facts) i.e. the landmark attributes are represented in units of degree/minute/second or degree/decimal minute, to obtain this measurements, first individual must convert them. Individual can refer to "Latitude/longitude conversion" to convert from angle measurements to degree measurments, table (4.10) gives an example of latitude/longitude in degree. Through this thesis, the location of any landmark will be translated to (x, y) coordinate of on the monitor by calculating its center point (see section 4.6) and stored as a set of facts in the data base.

Landmark Name	Type	Area	Point X	Point Y	Category
Alestiqlal Schools	School	Umm Alsummaq	35.85895	31.98063	Education
Alhejjawi Gas Station	Station	Khalda	35.86882	31.99244	Servies
Alhussain University Correlation Office	University	Umm Alsummaq	35.86366	31.98081	Education
Alkhasaneh Hospital	Hospital	Tlaa Alali	35.86372	31.99837	Health
Alma'aref Supermarket	Market	Khalda	35.84779	31.9902	Shopping
Alma'arif National College & Schools & kindergarten	University	Khalda	35.84169	31.98844	Education

Table (4.10) Example of metadata in degree reading .

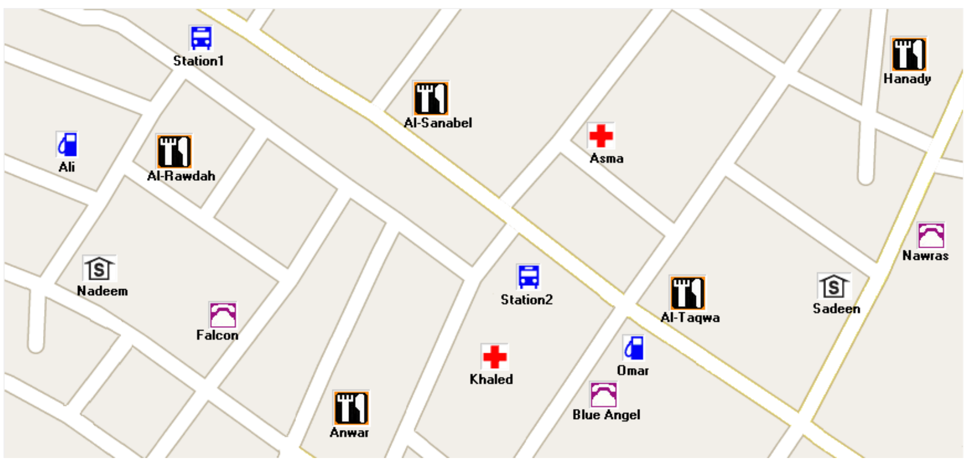


Figure (4.6) Simulation of geographical map

4.3.4.2. Procedural Knowledge Representation as Rules

The terms procedural knowledge and route knowledge have different concepts and usually misinterpreted. The route knowledge has been defined by (Niels Basjes, 2002) as “A set of procedures can only be used if an external entity explicitly specifies the initial situation and a desired end situation”. It encompasses information about the sequence of actions required to follow a particular route. Route knowledge is characterized as the knowledge about the actions to be performed in the environment to successfully traverse paths between distant locations, especially between an origin and a destination.

While (Fred Nickols, 2005) describes the definitions for Procedural Knowledge as: "knowledge about how to do something". Also (Deepak Kumar, 1995) states Procedural Knowledge: Knowledge is encoded in functions/procedures.

Therefore the route knowledge can be recognized as the sequences of functions or procedures to be accomplished for finding a route, while procedural knowledge is the knowledge that describes an action to be accomplished as a rule in the form (if conditions then action and usually called as Horn Clause) (Owied, 2009).

Route knowledge is the next level of spatial knowledge, in which routes are formed to connect the landmarks. A route can be described as a sequence of nodes that locate where the user selects a new bearing (Hunt & Waller 1999). In an urban environment a node can be e.g. a turn at a crossing of streets. However, this thesis will use pixel manipulations instead of nodes; this will be mentioned later in section (4.7) in this chapter.

With route knowledge, a person not only knows an exact route to his destination, but also finds the way from an arbitrary point on a route to another point further away on the route (Werner et al, 1997).

Route knowledge is generally acquired by applying a sequenced algorithm mentioned in section (4.2.2.), which can be considered as the rules, in general it obeys the rule if “requirements” then “satisfied job”. Through this thesis route knowledge is assessed by three methods. The first is the distance measurements task, where the distance between the start point and landmarks (goal point) is calculated under mathematical operation after passing several algorithms, the distance task algorithm will be described in section (4.6). The second is the path estimation which is gained as a result from the distance measurement task described in section (4.7). The third is the landmark position, which means the orientation of landmarks described in section (4.9), and that requires the individual judgment by referring to the fact base to retrieve the knowledge about the landmarks. The acquisition of this type of spatial knowledge seems to be primarily based on direct experience.

4.3.4.3. Survey Knowledge Representation as Blackboard

A blackboard is a knowledge base system which consists of a set of different knowledge base sources, (in this thesis it consists of declarative knowledge, procedural knowledge), its data structure and control strategy is used to activate the knowledge, “Each knowledge source monitors the blackboard and activates itself based on the state of the blackboard” (V. Pires, et al, 2004). The blackboard model provides a very flexible control structure for judging and solving problems (Xiaoyi Chi et al, 2001).

As a person picks up more and more routes to his cognitive map, he starts to understand the environment as a graph of nodes and edges (Timo Pietilä, 2009). This is the third and final level of spatial knowledge and it is referred to as survey knowledge. As it develops, the graph becomes complete and a person can generate routes between any two points as he is able to estimate their relative distances and directions. (Darken & Peterson, 2001).

The knowledge question arises in the blackboard when converting the route knowledge and landmark knowledge into an abstract representation, that in turn allows them to combine both of landmark knowledge and route knowledge and convert this knowledge to survey knowledge and vice versa if needed.

4.1. Threshold Module

Colored images are usually represented by the combination of its three basic colors (Red, Green, Blue), each color in the RGB color space can only have a discrete value between zero (black) and 2563 (white), the black color has the values (0,0,0) while the White color has the values (255,255,255) in the (R,G,B) space respectively, this work aims to convert colored image into binary image (Black and White only).

To achieve thresholding aim, many experiments were tested and concluded that the value (13500000) was suitable as a threshold value, by checking all pixels of the colored image, if the pixel color is less than the chosen threshold value, then the pixel color is changed to Black otherwise pixel color will be changed to White. The following pseudo code in figure (4.7) represents the conversion algorithm used.

The idea behind this technique is by making the background pixels to be more bright (white) and has the dominant number of pixels as shown in figure (4.8), on the other hand the foreground will be more dark (black) and has the lower number of pixels. The benefit of this technique is to make road extraction easier as maintained in the next section.

```
for each pixel in image
        if pixel color < 13500000    then
      change color to Black
    else
      change color to White
```

Figure (4.7) Threshold pseudo code

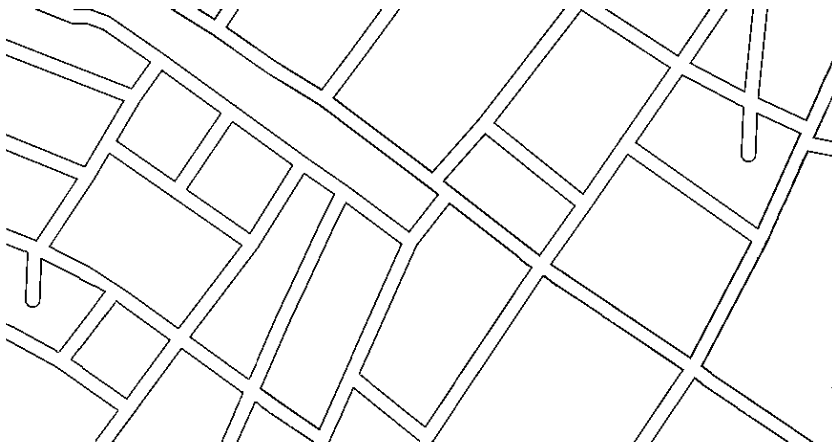


Figure (4.8) Map result after thresholding

4.2. Road Extracting Module

To extract the road, first the road edge should be detected, to do so it is assume that road width is set to a certain range of width, in this thesis it is assumed that the road width should be between [1-10] pixels, figure (4.9) shows different patterns of road width. To perform the filling algorithm, First, we choose a point that lies between two black points having a distance (D) that satisfies the previous condition: $1 \leq D \leq 10$, the selected point is called the seed point, then the filling algorithm will change the seed point to black and detect other points within the 4-neibours, each of them will act as a seed point and so on, until the whole of enclosed area is filled. Figure (4.10) describes the pseudo code of filling algorithm and figure (4.11) shows the result of the map after filling algorithm is applyed.

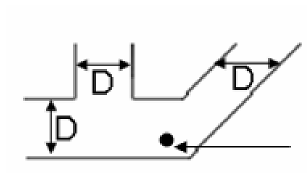


Figure (4.9) Different patterns of road width and seed point

```
Pop the seed from the stack
Change its color to black
Mark it as visited
Push its four neighbors into the stack
while stack is not empty
   pop a pixel from the stack
   if the pixel within the boundaries AND not visited AND pixel color is White then
     mark pixel as visited
     change pixel color to Black
   end if
push the four neighbors of the current pixel into the stack that satisfies
the previous conditions
end while
```

Figure (4.10) Filling Algorithm pseudo code

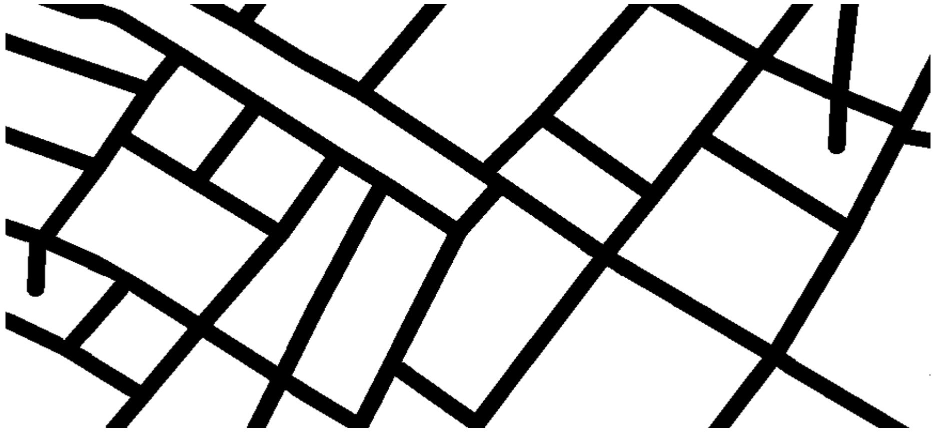


Figure (4.11) Map result after Filling.

4.3. Skeleton Module

SKELETON (or medial axis), which integrates geometrical and topological features of the object, is an important shape descriptor for object recognition (X. Bai and L. J. Latecki, 2008), like other morphological operators, the behavior of the skeletonization operation is determined by a structuring element. The choice of structuring element determines under what situations a foreground pixel will be set to background, and hence it determines the application for the skeletonization operation.

Thinning algorithms are a Morphological operation that is used to remove selected foreground pixels from binary images. It preserves the topology (extent and connectivity) of the original region while throwing away most of the original foreground pixels.

Thinning algorithms can be divided into two broad classes, namely: iterative and non-iterative. Although non-iterative algorithms can be faster than iterative algorithms they do not always produce accurate results.

This thesis utilizes Zhang-Suen thinning algorithm (T.Y. Zhang and C.Y. Suen, 1984) which is an iterative algorithm; this has the characteristics of thinned, centered, connected and accurate. It is a parallel method that means the new value obtained only depends on the previous iteration value. It is fast and simple to be implemented. Before starting the implementing for the algorithm, some definitions need to explain:

S (P): The connectivity: is the number of transitions from 0 to 1 of the eight neighbors pixels of pixel P. i.e. if the pixel changes its color status from White to Black while going clockwise. Figure (4.12) represents some examples of transition.

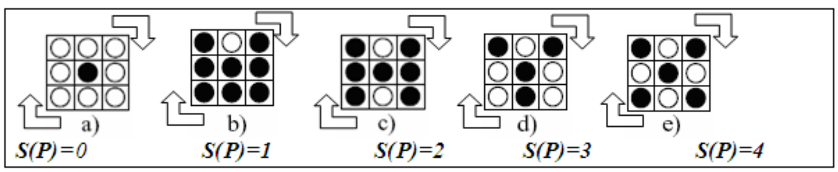


Figure (4.12) Example of transition

N (P): The extent: The number of black color pixels found in the eight neighbors pixels as in figure (4.13).

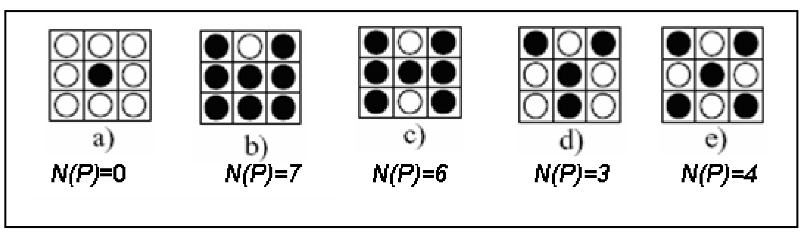


Figure (4.13) Example of connection

This algorithm is based on two sub-iterations, each iteration marks a pixel $P(x,y)$ if specific conditions are satisfied, and then all marked pixels are deleted. If at the end of either sub-iteration there are no pixels to be deleted, then the algorithm stops. The two iterations grant the processing its accuracy. The following pseudo code in figure (4.14) represents Zhang-Suen Thinning Algorithm.

```
first sub - iteration
  mark all pixels P that satisfy the following conditions
        pixel P color is Black
        S(P) = 1
        2 ¡ N(P) Ü 6  Ü
        (P2) AND (P6) AND (P8) = 0     // at least one of  pixel color is White
        (P2) AND (P4) AND (P8) = 0     // at least one of  pixel color is White
  delete all marked pixels

Second sub - iteration
  mark all pixels P that satisfy the following conditions
        pixel P color is Black
        S(P) = 1
        2 ¡ N(P) Ü 6  Ü
        P(4) AND (P6) AND (P8) = 0     // at least one of  pixel color is White
        P(2) AND (P4) AND (P6) = 0     // at least one of  pixel color is White
  delete all marked pixels
```

Figure (4.14) Zhang-Ssuen thinning algorithm pseudo code

After obtaining the binary image map, and applying Zhang-Suen Thinning Algorithm, a new map layer is produced as in figure (4.15) represents the center-line road of one pixel line.

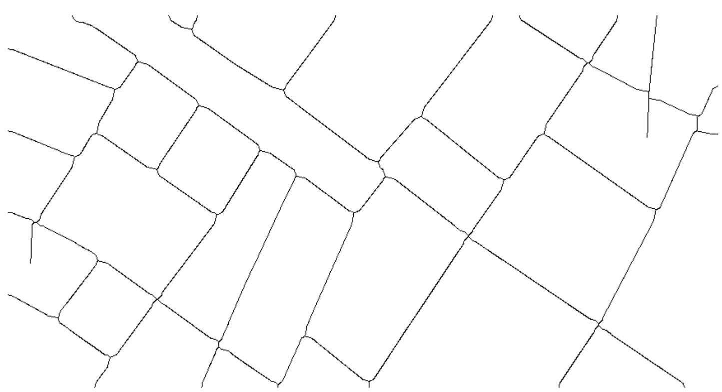


Figure (4.15) Map result after skeletonization

4.4. Localization

Referring to the original map, which consists of the road and the landmarks layers, and as maintained above, the path algorithm should find the shortest path from any point to any landmark on the map, so the start point could be any point on the image map, and the goal should be any landmark.

We need a way to refer to locations on the map. The `google.maps.LatLng` object provides such a mechanism within the Google Maps API. You construct a `LatLng` object, passing its parameters in the order {latitude, longitude}:

```
var myLatlng = new google.maps.LatLng(myLatitude, myLongitude)
```

Note: the process of turning an *address* into a geographic point is known as *geocoding* of the Google Maps API. For example, the map can be constructed to be on the center of Amman city as shown.

```
var latlng = new google.maps.LatLng(31.9300, 35.9363);
```

4.6.1 Start Point

The starting point is assigned by the symbol [] while implementing VB project this symbol can be placed any where in the map to indicate the position of the agent, the algorithm will detect its dimensions (width and height), and calculate the center point of the symbol. This point has the coordinate $S(x, y)$ that will be used as the starting point.

However, `LatLng` objects have many uses within the Google Maps API. The `google.maps.Marker` object uses a `LatLng` in its constructor, for example, Google Maps API uses the marker object to refer to the starting point, it is usually symbolized by [ ]. This symbol will appear when right click is used on the map. The `right_click event` will set the latitude and longitude of the chosen point then it will be considered as a starting point. The following segment code shows how can the marker object and the `right_click event` implemented using Google Maps API. However, the symbols [] and [] while implementing the Google Map website to indicate the starting point.

```
google.maps.event.addListener(map, "rightclick", function (event)
{ showContextMenu(event.latLng); });
```

4.6.2. End Point

By the same way, the end point is assigned by a symbol; this symbol can have a unique shape to indicate some landmark; landmarks can be found any where in the map and refers to the position of the goal of the agent, as described in figure (4.16) the algorithm will detect its dimensions (width and height), and calculate the center point of the symbol as clarified in figure (4.17). This point has the coordinate $S(x,y)$ which will be used as the ending point.

```
// find marks centers
    Marks(I).Center.X = (Mark(I).Width \ 2) + mark(I).Left - myMap.Left
    Marks(I).Center.Y = (Mark (I).Height \ 2) + Mark (I).Top - myMap.Top
```

Figure (4.16) finding start and end point centers pseudo code

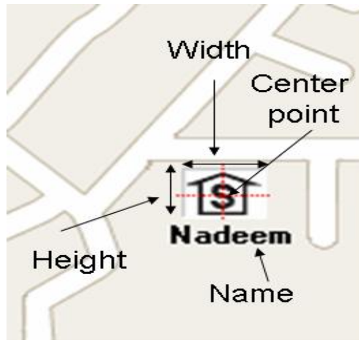


Figure (4.17) Landmark symbol details

By the same way, end point using Google map could be set by using the Google Maps API. This will require to use the API services to locate the latitude and longitude for a certain landmark, API also helps to use the marker icons to show the symbols used to indicate the landmarks. Figure (4.18) gives a segment code to show how Google Maps API can allocate the right position of landmarks which are stored in the database. The destination or the end point of the user could be the chosen landmark on the map, the symbols [] and [] will be used to indicate the end point while implementing the Google Map in addition to different symbols from Google Maps library used to indicate landmarks, for example, table (4.11) list some symbols of landmarks used by Google Maps API. Figure (4.19) shows an example of determining the start point and the end point on the map.

```
var markers;
       function loadDataXML() {
           var districtArrayUniq;
           downloadUrl("landmark.xml", function (data) {
markers = data.documentElement.getElementsByTagName("Export_Output");
```

Figure (4.18) localization API segment code.

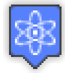
Landmark	**Symbol**	**Landmark**	**Symbol**	**Landmark**	**Symbol**
Bank		Institute		Restaurant	
Church		Mall		School	
Hospital		Mosque		Station	
Hotel		Nursery		Market	
kindergarten		Pharmacy		University	

Table (4.11) List of landmark symbols

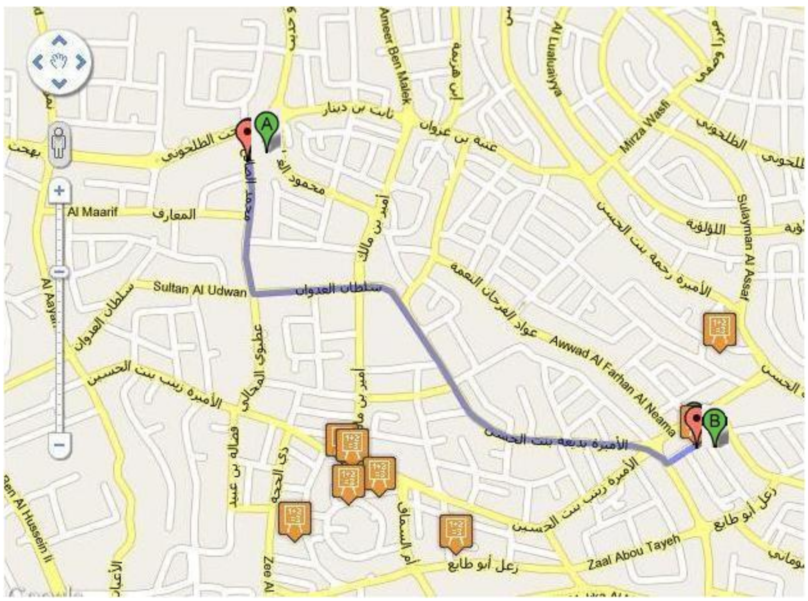


Figure (4.19) Start and End point using Google Maps API

4.6.3 Nearest Point

The algorithm will detect two points within the eight directions as in figure (4.20) starting from the centers of both the start and the landmark, this point will verify the minimum distance between each centers and the thinned line, and the agent will consider them as the start point and the goal point on the road.

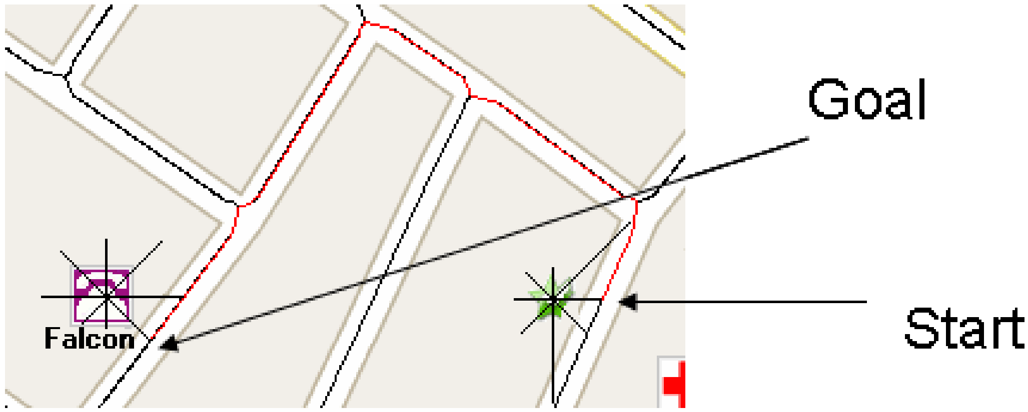


Figure (4.20) Start and end point estimation using nearest point.

4.5. Path Finding Module

Shortest path techniques have been mentioned by several scientists; there are many algorithms discussing such problem like Djikstra algorithm and others, most of them dealing with graph which consist of nodes and edges (weighted edges), and most of the graph examples have a limited and small number of nodes.

Through this thesis, it was hard to apply such algorithms to find the shortest path, the reason behind that is because the image has a large number of pixels, and through thesis each pixel is considered as a node in the graph especially when finding the paths between locations.Iin case of applying Djikstra algorithm for example, it will need a long time to execute and large size of the main memory, thus the algorithm consume the machine resources and will take a long time to give the result.

In order to make the path finding to easy and understandable, a traceable layer can be utilized to walk through all its pixels; decision points and navigation graphs in an unconstrained environment can be computed from binary images using skeletonizing algorithms(C. Gaisbauer and A. U. Frank, 2008). (Lynch, 1960) defined decision points as “...strategic foci into which the observer can enter, typically either junctions of paths, or concentrations of some characteristic” Formally let's consider the relation G= (P, N) where G is the graph, P is a pixel on the skeleton layer and N is the number of connected pixels of P within its eight neighbors. So there is a relationship between any pixel and other(s), and this relationship is notable and can make a sense guide to determine whether this pixel is on the path or not and also to determine whether it is end line or not. This benefit leads to construct a path from point to point. Figure (4.21) illustrates the different characteristics of pixels that are mentioned with path finding.

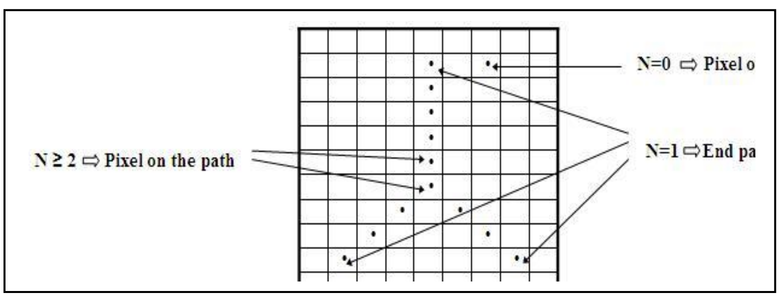


Figure (4.21) Distinct facilities of pixels.

Therefore, instead of using one of the algorithms mentioned, path finding algorithm used in this thesis is to detect the minimum distance between two points by using a well known mathematical equation of distance between two points.

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

where:

D: the distance between two points

(x_1, y_1) : The Start point,

(x_2, y_2) : The Goal point

Trying to obtain the shortest path, the algorithm will calculate the minimum distance between (goal point) and all pixels through the path starting form the (start point). The algorithm initially takes the first location (start point) and finds the distance between it and the (goal point), then it explores the eight neighbors of the current point (start point), the algorithm will continually select the pixels one by one and choose the pixel that satisfies the least distance between selected pixel and the (goal point) The algorithm will repeat this process until the last point which is the nearest neighbors of the (goal point). Figure (4.22) represents the pseudo code of the minimum distance algorithm.

```
PathFind(Start,Goal)
P = Start
if P = Goal then
    Finish = True
Else
    Finish = False
End if
Visited(P) = True
Push Road(P)
Color(P) = Road Color
While Not(Finished)
    N = 0
    For each neighbor(P)
        If Color(P) = Black AND Not(Visisted(P)) then
        {N = N + 1; D = Dist(P,Goal)}
  If N ≻ 1 then
            Choose pixel P such that Dist(P,Goal) is the least then
            {Push Road(P); Color(P) = Road Color}
                If P = Goal then
                    Finish = True
                End If
            Visited(P) = True
            Push the other pixels to Cross stack in a descending order
        Else      // Dead End
            P1 = Pop Road( ); P2 = Pop Cross( ); D = Dist(P1, P2)
    While D > 2
    { Color(P) = Black; P1 = pop Road( )}
End While
```

Figure (4.22) Path Finding Algorithm Pseudo Code

The other non-selected pixels are pushed into stack, the process of exploring and selecting pixels is repeated until one of two cases is raised;

- The goal is reached then the process is terminated.
- An end point is encountered.

If an end point is reached, the algorithm will roll back to the nearest cross point and select again the pixel of the cross point neighbors that has the minimum distance between the selected pixel and the goal point. Figure (4.23) shows the selection of the pixels which have the minimum distance with the goal.

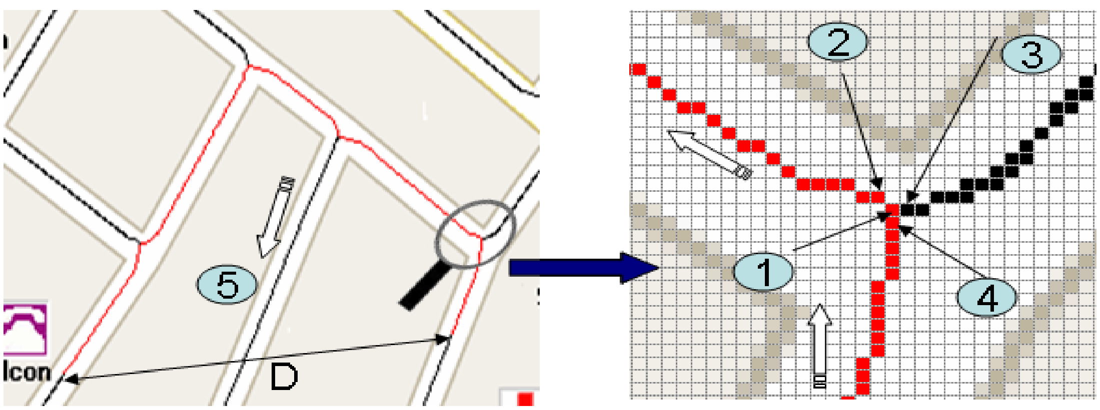


Figure (4.23) A cross point and the eight neighbors characteristics.

[1] ➔ Cross point.

[2] ➔ Pixel that keeps the minimum distance with the goal after the cross point.

[3] ➔ Pixel that doesn't keep the minimum distance with the goal after the cross point.

[4] ➔ Pixel that keeps the minimum distance with the goal before the cross point.

[5] ➔ A path reaches end point.

4.6. Shortest Path Module

After reaching the goal location, the algorithm computes the road length by counting the pixels that form the path line, then to reach more accuracy, the algorithm compute the path in the reverse direction i.e. from the goal point to the start point and computing the path length , then it compares the two lengths and draws the shorter one.

Figure (4.24) represents the pseudo code for how the length of the path is obtained by counting the number of pixels that makes the path. The variant lengths of the same path come from applying the algorithm of minimum distance between two points; this operation is performed with two iterations as the following scenario: imagine there are two persons, the first iteration states that person1 (goal point) holding a tight cord and person2 (start point) is engaged with that cord, person2 wants to go to person1, person1 can tighten or loosen the cord as required, and he keeps pulling the cord that forces person2 to keep the minimum distance between them until person2 reaches person1. The second iteration concludes that this scenario is repeated vice versa; i.e. person1 and person2 exchange their positions. Finally, both persons count haw many steps (pixels) they walked, then they compare the two numbers of pixels and decide which path is shorter to be considered as the shortest path.

```
DrawPath(Start,Goal)
   RL = RoadLength ( )
   RemoveRoad
   DrawPath(Goal,Start)
     If  RL < RoadLength( )  Then
         RemoveRoad
          DrawPath(Start,Goal)
    Else
      RL = RoadLength( )
   End If
```

Figure (4.24) comparison process pseudo code

After Appling the comparison algorithm, two paths will be generated as a result, figure (4.25) and figure (4.26) show the two different paths generated and figure (4.27) shows the selected path as the shortest path.

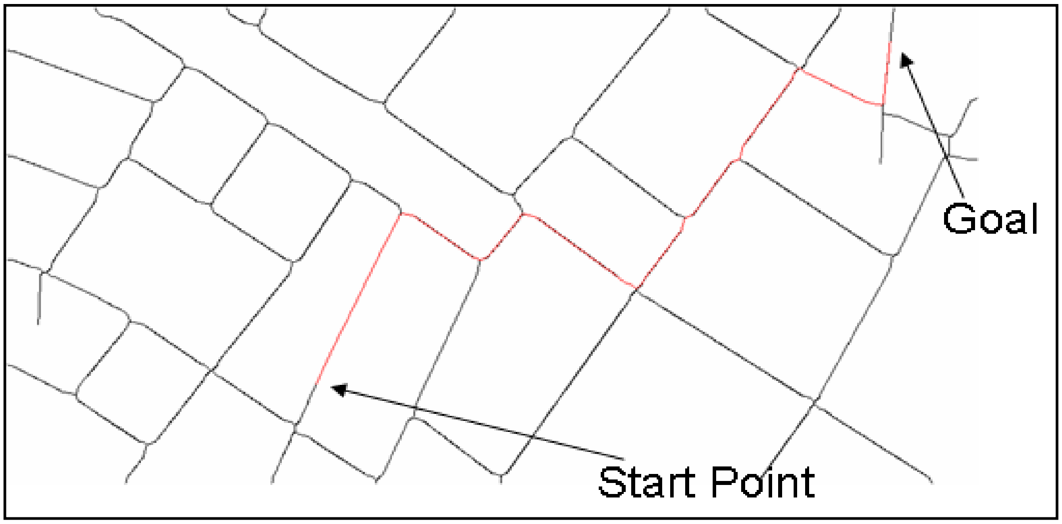


Figure (4.25) First path detected

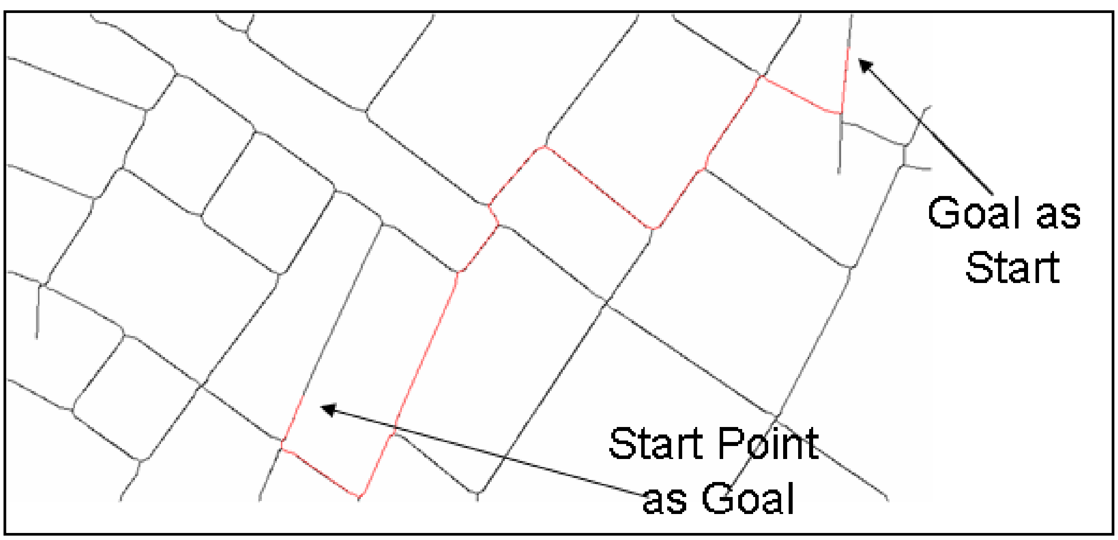


Figure (4.26) second path detected

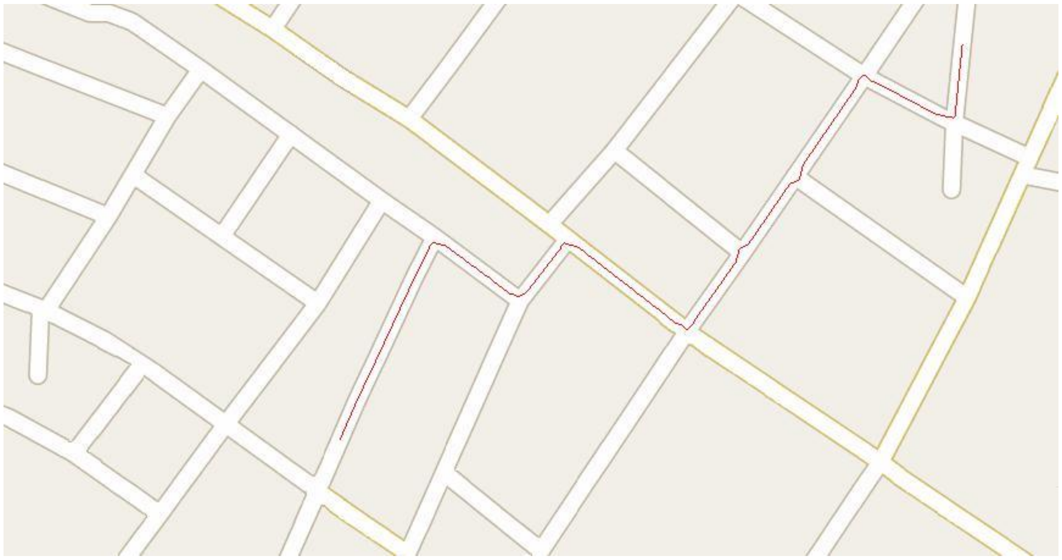


Figure (4.27) shortest path selected.

Path or rout as known with Google Maps can be implemented with the help of Google Maps API services, the following peice of code in figure (4.28) shows how rout is generated and drawn on Google Maps by using the function `calcRoute()`and the object `directionsService`.

```
function calcRoute() {
           if (fromPointRoute === null)
               alert("Please insert from value");// choose start point

           else if (toPointRoute === null)

               alert("Please insert destination value");// choose end point

           else {
               var start = fromPointRoute;
               var end = toPointRoute;
               var request = {
                   origin: start,
                   destination: end,
                   travelMode: google.maps.DirectionsTravelMode.DRIVING
               };
               directionsService.route(request, function (response, status) {
                   if (status == google.maps.DirectionsStatus.OK) {
                       directionsDisplay.setDirections(response);
                   }
```

Figure (4.28) segment code of rout generation on Google Maps API

4.7. Orientation

Finding Shortest Path Algorithm returns the path as an array of pixels, this array needs to be converted to a distance according to the map scale application as mentioned in section (3.4) to be understandable directions to be built as a cognitive map.

As shown in section (4.8) figure (4.29), the direction is initially obtained by estimating the angle between each pixel and the goal point starting form start point.

However, using Google Maps, path can be calculated by using the `DirectionsService` object. This object communicates with the Google Mapss API Directions Service which receives direction requests and returns computed results.

The direction is in stored the knowledge-base within the analyzed map knowledge section, and then next nodes should be taken within the shortest path, until reaching endpoint. Figure (4.30) shows how angle are translated into directions.

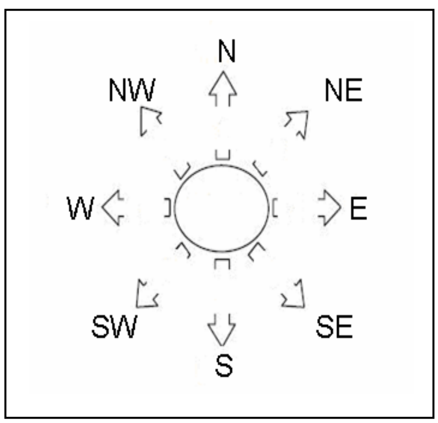


Figure (4.29) Common Directions

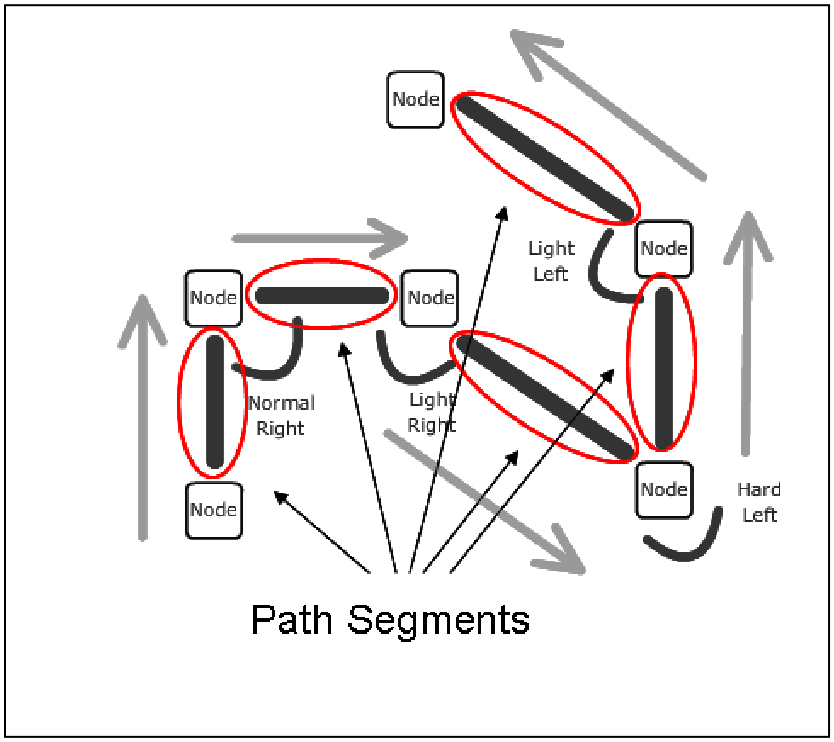


Figure (4.30) Direction translation in the natural language

With Google Maps API service, directions may specify origins and destinations as text strings for example (turn left after 0.3 km, go south through (some name) street… your target is located here). The Directions service can return multi-part directions using a series of waypoints. Directions are displayed as a polyline drawing the route on a map, or additionally as a series of textual description within a `<div>` element like tool tip. Figure (4.31) shows a full description of orientation used on maps.

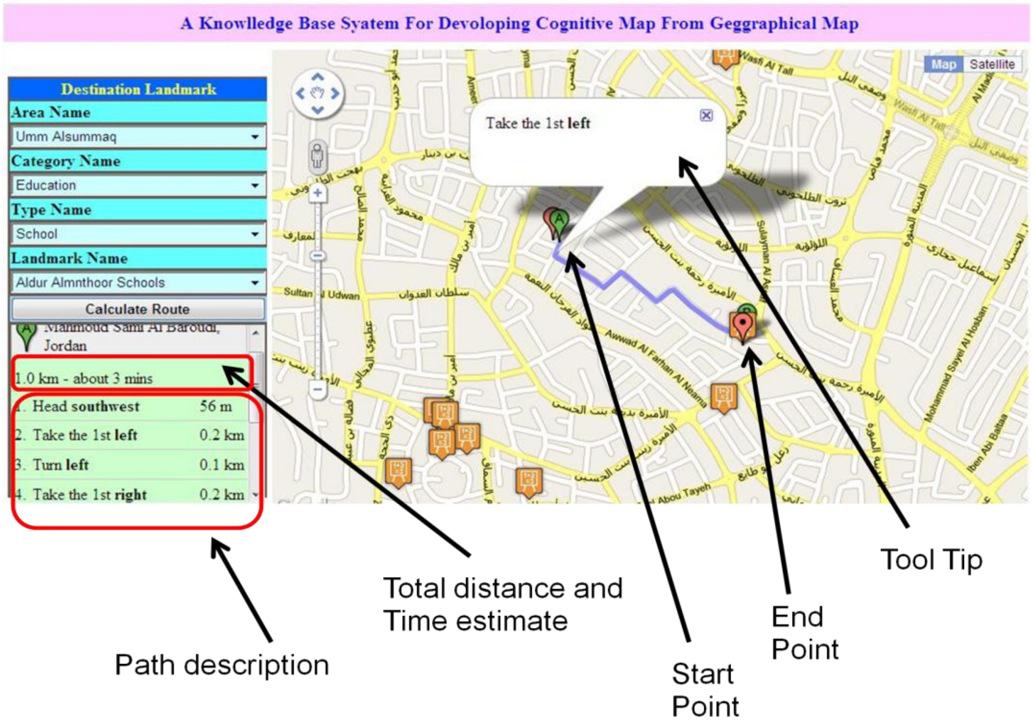


Figure (4.31): Angels Translated into Directions.

4.8. Developing Cognitive Map Module

This module based on the philosophy of human vision then the cognitive map is built as a graph where each node presents certain knowledge. (Diane M. Szaflarski, 2010) Said “We now know the basic function of the components of the human eye and how they participate in the vision process. Light that reflects off of objects around us and this reflection is imaged onto the retina by the lens. The retina is responsible for detecting the light from these images and then causing impulses to be sent to the brain along the optic nerve. The brain decodes these images into information that we know as vision.” But the philosophy of human vision is that the brain although decodes these images into information will add two important entities to these images which are the expectation and intend of the viewer in order to develop the final picture (Owaied 2010). For example individual my look at a tree and have expectation in his mind there are many birds on the tree, and intend to concentrate on the above the tree. So he will get his picture about the tree which contains his expectation and his intend together with the image. But if another individual looks at the same tree from the same position and has different expectation, say how the branches of tree are longer than others, and his intend, will concentrate on the branch of the tree, so he will get his picture about the tree that consists his expectation and his intend together with the image. Therefore the two pictures are different even though for the same tree and from the same position but the difference lies in intend and expectation of people.

To emphasize this idea of the cognitive map over a geographical map, let consider a map for an environment that contains of a lot of land marks as in figure (4.32). The crowded landmarks may cause confusion for individual while the individual searches for some particular landmark. Suppose that the individual explores a map and want to find the hospital named (Al Razi) on the map, in his intention, he will focus on those symbols that refer to the hospital sign, and in his expectation he will find one or more hospital located in different positions in that area as shown in figure (4.33). Therefore the cognitive map will be built first as an image of a map containing the hospital only, then the individual can use his cognition to find the position of that hospital, also can generate the path that leads to that hospital based on individual knowledge about that environment as in figure (4.34). However another individual may intend to find where the locations of schools are, and in his expectation, there are one or more schools and he wants to know their locations, so the cognitive map will be built as an image of a map containing the schools only and the same way the individual can find where his target is and what path leads to it.

Both of individuals look at the same map, but both of them create an image in his mind different than the other, the reason of that is neither of them pays attention to what is on the map except what is in his intends and expectations, thus the cognitive map of both of them varies due to variance of their intent and expectation.

Figure (4.32) map contains many landmarks

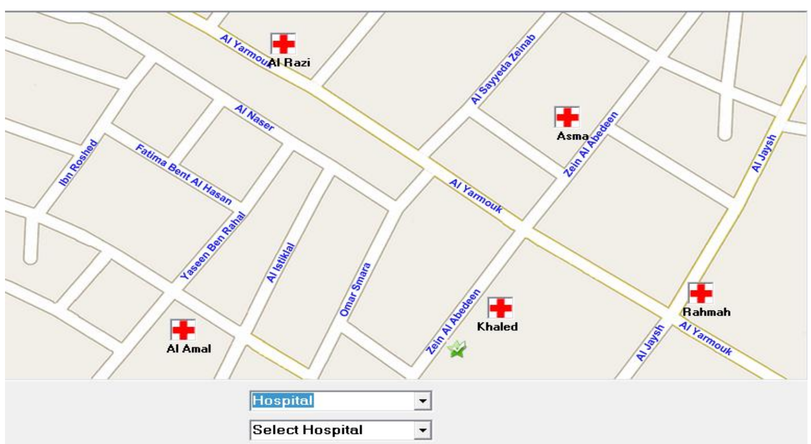


Figure (4.33) Cognitive map with hospitals only

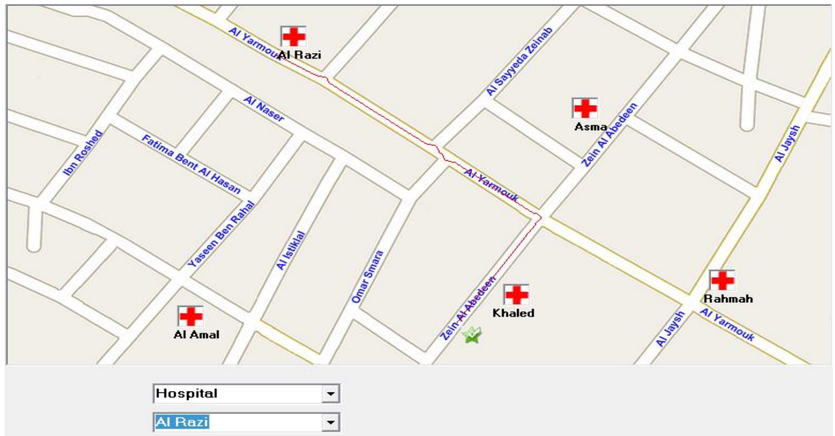


Figure (4.34) Cognitive map for hospital landmark with shortest path

However, developing a cognitive map also can implemented through Google Maps, to do so, the first step of thinking is how to find a landmark; it usually starts to determine the area where that landmark is located, then it determines what category it is, what type it is, and finally what name it is. Figure (4.35) shows the steps of choosing a specific landmark among different landmarks on a map.

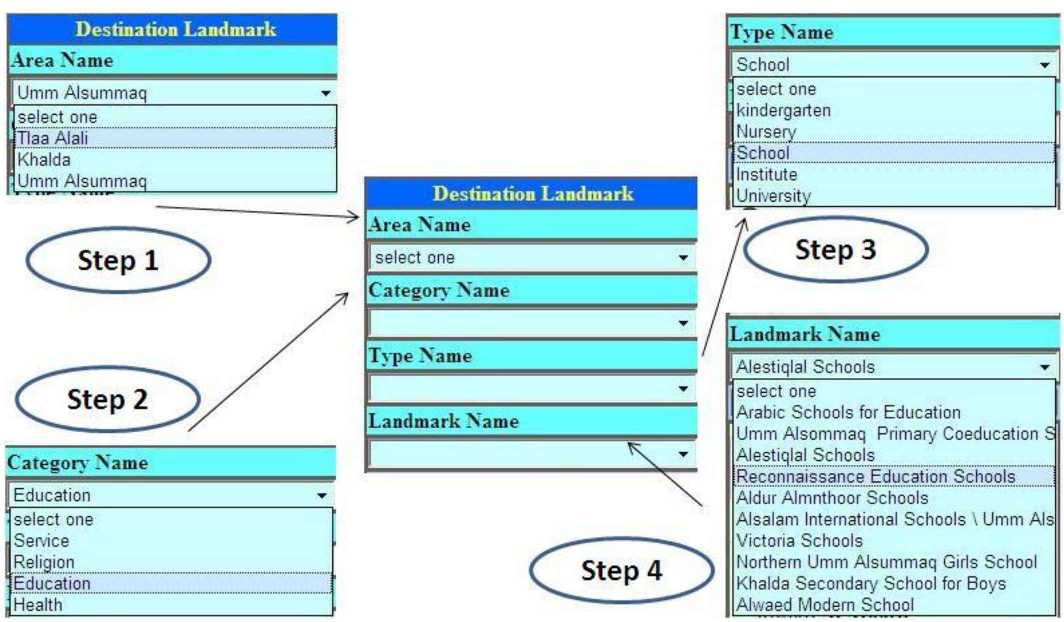


Figure (4.35) steps for finding landmark and path using CM.

To verify the concept of cognitive map (intend and expectation) throughout this thesis using Google Maps, we give an example for how it is possible for the user want to find some school. First, in his intend he is looking for a symbol indicating school, but in his expectation, he imagine different symbols related to school type or within educational category, so the cognitive map that will appear is a map generated according the rule base consisting of school landmarks in addition to related landmarks from the same category. Figure (4.36) show how cognitive map can be achieved using Google Maps API.

Figure (4.36) Final cognitive map using Google Maps.

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