



## **A Model for Cognitive Map Construction Using Spatial Information Indoor Environment**

نموذج لتكوين الخريطة الإدراكية باستخدام المعلومات المكانية في البيئة  
المغلقة

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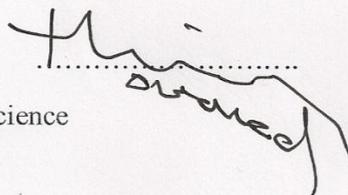
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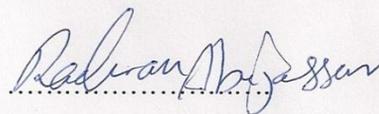
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## **Dedication**

I dedicate this work to my dear father, who died since my childhood, my dear mother, my uncle Abdul-Ghafoor , other uncles ,my sisters, my wife, all my friends and to everyone supported me in my life.

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## List of Abbreviations

<b>Abbreviation</b>	<b>Meaning</b>
<b>CAD</b>	Computer-aided design
<b>AI</b>	Artificial Intelligent
<b>CM</b>	Cognitive Map
<b>GIS</b>	Geographic Information System
<b>IE</b>	Indoor Environment
<b>IS</b>	Information System
<b>LOTOS</b>	Language Of Temporal Ordering Specification
<b>UML</b>	Unified Modeling Language
<b>SI</b>	Spatial Information
<b>VBA</b>	Visual Basic for Application

## **Abstract**

This thesis presents development of a model which will be used to construct a cognitive map for finding shortest paths for the same type of landmarks in different locations in the indoor environment based on the spatial information and according to the user task such as commercial centers, hotels, malls ... etc.

The development of the model a knowledge-based system consists of four parts; these are user interface, spatial database, inference engine and knowledge base. The developed model, is used to build a cognitive map, based on the Dijkstra algorithm which applied to finds many shortest paths for the same type of landmarks in different locations in the map, using AutoCAD, ArcMap & ArcCatalog software and VBA programming language.

This model is capable to infer relationships, distances and directions that connect different landmarks in the indoor environment related to specific task without direct human interfere. Accordingly the required cognitive map presents the shortest path within a network of interconnected information within the indoor environment.

The developed model guides people in critical indoor environment without the need of human guidance or interference, using spatial information as the only knowledge source in order to linking the task with spatial information to reach the intended destination.

The result of this work is to identify locations' landmarks of the internal environment within the mall map with network links among these locations by the existed paths. These paths connect these locations with each other. Moreover, this study shows how to get an explicit and

close to hand way for the user toward the desired way, so that many paths will be appeared for the three nearest landmarks of the same required kind for the task and select the appropriate order for the required task.

This work allows being more able to cope with maps and having the ability to read, benefit from the map. As a result, it displayed the optimal path, the distances and the information of the locations in the map.

## الخلاصة

تقدم هذه الأطروحة تطوير نموذج الذي سيستخدم لبناء الخريطة المعرفية لإيجاد أقصر الطرق لنفس النوع من المعالم في مواقع مختلفة في البيئة المغلقة استنادا إلى المعلومات المكانية وفقا لمهمة المستخدم مثل المراكز التجارية والفنادق ... الخ.

تطوير نموذج كنظام قائم على المعرفة ويتكون من أربعة أجزاء ؛ هذه هي واجهة المستخدم ، وقاعدة البيانات المكانية ، محرك الاستدلال وقاعدة المعرفة. النموذج المتقدم لبناء الخريطة المعرفية ، استنادا إلى خوارزمية ديكسترا التي تم تنفيذها مع عدة خوارزميات لتجد العديد من أقصر الطرق لنفس النوع من المعالم في مواقع مختلفة في الخريطة ، وذلك باستخدام برمجيات AutoCAD ، ArcMap ، ArcCatalog و لغة البرمجة VBA.

هذا النموذج قادر على استنتاج العلاقات، و المسافات و الاتجاهات التي تربط معالم مختلفة في البيئة المغلقة المتعلقة بمهمة محددة دون التدخل البشري المباشر . وفقا للخريطة المعرفية المطلوبة يعرض أقصر طريق داخل شبكة المعلومات المترابطة داخل البيئة المغلقة .

النموذج المتقدم دليل للناس في بيئة داخلية حرجة دون الحاجة إلى توجيه أو تدخل الإنسان ، وذلك باستخدام المعلومات المكانية كمصدر للمعرفة فقط من أجل ربط المهمة مع المعلومات المكانية للوصول إلى الوجهة المقصودة.

نتيجة هذا العمل هو تبيان مواقع المعالم في البيئة الداخلية ضمن خريطة السوق التجاري مع شبكات من الارتباطات في ما بين هذه المواقع باستخدام الطرق الموجودة والتي تربط هذه المواقع مع بعضها البعض. وكيفية الحصول على مسار واضح وقريب من ناحية موقع صاحب المهمة إلى الوجهة المطلوبة،

بحيث يظهر عدة مسارات بالنسبة لأقرب ثلاثة معالم لنفس النوع المطلوب للمهمة واختيار الأنسب للمهمة المطلوبة.

هذه الدراسة تمكن من القدرة على التعامل مع الخرائط، و ذلك من خلال القدرة على القراءة و الانتفاع من هذه الخرائط. حيث بالنتيجة تمكنا من عرض المسار المثالي، المسافة و المعلومات عن الأماكن الموجودة بالخريطة.

# **Chapter One**

## Introduction

# CHAPTER ONE

## Introduction

### 1.1. Overview

The construction of computer programs that engage in tasks is, for the moment, performed most of its satisfactorily by human beings because they require high-level mental processes such as: perceptual learning, organization of the memory and critical thinking.(Lee, 2006).

As defined by John McCarthy, the goal of Artificial Intelligence (AI) is the study of the structure of information and the structure of the problem solving process, independently of applications and regardless of achievement (William, 2012). An essential condition to act intelligently in a general way is the ability to produce and manipulate symbolic structures (Allen, 1990). Recently, there has been a review of the term artificial intelligence and to give a new concept for this very important field of study. Many researchers in this field have been trying to build systems that have some sort of intelligence.

In order to understand AI concept, a clear and recent definition was mentioned by (Owaied, 2012) who stated that "Artificial Intelligence is a concept of study and research for finding relationships between cognitive science and computation theories in order to represent these relationships as either data structures, search techniques, problem solving methods or representation forms of knowledge. However, the final goal of AI is to build an intelligent machine, with another benefit which is better understanding of human thinking". This definition is based on the philosophy that for a machine to be intelligent it should be smart, and be able to solve problems. Smart can be defined as "everything gives pleasure and happiness to humans, through the facilities available in all sort of multimedia equipments", also to build such

machines, it should have certain capabilities such as behaving like a human being, smart, be able to solve problems of unstructured and complex problems as does human, understands languages, learning, and being able to reason and analyze data and information, and so on.

Systems are designed to assist human beings to complete tasks. As described in many research journals and scientific fictions, researchers and the general expect that one day system can complete certain tasks independently and autonomously in our world (Tan, 2012).

To understand the concept of the cognitive mapping, which is used throughout this research, in a general sense, is a mental construction that is used to understand and know the environment. This assume that people store information about their environment, which they use to make spatial decisions, helps simplify coding the complex interaction of human with his environment. It is a mental representation of environmental knowledge that includes knowledge about places as well as knowledge of spatial relationships. The integration of images, information, attitudes on the environment make us to conclude that: it is not an isolated entity context (Daniel and Martin, 2013).

On other hand, the term cognitive map refers to the internal mental representation of environmental information. Both for a process and a product of the mind, the cognitive mapping is essential for spatial behavior and decision-making whether rummaging in a refrigerator, traveling across a continent, or traversing a metropolitan area (Mondschein et al. 2005). The primary purpose of cognitive mapping is to enable individuals making choices related to the spatial environment.

Some transportation researchers have begun to engage with cognitive mapping to a limited degree, acknowledging that travel and transportation systems are influenced by spatial

cognition, cognitive mapping is a construct which encompasses those cognitive processes which enable people to acquire, code, store, recall, and manipulate information about the nature of their spatial environment. This information refers to the attributes and relative locations of people and objects in the environment, and it is an essential component in the adaptive process of spatial decision making. Usually, the most important part of the knowledge-based systems and also the expert systems is the knowledge base. Therefore, to build a knowledge-based system, prior knowledge in this field is required, and then proposing the inference engine and user interface according to the forms used for representing the knowledge base (Mondschein et al. 2005).

In order to design a model for cognitive map construction in an indoor environment, it must take the advantage of studying construction of cognitive map by human. The Intelligent system needs to use spatial information about the environment to make plan and execute navigation tasks. This information can be represented at different levels of abstractions.

This study depends on the acquisition of appropriate spatial information (perceptual and conceptual) through compensatory within a virtual environment, is simulating a real target space that may assist people who are in their anticipatory exploration and cognitive mapping of the unknown space.

The geographic databases are today operational and necessary tools that allow user to organize and manage geographic information in digital form, affecting virtually a multitude of applications. These databases consist of structured data sets describing objectives or localized phenomena on Earth. These data are used in system management for the updating, archiving and disseminating through the advent of geographic information systems (GIS) (Longley and Maguire, 2011).

A few years ago, the establishment of GIS (geographic information system) seemed reserved for large structures. Today's computer technology and opportunities in management and analysis, lead to the generalization of this tool at all levels of the territory.

Geographic Information Systems can be of a great help in gathering spatial information for people. Systems are designed to assist human beings to complete tasks

## **1.2. The problem Statement**

To build the cognitive map without the need of a direct human interaction, to guide people based on the spatial information, the following problems have been identified:

1. How the spatial information would be represented?
2. How the task would be represented?
3. How to make relationship between the spatial information of the environment and the task required?

This thesis represents the spatial information using the GIS software by tracing the needed representation as routs and locations...etc. This tracing allows creating a data base which is necessary for saving data and editing data. The indoor environment of this thesis uses two types of spatial information; points which represent locations of the environment and lines which represent the path between two points (locations). The representation of the task has a relationship between spatial information using the tools of ArcGIS and editing the data, especially the mutual relationships between points . The task concerning locations (points) such as eating task which is expressed by restaurant. Finally, the VBA (visual basic for application) language applies algorithms for gaining a relationship between the spatial information and the required task and display the cognitive map.

### **1.3. The Objectives of the Proposed Project**

The objectives of this thesis can be summarized as follows:

1. Investigate the methodology used for representing the spatial information and apply the appropriate methods.
2. Find a relationship between the spatial information in the environment and the task required.
3. According to the above mentioned objectives, the researcher shall construct a model to build a cognitive map.

### **1.4. Motivation**

Many people when having a certain task in indoor environment such as in a mall or in a governmental department, they need to know the location of the intended point to accomplish a task. Usually human performed this job through building a cognitive map then following this map. Building a cognitive map is dependent on spatial information for each point in the environment and its relationship with the intended task of the user to facilitate the process of completing the task in a limited time and the best way to reach the intended point. So, building a model for constructing a cognitive map is important and can be regarded as mimic of human behavior.

## 1.5 Thesis Structure

To properly carry out the present work, this thesis is structured as follows:

**The first chapter "Introduction"** presents an overview of the terminology of the study objectives.

**The second chapter "The literature survey and related work"** shows the related work regarding cognitive map, Environment, AI and spatial information.

**The third chapter "Terminology"** defines as much as possible the terms used in this study: the types of environment, tasks specification, cognitive map definition and geographic information system (GIS).

**The fourth chapter "The Proposed Model"** presents the design of the representation of spatial information and the design of the proposed model.

**The fifth chapter "Implementation"** shows the implementation of the work, the results of this study and make a comparison with another study.

**The sixth chapter "Conclusion"** presents the general conclusion and the future work.

# **CHAPTER TWO**

## Literature Survey And Related Work

## CHAPTER TWO

### Literature Survey and Related Work

#### 2.1. Overview

Several studies and researches have built an intelligent cognitive map by using several techniques and methods. The following sections provide a review of the related works to AI, cognitive map, environment and spatial information that are of concerned to this thesis present :

#### 2.2. Literature Survey Related to AI

The goal of AI is to design systems capable of reproducing the behavior of the human activities in reasoning.

Robotic mapping addresses the problem of acquiring spatial models of physical environments by mobile robots. Robots must be equipped with sensors that enable them acquiring a map and giving a look the world that surrounds it, for example, cameras, rangefinders as sonar, laser and infrared, radar, tactile sensors, compasses and GPS. All these sensors are subject to errors, measurement noise, and resolution and limited range. At present, there are robust methods for environments that are static mapping, structured, and limited size.

The study of Karel Košnar, 2011 realizes the autonomous mobile robot in a great environment of every day. Therefore to make it as an appropriate representation to find the spatial knowledge on the environment, two sources of inspiration are used: cognitive theories of how humans and animals represent the knowledge of space, and existing implementations robotic cards, which are the representation of space robotics knowledge.

The mechanism of the robot is used to build the map autonomously (the internal representation of the knowledge of the environment). Therefore, they had presented the algorithm for autonomous exploration of the unknown environment.

When human being explores a new environment, it uses these fragmentary knowledge about the places visited and find their way. Human being use methods that tend to use two pieces of information, namely distance and orientation information. Their methods are differed depending on how they perceive their environment.

The study of Chee K.Wong et al. 2007 had presented a new approach using a mobile robot to do cognitive mapping. This robot computes a "cognitive map" and uses distance and orientation to find its way. The process developed provides interesting insights into the nature of cognitive mapping and encourages us to use a mobile robot to do cognitive mapping in the future, as opposed to its popular use in robot mapping.

The study of Suhaib Ibrahim al-Ghazi, 2010 presents how to give the ability to mobilize intelligent robots in critical and dangerous city buildings without needing advice or human interference. This approach uses only cards architectural knowledge model to meet its needs. The solution is needs to be more intelligent to be able to deal with cards, and have the ability to read and enjoy these types of cards robot.

Navigation in a game environment is essential for any computer-controlled agent involved in a video game. The essential element of any navigation system agent is Pathfinding. Pathfinding is to find a route between two points in an environment. This study (Bobby, 2011) aims to provide the first comprehensive assessment of the current state of the video game

pathfinding both as regards the graph search algorithms used and as the implications of pathfinding in dynamic game environments.

### **2.3. Literature Survey Related to Cognitive Map**

The mental representation of the environment is called cognitive map. This term was created by E. Tolman, 1948. During his experiments with rats in a maze, he observed that rat's behavior is not a matter of mere simple stimulus-response connections. Rats rather use an inner representation of the surroundings which Tolman calls the cognitive map. The cognitive map was used in the case the learned path was closed. The rats were able to choose the correct alternative route even they never through them.

In an environment with large scale human rely on their cards - mental representations, cognitive solve navigation problems. To approach the understanding of how humans acquire, process and use information from the environment. (Rui Li, 2007) had proposed in his study three groups of participants and several experiments that are related to finding their way in an environment previously unknown.

Experimental tasks included tracing route, pointing to places previously visited and a questionnaire on way finding strategies and the development of the cognitive map. The results confirm the hypothesis that, during the early stages of the visit of an unknown environment, we gain new metric as well as the lack of knowledge-metric associated with major categories landmark and knowledge of the route. In addition, the medium plays an important role in the performance characteristics and details of the medium differently contribute to the development of our cognitive map.

Human's strategies that are used to solve problems in a new environment way finding are not based on a particular type of knowledge of the environment, in fact, we move between different types of knowledge about the environment when necessary.

The study of Angelo Arleo et al. 1999 had presented an approach that is based on mobile robots that enable, learning cognitive maps progressively indoor environments and online. This approach is to model the environment by means of a separation variable resolution discrete the world in homogeneous regions perception. Results for a compact geometric representation of the environment and a topological map of the spatial relationships between areas without obstacles. Techniques using local memory for the separation and active learning techniques for selecting the most appropriate region to be explored next are used for the effectiveness of the learning process. Also, a neural network direct action is used to interpret the sensor readings. This work is experimenting with two different mobile robots, namely a Nomad 200 and a Khepera .

The current implementation of the method rests on the assumption that barriers are parallel or perpendicular to each other. This results in a variable resolution partitioning consisting of simple rectangular walls and reduces the complexity of the treatment of the underlying geometric properties.

The study of Yoichiro Endo et al. 2003 had proposed, a mobile robot that uses a method to build and locate relation to a "cognitive map", where the representation of spatial information and behavior describes the structure of the cognitive map. This approach allows us to limit the use of sensor installation, which is known for its limitations and susceptibility to various errors. As localization is performed by applying a generic Bays filter and provides new behavior using

cognitive map that allows the robot to anticipate future events in a robotic system based on behavior.

The study of Farhan Hazim et al. 2011 had focused on finding the optimal shortest path algorithm by improving the central axis to develop a cognitive map. The latter is based on the architectural maps. The use of the central axis allows representing the distance between the centers of two boundary pixels side. By result, each pixel represents the nodes of a network for the road where each node represents a turning point in the real world (left, right, left critical, critical right ...). The idea of this algorithm is to find the shortest distance possible between the start point and end. The objective of this work is to have a simple and robust representation, which builds the shape of the cognitive map with the shortest optimal path. This algorithm is applied by the intelligent robot in order to reduce the time required for scanning the target construction.

The study of Shrihari Vasudevan et al. 2007 had mentioned that Robots are rapidly evolving from factory work-horses to robot-companions. The future of robots, as our companions, is highly dependent on their abilities to understand, interpret and represent the environment in an efficient and consistent fashion, in a way that is comprehensible to humans. The work presented here is oriented in this direction. It suggests a hierarchical probabilistic representation of space that is based on objects. A global topological representation of places with object graphs serving as local maps is proposed. The work also details the first efforts towards conceptualizing space on the basis of the human compatible representation so formed. Such a representation and the resulting conceptualization would be useful for enabling robots to be cognizant of their surroundings. Experiments on place classification and place recognition are

reported in order to demonstrate the applicability of such a representation towards understanding space and thereby performing spatial cognition. Further, relevant results from user studies validating the proposed representation are also reported. Thus, the theme of the work is — representation for spatial cognition.

The study of A. Vanclooster, Ph. De Maeyer, 2012 had aimed at improve a pair of algorithms for several indoor and outdoor spaces in the cognitive structure of the 3D network. Another way, to study the structural differences between the two algorithms. This approach is based on the simple extension of the algorithm to be implemented in three dimensions in the built environment.

## **2.4. Literature Survey Related to Environment**

The geographic environment is an interaction between nature and society. It can develop the society and accelerate or retard this development. Many researches had worked on developing this environment.

This study of Guilherme N. DeSouza and Avinash C. Kak 2002 had claimed the developments in the field of vision for mobile robot navigation. Two main elements deal with indoor navigation and outdoor navigation. For each element, the treatment is divided into two basis of structured and unstructured environments. In the case of geometric and topological models of space, the indoor robots are treated separately in structured environments, or unstructured environments.

This study of Dirk Hahnel et al. 2003 had solved the problem of mapping in dynamic environments. Present an approach that intertwines the identification of measures that correspond

to dynamic objects using the expectation–maximization (EM) algorithm, a map and a location algorithm. By results, getting gradually improving its rating on parasites and measures the quality of the card. The maps contain fewer parasites built objects and are also more accurate due to the improved range of recording. This technique has been implemented and tested on different platforms with indoor and outdoor environments. It demonstrated that the approach gives accurate maps, even if it is used on a vehicle moving fast without odometer information.

This study of Safa'a Yousef Abu Hadba 2011 had described the properties of the environment that are very important, especially in the design of intelligent agent program. Such as the need to specify the working environment as well as all the features possible.

The environment can be illustrated as fully or partially observable, deterministic or stochastic, episodic or sequential, static or dynamic, discrete or continuous, and a single agent or multiple agents. Therefore, it is strongly advised to start construction on these rules, even if it takes a long time.

## **2.5. Literature Survey Related to Spatial Information**

There are many researchers who have been concentrating on the field of spatial information and how can be represented.

This study of Berendt, B et al. 1998 had Represented modeling the processing of geographic maps that are described by the spatial representation and are used in many processes of human spatial cognition. More precisely on the spatiality of representation in which one or

more aspects of geographic entities are presented to solve cards look. AI model of processing geographic maps is presented. This model contains two processes are discussed in more detail or processing of aspect map into another aspect that retains selected entities and aspects (extraction) plane and the combination of two aspect maps, so obtaining a third card format. The results of an empirical study show that formal approach can describe and distinguish the ways in which people solve this task.

This study of Shalini P. Vajjhala and Wendy M. Walker, 2009 had presented an integrated GIS pilot application and participatory sketch mapping to obtain and evaluate the mobility models and differential access of villagers in the rural highlands of Lesotho. The resulting cognitive maps and interviews with focus groups revealed significant differences between the sexes in terms of mobility and access with implications for health, education and transport planning differences, they also provide a basis for decision participatory decision intersect oral through the integrated GIS.

This study of Tingting Zhao, 2010 had presented the navigation system of the virtual building. This navigation is based: first, the walk through that allows users to navigate freely to obtain the spatial and geographic information of the virtual environment, second, the tourist guide navigation optimal path leading mobile users from a specified starting position to the target position along the optimal path. "An improved algorithm shortest path is used for the calculation of the optimal path".

## 2.6 Conclusion

After studying the survey cited in this current chapter, this thesis is similar to them to reach the goal which is in result build a Cognitive Map using AI in chosen environment indoor or outdoor. Otherwise, this thesis has its own methods and algorithms to build a cognitive map.

This cognitive map is based on spatial information and relationship between them and between the tasks represented in indoor environment without using intelligent robot.

In the above sections a number of papers from the literature have been reviewed and classified according to the related work used to build the cognitive map. Besides, some considerations about the representation of spatial information have been presented.

In this paper we will propose a model which intends to build a cognitive map.

Our goal is to propose a model to find the many shortest paths accomplishing with the following requirements:

- Choose an adequate representation to spatial information.
- Choose an adequate representation to the task.
- Make a relationship between SI and tasks and build the map.

# **CHAPTER THREE**

## Terminology and Background

## CHAPTER 3

### Terminology and Background

#### 3.1 Overview:

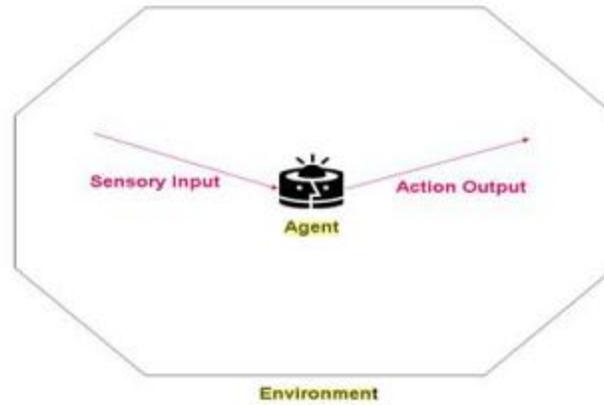
This chapter describes and explains the essential terms used in this thesis. It illustrates the types of environment and compares between them. Also explains the specification and structure of the task. Moreover, it explains the cognitive mapping and its benefits.

Finally, it presents the domain of geographic information system which includes the declaration of the methods and terms that are used in the representation of the spatial information.

#### 3.2 Environment types

There are three used map types, these are; metric, topological, and hybrid. According to which part of the environment is represented by the map, it distinguishes local and global environment maps. Local maps represent near vicinity of mobile robot and global maps represent whole explored environment. Maps could be optimized for representation of static environment or changing dynamical environment (Russel & Norving, 2003).

Figure 3-1 represents as example of an agent in the environment .



**Figure 3-1 An Agent with its Environment**

### **3.2.1 Static Environment**

Static environment is the environment that does not change and allow an agent to take measures and decisions easily. The agent, then, does not need to adapt to new situations. An example of such an environment where there are no objects changes or moves. Figure 3-2 shown an example of a static environment.



**Figure 3-2 Static environment**

Where the doors and halls never change.

### 3.2.2 Dynamic Environment

A dynamic environment is changing in which the agent must adapt to new situations and navigates. It is non-static environment. The parking shown in the Figure 3-3 is an example of dynamic environment.



**Figure 3-3 An example of dynamic environment**

### 3.2.3 Discrete Environment

The discrete environment can be defined as the environment consists of many finite numbers of distinct states, for example a chess game has a discrete set of action.

### 3.2.4 Continuous Environment

The continuous environment can be defined as the environment consists of many continuous finite numbers of states. The continuous states environment for example is car speed

and location of the car with respect to other vehicle and passing cars through a range of continuous values.

As cited previously, each environment has its own properties. Gerhard, 2013 had compared these environments by properties which can be classified as in the following :

### **3.3.1 Accessible and inaccessible**

In point of accessibility, there are two types of environments where accessibility is either complete or not. The accessible environment gives complete, accurate, update information's on the state of the environment, as it is easier for agents to operate in this construct. Instead inaccessible environment which have complex inaccessible information's such as Internet.

### **3.3.2 Deterministic and non-deterministic**

A deterministic environment is an environment where an action is known with granted effect.

On the other hand, a non-deterministic environment is an environment where an action is unknown which presents more problems for the designer of the agent, for example, the physical world.

### **3.3.3 Episodic and non-episodic**

In an episodic environment, the performance of an agent is dependent on a number of discrete episodes, with no link between the different performances of an agent in different scenarios. An example of an episodic environment would be a mail

sorting system. Episodic environments are simpler from the agent developer's perspective because the agent can decide what action to perform based only on the current episodes it need not reason about the interactions between this and future episodes.

### **3.3.4 Static and Dynamic**

A static environment is an environment that does not change with what the agent can take measures and decisions easily. A dynamic environment is one that often changes independently of the will of the agent.

### **3.3.5 Discrete and Continuous**

An environment is discrete when the number of actions is fixed and finite and the percepts is fixed. Contrary to the continuous environment that has continuous actions like an example of a taxi driver.

## **3.4 Task specification and Task structure**

The hypotheses of the simple-tasks are mentally represented as concepts. The trust of this suggestion is that the internal structure of tasks and the intentional relations among tasks are both of major importance in the user's mental representation of task languages. There exist in the literature a lively debate about the mental representation of concepts. Usually the concepts represented by sets of defining features, as the classical view maintains or as schematic prototypes or even as networks of exemplars. The general view of concepts would appear to be a permissive one, all of these representational forms exist, but they are used for different purposes.

By taking this stance, one is able to offer a theory of certain aspects of conceptual performance without being necessarily committed to a unitary view of concepts (Stephen J. Payne 1986).

It must show how the structure of a more complex interactive system is expressed these terms as a tool to help the analyst uncover subtle aspects of the structure of an interface. An important feature to bring out is how subtasks are captured by sub rules, thus:

Task = subtask 1 + subtask 2+ subtask 3+.....subtask n.

This above procedure (which closely resembles sub-routing) is assumed to model hierarchical task structure as perceived by the user. If this task structure is directly used as a design basis, it gives the following method for object creation:

Task [Effect = create, Type] → select tool + point-to-place + point-to-place.

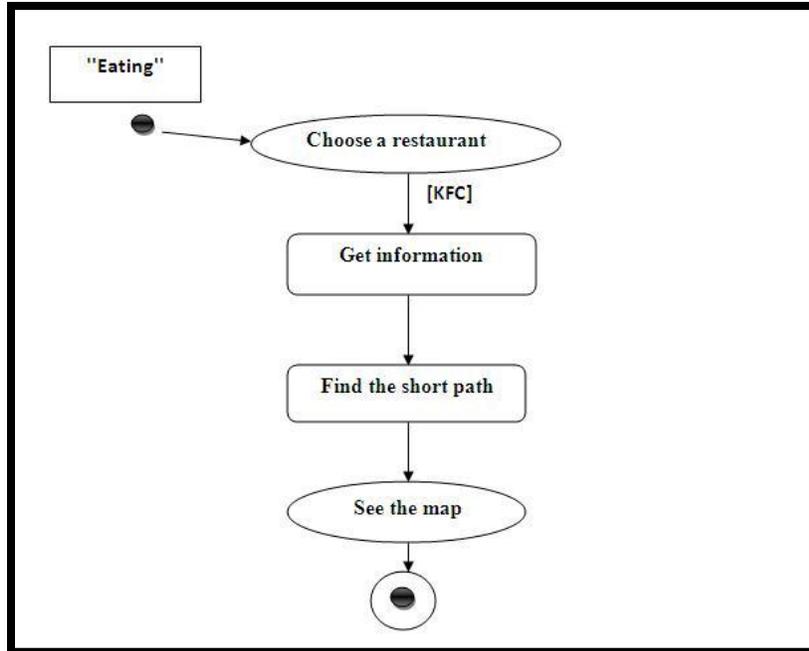
### 3.4.1 Task and subtask

Usually the real world problems are decomposed into a sequence of distinct tasks. In the tourist field, for example, visited places is usually followed by the task wanted. Sometimes the task “eat” depend to the nature of food wanted and the location of the restaurant (near or far).

In short, a complex problem is decomposed into sub problems which in turn can be decomposed into simpler sub problems.

A pass in tasks, when it is known, can be graphically representing activities in a UML diagram.

Figure 3-4 describes an example of the activation tasks in a task "Eating".



**Figure 3-4 An activity diagram of the task "Eating".**

## 3.5 Cognitive map

### 3.5.1 Definitions

The cognitive map is a concept widely used in the humanities to specify the internal mental representations of spatial information. It can be defined as a mental construct that is used to understand and learn an environment. Generally, we define a cognitive map as a mental image of a place, "a network representation of places and relationships enter them" (Johns, 2002). "Specifically and simply, it is a mental representation of environmental knowledge". (Kitchin, 1994).

Edward Tolman used the first time the term cognitive map in 1948 to describe how his rats, and by analogy the human, behave in an environment. He asserted that in our nervous system, there

is a map that is used to guide us in our every day movements, which presents itself as a mapping that changes depending on the time of exposure to an environment. On the other hand, a majority of researchers argue that the term "cognitive map" refers to a real internal thought processes whose external representation is the product space (spatial product).

(Arthur and Passini, 1992) overlay detail on the size of the environment in their definition of the cognitive map, "a cognitive map is a mental construct of an environment all which cannot be seen from one single vantage point alone." Thus, as the environment can be complex, the formation of this mental map requires cognitive processes (cognitive mapping) that directly appeal to the spatial abilities of the subject previously illustrated. For (Passini, 1994), "cognitive mapping is a mental structuring process leading to the establishment of a cognitive map."

Finally, the main function of the cognitive map is memorization. For (Kitchin, 1994), the cognitive map is the most advanced and most complex known spatial structure, it saves time by using past experiences to understand the future situations. (Passini, 1994) also points out that the formation of cognitive maps is not based only on visual information, "recent research has indicated that the congenitally blind can convert environmental messages to all." Even today, the precise functioning of cognitive maps is a mystery that we try to solve a multitude of laboratory experiments worldwide.

### **3.5.2 Benefits of cognitive map**

Mental map enables:

- Understand a situation more quickly;
- Make connections between ideas;

- To capture information quickly by adding color illustrations;
- Store and return the info, especially before and during examinations;
- Teamwork, using a map that everyone understands;
- To take action, for example a project, etc..

### **3.5.3 Definition of environmental cognition**

It is consciousness, impressions, information, images and beliefs that people have environments. This implies not only that individuals have information and images on the existence of these environments and their components, but they have impressions on their function, dynamics and structural, meaning and symbolic properties. This definition refers to the concept of ' space cognition ', which can be summarized by referring to union spatial, social knowledge and understanding of the nature of the physical and social environments in relation to cognitive functioning (Waller and Nadel, 2013; Smelser and Baltes, 2001).

### **3.5.4 Definition of spatial cognition**

Spatial cognition is knowledge and internal or cognitive representation of the structure of entities and relationships of space. It is an internal reflection and reconstruction of space in mind (Daniel and Martin, 2013; Waller and Nadel, 2013; Smelser and Baltes, 2001).

## **3.6 Geographic Information System (GIS)**

This section presents background on GIS by providing definitions and illustrations of some concepts used in this domain.

### 3.6.1 Definitions

GIS is a computer system (hardware and software) capable to manage, analyze and represent geographic data to help understand the development and planning processes.

The ultimate goal of the GIS is to provide a basis for decision making in all areas, from satellite data, particularly in the areas of:

- **Oil research:** Map of potential ore to decide priorities for exploration.
- **Geology:** to assess the effects of acid drainage to determine the most efficient way to intervene.
- **Socioeconomics:** pastoral conflicts impact on the degradation of the vegetation cover, migration based on cultural practices and workplace destination.
- **Forestry:** analysis and monitoring of biodiversity
- **Fishing:** resource assessment and monitoring of fish migration
- **Protection of nature:** measuring the degradation ecosystems and assessment of future risks from pollution.

Touching all sectors of an activity, the use of GIS has exceeded its primary function or rather the context in which we wanted to confine was essentially mapping. Today this use goes much further especially in the economic and environmental analysis; it also provides simulation elements that allow statisticians to influence future decisions by drawing the attention of policy makers from the simulation results.

Subsequently, the classification of the information collected has expanded the scope of these definitions to reflect the one hand, the different types and forms of information that

satellites are capable of reproducing in a adapted to form the combination and to the statistical analysis, and on the other hand, the elimination of the partitions decision information regarding the preparation, implementation and evaluation of development programs: this is known as metadata.

Models tabular data may include any type of geographic data or not. This is the content of the table which will determine its use. Data may be intended for direct display (like tables in Excel, on Lotus, bases of raw data, other raw formats) is to serve as attributes of spatial data (such as data from ORACLE, of INGRES, SYBASE, INFORMIX, dBASE, INFO, delimited text, etc..).

Three concepts are important to consider for the statistician in the acronym GIS. The first concept is that of system. A **system** can be likened to a framed poles and poles similes incoming products delivered by the functional structure functional structure. In the case of GIS, halftones (input or input) are various information relationships are configured in the functional unit. The products supplied also called output or output are the answers posed by GIS users in a query formulation and algorithm structure (SAIF French and Query Structure and Algorithm Building QASB English) included previously in Scheme functional GIS.

Thus, the control of the tool by the statistician and quality databases that will manipulate assume them obviously important. The relevance of GIS products (information decision making) is a function of the quality of the additional information in addition to those provided by satellites and processed by specialized software for image processing and satellite data. This additional information is drawn from outside the integral geostatistics module functional structure of the GIS.

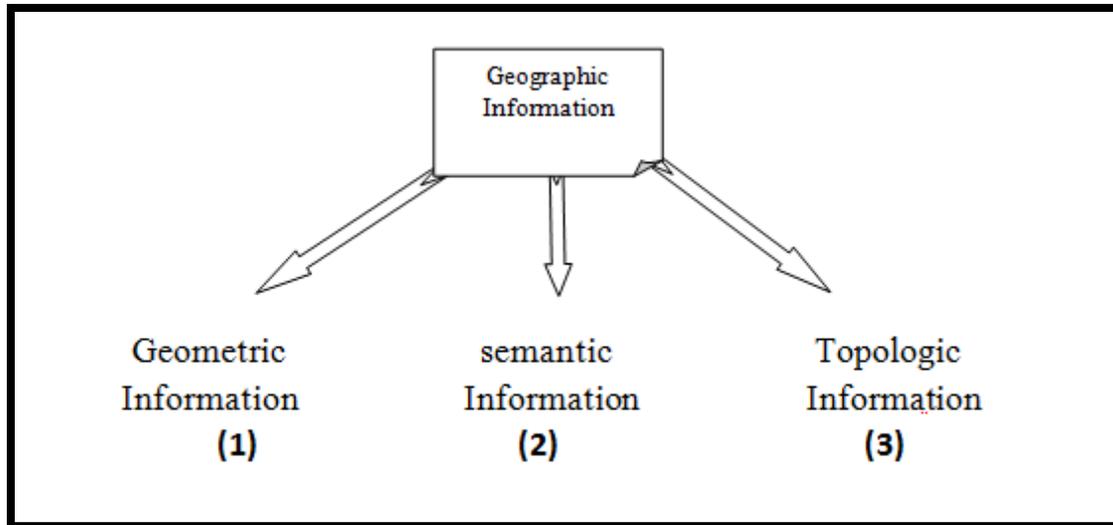
A second concept relates to **information**. It will be for the compiler to treat all incoming flow (inputs) and regularly feed the functional system. This flow of information, once processed within the functional structure comes in a specific form called aggregate configured. This gross aggregate is often retired to lend themselves to statistical analysis.

The accuracy of the geostatistical GIS is related to the degree of performance of the type of geographic information system used and the type of satellite coverage. Indeed, GIS has a basic architecture built around geographic phenomena and their dynamic or stable relationships with nature and its various modifications vectors (type of economic development, type of resource use, tenure, etc. .).

The third concept is a generic **Geographic**. According to the user, the raw or processed aggregate takes various qualifications generally absorbed by the generic term "geographical" (because subsequent developments in the use of GIS have been built around the core concept of GIS). Thus, geographic information is multidimensional.

### **a. Geographic Information**

Geographic information (or spatial information) is defined as a connection between an object and its position on the earth's surface. It is a combination of graphical and alphanumeric information can be viewed in a particularly clear way through drawing, and you can add the topology to help users to master information.(Wolfgang and David, 2012) It can be describe the geographic information as shown in Figure 3-5:



**Figure 3-5 Representation of the Geographic Information.**

(1) Where Describes the object geometric shapes (point, line, polygon .....).

- A node ("point") to represent the drilling, geodetic points...
- A line ("linear") to represent roads, rivers...
- A surface ("polygons") to represent plots, common...

In this mode the point is represented by its coordinates (this is the most basic spatial object), the line is represented by a list of points (<point>) and the polygon is represented by a list of arcs in the model topological (<arc>) and the lists of vertices in the model network and spaghetti.

(2) Describes the object attributes that can be alphanumeric or calculated.

(3) Describes the Relations between geometric information, such as inclusion, adjacency, neighborhood, intersection, etc.

### **b. The models of representation of geographic objects**

GIS manage data coming from different sources; these data are of two main types namely raster mode and vector mode.

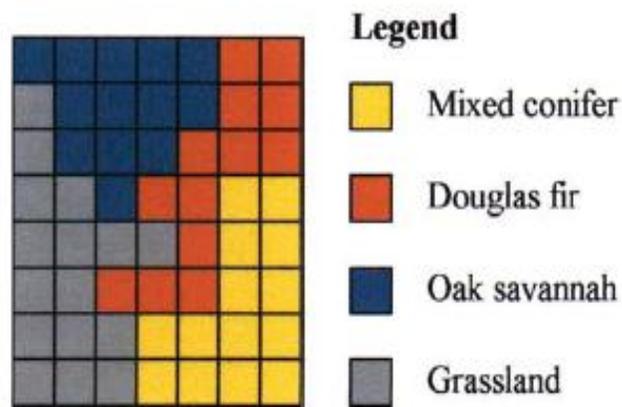
## 1. Raster model

Raster is an English word for a digital image composed of a matrix of pixels

In the raster mode, the world is divided into cells or mesh called pixel.

- The point is represented by the coordinates of the pixel.
- The geometry of an area (line) is the set of pixel that composes.

Figure 3-6 represents a sample of the satellite images of the scanned maps.

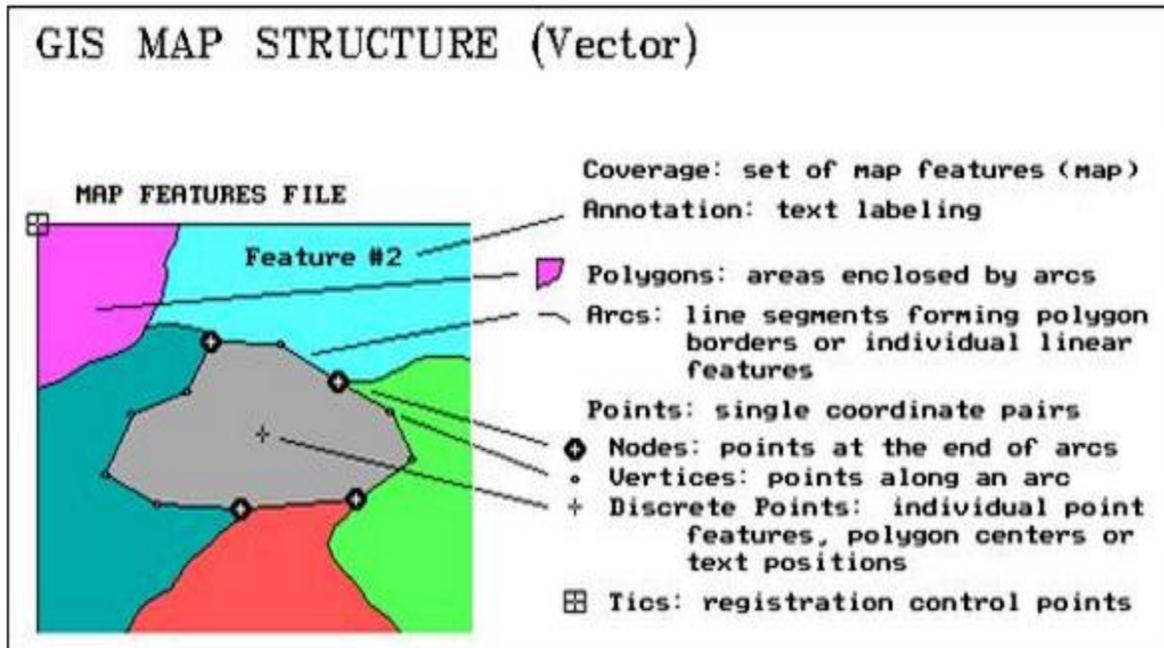


**Figure 3-6 Raster representation (Longley et al. 2011).**

Each color represents a different value of a nominal-scale variable denoting land cover class depending of the image data representation.

## 2. Vector Model

It is a mode of representation which is to draw points, lines and polygons. The vector modes are very useful for representing and storing discrete entities such as buildings, pipelines or parcel boundaries. The points are represented by pairs of coordinates  $(x, y)$  in the 2D case of a space or by a triplet  $(x, y, z)$  in the case of a 3D space. A sample of vector representation is shown in Figure 3-7.



**Figure 3-7** Sample vector Representation. (David, 1997).

Table 3-1 illustrates the comparison of the two models.

**Table 3-1 Comparison of the mode of representation.**

	Raster mode	Vector mode
Advantage	<ul style="list-style-type: none"> <li>• Good representation of reality.</li> <li>• simple data structure.</li> <li>• simple spatial analysis.</li> <li>• Combination of affluent.</li> </ul>	<ul style="list-style-type: none"> <li>• Takes up little memory space.</li> <li>• Excellent image quality, printing.</li> <li>• Representation of the precise position and shape of objects.</li> </ul>

Disadvantages	<ul style="list-style-type: none"> <li>• Large amounts of data.</li> <li>• Low quality display, print.</li> <li>• The position and shape of the objects specified bit (depending on resolution)</li> </ul>	<ul style="list-style-type: none"> <li>• ill-suited to the representation of reality.</li> <li>• Structure of complex data.</li> <li>• Crossing complex layers</li> </ul>
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### 3.6.2 General Terminology

For better cooperation with managers GIS, the statistician will have to master some basic concepts that will help him understanding by opening its ability to use metadata and meta loaded into the central GIS system. The Table 3-2 gives the form of simple summary, some elements of terminology useful for the statistician (Michael, 2013).

**Table 3-2 The simple summary of some elements of terminology useful for the statistician.**

CONCEPTS	DEFINITION OR CONTENT
Geocoding	Displays as dots on a map, tabular data containing addresses. Each life event was conducted at a place and at a given time. Addresses events are information database events by addresses that are the main form of storage of geographic data. Geocoding is the mechanism that allows the use of addresses to identify locations on a map.
	Set of distinct geographical entities corresponding to a spatial data source (coverage, polygons, points), satellite data (photo), tabular data (tables, databases geocoded data) from a particular source (weather offices health, employment,

a Theme	investment, customs, trade, justice, hydraulic, environmental, mining, infrastructure, agriculture, water and forestry, industry , education, etc).. Themes have several properties that the compiler can define and control.
Views	Set of topics represented by a blank which has the advantage of interactivity. The view determines which affected geographic data and how we will use. It reflects the position provided by the data. The view is dynamic and is correlated with the data structure. Different views can be created with the same data (just change one of the themes of the whole).
Project	File created by GIS software following the instructions and the organization of work by the statistician. It is a product of the user archive (to wish) all combinations of elements developed by itself (new project) or other users (old project). A new project may consist of a modified existing project.
Geographic data	Given that describes any part of the earth's surface and its characteristics. These mapping data, scientific, cadastral, economic, photographic, databases of customers or retail outlets or distribution sites, tourist guides, buildings legal documents, videotapes, etc... More than 80% of the data used by businesses and governments have direct links with geographic data (postal codes, addresses of facilities, inventory, location towns or municipalities / states / districts / rural communities / projects, etc...
Spatial data	Geographic data containing the geometric position of geographic features (spatial object) and attribute data describing these entities. It also called digital cartographic data. It is a given vector.
	Satellite imagery, aerial photography, remote sensing data. There are several types:

An image data	a) single channel (monochrome image, false color image, grayscale image) and multiband (true color image). In any format, the image is plotted frame (or raster). They are said raster or gridded data where each grid or pixel (picture element) has a certain value that depends on how the image was captured (georeferenced). For example, satellite images obtained by remote sensing, each pixel represents the reflected part of the earth's surface light energy. If the image is scanned (digitized), a pixel is a brightness value attached to a fixed point on the document.
Tabular data	Any data set or not containing geographic data. Content determines the use to make a table events contains the exact position of geographical objects as X, Y coordinates (e.g. points of sampling soil, agricultural production, air, etc.).. You can get the coordinates (longitude, latitude, meters, other unit) by reading card, measuring positions on a view, by field survey using GPS (Global Positioning System) receiver, for geocoding the table containing the address information, etc..

### 3.6.3 Components of a GIS:

A GIS consists of five components, (Satheesh, 2007) as follows :

- **The hardware:** the data processing is done using the software on a computer.
- **The data:** they are the basis of GIS "geographic data".
- **Software:** GIS software that provides the tools and functions to store, analyze and display all the information.
- **Users:** GIS cater to a large community of users who are not necessarily specialists, GIS offers a series of toolkits for the user assembles his project.

- **Methods:** the implementation and use of GIS cannot be achieved without the application of methods, rules, and procedures.

### 3.6.4 The GIS software's

There are several types of software for geographic information systems. Categorization divides them into those whose turn depending on the object we distinguish among others, (K. Elangovan, 2006) such as:

- **For general use :** ARC / Info, SICAD Open, MGE, SPAN, Smallworld GIS.
- **for land management and cadastre :** SICAD, GRIPS, STRINGS, ALK / GIAP, GEOGRAH, GRADIS -GIS.
- **To capture and satellite image processing:** ER- Mapper, ERDAS, EASI.
- **For mapping:** MGE LANDCAD GEOMAP, MAPGRAPHIX, AutoCAD.
- **For small projects:** ATLAS -GIS TNTmips GSMAPPER, POLYGIS.
- **for tracers** ARCVIEW, MapInfo.

Each software has its own data format which can export and import data between them with loss or no loss of data. This software can be divided on two groups, some are based on the raster mode and other software are based on the vector mode.

The geographic information systems are now tools (some would say concepts) used frequently in all areas managing, analyzing and directing our territories and their future.

The objective of this section is not to create a complete and comprehensive resource on these areas, but to give a few items and a few ways to make concepts.

## 3.7 Spatial Models

The purpose of this section is to describe the different spatial models (spaghetti, network topology). (Shashi, 2008).

The vector mode can be categorized on three models for representing spatial information.

### 3.7.1 Spaghetti Model

This is the simplest model; it does not contain any topological relationship. Indeed no intersection is recorded between lines and polygons.

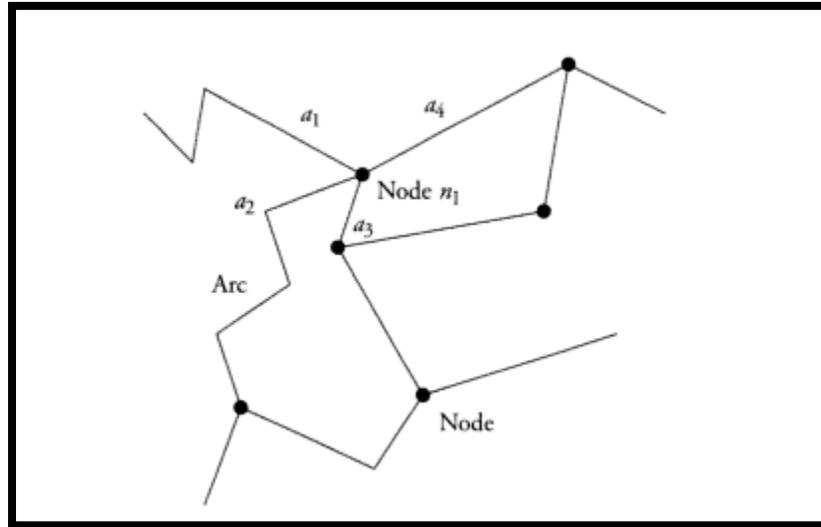
In this model:

- A point is described by these coordinates point.
- A line is described by a list of coordinates.
- A polygon is described by a list of coordinates of the vertices

### 3.7.2 Network Model

This model represents all the relationships between the lines and lines and points. The point is replaced by a new primitive called node. A node is either a single node (the single point of spaghetti model) or one of the ends of an arc.

The node allows the description of the topology of a network and makes more efficient operations as shown in Figure 3-8.



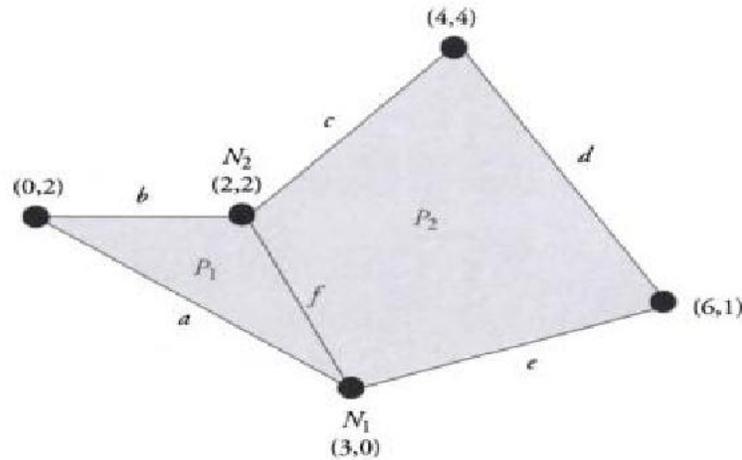
**Figure 3-8 Network model representation.**

In this model:

- A node is described by the coordinates followed by a possibly empty list.
- An arc is described by its end nodes and the intermediate vertex coordinates .
- A polygon is described by a list of coordinates of the vertices.

### 3.7.3 Topological Model

This model accounts for all relationships in the network model, adding all the relations between areas, between regions and between regions and lines and points. It allows a very rich representation of the topology of a layer. It represents all the intersections of lines per node, even if such a node has no meaning. We obtain in all cases a partition plan polygon, all listed, even those that have no meaning, as shown in Figure 3-9.



**Figure 3-9 Topological model representation.**

In this model:

- A node is either an isolated point or an arc end.
- An arc is defined by a list of coordinates of points that describe its two ends nodes and also by sharing the arc polygons.
- A polygon is described by a list of arcs borders Polygon .

### 3.8 Comparison of the Three Models

Each model has its own advantages and disadvantages that will be illustrated in Table 3-3:

**Table 3-3 Comparison of Models.**

	Advantages	Disadvantages
Spaghetti Model	<ul style="list-style-type: none"> <li>- This representation is very</li> </ul>	<ul style="list-style-type: none"> <li>- No topological relationship between spatial objects (e.g.</li> </ul>

	<p>simple.</p> <ul style="list-style-type: none"> <li>– The search for a particular object is very effective.</li> </ul>	<p>connectedness, adjacency of two polygons).</p> <ul style="list-style-type: none"> <li>– Each request must be calculated the same topology if there is no update.</li> <li>– Failover issue (e.g. the coordinates of a point or more arcs polygons are stored as many times).</li> </ul>
<b>Network Model</b>	<ul style="list-style-type: none"> <li>– Less redundancy in geometry.</li> </ul>	<ul style="list-style-type: none"> <li>– Redundancies introduced for reasons of efficiency of access (can be accessed by a polygon or polygon file or by the arc file).</li> <li>– Does not exist relationships between areas, lines and points.</li> </ul>
<b>Topological Model</b>	<ul style="list-style-type: none"> <li>– Very rich in topological relations.</li> <li>– This structure allows the consistency of spatial data.</li> </ul>	<ul style="list-style-type: none"> <li>– Redundancies introduced for reasons of access efficiency.</li> <li>– Their structure is very heavy.</li> </ul>

	<ul style="list-style-type: none"> <li>- The update is fast without error in all areas of the layer.</li> <li>- The overlay is pre- calculated for all areas of the layer.</li> </ul>	<ul style="list-style-type: none"> <li>- Each time you insert a new theme in the film, it is necessary to calculate the intersections of the geometry of this theme with the existing geometry of the layer.</li> <li>- The file structure is complex, and research and slower than the spaghetti model.</li> </ul>
--	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

In choosing a model, there is a tradeoff between simplicity and richness in topology. So the choice depends on the application using the model and the resources available.

### **3.9. Software's and Programming Language**

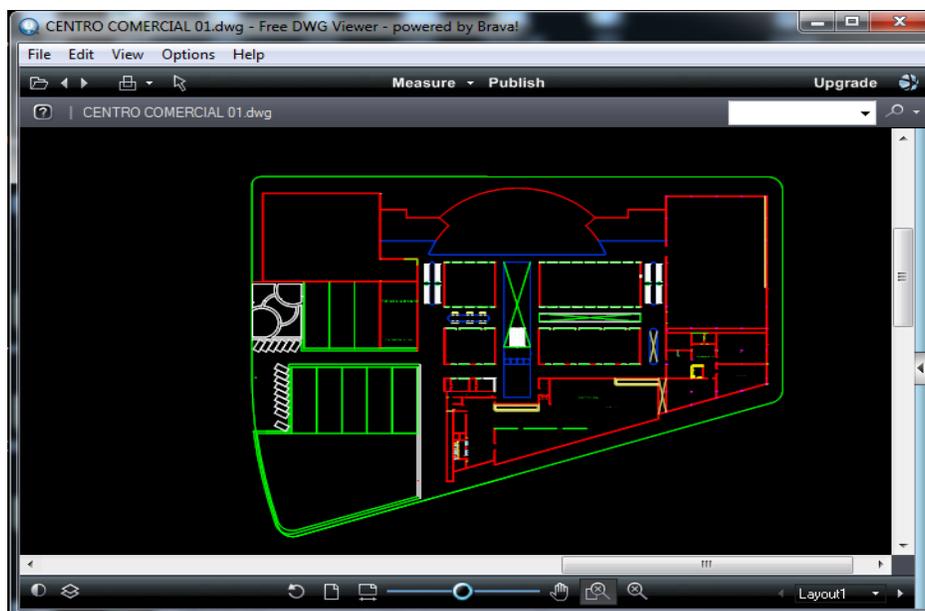
#### **3.9.1 AutoCAD**

AutoCAD is a program designed for two and three-dimensional design issued by the U.S. Company Autodesk which released the first copy of it in 1980 under the name of the product CAD, which means Computer-aided design. This program can be used in any of the areas of design such as designing the costumes, civil engineering, architecture, mechanical engineering, interior design. It is also used to create all project designs and seeing them as it is in

fact, it can be through the attachments as a program output render that conducts some experiments on the design, such as the choice of colors and lights and Preview spaces in the field of architecture. It is also can be used for some accessories such as mechanical work designs and conduct some tests on it. It can also publish special manufacturer copies such as AutoCAD Architecture Autodesk Architectural Desktop and AutoCAD Electrical Engineering. As also for all specialties AutoCAD-based applications, AutoCAD works under Windows and UNIX. (An ESRI, 2003)

AutoCAD generates files with extension ".dwg" type for the word “drawing”.

Figure 3-10 presents the plan of a sample mall using AutoCAD Viewer



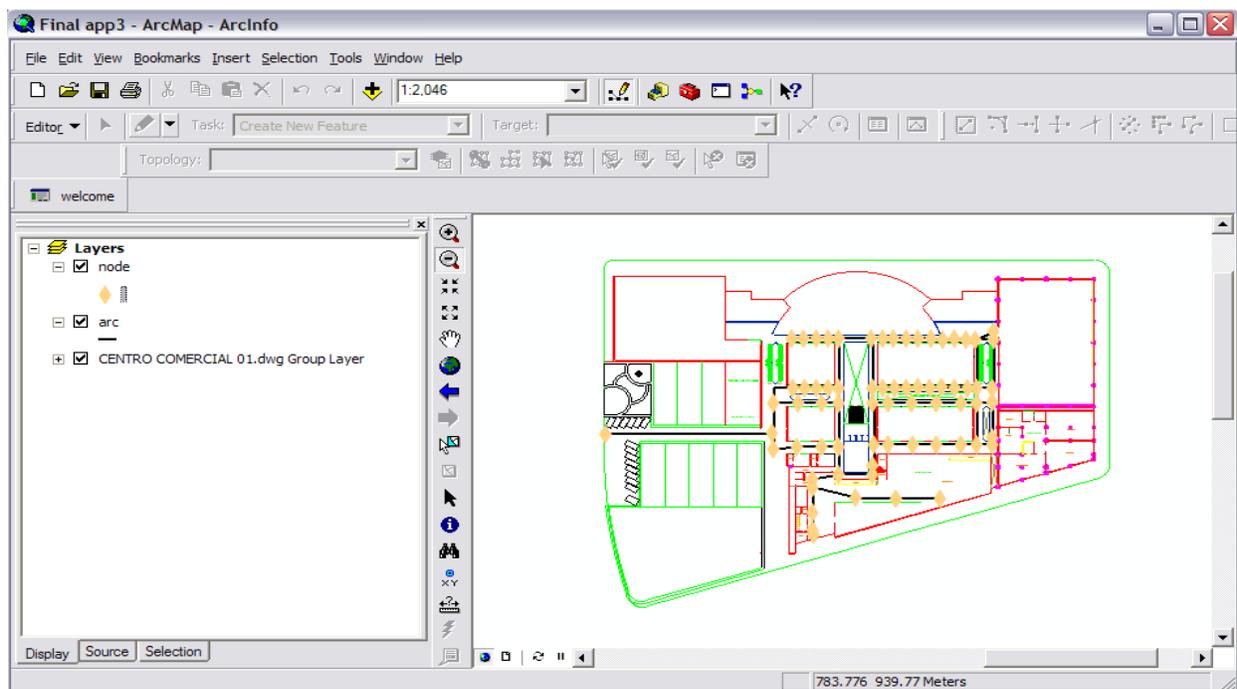
**Figure 3-10 Sample presentation of mall by AutoCAD**

### **3.9.2 ArcGIS:**

ArcGIS is actually a suite, which comes in three versions (**ArcView**, **ArcEditor**, and **ArcInfo**), the difference between these versions is in the number of additional options. Arcview

is the newest version. Each of these three versions of the following ArcGis comprises the following components : (Bob and Andy, 2001)

1. **ArcMap:** this component performs the following tasks : watching, questioning, editing, creating or performing data analysis. the software interface of the component is shown in figure 3-11.



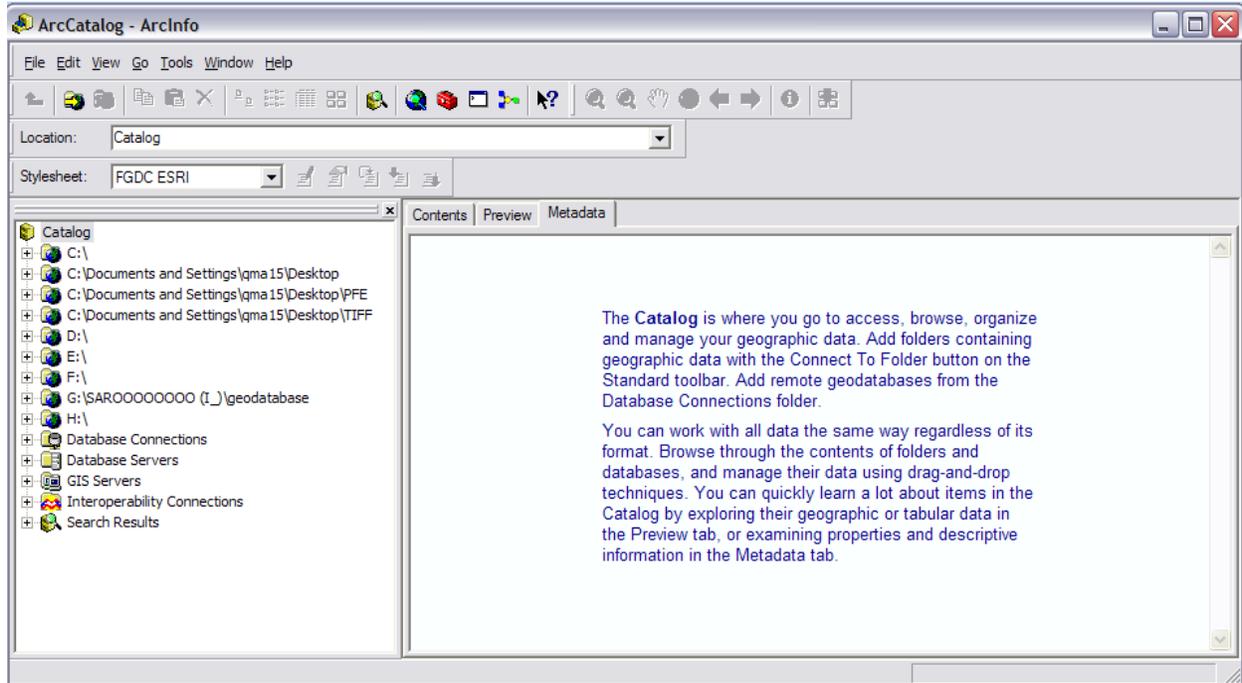
**Figure 3-11 Representation of ArcMap.**

2. **ArcCatalog:** this component allows user to browse, organize, distribute and modify the properties of the geographical given elements .

This component executes the following actions:

- Create new data (layers or shapefiles, geodatabases .....)
- Assign a coordinate system when it is not recognized by the software, or not assign.
- Remove a layer (or all matching files in shapefile) permanently from the computer.

Figure 3-12 shows the ArcCatalog component.



**Figure 3-12 Representation of ArcCatalog**

3. **ArcToolbox:** is a component of ArcGIS, which allows access to all the powerful features for processing and analysing as it is shown figure 3-13



**Figure 3-13 Representation of ArcToolbox.**

- 4. ArcScene:** this component an application for 3D visualization, which allows the user to view GIS data in three dimensions.

this component allows for layering data in a 3D environment. The features are arranged in the 3D information reading height feature geometry, characteristics attributes, properties of the layer, or a 3D surface direction, and each layer in the 3D view can be treated differently. Data with different spatial references will be projected on a common projection, where data can be displayed by using the relative coordinates only. ArcScene is fully integrated with the geoprocessing environment, that provide access to many functions and analysis tools.

### **3.9.3 Using CAD in ArcGIS:**

The infrequent user just wants to see a CAD drawing in ArcMap, ArcScene or ArcCatalog. CAD drawing is presented in ArcGIS software as layers. CAD files are organized in ArcGIS as GIS datasets and as a special CAD Drawing Layer. CAD drawing layer tries to imitate the symbology of the original CAD drawing. All contents drawing are included in a single layer in ArcGIS. Visibility of the layer of CAD is controlled by a single entry in the table of contents.

CAD drawing can be used as background for a map in ArcMap, The properties of CAD objects can include cells and blocks in ArcGIS. The ArcGIS can edit the CAD drawings as needed by users using the powerful editing tools.

### 3.9.4 The Programming Language VBA (Visual Basic for Application):

VBA programming language is provided with ArcGIS Desktop. It interacts with the different components of ArcGIS to be able to customize and extend its functionality as do developers ESRI(Environmental Systems Research Institute) (Pythagoras).

Figure 3-14 illustrate VBA window

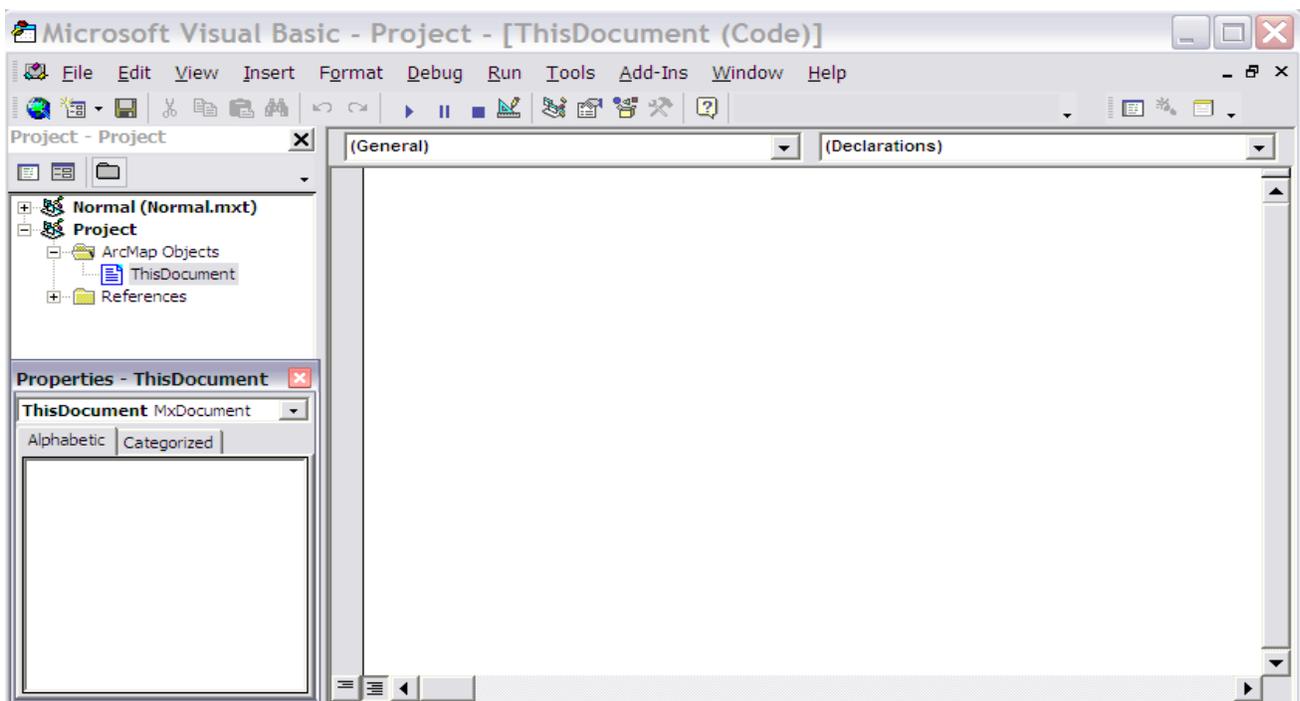


Figure 3-14 Presentation of the VBA window.

# **CHAPTER FOUR**

## The Proposed Model

## CHAPTER FOUR

### The Proposed Model

#### 4.1 Overview

This chapter presents the proposed model of creating a cognitive map using spatial information in indoor environment. The methodology consists of the representation of SI and tasks. The algorithms are used for gaining knowledge to build the cognitive map. They will be used by the inference engine of the knowledge based-system. These algorithms will be explained in the next section.

#### 4.2 The Proposed Model

Figure 4-1 presents the model of developing cognitive map, based on the spatial information, as a knowledge-based system. The model consists of four components; namely user interface, spatial database, inference engine and knowledge base. In the following subsections, a brief description of each component will be given .

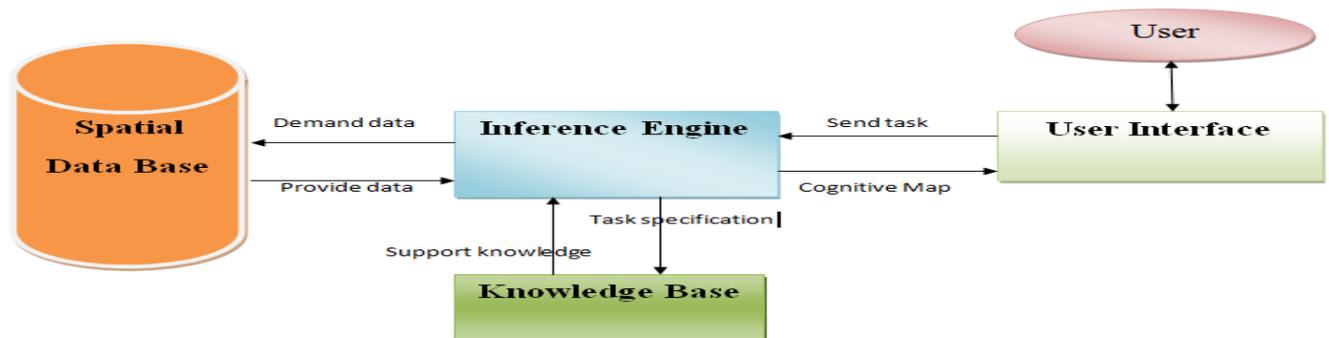


Figure 4-1 The proposed model of developing a cognitive map based on spatial information

### 4.2.1 User Interface

The communication between the user and the system is simplified by providing most of the facilities for the user to interact with the system, (Owaied and Abu Arr'a, 2007), this can be done through dialog boxes, command prompts, forms, menu or other input methods. Some systems interact with other computer applications, and do not interact directly with a human. In these cases, the knowledge-based system will have an interaction mechanism for communication with other applications via interface port. The user interface may be consists of three components as follows:

1. **Start Menu:** consists of several buttons, each button represents an action; when the system starts a menu will be displayed in order to allow the user to select one of the actions.

Figure 4-2 presents the start interface page.

2. **Data Grid:** A grid view or a data grid is a graphical user interface element that presents a tabular view of data. A typical grid view also supports the following:
  - A. Dragging column headers to change their size and their order.
  - B. In-place editing of viewed data.
  - C. Row and column separation, and alternating row background colors.

Figure 4-2 shows the background of the interface as a picture of mall which expresses the idea of the program, buttons and labels with a particular order.

- 3. Buttons:** They are the controls in which a user clicks on to perform some actions. Buttons are used mostly for handling events in code. Figure 4-2 shows the button “Click here to start” which takes users to the handled page.

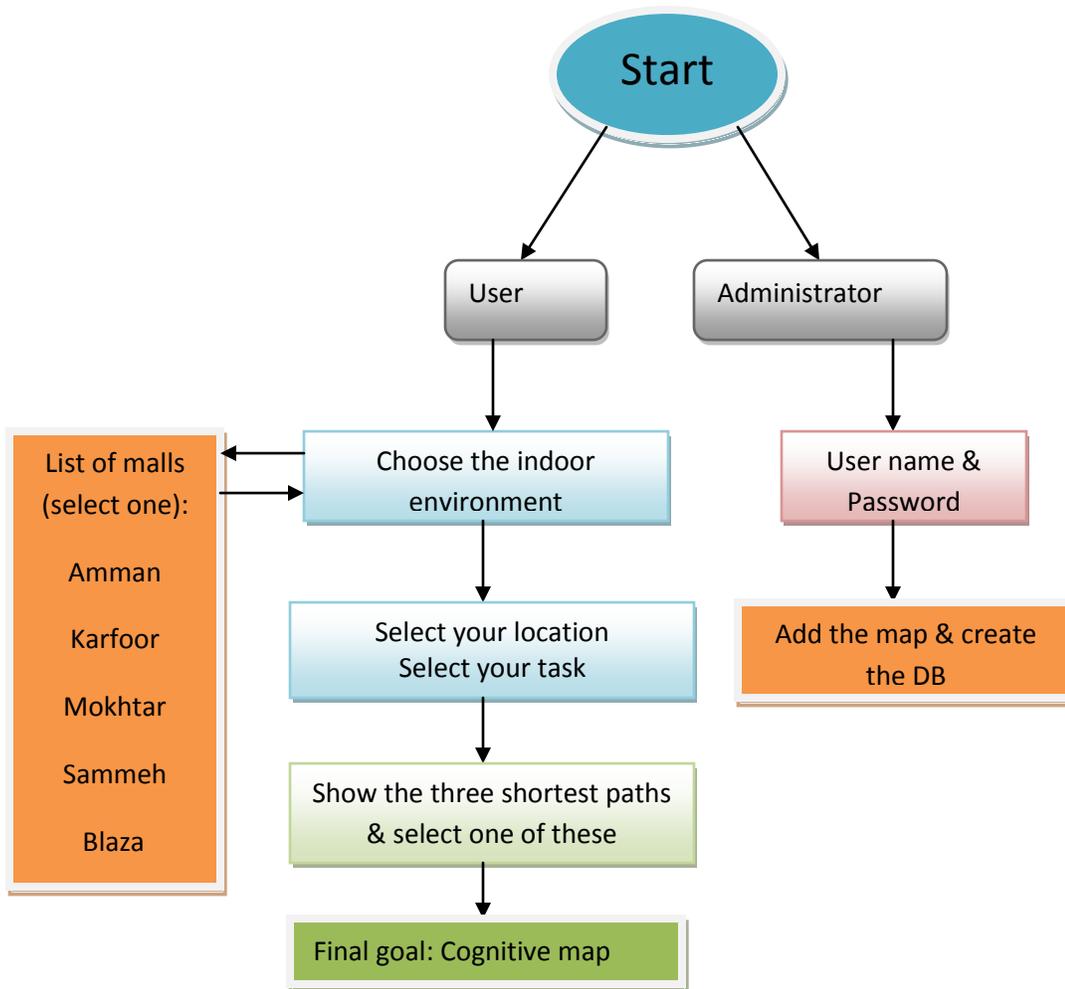
The user interface is a selection that screen consists of two parts:

- A. Set goal and analysis of the user, where the user enters the job he wants at this stage.
- B. Returns information that the task of the user by giving the final results to the user as a cognitive map of the task



**Figure 4-2 The start user interface.**

The flow chart of Figure 4-3 describes the mechanism of using the application by administrator and users.



**Figure 4-3 Present the application**

#### 4.2.2 Inference engine

The implementation of the Inference Engine depends on the representation of knowledge in the knowledge bases of the proposed system. The implementation of inference engine will be regarded as a combination of problem solving method, reasoning agent and search technique.

This thesis present a solution to the problem of constructing a cognitive map using spatial information according to task. The applicable technique is to represent the task and make a

relationship within the SI. The task ordered by users refers to a particular location in this indoor environment. The locations are represented as points demanded from spatial data base.

The reasoning agent is responsible to accept sophisticated queries concerning some specific problems to execute on the appropriate knowledge. The use of case base format will facilitate the analogical reasoning. Moreover, the use of frame base format will facilitate the induction, and the use of rule base format will facilitate the deduction.

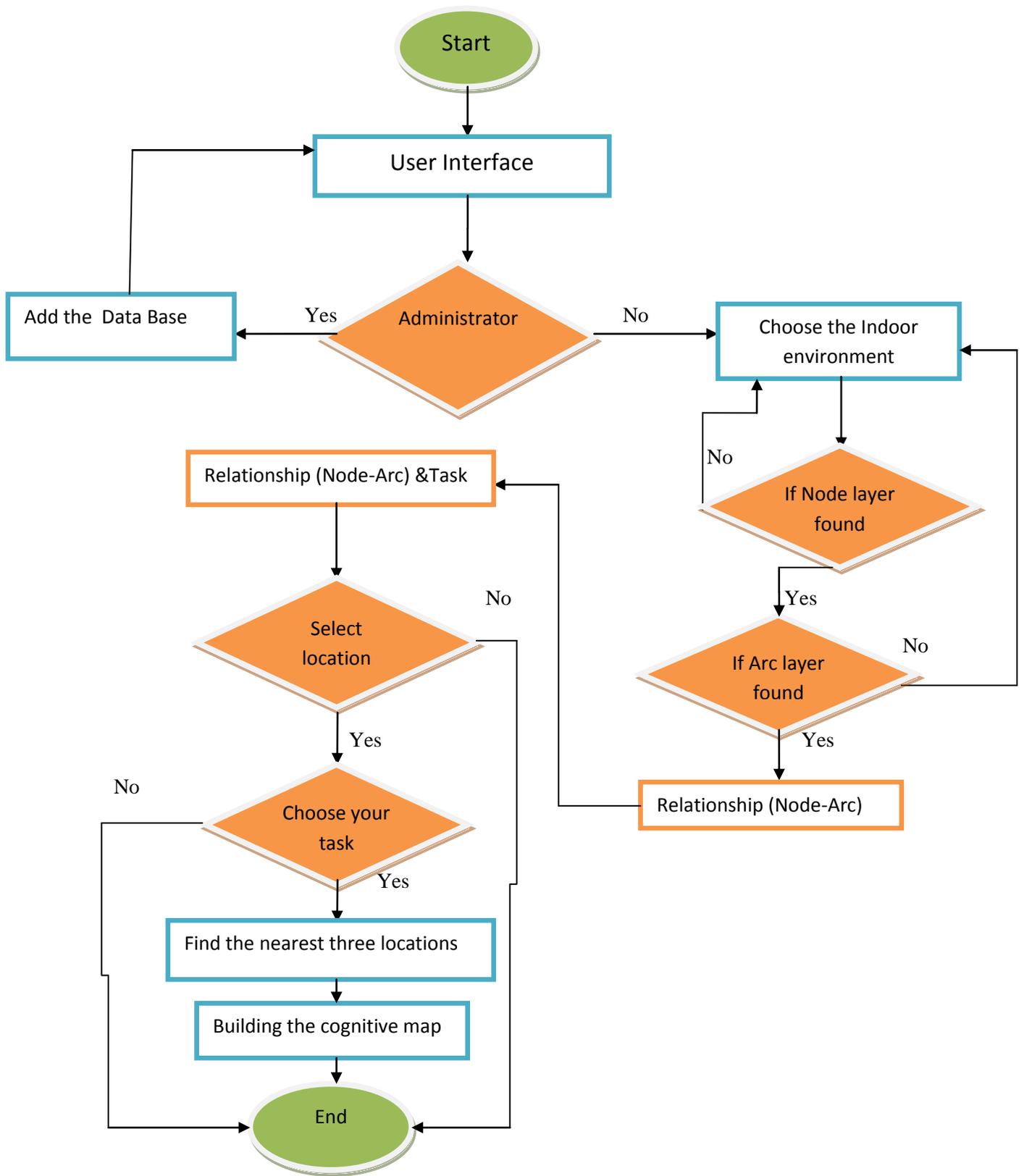
Some algorithms that will be used by the inference engine are used for gaining knowledge from the indoor environment (data base) in order to accomplish a specific task and build a cognitive map.

When users select a task "Eating" for example, the first step is to bring the data and lookup for the existence of the location "Restaurant" according to the database. The next steps are to accomplish the task with the current location (to be chosen by the user) and make the start point and end point to find the short path between these points. These steps are repeated depending on the number of restaurants (the end points) exists in this indoor environment that were saved in the database. The three optimal paths are the three shortest restaurants from the current location.. Figure 4-4 represents the reasoning agent with the task "Eating" using the source location (SI) "Restaurant" as knowledge.



**Figure 4-4 Reasoning Agent**

The workflow of the inference engine is illustrated in Figure 4-5 resumed the whole process:



**Figure 4-5** Flow chart describe the inference engine whole process

### **4.2.3 Knowledge-Base**

There are two types of knowledge representation, which are procedural and declarative knowledge representation formalisms. So, for each type many forms such as the Rule, Case, Semantic Nets, Model, and Frame bases formats are used and most of them are converted into database tables through the application of relational database.

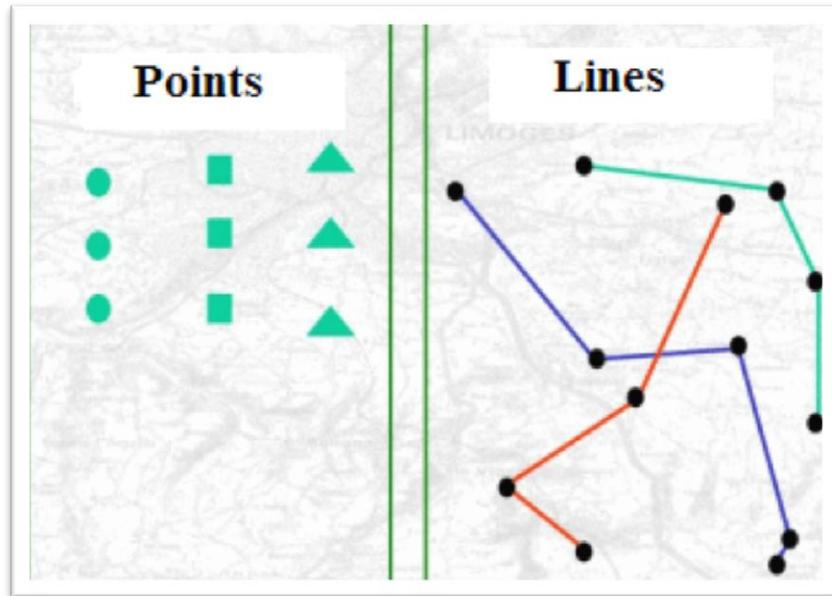
This thesis represents the knowledge as procedural and declarative knowledge. A specification task sent by a user in particular location converted to database tables to make support knowledge. The algorithms applied give a support for three short paths locations related to the task specified with its own information. This support knowledge gives at the end the cognitive map and send it to the user.

### **4.2.4 Spatial data base**

The spatial database presents the spatial data storage for the indoor environment. It is collected by the architectural map of the building and implemented for the considered indoor environment such as mall.

In this spatial database the data is optimized for storing and querying data related to geo-referenced objects, including points and lines. It also included different types of numeric and character data, additional features need to be added to handle spatial data types. These are typically called geometry or character.

In the domain of GIS, the data is stored in vector format or raster format. The vector format handles points and lines which are supplemented by alphanumeric information. This thesis represents the data as a vector format as shown in Figure 4-6.



**Figure 4-6 Mode vector**

The Map in Figure 4-7, presents two layers representing in this work: a layer arc (path) is formed of lines and a layer node (location) is formed of points. Each line or point is attached to a descriptive attributed data of arc or node under consideration.

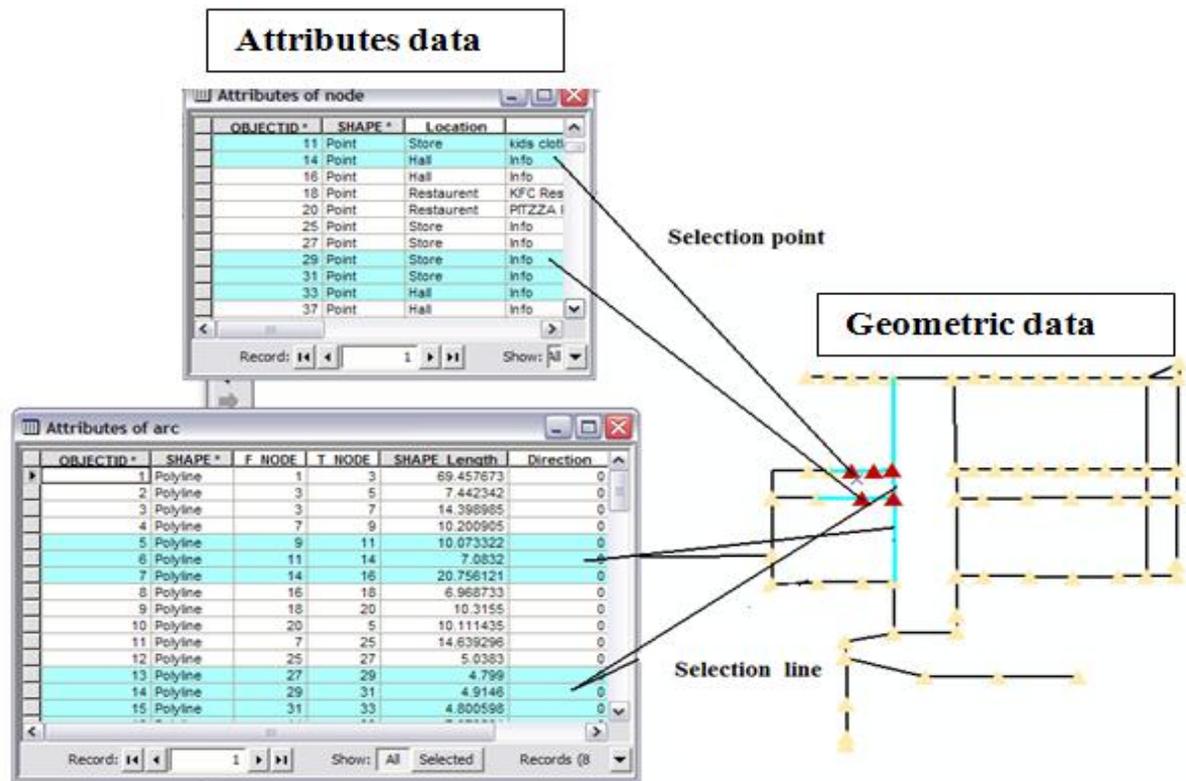


Figure 4-7 Vector data

### 4.3 Investigating the representation of spatial information methodology

As shown in chapter 3, the spatial information can be represented with either of the three models spaghetti, network or topology (Shashi, 2008) which convert the image from raster mode to vector mode.

The spaghetti model is a simple model that does not contain any topological relationship. Indeed no representation of the relationship between the arc and point that cannot responds to the objectives of the work. The network model represents all the relationships between the lines and other lines and points. In this case, the point is replaced by a new primitive point called node. This model represents the arc and the node and relationships between them. The topological

model accounts for all relationships in the network model, adding all the relations between areas, between regions and between regions and lines and points. It allows a very rich representation of the topology of a layer. It represents all the intersections of lines per node, even if such a node has no meaning.

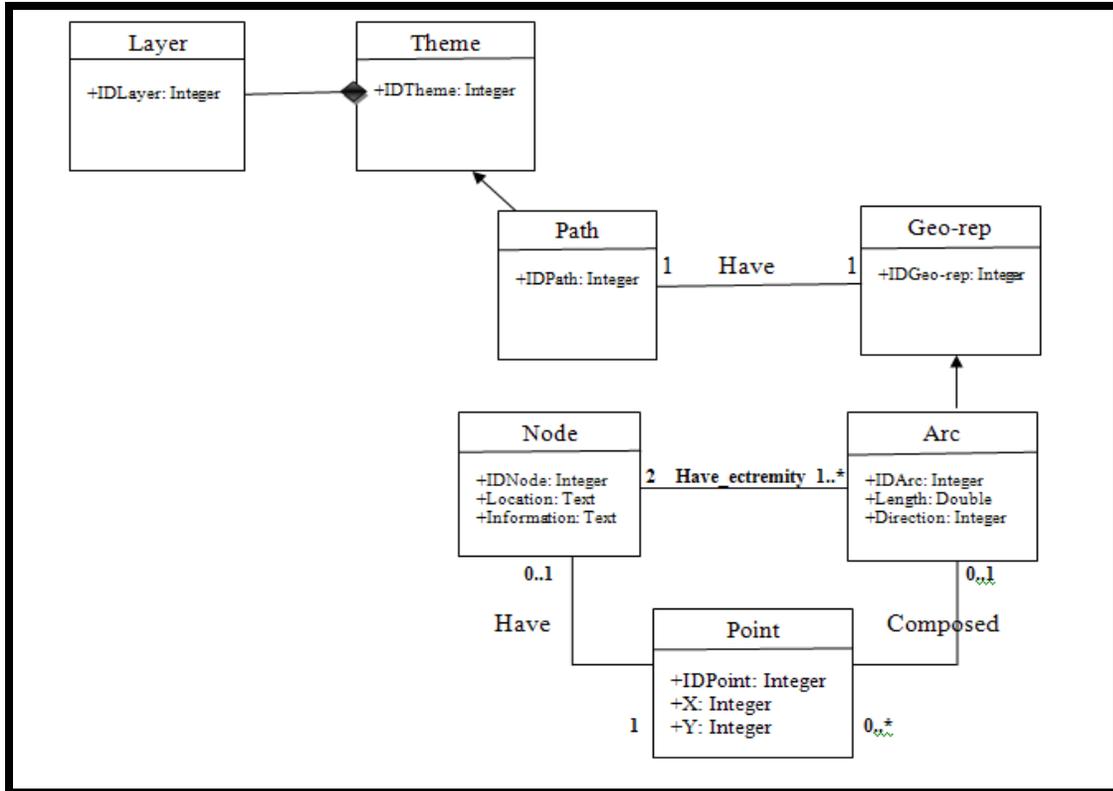
At the end, this work uses the topological model to represent the spatial information. It is rich in relations and makes the possibility to enhance the work in the future.

#### **4.4 Design of Spatial Information**

This part concerns with the design of a geographic information, i.e. how the data will be inter connected.

The data imported from CAD drawing can be used as background to a map in ArcMap, also the properties of CAD objects may include cells and blocks, in ArcGIS. The ArcGIS can edit the CAD drawings as it is need by users using the powerful editing tools.

The mall is the theme in a given layer. In order to simplify the class diagram, the work is concerned with some of the characteristics of the mall, that is mainly used in the application that we have implemented as it is shown in Figure 4-8.



**Figure 4-8 Class diagram of mall.**

Table 4-1 illustrates the classes used in the diagram above:

**Table 4-1 The objects class details.**

Objects Class	Attributes	Values
Theme	IDTheme	The identifier of the theme (Data values incrementally).
Layer	IDLayer	The identifier of the Layer (Data values incrementally).
Path	IDPath	The number of the path identifies the paths (Data values incrementally).
Geo-ref	IDGeo-ref	The identifier of the representation (Data values incrementally).

Arc	IDArc	The identifier of the Arc (Data values incrementally).
	Length	Represent the length of each arc.
	Direction	The direction of the path Left or Wright (Data values are 0. It means double direction).
Node	IDNode	The identifier of the Node (Data values incrementally).
	Location	The signification of the location of each node.
	Information	The signification of the location information of each node.
Point	IDPoint	The identifier of the Point (Data values incrementally).
	X	Abscissa
	Y	Ordered

#### 4.5 Investigating the representation of tasks methodology .

The representation of the task is to represent the task to the agent without telling it how to do the task.

There are many researchers concentrating on the field of task specification and how it can be represented. The different operators are built for different task model.

Generally, the problem of representing a task maybe the ambiguity of some expressions. The solution proposed for this ambiguity is the use of the priority order among operators defined in the standard LOTOS (choice > parallel composition > disabling >

enabling), and when building, the task model must use Concur Task Trees: A Diagrammatic Notation for Specifying Task Models ,they contain three phases :a hierarchical logical decomposition of the tasks representation , identification of the temporal, and identification of the objects associated with each task , using graphical constructions and operators derived from a formal specification. The result gives specification of a wide variety of dynamic task behaviors.

Also this task can be represented by an architecture and interface language. Ian, Michael & Peter,( 2009) had introduced the BLTL (Bootstrap Learning for Task Learning) language that allows tasks to be specified concretely in terms of starting states, reward functions, and termination conditions.

In addition, they provide advice and suggestion for new task sources for future action. The BLTL language forms the cornerstone for the larger Bootstrap Learning project, which integrates even more machine learning methods for teaching agents to solve many different types of problems, not only sequential decision making tasks Therefore we need to describe the tasks that need agents to carry out on our behalf.

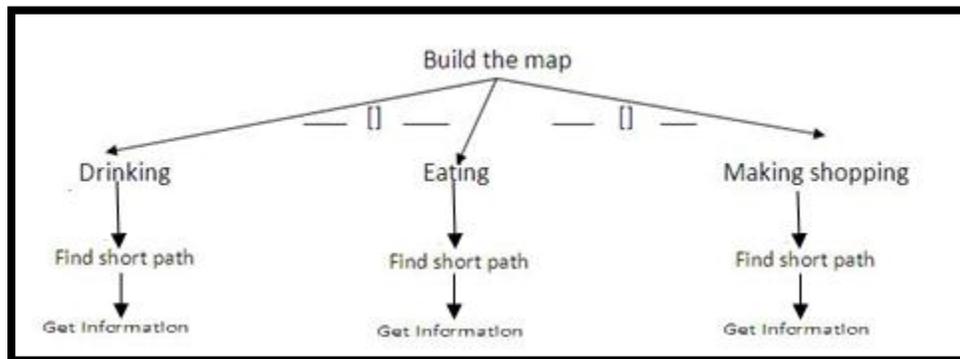
This work defined the task of how an individual can reach a goal in a specific application domain. The goal is to build a cognitive map of the environment of the task.

Tasks are classified according to their semantics, i.e. by giving each task a type. The task specification of this work is classified into the category of **System Task** with type of **Locate** which the system provides information useful to locate something.

**System Task** is performed by the application itself, such as generating the results of a query (Fabio, Carmen, Lucio and Dave, 2012).

In this representation there are some requirements that have been specifically identified as follows:

**Choice** ( $T_1 [] T_2 [] \dots T_N$ ): is to choose one task from a set of tasks (eating, drinking...) and, once the choice has been made, the chosen task can be performed.



**Figure 4-9 Example of the task model.**

## 4.6 Algorithms

After representing the spatial information and storing the data, the process of consists of five algorithms as listed briefly below:

- 1 Verifying the data (spatial information) algorithm:** verifies the table's arc and node are added in order to be used in the application.

- 2 **Relationships between spatial information algorithm:** finds the relationship between arcs and nodes and update the tables (the arcs have two extremities first node and terminal node identified by number ID).
- 3 **Relationships between the Spatial Information and the required task algorithm:** defines the task of each node depending on its location name. (task eating  $\longrightarrow$  node location restaurant).
- 4 **Find the short path algorithm:** finds the shortest path between two points in the network. (Start point of current location ( to be chosen by the user) and end point of task desired).
- 5 **Build the map algorithm:** builds and displays the path as network of points.

To declare the whole program, the process uses the CAD drawing of mall as an image and, simplifies it using the edit tools of ArcMap to trac spatial information (layers arc and node) and applying a model topologic which allows finding a relationship between them by the algorithm created. Then it makes a relationship between spatial information and tasks based on the location name and the task on the map. After that, it finds the three short paths based on the current location as a start point and the task desired as end point using Dijekstra algorithm. Finally, it builds the shortest path chosen by the user and displays the cognitive map.

# **CHAPTER FIVE**

## **IMPLEMENTATION**

## CHAPTER FIVE

### Implementation And Results

#### 5.1 Overview

This chapter presents the implementation and results of the proposal model.

#### 5.2 The process

The Stages of implementation can be illustrated as shown in diagram of Figure 5-1.

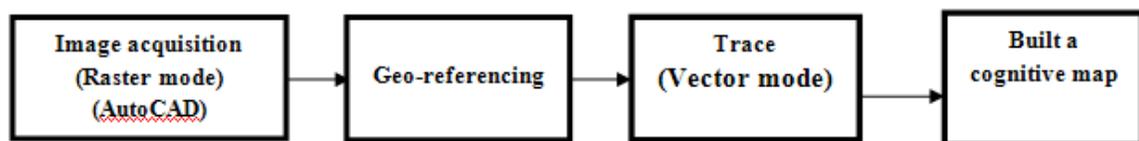
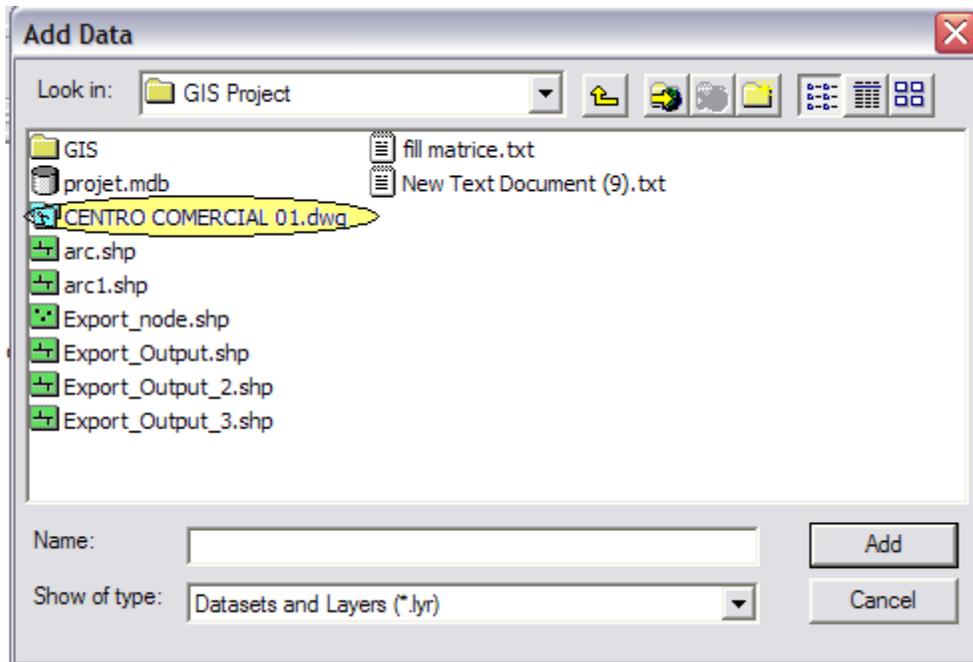


Figure 5-1 The Implementation Stages

##### 5.2.1 Image Acquisition

Images can be acquired in several formats such as \* Gif, \* map, \* jpg, \*dwg....Etc. The data used are acquired from AutoCAD format that "\*dwg" extension for the mall sample (indoor environment). This data is imported using ArcMAP Window to have a first layer as background to create the database as shown in Figure 5-2.



**Figure 5-2 Add Data (layers) of type “\*.dwg”.**

### 5.2.2 Geo-referencing:

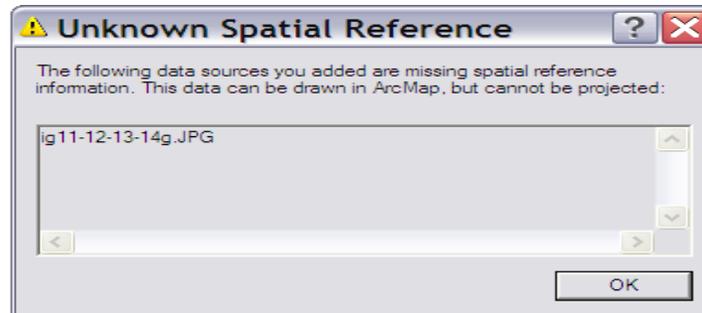
Geo-reference is to an image or graphic objects, geometric conformity with reality in a given projection system.

Geo-referencing is essential to ensure the validity of the location of objects in a spatial database. It is essential when images are used as background for the graphical input of localized objects (Figure 5-2). So geo-references are used to determine the location of entities on earth more or less accurate. It should be noted that the geo referencing is essential to all forms of spatial analysis. This was done on ArcGIS (setting operation of the image) before starting the procedure trace.

## Calibration procedure in ArcGIS

The calibration procedure in ArcGIS begins with the choice of the projection (WGS 1984 UTM zone 31N (the projection chosen)), otherwise an error message is displayed as shown

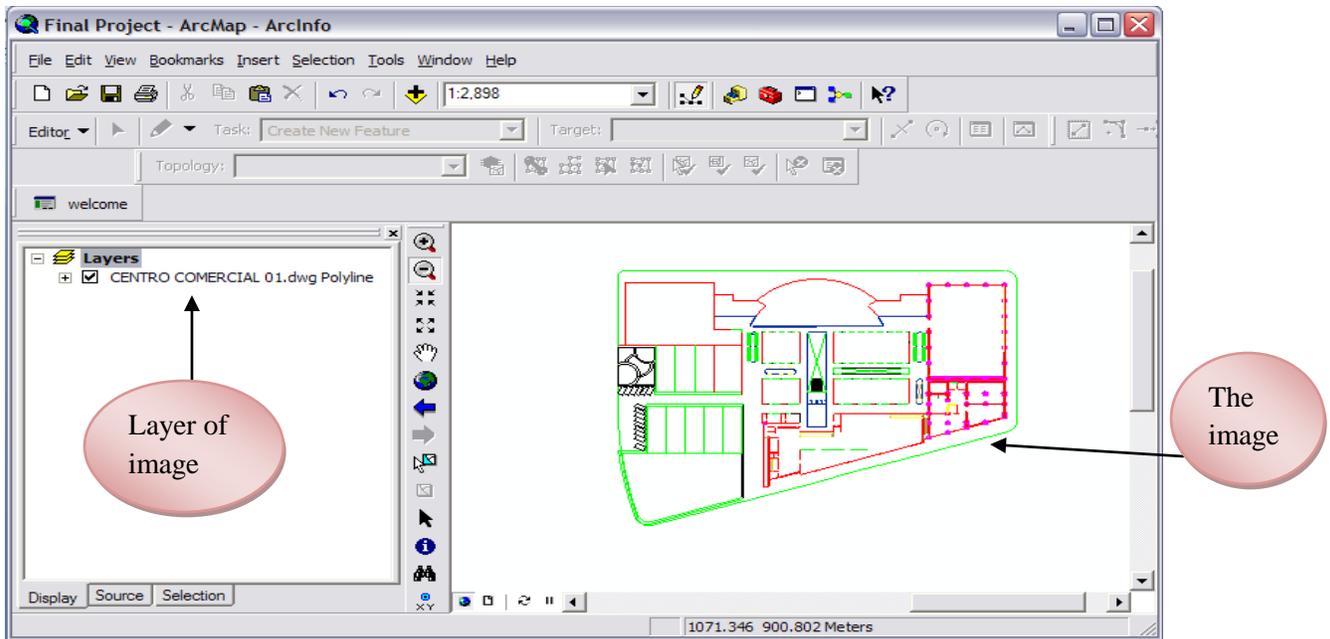
Figure 5-3



**Figure 5-3 The projection error message.**

Once an image is seated , it can be saved in a format that supports the projection (DWG for example). Once saved in this format, it can be open of in ArcMap as a raster mode.

In this work, the projection is chosen randomly, it is difficult to obtain the real coordinates of this sample. The objective is to create spatial information based on this image. Figure 5-4 shows the image geo-referencing as the first layer created by ArcMap.



**Figure 5-4 Image geo-referencing**

### 5.2.3 Trace

In order to link this layer (image,\*dwg) to the overall conceptual model, the creation of the database using ArcCatalog is done as follows:

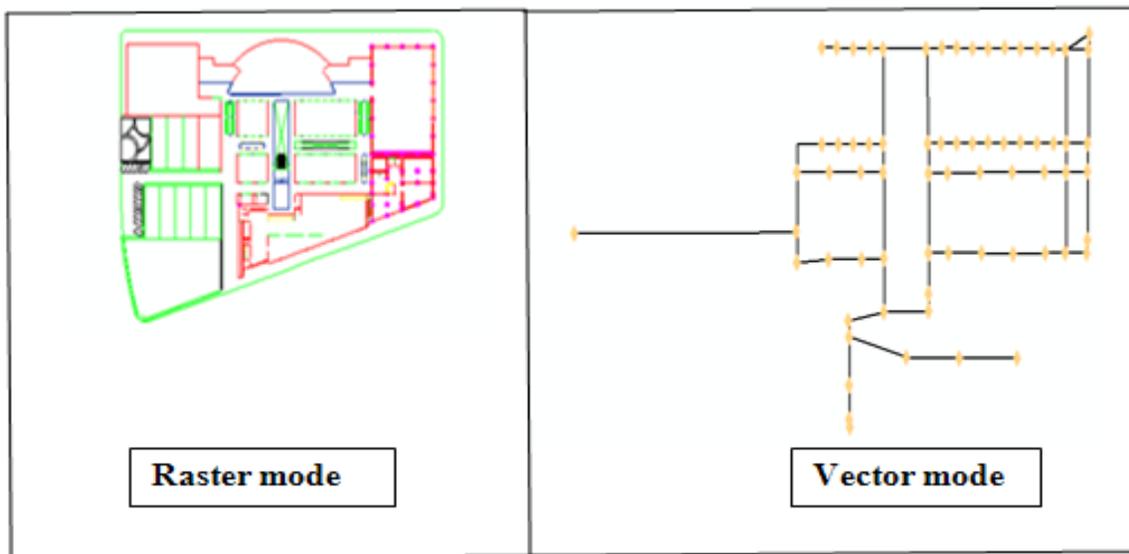
- Create "geodatabase".
- Create "class entities (Feature Class)" inside the geodatabase.

This step needs to create geodatabase a file this saves all the class entities that will be used. To reach this goal, two classes of entities such as "line" and "point" should be created, to allow the representation of the spatial information in this indoor environment. As for its creation, it should respect the projection of 'WGS1984 UTM zone31N' the same of the background image.

The class "line" is created with three fields for default values : 'OBJECTID', 'SHAPE' and 'SHAPE\_LENGTH'.

The next step is to pass to the operation the trace of the digitizing layer path from the raster image. This is a manual operation that is to follow the path on different sections of the raster image using dedicated tools of ArcGIS. To fill the three fields automatically in layer Arc of class line as a database.

The Figure 5-5 presents is the final result from the mode raster to the mode vector.



**Figure 5-5 Represent the lines traced using ArcMAP (mode vector).**

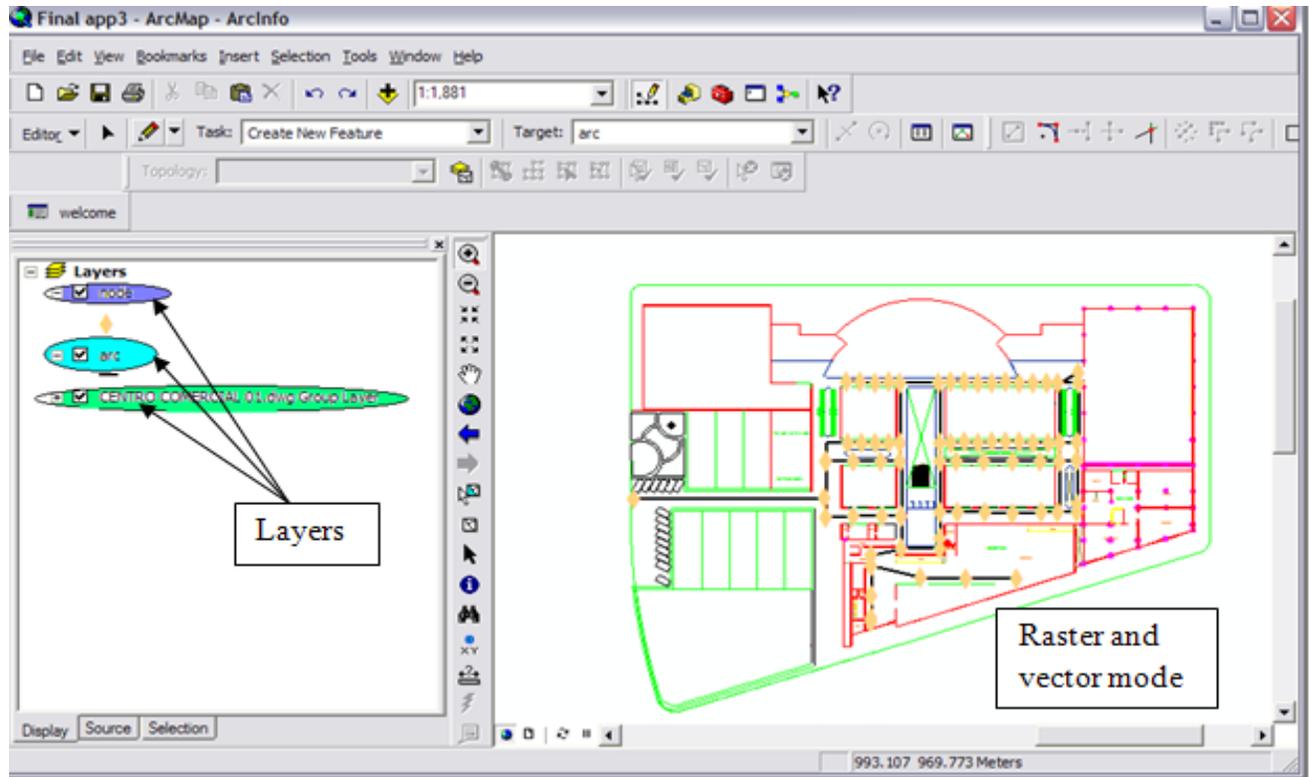
During this operation, the choice of the parts of the image is important.

The result of this operation is a path layer in vector shape spaghetti mode (model used by ArcGIS).

The layer **arc** is created as shown in Figure 5-6.

This layer “Arc” contains a single spatial object that is a line. And from this layer a second layer **node** is obtained that represents the topologic mode as relationship between the

beginning and the end of each arc, otherwise it is the place we want to achieve as shown in Figure 5-6.

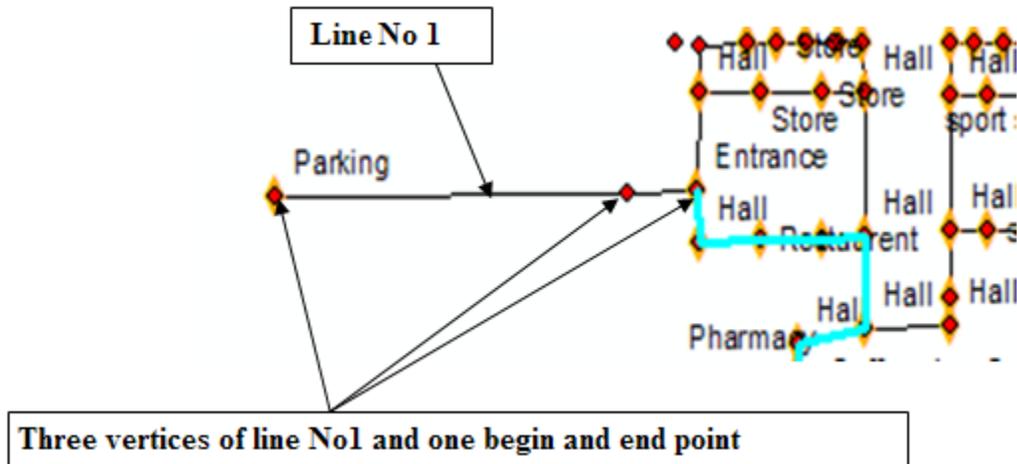


**Figure 5-6 Represent the layers created.**

The relationship used to pass from the model spaghetti to the model topologic is the intersection. The intersection is the point that gathers two lines between them. The lines length of an environment is traced as the beginning end of locations seen in the map (image raster). The locations are the intersections represented as point in the map saved in the database of the class “node” table.

The tools of ArcToolbox converts the class “arc” to the new class “vertices\_to\_points”. The “Vertices\_to\_points” is a new class which saves a collection of points of mouse clicks when

tracing the lines. The class “node” loads and saves only the points which represent the beginning and end of lines. Figure 5-7 shows an example of lines, vertices and begins and ends of lines.



**Figure 5-7 Represent the vertices of particular line.**

To reach the goal of this thesis and make the relationships between the spatial information and the tasks, the work needs to edit the database with static, manual and automatic modifications as follows

**a- In the database table arc**

This table needs to add:

- The field "direction" type Integer that represents the double direction of each path (arc) as the number “0”.
- The field "F\_NODE" type Double is the IDNumber of the point in the table “node” that represents the first node of each path (arc).
- The field "T\_NODE" type Double is the IDNumber of the point in the table “node” that represents the terminal node of each path (arc).

Such that filling these fields manually as shown in Figure 5-8.

OBJECTID *	SHAPE *	F.NODE	T.NODE	direction	SHAPE Length
1	Polyline	1	3	0	69.457673
2	Polyline	3	5	0	7.442342
3	Polyline	3	7	0	14.398985
4	Polyline	7	9	0	10.200905
5	Polyline	9	11	0	10.073322
6	Polyline	11	14	0	7.0832
7	Polyline	14	16	0	20.756121
8	Polyline	16	18	0	6.968733
9	Polyline	18	20	0	10.3155
10	Polyline	20	5	0	10.111435
11	Polyline	7	25	0	14.639296
12	Polyline	25	27	0	5.0383
13	Polyline	27	29	0	4.799
14	Polyline	29	31	0	4.9146
15	Polyline	31	33	0	4.800598
16	Polyline	14	33	0	7.079581
17	Polyline	33	37	0	23.0354
18	Polyline	37	39	0	4.198812
19	Polyline	39	41	0	5.014934
20	Polyline	41	43	0	5.278662
21	Polyline	43	45	0	4.7991
23	Polyline	50	51	0	23.040537
24	Polyline	51	53	0	7.20247
25	Polyline	53	55	0	5.9948

**Figure 5-8 Represent the fields of the table arc**

**b- In the table node**

This table needs to add:

- The field "node" type Double that represents the node of each path (arc).
- The field "arc" type Double that represents the arc in relation with node (arc).

Such the filling of these attributes is automatically using code 3. As represented in Figure 5-9.

- The field "Location" type Text that represents the location name of each node.

The filling of this attribute is manually like "Restaurant", "Coffee Shop"....est. chosen by the user who describes the part of the environment as shown in Figure 5-9.

OBJECTID *	SHAPE *	Location	node	arc
1	Point	Parking	1	1
3	Point	Entrance	3	1
5	Point	Hall	5	2
7	Point	Hall	7	3
9	Point	Store	9	4
11	Point	Store	11	5
14	Point	Hall	14	6
16	Point	Hall	16	7
18	Point	Restaurent	18	8
20	Point	Restaurent	20	9
25	Point	Store	25	11
27	Point	Store	27	12
29	Point	Store	29	13
31	Point	Store	31	14
33	Point	Hall	33	15
37	Point	Hall	37	17
39	Point	Store	39	18
41	Point	Store	41	19
43	Point	Store	43	20
45	Point	Store	45	21
50	Point	Hall	50	23
51	Point	Hall	51	23
53	Point	Hall	53	24
55	Point	sport sale	55	25

**Figure 5-9** Represent the fields of the table node

## 5.2.4 Building Cognitive map

After representing the spatial information and storing the data, the process of building a cognitive map consists of five algorithms as listed below:

### 5.2.4.1 Data verification (spatial information) algorithm

This algorithm verifies if the arc and the node of tables are added in ordre to be used in the application. It is a necessary step because the tables are the sources of the database used in the application. Figure 5-10 shows the algorithm. ( detailed with code 1 in the appendix-1).

```

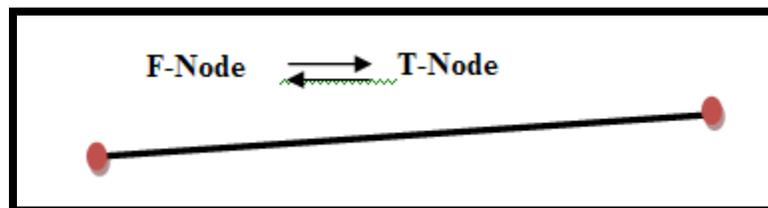
Data_verification ()
| Let collection: collection layer
| Layer 1: the first of collection layer
| Layer 2: the second of collection layer
|| If layer 1 ? "node"
    Data_verification()=false
|| Else if layer 2 ? "arc"
    Data_verification()=false
|| Else
    Data_verification()=true
|| End if
End

```

**Figure 5-10 Data verification algorithm.**

#### 5.2.4.2 Establishing relationship between spatial information algorithm

This approach allows finding the relationship between arcs and nodes as each arc has two extremities first node and terminal node identified by number ID. The node can have more than one arc as shown in Figure 5-11.



**Figure 5-11 Represent the relationship arc-nodes**

This approach edits the table “node” using the algorithm presented in Figure 5-12.

```

Rel_arc_node()
| Let collection: collection node
| Let collection1: collection of arc
| Node1: the first point of collection
| while node1 ≠ null
| | ARC1: the first arc of the collection1
| | while ARC1 ≠ null
| | | If extremity (ARC1, node1) = true then
| | |   Rel_arc_node()=true
| | | End if
| | | ARC1: = move (collection1);
| | End while
| | Node1: = move (collection);
| End while
End

```

**Figure 5-12 Relationship between spatial information algorithm.**

This algorithm is achieved by code 2 and code 3 shown in the appendix-2 and appendix-3 .

Code2 is the step for creating two attributes “Arc” and "Node" in the table "node" and code3 is the step to check all nodes (first node and terminal node) with all arcs and fill the table “node” of the relationships between them if exist.

#### **5.2.4.3 Relationship between the Spatial Information and the required task algorithm**

This algorithm defines the task depending of the location name of each node. The list of tasks is obtained by the list of locations in this environment, for example:

task eating → node location restaurant.

As seen previously to achieve the goals, the solution must add the attribute "Location" of type Text of table “node”. This attribute allows recovering the node ID that is in the relationship with arcs ID.

The proposed solution for this operation requires the use of a set of conditions. The conditions are worked as follows:

For example, the task **eating** describes the location **Restaurant**; the task **drinking** describes the location **Coffee shop...** with different ID node in relation with arc ID. Figure 5-13 shown the algorithm. (details in code 4 in the appendix-4).

```

Rel_task_SI()
| Let collection: collection task
| Let collection1: collection of node
| task1: the first task of the collection
| | node1: the first point of collection1
| | while node1 ≠ null
| | | If name (task1) = "Eating" and location (node1) = "Restaurant" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "Drinking" and location (node1) = "Coffee shop" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "Shopping" and location (node1) = "Store" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "Playing" and location (node1) = "Games" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "Watch Movies" and location (node1) = "Cinema" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "Buy shoes" and location (node1) = "GAP" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "Buy clothes" and location (node1) = "Addidas" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "buy drugs" and location (node1) = "Pharmacy" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | | If name (task1) = "Washing" and location (node1) = "W.C" then
| | |   Rel_task_SI()=true
| | |   Num=Num+1
| | | End if
| | node1 = move (collection1);
| | End while
| task1 = move (collection);
End

```

Figure 5-13 Relationship SI and task algorithm.

#### 5.2.4.4 Shortest path algorithm

This algorithm finds the shortest path between two points in the network which the start point of current location and the end point of the desired task.

The algorithm is based on the algorithm of Dijkstra (Robert, 2007). So from the path, it is necessary to build the corresponding graph (cognitive map), where the weight of an arc is its length.

The proposed solution for this operation requires the use of an  $N \times N$  square matrix (number of nodes  $\times$  number of nodes). The filling of the matrix is as follows:

- -1: when no relationship between the node corresponding to the row and column corresponding to the node.
- 0: diagonal (where the same node).
- Val: real type, corresponding to the distance between the two nodes.

Algorithm of filling the matrix is shown in Figure 5-14. (Code 5 in appendix-5).

```

Fill_Matrix ()

| Let collection: collection node
| Node1: the first node of collection
| while Node1 ≠ null
    || Node2: the first node of collection
    | while Node2 ≠ null
        Matrix [node1 node2]:=-1      /* initialize the matrix to -1
        || If equal (node1, node2) = true /* the same node
            Matrix [node1 node2]:=0
        || End if
        || If relation (node1, node2) =true
            Matrix [node1 node2]:=Distance
        || End if
    | node2: = move (collection);
    || End while
| Node1: = move (collection);
| End while
End

```

**Figure 5-14 Filling the matrix algorithm**

The algorithm in Figure 5-15 is the connectors of each node as a graph. (Code 6 in the appendix-6).

```

Graph_connectors{()
| Let collection: collection node
| Node1: the first node of collection
| while Node1 ≠ null
    Graph (i). Name = node1
    Graph (i). Code = arc-rel (node1)
    || Node2: the first node of collection
    || while Node2 ≠ null
        If matrix [Node1 Node2] ≠ -1 and matrix [Node1 Node2] ≠ 0
            Nbr=Nbr+1
            Graph (i). Connections (Nbr). Destination: = node2
            Graph (i). Connections (Nbr).Weight:= Distance (Node1, Node2)
        End if
    || Node2: = move (collection);
    || End while
    Graph (i). Numconnect:=Nbr
    i:=i+1
| Node1: = move (collection);
| End while
End

```

Figure 5-15 Graph connectors algorithm.

**Dijkstra's Algorithm** (Robert, 2007).

The algorithm uses the following additional functions:

**- Initialization of the algorithm:**

**Initialization (G, CP)**

For each point  $s \in G$

Do  $d [p] := \text{infinity}$  /\* initializes the points other than closest point to infinity \*/

$D [CP] := 0$  /\* CP being the closest CP point \*/

**Done**

– **Find the nearest node:**

This algorithm looks for the nearest (connected by the edge of the lower weight) CP among the nodes in a node set Q consisting of remote nodes of edge elements of P. This is done using the `found_min ()` function. The found node is deleted from the set Q and then returned to the main function as a result of the function.

– **Updating distances**

It updates the distances between CP and  $s_2$  by asking the question: is it better to go through  $s_1$  or not?

*maj\_distances (s1, s2)*

*/ If  $d [s_2] > d [s_1] + \text{Weight} (s_1, s_2)$*

*/ Then  $d [s_2] := d [s_1] + \text{Weight} (s_1, s_2)$*

***End***

– **Main Function:**

Here is the main Dijkstra function:

***Dijkstra (G, Weight, CP)***

*/ Initialize (G, CP)*

*/ Q: = set of all nodes*

*/ As Q is not an empty set*

*/ / Do  $s_1 := \text{found\_min} (Q)$*

*/ / Q:= Q is private of  $s_1$*

*/ / For each  $s_2$  neighbor node of  $s_1$*

*/ / / Do *maj\_distances* ( $s_1, s_2$ )*

*/ / End*

*/ End*

**End**

Table 5 present the summary of variables in Dijkstra's algorithm.

**Table 5-1 The summary of Dijkstra's algorithm parameters.**

<b>Parameters</b>	<b>Definitions</b>
G	The graph
CP	The Closest Point
D	The Distance
P	Point from the graph
D	The distance of the Closest Point
Q	The set of nodes
s1	The first adjacent node chosen to compare
s2	The second adjacent node chosen to compare
Weight	The distance

This approach is developed by the code 7 in appendix-7.

The new algorithm developed based on the algorithm of Dijkstra to find the many shortest paths in the environment. The tasks are in relations with locations in the environment. Each task represents a number of nodes in the database. This algorithm is developed as following:

- Calculates the numbers of nodes in relations with the task chosen.

- Recovers the ID of each node and save it in the *Vector*.
- From the current location chosen, applies and repeats the algorithm of dijkstra the number of nodes.
- Save the distance between the current location and each node in the *Vector*.
- Compares the *Vector* and returns the three shortest distances.
- Gets the three shortest paths from the three shortest distances of IDs number.

Figure 5-16 shows the developed dijkstra's algorithm.

```

Three_paths ()
| Let collection: collection of node
| Let collection1: collection of task
| Task1: the first task of collection1
| Node1: the first node of collection
| while node1 ≠ null
| | if relation (Task1, Node1) = true
| |   Vector (i). ID = Node1
| |   Vector (i). Distance = Dijkstra (cuurent_location, Node1)
| |   i:=i+1
| | End if
| | Node1: = move (collection);
| End while
| Min1:= Minimum1 (Vector)
| Min2:= Minimum2 (Vector)
| Min3:= Minimum3 (Vector)
| Task1: = choose (collection1);
End

```

**Figure 5-16 Three shortest path algorithm.**

#### 5.2.4.5 Built the map algorithm

It builds and displays the path as network of points saved in the vector. This approach are developed with the code 8 in the appendix-8.

Figure 5-17 shows the algorithm of building the map.

```

Cognitive_map ()
| Let Vector_node: Vector_node node
| Let collection1: collection of arc
| Node1: the first node of Vector_node
| while Node1 ≠ null
  || ARC1: the first arc of the collection1
  || while ARC1 ≠ null
    || | If extremity (ARC1, node1) = true then
      | Display (ARC1)
      | Break;
    || | End if
    || | ARC1: = move (collection1);
  || End while
  || Node1: = move (Vector_node);
| End while
End

```

**Figure 5-17 Build the cognitive map algorithm**

### 5.3 Results and Interfaces

The application is presented in the form of interfaces, this section choose some windows.

Before moving on to other steps we must go through the first user interface user as show in Figure 5-18. This interface describes the functionalities of the application and guides users to start.



**Figure 5-18 Presentation Page.**

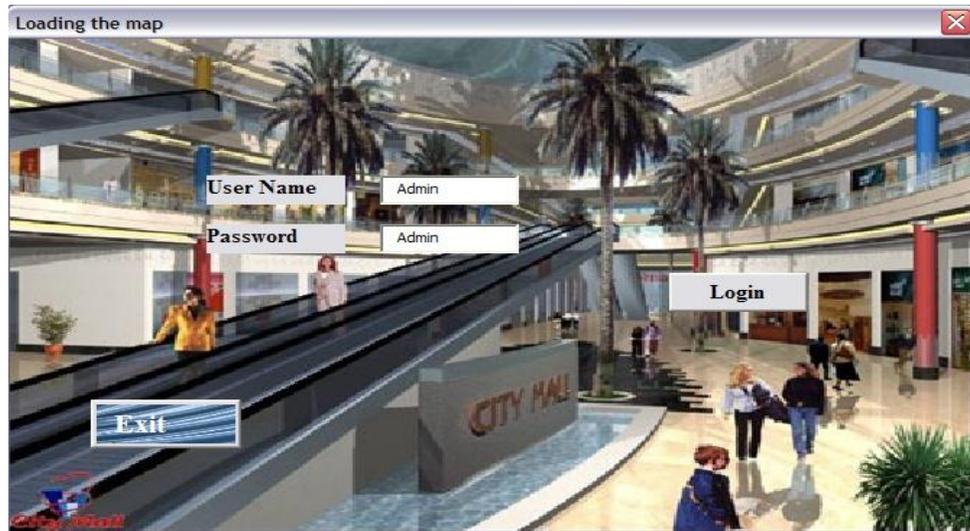
To begin, the application distinct two types of users Administrator and simple User.

Each one has his own privileges as shown in Figure 5-19.



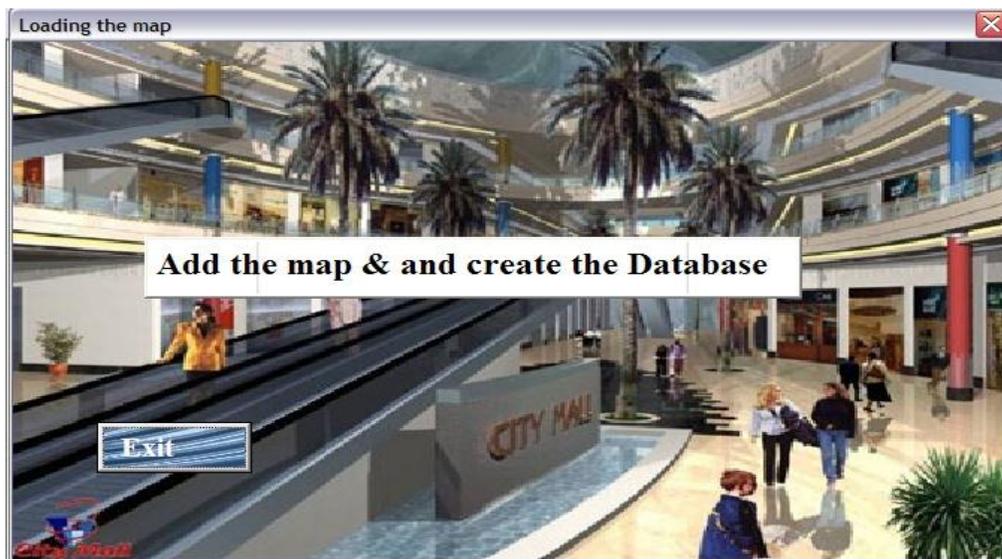
**Figure 5-19 Users window.**

The administrator can select and add the database using password and username as in Figure 5-20.



**Figure 5-20 Password and username window.**

The new form of an administrator allows relationship between the SI as in figure 5-21.



**Figure 5-21 Loading the data base form**

The user which is an administrator or client have permission to select the environment being used in the application as an example of Amman Mall, which can be achieved as shown in Figure 5-22.

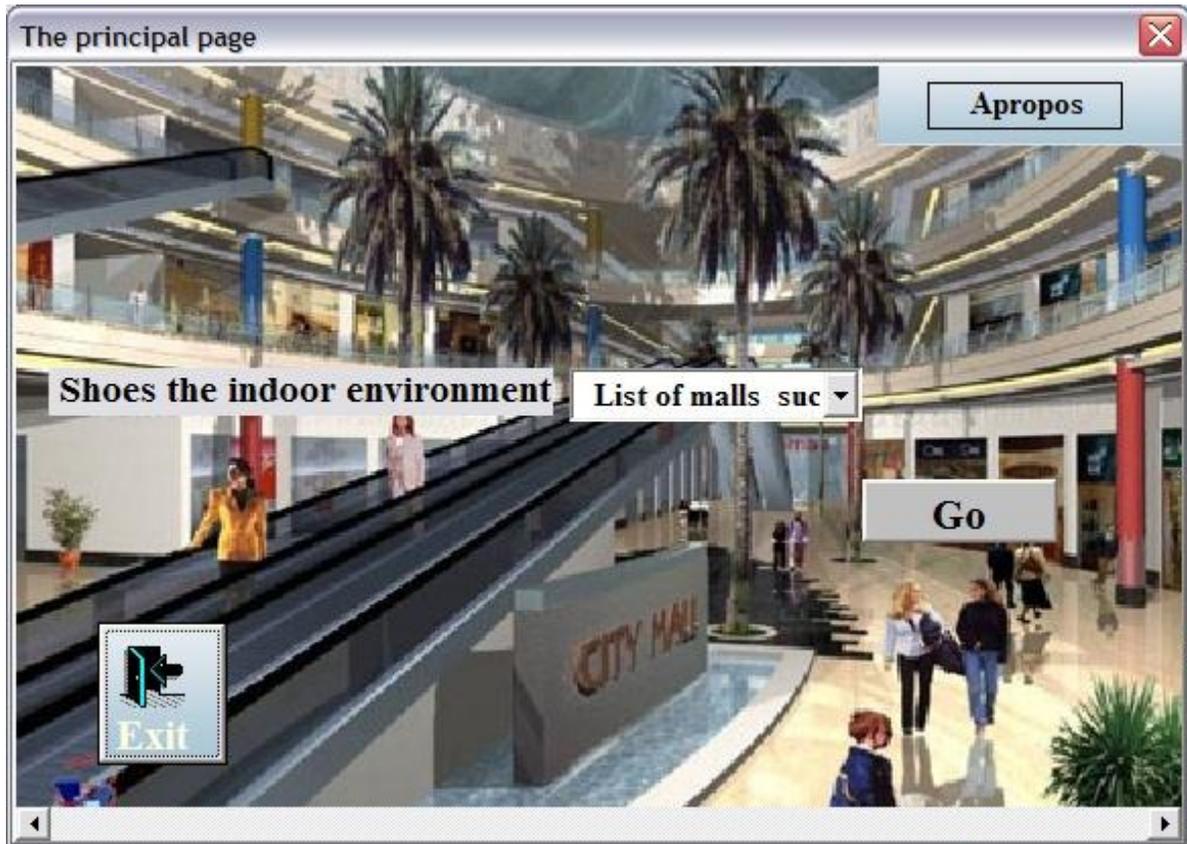


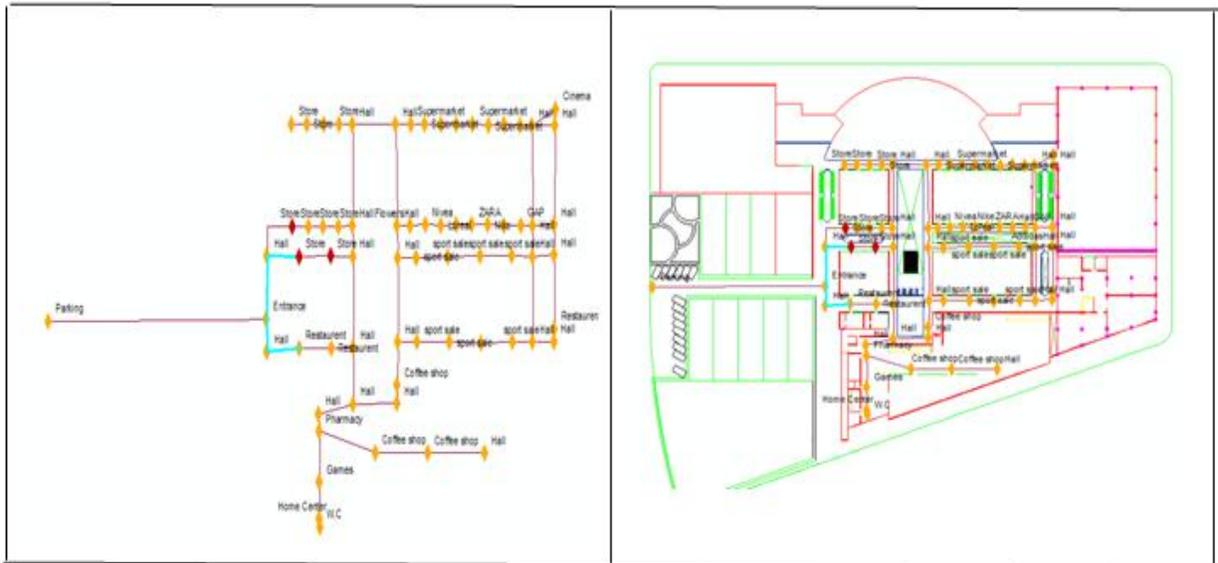
Figure 5-22 The environment form

The next step is to build the cognitive map by choose the current location and the task desired organized in a lists. At the end the search gives the result as three shortest paths ordered and displayed the path chosen in the map as in Figure 5-23.



**Figure 5-23 Finds the 3 shortest paths form**

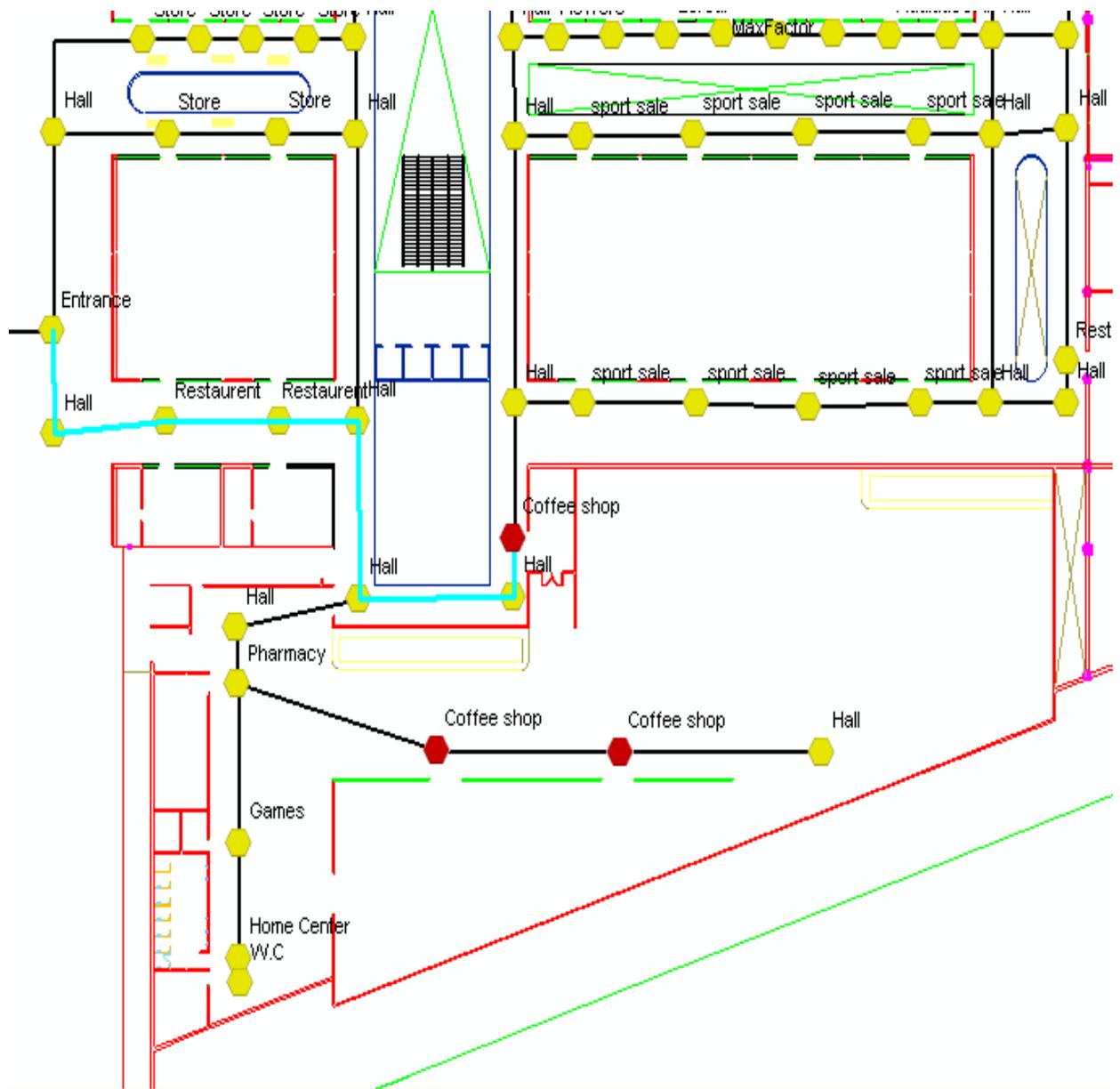
The Figure 5-24 shows the cognitive map of the shortest path with and without the background.



**Figure 5-24 The cognitive map.**

Figure 5-25 represents the image enlarged to overview more details.

The result displayed in figure 5-25 is the cognitive map obtained from an image of mall (map) used as background. This figure shows all paths exist in the map with color black labeled with the name of locations on each extremity colored with yellow. The extremities with Color red represents the three shortest Coffee shops from the entrance. The path with color blue is the shortest path of coffee shops from the entrance.



**Figure 5-25 Overview of the cognitive map.**

### 5.3 Comparison:

**Discussion:** Comparison with (Al-Ghazi, Suhaib Ibrahim 2010) and This work

Auction solution was proposed by (Al-Ghazi, Suhaib Ibrahim 2010) as seen in chapter 2, to allow using architectural blueprints for intelligent robot cognitive mapping as a knowledge-based. This solution is one that has been proposed to address our problem solutions.

We compare in this section the architectural blueprint proposed by (Al-Ghazi, Suhaib Ibrahim 2010) and the model proposed in this work based on spatial information. Both methods have the same goal is to make easy the building of the cognitive map without the need of direct human interaction.

First two methods are two good methods because they allowed finding the shortest path between two points and drawing their map .

The solution was proposed by (Al-Ghazi, Suhaib Ibrahim 2010) as seen in chapter 2. The idea of this algorithm is to find the shortest distance possible between the start point and end point. The objective of this work is to have a simple and robust representation, which builds the shape of the cognitive map together with the shortest optimal path based on architectural blueprint maps. An enhancement of the medial axis algorithm to be used for finding the optimal shortest path for developed cognitive map. The intelligent robot will use this algorithm in order to decrease the time that is needed for sweeping the targeted building.

The objective of this study is to build the cognitive map based on the representation of spatial information. The steps of achieving the cognitive map together of the optimal shortest path are presented by developed the algorithm of dijkstra. The tasks represented in relationship with spatial information recover the number of nodes to calculate the distance from the start point and compared.

The similar between this study and the previous study is to finding the shortest path. In the (Al-Ghazi, Suhaib Ibrahim 2010) study the optimal shortest path is the shortest path that has fewer turnings

on it which means less processing time during navigation. To find the optimal shortest path, the algorithm finds the shortest path that has fewer nodes, and passes it on. Otherwise, the optimal shortest path in this study is the shortest path that has the minimum distance with the start point.

This study is more practical than the previous study. The minimum numbers of nodes can have a long distance.

This study can also give the details of the optimal short path and display the map with find out all the places that can be followed on the map. The cognitive map developed in this study is more descriptive than (Al-Ghazi, Suhaib Ibrahim 2010) study.

Table 5-1 Presents a summary of a comparative study between the two methods:

<b>Comparison Elements</b>	<b>the Previous work 2011</b>	<b>This Work</b>
Algorithm	Previous work contains 8 algorithms to response to the goal (builds the cognitive map).	This work contains 5 algorithms to response to the goal (builds the cognitive map).
	Finding the short path algorithms between start and end point labeled in the map with different colors and symbols using connections node and used some algorithms Including Floyd's algorithm.	Finding the short path algorithms between two points, current location and the terminal location. (Each location represents the spatial information node) and used some algorithms Including Dijkstra's algorithm.
Result	1. The Path from fixed start point to one end point.  2. search for a destination.	1. The path from start point (any point choosing in environment) to many end points .  2. Search for a task which leads to multi destinations.
Software and language programming	These algorithms were defined and written using the standard programming code (pseudo code). Some of these algorithms were tested and proved using MATLAB R2009b	These algorithms were defined and written using the VBA. All of these algorithms were tested and proved using Arctic 9.3

# **CHAPTER SIX**

## Conclusion and Future Work

## CHAPTER SIX

### Conclusion and Future Work

#### 6.1 Overview

This chapter presents the conclusion of our work and proposes many of future works can be do it so far.

#### 6.2 General Conclusion

It is above all essential to identify needs and to derive the project objectives and its applications and to select the right tools taking into account the context and constraints.

The success of a GIS depends to a large extent, non-technical factors such as needs analysis, methodology of implementation, economic and legal conditions related to geographical data.

A GIS project is both a draft "On" and "specific" project, due to its geographical character.

The work presented in this thesis has allowed us to acquire basic knowledge, and to become familiar with this vast field: Information System.

In this thesis, we have developed the design of our application using UML, its importance to give a global and comprehensive view of what to design language, this has

enabled us to give a clearer picture of the problem, to develop concepts and the basic elements of our application, and identify features that should be covered.

Also we have developed algorithms for building cognitive map using spatial information based on algorithm of dijkstra (short path).

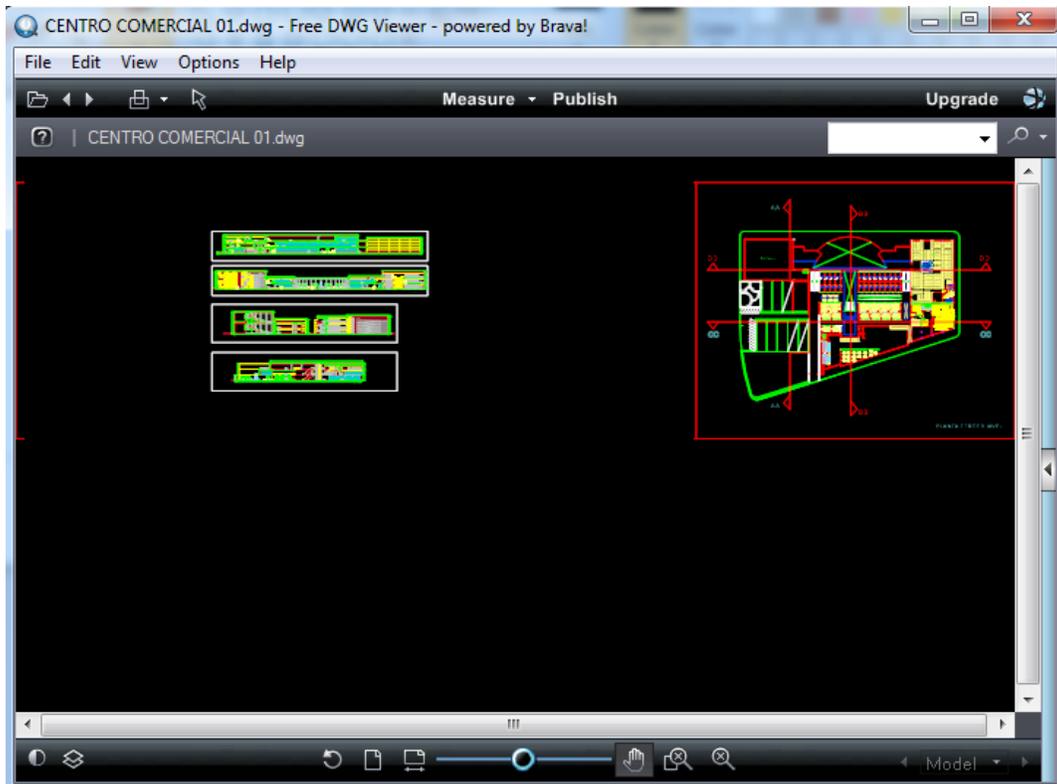
The work presented the main aim which is to show how the cognitive maps could be generated from the relationship between the spatial information and the required task and the main features of the developed algorithm which are to build the cognitive map without the need of a direct human interaction.

This work also allowed us to study the algorithm of Dijkstra and better understand how it can be used to calculate the shortest path.

At the end, the work allowed us to know how we can use the indoor environment to build our cognitive map by the help of many of software's, so that can run this work on both PC and Mobile Smartphone.

### **6.3 Future Work**

So far, this work can be enhanced and developed new algorithms and models to build a cognitive map using spatial information. Is to thinking to apply the algorithms developed of more than one organization in the same time with each organization as a layer connected with the other layers (organizations). The following figure 6-1 present more than one organization.



**Figure 6-1 Represents two different organizations.**

As another future work, the future work may also generate an algorithm to require multi-task in the same time and to finding the shortest path of different desired locations in the same time.

Furthermore, the future work can also develop a new algorithm to build a cognitive map in 3D environment with using spatial information (X, Y, and Z) with new criteria to make a relationship between them.

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## Appendices

### Appendix -1

#### Code 1

```
//  
//  
If pMap.LayerCount > 0 Then  
  
    If pMap.Layer(0).name <> "node" Then  
        MsgBox "you must add the layer node"  
    End  
  
    ElseIf pMap.Layer(1).name <> "arc" Then  
        MsgBox "you must add the layer arc"  
    End  
  
    Else  
        Label8.Visible = False  
        Label9.Visible = False  
        MsgBox "The map is selected wait to add it"  
  
//End  
//  
//
```

**Appendix -2****Code2:**

```
Set pFields = pFClass.Fields
```

```
Set pField = pFields.Field(pFClass.FindField("node"))
```

```
If Not pField Is Nothing Then
```

```
    pFClass.DeleteField pField
```

```
End If
```

```
' Creation of a field of type double
```

```
Set pField = New Field
```

```
Set pFieldEdit = pField
```

```
With pFieldEdit
```

```
    .Precision = 15
```

```
    .Scale = 2
```

```
    .name = "node"
```

```
    .Type = esriFieldTypeDouble
```

```
End With
```

```
pFClass.AddField pField
```

```
Set pFields = pFClass.Fields
```

```
Set pField = pFields.Field(pFClass.FindField("arc"))
```

If Not pField Is Nothing Then

    pFClass.DeleteField pField

End If

    Set pField = New Field

    Set pFieldEdit = pField

    With pFieldEdit

        .Precision = 15

        .Scale = 2

        .name = "arc"

        .Type = esriFieldTypeDouble

    End With

    pFClass.AddField pField

    ' Creation of a field of type double

    Fill\_arc\_node

**Appendix -3****Code3:**

```
If (pRow.Value(0) = pRow1.Value(pTable1.FindField("F_Node"))) Then
    j = j + 1
    If (j > 1) Then
        Set pNewRow = pTable.CreateRow
        pNewRow.Value(pTable.FindField("node")) = pRow.Value(0)
        pNewRow.Value(pTable.FindField("arc")) = pRow1.Value(0)
        pNewRow.Store
    Else
        pRow.Value(pTable.FindField("node")) = pRow.Value(0)
        pRow.Value(pTable.FindField("arc")) = pRow1.Value(0)
        pRow.Store
    End If
End If

If (pRow.Value(0) = pRow1.Value(pTable1.FindField("T_Node"))) Then
    j = j + 1
    If j > 1 Then
        Set pNewRow = pTable.CreateRow
        pNewRow.Value(pTable.FindField("node")) = pRow.Value(0)
        pNewRow.Value(pTable.FindField("arc")) = pRow1.Value(0)
        pNewRow.Store
    End If
End If
```

Else

pRow.Value(pTable.FindField("node")) = pRow.Value(0)

pRow.Value(pTable.FindField("arc")) = pRow1.Value(0)

pRow.Store

End If

End If

**Appendix -4****Code 4:**

```
Dim pLayer2 As IFeatureLayer
```

```
Set pLayer2 = pMap.Layer(0)
```

```
Dim pFClass2 As IFeatureClass
```

```
Set pFClass2 = pLayer2.FeatureClass
```

```
Dim pTable2 As ITable
```

```
Set pTable2 = pLayer2
```

```
Dim pCursor2 As ICursor
```

```
Dim pRow2 As IRow
```

```
Dim Query2 As IQueryFilter
```

```
Set Query2 = New QueryFilter
```

```
Dim g As Integer
```

```
Dim NB As Integer
```

```
NB = 0
```

```
count = 0
```

```
Dim arrive As Integer
```

```
""My location
```

```
If ComboBox2.Text = "Parking" Then
```

```
sourceP = 1
```

```
End If
```

```
If ComboBox2.Text = "Entrance" Then
```

```
sourceP = 3
```

```
End If
```

```
//
```

```
//
```

```
//
```

```
//
```

```
//
```

```
End If
```

```
//
```

```
//
```

```
""""My tasks
```

```
If ComboBox1.Text = "Eating" Then
```

```
sourceloc = "Restaurent"
```

```
End If
```

```
If ComboBox1.Text = "Drinking" Then
```

```
sourceloc = "Coffee shop"
```

```
End If
```

```
If ComboBox1.Text = "Shooping" Then
```

```
sourceLoc = "Store"

End If

//

//

//

End If

If ComboBox1.Text = "" Then
If ComboBox2.Text = "" Then

MsgBox "No selection"

Exit Sub

Else

MsgBox "No task selected"

Exit Sub

End If

Else

If ComboBox2.Text = "" Then

MsgBox "No location selected"

Exit Sub

End If

End If
```

**Appendix -5****Code 5:**

```
For i = 0 To 1200
```

```
    graph(i).name = rel_nod_matr(i, 0) ' nodes
```

```
    graph(i).code = rel_nod_matr(i, 1) ' arcs
```

```
    nbr = 0
```

```
        For j = 0 To 1200
```

```
            If Matrice(rel_nod_matr(i, 1), j) <> -1# And Matrice(rel_nod_matr(i, 1), j) <> 0#
```

```
Then
```

```
    nbr = nbr + 1
```

```
    graph(i).connections(nbr).destination = rel_nod_matr(j, 0)
```

```
    graph(i).connections(nbr).weight = Matrice(rel_nod_matr(i, 1), j)
```

```
End If
```

```
Next j
```

```
graph(i).numConnect = nbr
```

```
Next i
```

```
//
```

**Appendix -6****Code 6:**

```
For s1 = 0 To 1200
```

```
For s2 = 0 To 1200
```

```
Matrice(s1, s2) = -1#
```

```
Next s2
```

```
Next s1
```

```
//
```

```
//
```

```
//
```

```
If i < 1200 Then
```

```
    i = i + 1
```

```
    bl = 0
```

```
For j = 0 To i
```

```
    If rel_nod_matr(j, 0) = pRow.Value(pTable.FindField("node")) Then
```

```
        bl = 1
```

```
    End If
```

```
Next j
```

```
If bl = 0 Then
```

```
    rel_nod_matr(i, 0) = pRow.Value(pTable.FindField("node"))
```

```
        rel_nod_matr(i, 1) = i
        MsgBox rel_nod_matr(i, 2)
        Matrice(i, i) = 0#
    End If

End If

//
//
//

Do While s < 1200

If rel_nod_matr(s, 0) = pRow1.Value(pTable1.FindField("F_Node")) Then

ind1 = rel_nod_matr(s, 1)

Exit Do

End If

s = s + 1

Loop

'Dim s1 As Integer

s1 = 0
```

```
Do While s1 < 1200
```

```
If rel_nod_matr(s1, 0) = pRow1.Value(pTable1.FindField("T_Node")) Then
```

```
ind2 = rel_nod_matr(s1, 1)
```

```
Exit Do
```

```
End If
```

```
s1 = s1 + 1
```

```
Loop
```

```
'If ind1 = 298 And ind2 = 171 Then
```

```
'MsgBox "find2"
```

```
'MsgBox "et" & pRow1.Value(pTable1.FindField("F_Node"))
```

```
'MsgBox "et" & pRow1.Value(pTable1.FindField("T_Node"))
```

```
'End If
```

```
Matrice(ind1, ind2) = pRow1.Value(pTable1.FindField("Shape_Length"))
```

```
Matrice(ind2, ind1) = pRow1.Value(pTable1.FindField("Shape_Length"))
```

```
//
```

**Appendix -7****Code 7**

```
For c = 0 To count - 1
```

```
    'set default values to not dead and distances to infinity (unless distance is to it self)
```

```
    For i = 0 To long_matrice
```

```
        If graph(i).name = sourceP Then
```

```
            graph(i).distance = 0#
```

```
            graph(i).isDead = False
```

```
        Else:
```

```
            graph(i).distance = infinity
```

```
            graph(i).isDead = False
```

```
        End If
```

```
    Next i
```

```
    Dim code_arriv As Integer
```

```
    For o = 0 To long_matrice
```

```
        If graph(o).name = source(c, 0) Then
```

```
            code_arriv = graph(o).code
```

```
        End If
```

```

Next o

For i = 0 To long_matrice
    min = infinity + 1#
    'determine closest point that is not dead
    For j = 0 To long_matrice
        If Not graph(j).isDead And graph(j).distance < min Then
            nextP = j
            min = graph(j).distance
        End If
    Next j

    'calculate distances from the closest point & to all of its connections
    Dim code1 As Integer
    For j = 0 To graph(nextP).numConnect
        code1 = graph(nextP).connections(j).destination
        Dim namedepar As Integer

        For o = 0 To long_matrice

            If graph(o).name = code1 Then
                code1 = graph(o).code
            End If
        Next o
    Next j
End For

```

```

        Exit For
    End If

Next o

    If      graph(code1).distance      >      graph(nextP).distance      +
graph(nextP).connections(j).weight Then
        graph(code1).distance      =      graph(nextP).distance      +
graph(nextP).connections(j).weight
    End If

Next j

'kill the value we just looked at so we can get the next point
graph(nextP).isDead = True

Next i

outString = ""

If graph(code_arriv).distance <> infinity Then

    outString = outString & "The distance between nodes " & sourceP & " and " &
arrive & " is " & graph(code_arriv).distance & vbCrLf

/
/
/

If graph(code_arriv).distance = infinity Then

```

```
    MsgBox "No path"
    Exit Sub
End If
Next c

Dim K As Integer
K = 0
Dim path As Integer
Dim min1 As Double
Dim arret As Integer

path = source(0, 0)
pathe(K) = source(0, 0)
K = K + 1
Dim l As Integer
Dim path1 As Integer

For t = 0 To 500

    If t = 0 Then
        min1 = infinity
    path1 = -1
        l = 0
```

End If

If path = sourceP Then

pathe(K) = sourceP

Exit For

End If

For j = 0 To graph(t).numConnect

If graph(t).connections(j).destination = path Then

If l = 0 Then

End If

code1 = graph(t).code

arret = 0

If K > 0 Then

Dim k1 As Integer

k1 = 0

While k1 < K

If pathe(k1) = graph(t).name Then

```
        arret = 1
        ' MsgBox "bloc " & graph(t).name
    End If
    k1 = k1 + 1
Wend

End If

If graph(code1).distance <> infinity And arret = 0 Then

    If l = 0 Then
        min1 = graph(code1).distance + graph(code1).connections(j).weight
    path1 = graph(t).name
        ' MsgBox "path1" & path
        l = l + 1
    End If

    If l > 0 Then

        If graph(code1).distance + graph(code1).connections(j).weight < min1
Then
path1 = graph(code1).name
        min1 = graph(code1).distance + graph(code1).connections(j).weight
```

```
        MsgBox "path" & l + 1 & "=" & path
    End If
End If
End If
End If
Next j

If t = 500 Then

    If min1 <> infinity And path1 <> -1 Then
path = path1
pathe(K) = path
        MsgBox "path_final" & path
        K = K + 1
        t = -1
    End If

End If

Next t

//
```

## Appendix-8

### Code 8

```
lo = K - 1
```

```
'MsgBox lo
```

```
While lo >= 0
```

```
    'MsgBox "Please select between " &pathe(lo + 1) & "et " &pathe(lo)
```

```
.....
```

```
    Set pCursor1 = pTable1.Search(Query1, False)
```

```
    Set pRow1 = pCursor1.NextRow
```

```
Do While Not pRow1 Is Nothing
```

```
    s = 0
```

```
If pRow1.Value(pTable1.FindField("Direction")) = 0 Then
```

```
    If pRow1.Value(pTable1.FindField("F_Node")) = pathe(lo + 1) Then
```

```
        If pRow1.Value(pTable1.FindField("T_Node")) = pathe(lo) Then
```

```
            Set pQueryFilter = New QueryFilter
```

```
            pQueryFilter.WhereClause = "OBJECTID=" & pRow1.Value(0)
```

```
        If NB = 0 Then
```

```
            Set pFeatureSelection = pFeatureLayer
```

```
            pFeatureSelection.SelectFeatures pQueryFilter, esriSelectionResultNew, False
```

```

        NB = 1
    Else
        If s = 0 Then
            Set pFeatureSelection2 = pLayer1
            pFeatureSelection2.SelectFeatures pQueryFilter, esriSelectionResultAdd, False
            MsgBox pRow1.Value(0)
            s = 1
        End If
    End If
End If

End If

End If

=====

===

If pRow1.Value(pTable1.FindField("T_Node")) = pathe(lo + 1) Then
    If pRow1.Value(pTable1.FindField("F_Node")) = pathe(lo) Then
        Set pQueryFilter = New QueryFilter
        pQueryFilter.WhereClause = "OBJECTID=" & pRow1.Value(0)

        If NB = 0 Then
            Set pFeatureSelection = pFeatureLayer
            pFeatureSelection.SelectFeatures pQueryFilter, esriSelectionResultNew, False
            NB = 1
        Else

```

```
If s = 0 Then
    Set pFeatureSelection2 = pLayer1
    pFeatureSelection2.SelectFeatures pQueryFilter, esriSelectionResultAdd, False
    MsgBox pRow1.Value(0)
    s = 1
End If
End If
End If
End If
End If
```