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Mobile Robot Navigates Based on Geographical Information Systems

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Abstract: - The article focuses on importing geographic data from base maps and is modified in several stages, including correction and geographic reference, designing geographic data and its accurate projections on the map, and others. Since the mobile robot moves using different theories, including the shortest path and overcoming obstacles, the research paper focuses on designing the movement path of the mobile robot through high-definition inspection of the geographic map and drawing the best and shortest path for the robot by integrating the indicated data to be transmitted with a special code written in the C language and within the virtual environment of the program. MATLAB then moves the robot straight to the desired destination and plots its movement on the MATLAB simulation platform to closely inspect how the mobile robot behaves and monitor its movement. From the above, we will briefly explain two works, the first related to the geographical network, and the other related to the mobile robot and its movement on the geographical data of the network.

Keywords: GIS network: geographical Network, mobile robot: robot type chassis, ARCMap: Programe product by Esri Company, Spatiaal Database: database with longitude and latitude

Introduction

Our research focuses on the movement of wheel motors relative to signals received from the geographical network to DC motors through a tiny GPS module. These signals will represent the precise geographic coordinate extracted after several procedures are followed in geographic systems, such as using base maps and correcting the geographic layers necessary to determine the desired location and right map geo referencing. The figure (1) shown explains the procedure of our project which is divided into two sections GIS and mobile robot.
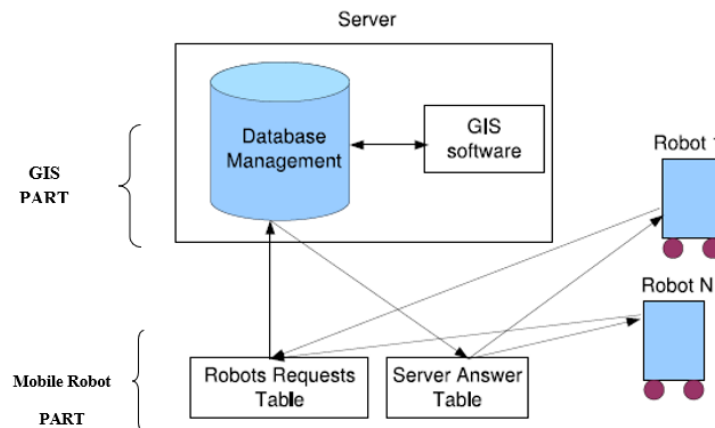

Figure (1).Brief work for both the GIS and mobile robots of the project [1].

1-Geographical information system part

In the GIS section, we will give an overview of the following topics in relation to the requirements of the research paper

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1-1.   Design and execute The GIS NETWORK

Human information needs a geographic coordinate to be transformed into geographic information [2]. Crisis management, such as preparation, recovery, and mitigation, depends on technologies and geographic information [3]. Through computer networks, people can communicate with each other from different places. Connecting computers to a secured network requires many special devices and software such as routers, switches, servers, the carrier medium, and the protocols used (IP and TCP/IP) and others. As it is known, programs that provide a computer network environment or programs that have server and client software. The server program is installed in the network's servers, and the client program is installed in the network's personal computers. For example, in geographic information systems programs (ArcGIS for the server), it is installed in the servers and connected to the personal computers on which the personal ArcMap program is installed. So we have what is called a geographical network, which consists of a program on the server (ArcGIS for the server) and a program (ArcMap) in personal computers that is connected to the ArcGIS server in the server [4]. The requirements for a geographic network can be summarized in figure (2) and figure (3) [2].
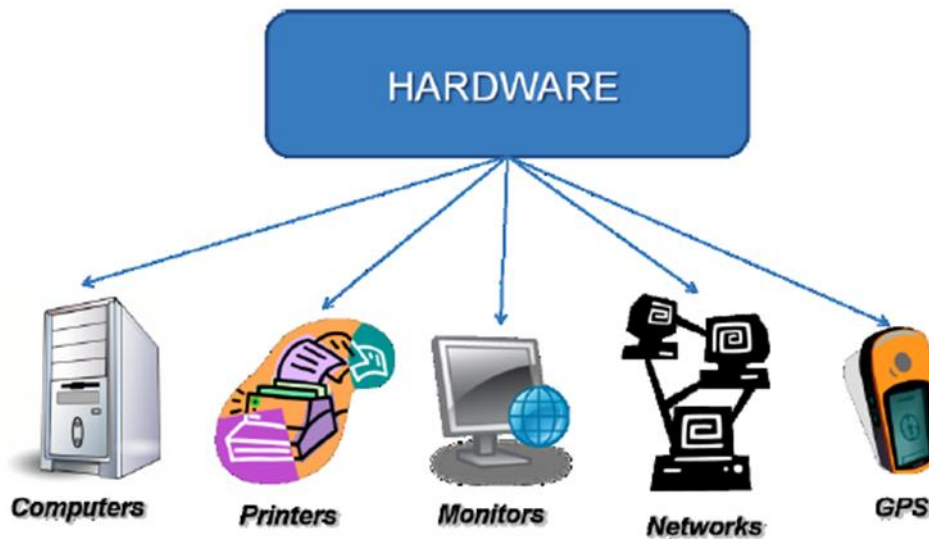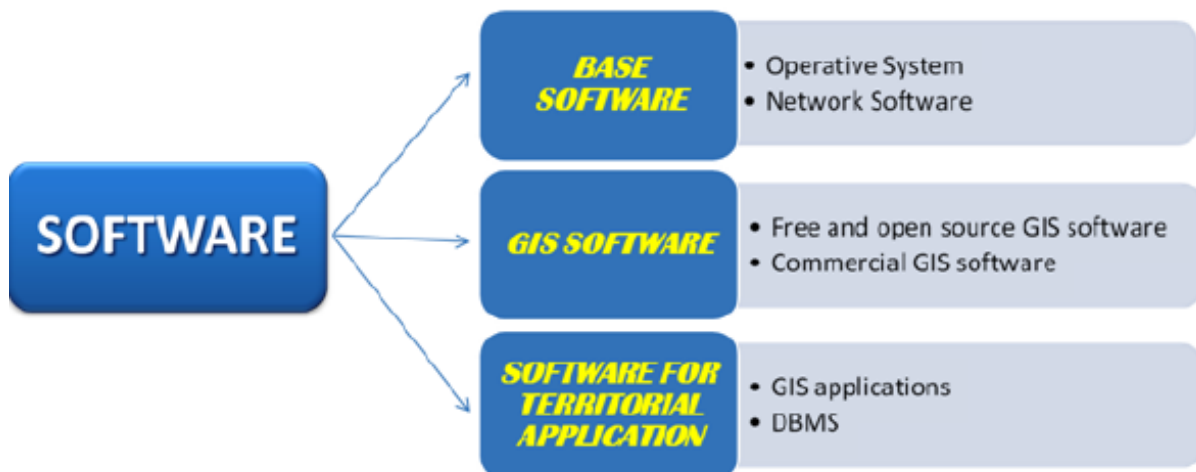

Figure (2). Requirements (H/W) for GIS_Network [2].

Figure(3). Requirements (S/W) of GIS_Network [2].

1-2.   ArcGIS for Server

The main program for the geographic network, through which web and desktop applications are developed, in addition to data management and analysis, image sharing, and geographic electronic services for all users of the geographic network with high flexibility. Geographic information is designed on personal computers using ArcMap and uploaded to the cloud using ArcGIS for the server [3].The GIS environment varies depending on the designer, some of which are based on the Internet and some of which are implemented without the Internet. If there is no need to share data outside the local environment, then a desktop application of GIS is better for storing geospatial data, which leads to all users connecting to the same data at the same time. One but the current culture prefers remote work to be able to access data anywhere and anytime. Hence, it has become necessary to share data to the cloud or to the web services of the internal network. The typical structure of the server or cloud includes the following parts (geographic database, file storage, geographic systems servers Cloud services servers store cloud data and client applications). Client applications include everything related to desktop applications and mobile applications to web-based services. The figure (4) showed the network of GIS.
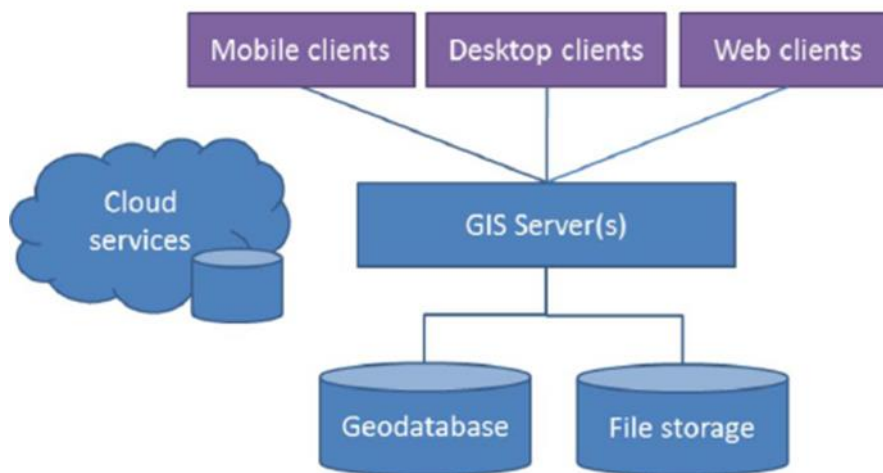

Figure (4). Typical GIS architecture [5].

1-3.   ARCMap 10.x

  Geographic systems programs can be divided into two parts based on their use, which are creating maps and solutions for browsing these maps. One of the important programs recently presented by esri Company is the ArcMap program, which is considered a wonderful qualitative leap from desktop applications, and one of its important functions is the creation of geographical databases of various types, including point, Line and polygon while browsing the map through web applications or mobile phone applications. The map is created by specialists and professionals in the use of geographic information systems, in addition to the skill in using computing. For example, creating and designing geographic data, researching it, drawing maps, conducting spatial analyses, working on various projections, and dealing with large-sized data. All of these tasks fall on the user. Desktop programs that ArcMap deals with are highly flexible, while the designed data is published through the web browser, and this is what the client does not deal with. The ArcMap applications are installed on the desktop on the end user's personal computer. Therefore, some recommendations must be taken into account regarding the requirements for installing the program, including operating systems, security settings, and other local settings. Manual installation is the most successful for deploying desktop applications. The MXD document is the basic document for the ArcMap program, which contains all the geographic information that will be published by the ArcGIS Server as a service [5]. Figure (5) gives steps for creating and publishing the service after designing it by ArcMap and then publishing it through the ArcGIS server [5].
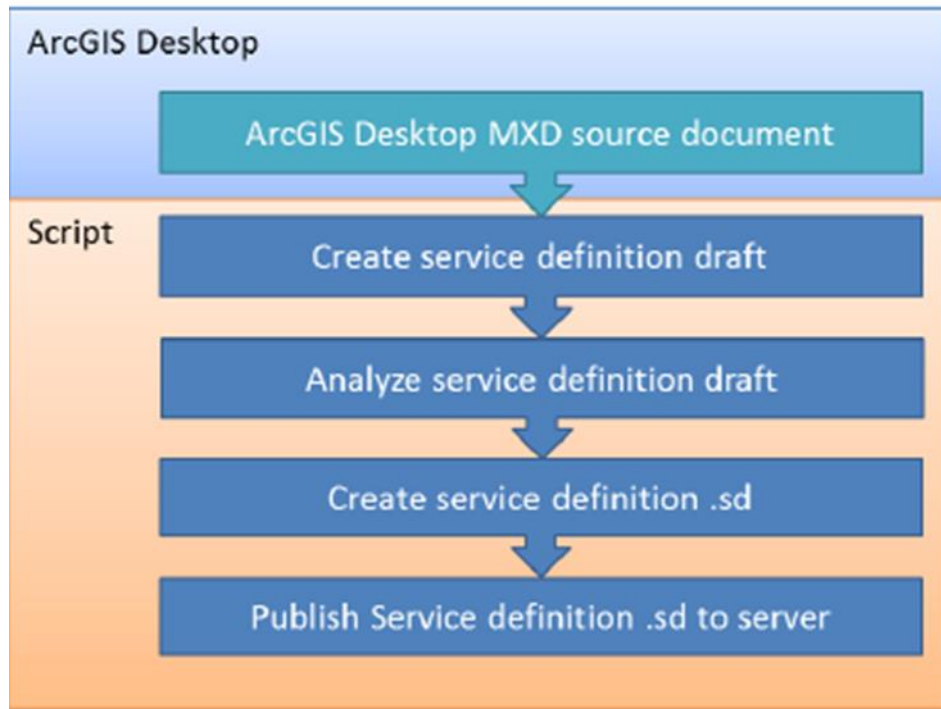
Figure (5). Service publishing steps [5].

1-4.   Spatial data base

In the geographical network, data management and the rules associated with it are given special importance. The difference between data management and databases is that the latter is concerned with managing the external database system (DBMS). Geographic information systems programs, including the most important of them (ArcMap), are considered database search engines capable of creating geographic data and processing them with non-geographic data. Therefore, a synonymous term known as GeoDBMS (Geographic Database Management System) is used. Geographical data is divided into three sections, as shown in the figure (6), which are raster, vector, and spatial data. All types of data within the GIS platform are handled, displayed and shown with a structure of overlapping layers as shown in figure(7) in which each layer can be used and represented separately [2].

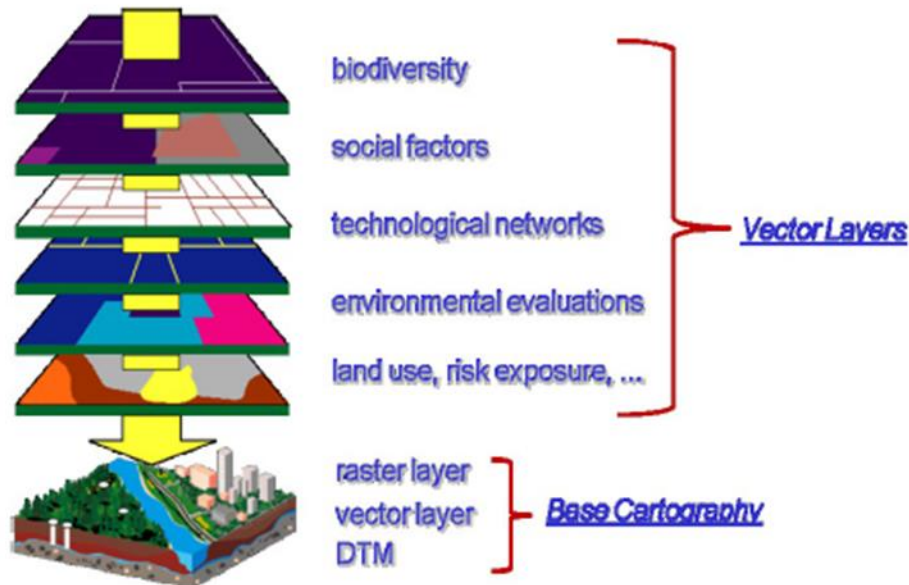Figur (6) Different type of GIS data [2].

Figure (7). Data within the GIS platform organized in separate layers [2].

2- <u>The Mobile robot part</u>.

 In the Mobile Robot section, we will cover the following topics

2-1.   <u>Mobile robots with GIS concept</u>.
Advanced global technology is interested in integrating the robot with geographic information through several methods, including through sensors with different functions, such as the GPS sensor that determines the geographical location and moves the robot based on that location, as well as cameras, etc. The professions of these companies, for example, are Precision Agriculture, which used what was mentioned about the agricultural harvesting machine [6].

2-2.   <u>Mobile robot & Geographical information system</u>.

In studying the theories of mobile robots and geographic systems, in this chapter we will study some of the theories that combine the two fields (mobile robot and geographic information systems) and how the robot moves based on different maps. There is a lot of research that talks about the necessity of the robot knowing the external environment in which it moves. It has several benefits, including avoiding obstacles or reaching the goals set for it, and many others, and this is done through the various sensors that are included in the robot (2).

2-3.   <u>MAP in robot</u>

Mapping is one of the necessary tasks for robot movement, in order for the robot to discover the semantic environment in which a single robot moves, as in the figure (8), and in order to build its semantic map, it requires two things. . The first is to obtain and process data the second is data representation With regard to obtaining data, it is divided into two parts: geometric data and semantic data. As for the engineering data that the robot obtains from the sensors associated with it, which is numerous, such as various types of sensors and geographical positioning devices. As for semantic data, it can be obtained through several sources, including extracting important features from sensor data and integrating them through HRI. The task of representation is to organize the geometric and semantic shapes of this data so that it is arranged in the form of a map so that the robot can understand the environment in which it moves [7].
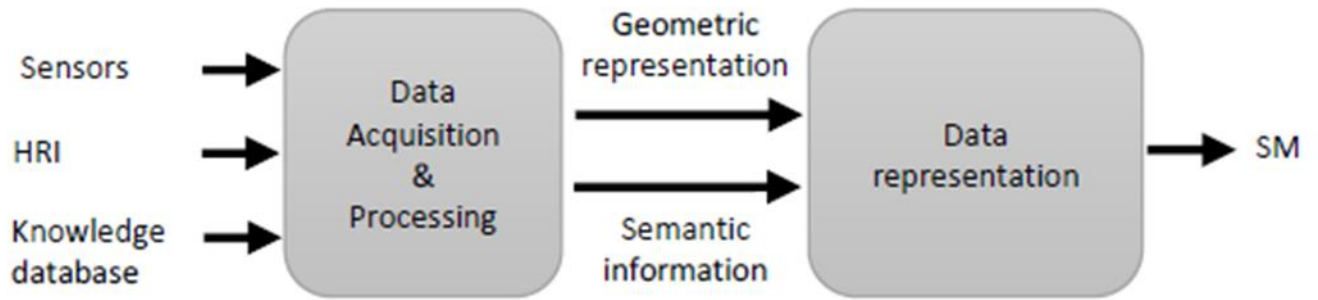
Figure (8). The single-robot semantic-mapping process [7].

2-4. Connect between Mobile robot and GIS Network (From mobile robot to GIS) .

   Work similar to our research is the research paper in Reference No. (1), where the work of this paper depends on receiving geographical coordinates from the geographic network servers to the mobile robot, but the difference is that the movement of the robot is through the robot's request for a specific map from the network and then the movement. As for our project The movement is done by drawing a path or specifying a point on the geographical map accurately corrected in geographical systems programs (Arc Map), and then the movement begins. In short, our research focuses on programming the movement starting from the geographical network.

2-5. Connect between Mobile robot and GIS Network (Form GIS to mobile robot) .

 Geographic network servers contain carefully designed maps related to the geographical environment in which the robot is located. These maps are translated into a format that the robot understands, for example, programming the route that must be followed, specifying a destination point, or providing maps of nearby places. The robot's map that it obtains is by converting the geographic systems file into a text file as in Figure (7) through the software code used in the mobile robot. Since geographic information works in the form of layer systems, the layers are sent separately to the mobile robot based on its requests [1].

```
border;
-4;100;
100;-4;
#
obstacle;
1;1;4;column,A5;
#
4.53;12.10;
7.29;12.10;
5;1;wall,orange,brick;%11
#
obstacle;
110;2;1;wall,A4;
#
-3;0;
-4;0;
1.2;1;wall,grey,cement;
#
```

Figure (7) Generated text file containing the map in a robot understandable [1]

Figure (8).mobile robot type (Chassis) [8].

2-5-1   Import Geodatabase (point) to robot.

   The second type of geographic data imported from the geographic network, which was practically used as a destination for the mobile robot, is the raster data, which was written in the Arduino code in the form of an accurate geographic coordinate produced after correcting the base maps in the geographic network.

2-5-2   Import Geodatabase (polyline) to robot.

   After working on the geographical network, we chose the robot's movement to be based on two types of geographical data, as mentioned previously. The first is for the robot to move from the source to the destination based on geographical coordinates determined after zooming on the map to reach the accurate coordinates for the robot's movement. It must be noted here that using A point in the form of a geographical coordinate to be a direction for the robot's movement requires making other settings, such as choosing the best path, and this also requires connecting several devices, such as the ultra-sonic sensor to avoid obstacles on the way and other matters and theories, which are many, but the research point focused on the necessity of reaching the goal (the specific coordinate). With geographical maps and we leave it to the future work of the researcher to add what he deems appropriate to his design in the movement of the robot.

2-5-3   Move mobile robot type chassis according to Geodatabase in both polyline and point.

   The theoretical implementation of the robot's movement along the path imported from the base maps of the geographic network using the MATLAB and Python simulation platforms, as indicated by the figure (9) mentioned above proved successful by clearly examining the robot's behavior along the geographical path. All of what was mentioned was done through a special code written in the C language for the MATLAB program. The robot moved on the same path on the Python platform, crossing an obstacle determined by a geographic coordinate. It was also imported from geographic maps if it was inspected on the high resolution of the geographic information of the network.
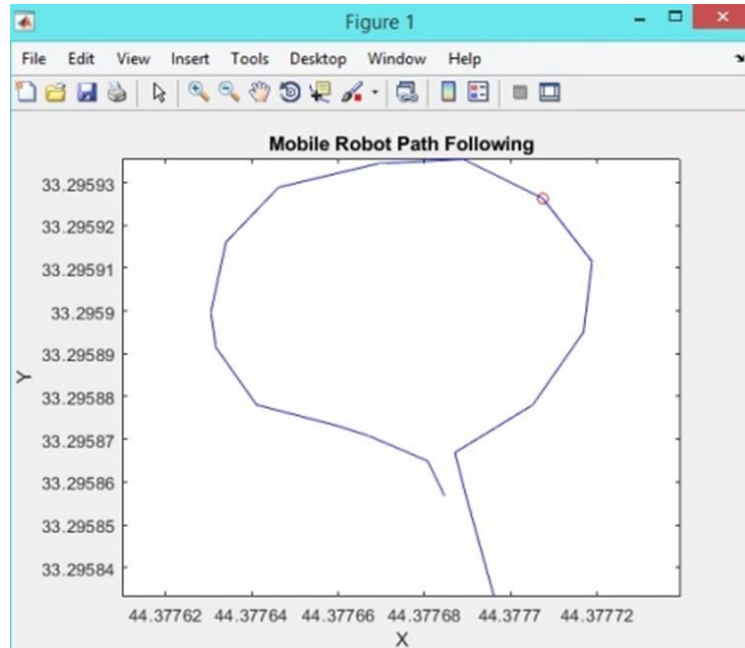
Figure (9) Matlab plate form of Robot navigate according to geodatabase (polyline)

3-<u>Experimantal work</u>

The practical aspect is summed up in implementing the robot's movement using both theories for importing geographic data (polyline and point).

3-1 <u>Navigate according to geodatabase (type point).</u>

  After implementing the geographical network as shown above and making accurate geographical correction of the base maps, a geographical coordinate will be determined to be the next destination for the robot's movement, and the following code written in the Arduino Uno ensures the practical movement of the robot to the coordinates indicated in the code, as in the following practical images as the experimantal figure (10) shown below.

Figure (10) Mobile robot navigate to this coordinates destination (44.377098, 33.295803)

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