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Finding the Best Route for Connecting Citizens with Service Centers in Baghdad Based on NN Technology

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Abstract

A geographic information system (GIS) is a very effective management and analysis tool. Geographic locations rely on data. The use of artificial neural networks (ANNs) for the interpretation of natural resource data has been shown to be beneficial. Back-propagation neural networks are one of the most widespread and prevalent designs. The combination of geographic information systems with artificial neural networks provides a method for decreasing the cost of landscape change studies by shortening the time required to evaluate data. Numerous designs and kinds of ANNs have been created; the majority of them are PC-based service domains. Using the ArcGIS Network Analyst add-on, you can locate service regions around any network site. A network service area is a region that comprises all accessible roadways (that is, routes that are within defined impedance) (that is, streets that are within specified impedance). In contrast to the Google Maps application, the 5-minute service area for a site on a network comprises all streets that can be accessed within five minutes.

Keywords: Service area, Path finding, Artificial neural networks (ANNs), Geographic Information System GIS, Remote sensing.

نظام لأيجاد الطرق في محافظة بغداد باستعمال تقنية الشبكة العصبية

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الخلاصة

يعد نظام المعلومات الجغرافية أداة قوية للغاية لإدارة وتحليل بيانات المواقع الجغرافية. ثبت أن الشبكات العصبية الاصطناعية (ANNs) مفيدة في تفسير معلومات الموارد الطبيعية. تعد الشبكات العصبية ذات الانتشار العكسي واحدة من أكثر البنى شيوعًا والأكثر استعمالاً. يوفر تكامل أنظمة المعلومات الجغرافية والشبكات العصبية الاصطناعية آلية لخفض تكلفة تحليل تغيير المناظر الطبيعية عن طريق تقليل مقدار الوقت الذي يقضيه في تفسير البيانات. تم تطوير العديد من البنى وأنواع شبكات ANN ، والعديد منها عبارة عن منطقة

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خدمة قائمة على الحاسوب باستعمال ملحق ArcGIS Network Analyst ، يمكنك العثور على مناطق الخدمة حول أي موقع على الشبكة. منطقة خدمة الشبكة هي منطقة تشمل جميع الشوارع التي يمكن الوصول إليها (أي الشوارع الواقعة ضمن مقاومة محددة). تظهر النتائج التجريبية الحالية أن منطقة الخدمة التي تبلغ مدتها 5 دقائق لنقطة ما على الشبكة تشمل جميع الشوارع التي يمكن الوصول إليها في غضون خمس دقائق من تلك النقطة مقارنةً بتطبيق خرائط Google.

1. Introduction

Artificial neural networks (ANNs) are potent tools that solve numerical input-output problems using a machine learning technique. ANNS are used in a range of fields, including law enforcement agencies, engineering service networks, and medical care services [1]. Recent years have seen a tremendous growth in the usage of neural networks owing to improvements in computer speed and the greater availability of robust and versatile neural network software [2]. ANNs are created to replicate neuronal activities in order to gain high parallel processing capabilities. Typically, ANNs are composed of several basic processing units that are interconnected through a sophisticated communication network. Each unit or node is a simplified representation of a real neuron that fires (transmits a new signal) when it gets a sufficiently strong input signal from the other nodes to which it is connected. The strength of these connections may vary, allowing the network to carry out a variety of tasks according to distinct patterns of node launch activity [3]. The current research work system is used by sending the requested site with specific type coordinates and in a specific way to the center, establishing the closest path between the patrol or the hospital and the desired site, and informing the sender of the site. What is required is to move as soon as possible to the specified place and help save the life of the person requested.

The main objective of this paper was to study and test the shortest path algorithm that will be used in ArcGIS 9. The shortest route problem is a basic combinatorial optimization issue that arises in a variety of planning and design situations. This article describes a neural network approach for resolving shortest route issues. The fundamental concept is to replace the shortest path issue with us and appropriate algorithm support in ArcGIS 10.8, map roads, and center location. Baghdad suffers from traffic jams and poor strategies for controlling and managing the service. They use the neural network to build a service area to find the areas the service does not cover, find the shortest path to lead to the cases, and do the job in perfect time.

The contribution of the current research work is in collecting data, projecting it onto accurate coordinates of the Baghdad map, and linking service centers using an important mathematical tool (Neural Networks Algorithm Technology).

1.1 Related Works

There are many differences between previous research and the current research, which could be summarized as follows:

• In 2017, Shao et al. [3] presented a time-delay neural network for the solution of the time-dependent shortest route issue.

• In 2021, Mittal et al. [4] will demonstrate how a graph network with attention read and write may conduct shortest route computations using neural networks. After a little training, this network completes the job with 100 percent accuracy.

• In 2021, Kim et al.'s [5] detection may solve the issue of the shortest route. A neural network with recurrent connections for solving the shortest route problem.

1.2 Methodology

The way the overall research works is to adopt an application in the future that works using GIS maps but works in a different form using Wi-Fi. The application is made in the form of maps loaded in advance, and by using the application feature with one click, the required location coordinates are sent to the center of origin by covering the towers of the regular communication networks with a lower-cost message than the regular paid message. After the nearest and shortest route is established between the site and the responsible party, assistance is sent to the designated site, and a notification is sent from the main center. A service is provided, and the case is saved as soon as possible. This is less expensive and more accurate. Adopting methods different from the existing ones in countries around the world is to adapt to the current situation the country is going through and to find creative, new, and exceptional ways to take the circumstances into account [6].

2. Study area

Baghdad City is located at 33.33333°N 44.43333°E and 38S 377438.49560684 3676550.0895564 in the UTM map project, in the middle of Iraq, which has a very strategic location and has a very high population. This makes it a challenge to do the service for police stations, fire stations, and hospitals to reach the cases in an area that reaches 204.4 kilometer squares. The service should cover all the area of Baghdad City in this feature, which has not been covered enough until now, in the hope of developing these services to cover more area in the short time it takes. Figure 1 shows the study area [4].

Figure 1: Study area of Baghdad city and all map information used in the current research work .

2.1 Data Sets

Collecting data is one of the problems facing the current research work, and it is hard to find accurate data for the locations of the data, so instead the data locations are collected from many sources like Google Earth, which allows to build a geodatabase with this information about locations. Before NASA and the USGS launched the Landsat 8 satellite, Google used some images from Landsat 7, which had a hardware problem that caused diagonal gaps in the images [6].

Data collection is an open-source application created with the ArcGIS Runtime SDK that enables users to browse and update geographic data online and offline. Utilizing a web map, geographical information is accessible. Users may add, update, and remove geographic data while the application is disconnected from a network. When connectivity is restored, offline work may be synchronized with the online map. It was collected from Google Earth and Map.me and used for police stations, emergency services, and hospitals using the base map (WGS84). The study area is Baghdad City, located Latitude and longitude coordinates are: 33.312805 and 44.361488.

2.2 Data Service areas

Network analyst service zones also aid in evaluating accessibility. Concentric service zones demonstrate how accessibility differs depending on the impediment. After creating service areas, you may utilize them to determine how much land, how many people, or how much of whatever else is in the neighborhood or region [ESRI software]. In ArcGIS Network Analyst, a form of network analysis that identifies the area, including all accessible streets (streets that lie within a specified impedance), for instance, the 20-minute service area for a network point such as a fire station covers all streets that may be accessed within 20 minutes. Karaada, Shaab, Mansour, and Rusafaa are very densely populated neighborhoods of Baghdad. [https://store.usgs.gov/product/114515]

3. Research Methodology

3.1 Shortest Path finding

Finding the shortest route between two places is a typical sort of network analysis. In a network of streets, "shortest" may refer to a variety of characteristics, including distance, duration, and cost. An ambulance driver seeking the quickest route to his destination will choose the route that will take the least amount of time to go from point A to point B. Using the trace tool's “shortest path” trace type, the shortest route between two beginning locations may be determined. The shortest route is computed using a numeric network parameter, such as shape length, to determine its length. The shortest route trace may be used to attain cost- or distance-based pathways. The current proposed research procedure involves the following steps:

1. Data Collection and Preparation.
2. Study area image preparation.
3. Geodatabase building and feature class creation.
4. Identify their locations on the map and perform georeferencing for each of the data points.
5. Classifying the data into many classes to make the work easier.
6. Using the street map as a base map for the research.
7. Preparing a road map to build the network.
8. Creating an ANNS on the data and street map.
9. Do the experimental work on this network and build the service area.
10. Evaluating the results and identifying the problems discovered.
11. Make a set of recommendations and solving problems steps to make the program success.

3.2 Artificial neural networks (ANNs) and GIS

Actually, GIS and ANN are technological fields that incorporate geographical features with tabular data in order to map, analyze, and assess real-world problems. The key word for this technology is geography, which means that the data or at least a portion of the data is spatial or that it is in some way related to locations on the earth. Coupled with this data is usually tabular data known as attribute data. The broad definition of “attribute data” is descriptive information about each of the geographic characteristics. An example of this would be schools [7]. The geographic data consists of the actual locations of the schools. Attribute data would consist of

descriptive information such as the school's name, degree of education provided, and student capacity. The combination of these two data sets is what makes GIS such a powerful problem-solving tool via spatial analysis. The GIS functions on several levels. GIS is used at its most fundamental level as digital cartography, i.e., mapping. Utilizing spatial and statistical approaches to analyze attribute and geographic data gives GIS its true strength. Analysis may provide derivative information, interpolated information, or ranked information.

Adaptive neural networks The ANN can detect complex patterns within the databases that the arithmetic formulas cannot find [8], [9], [10], and [11]. In addition, it produces quite accurate forecasts, even for noisy data. Therefore, this form of network is capable of providing very accurate sets of classified characteristic points resulting from complicated interactions. This network must be trained to generate a network structure depending on the chosen study metrics. Network training requires an appropriate selection of training criteria [11], [12], and [13]. The most significant aspect is the network's efficiency, which is strongly dependent on the training method and network design.

3.3 ANNs Framework

A fundamental artificial neural network is a logical progression from the perceptron. A feed-forward neural network is a multi-layer perceptron, often known as a "basic neural network." This would include Figure 2:

•Hidden Layers
•Bias Units
•Neurons(input, output and perceptron)
•Synaptic weights
•Activation Function

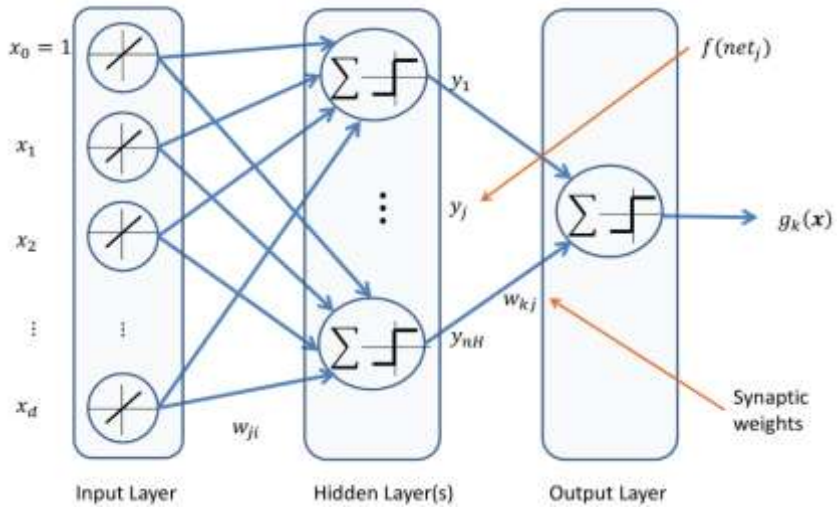

Figure 2: ANNs Framework.[14]

Any neural network's objective is to estimate a function f that provides an estimate for a set of outputs given a set of inputs.

The neural network described above is known as feed-forward since there is no output-to-input feedback, unlike the recurrent neural network. Input is multiplied by weights, bias is added, and then it is activated. Then, Eq1 determines the neural network:

$$net\ j\ = \sum_{i=1}^{d} x_i w_{ij} + w_{j0}\ = \sum_{i=0}^{d} x_i w_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$
$$\Longrightarrow\ y_j = f(net_j)$$

When f refers to the activation function, it becomes:

$$net_k = \sum_{j=1}^{nH} y_j w_{kj} + w_{k0} = w_k^t y \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This refers to the number of perceptrons.
Hence, the output neurons, derived as:

$$z_k = f(net_k) = sgn(net_k)$$
$$\Rightarrow z_k = f(\sum_{j=1}^{nH} w_{kj}\, f\left(\sum_{i=1}^{d} x_i w_{ji} + w_{j0}\right) + w_{k0})$$

The main methodology of this research lies in the use of a lot of data and the technique of analyzing road networks in geographic information systems, where the data of all hospital locations in the governorate of Baghdad and many police, security, and defense centers have been identified as they were set on the map. The information was taken from many data sources and used the base map streets from ARCGIS to identify the locations, starting with governmental and private hospitals, police stations, and civil defense, using very accurate grid streets for the area placed on the map, and using the artificial neural network for network analysis to find the shortest path between two points and the shortest time. This found the shortest path between the civilian and the service by building a service area around the address of the current point. In this way, using ARCGIS to calculate the time and path,

When trying to automatically locate directions between two physical places, such as driving instructions on online mapping services like MapQuest or Google Maps, shortest path algorithms are performed. These algorithms are used to identify the quickest route between the two locations. There are quick, specialized algorithms available for use in this application. If one represents a nondeterministic abstract machine as a graph, in which vertices describe states and edges describe possible transitions, then one can use shortest path algorithms to find an optimal sequence of choices to reach a certain goal state or to establish lower bounds on the amount of time required to reach a given state. This is possible if one imagines the machine as a nondeterministic abstract machine that is represented as a graph. For instance, if vertices represent the states of a Rubik's Cube-like puzzle and each directed edge corresponds to a single move or turn, shortest route methods may be used to discover a solution that requires the fewest feasible movements. The use of neural networks for the routing issue was prompted by the desire to take advantage of the neural network's great computing capabilities and the fact that a neural network implemented in hardware may achieve rapid reaction times. Optimal routing is addressed in certain neural network applications for high-speed communication networks. The use of neural networks to handle the issue of call admission control and routing in high-speed networks was also studied.

4. Experimental results

In order to apply these trials to the study region and determine the shortest route between the police station and the hospital, an artificial neural network constructs the shortest route based on the required time. Figure 3 depicts the research area and the quickest construction route.

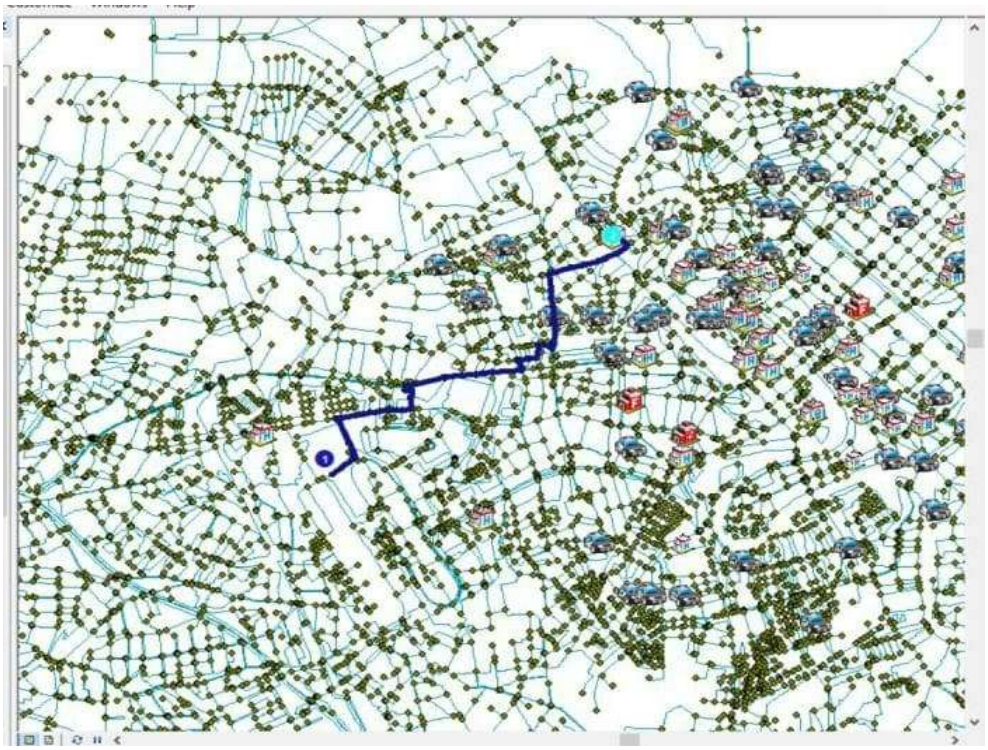

Figure 3: shortest path map of the study area.

In figures 3 and 4, the shape  represent hospitals , the shape  represent police stations and the shape  represent fire stations.

To build the shortest path, the steps written using ArcGIS are:

- Click New Route on the Network Analyst toolbar after clicking Network Analyst. Click Stops is chosen in the Network Analyst box, indicating that it is the current network analysis class.
- Click the "Create Network Location Too" button in the Network Analyst toolbar. With the Create Network Location Tool, you may add network analysis objects to the current network analysis class by clicking on the map.
- Click anywhere on the network of streets to set a new stop.
- ArcGIS Network Analyst computes the closest network location and represents it with a located symbol. The stop will stay chosen until another stop is added or the selection is cleared.
- Additionally, the nearby stop shows the number 1. Each stop is assigned a unique number that indicates the order in which it will be visited by the route. Also see that the Network Analyst window's Stops class now has a single stop.
- Add two more stops somewhere on the street or nearby.
- By selecting the start and end points, click on "solve" in the network analyst toolbox to build the shortest path between the points we used.
- Using the artificial neural network in further tests by picking the fire station sites and establishing a service area around each one. The map shown in Figure 4 represents the areas that are covered by them.

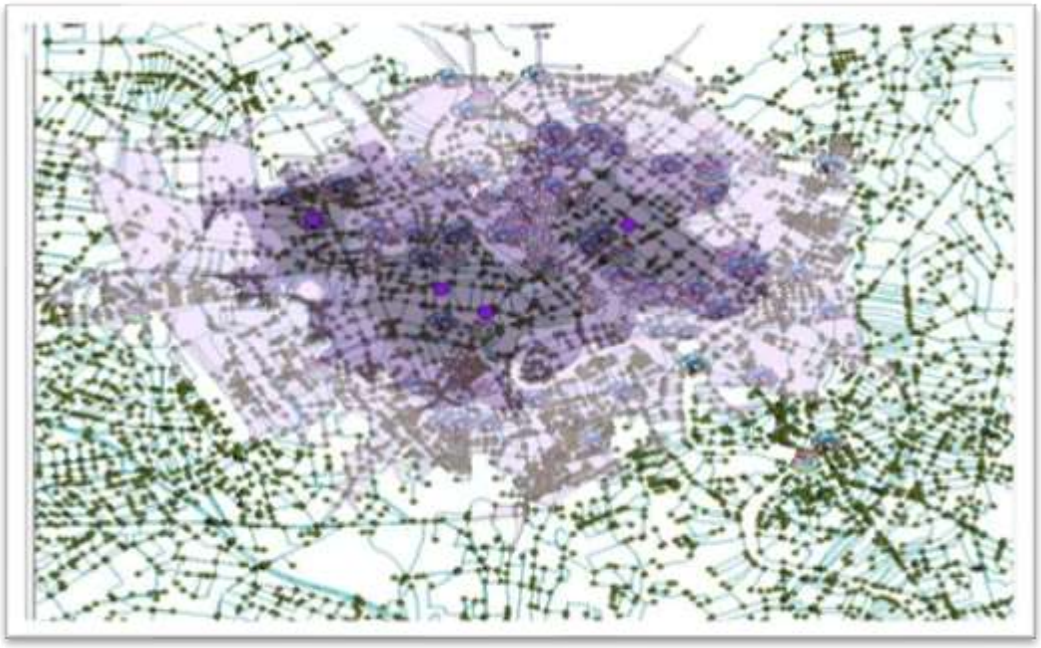

Figure 4: The map shows the study area need more fire stations to cover all the city of Baghdad.

As shown in the map, the area is divided into regions based on the time they reach these areas. It appears that there are large areas around the fire stations that are not covered at the specified time. Obviously, this shows the study area needs more fire stations to cover the entire city of Baghdad. To show another experiment, we took the governmental hospitals in the study area and analyzed their distribution in the area to find their coverage area in the city and whether they needed more hospitals to serve the city (Figure 5).

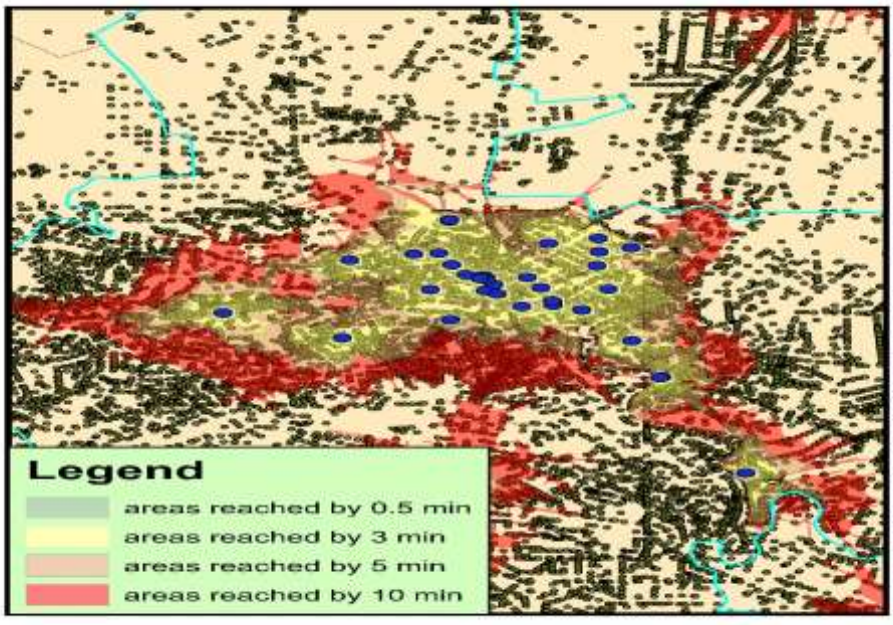

Figure 5: hospital distribution in study area

The study showed that there is a concentration of hospitals inside the city, which is a very good indicator for serving the areas, and it also shows a poor distribution in the other areas, since there are areas that do not contain any hospitals and depend only on the healthy centers, like the outskirts of the city.

5. Conclusions

Using Hopfield neural two-layer networks, an efficient solution is presented for the shortest route issue. This method tries to increase the number of successful and valid convergence procedures, one of the primary constraints of earlier neural network-based systems. In addition, it needs fewer neurons. Experimental findings demonstrate that the primary objective of network design is to produce high reliability; that is, it delivers successful and almost accurate convergences at the price of results, which is a drawback of this technique.

There are two unresolved concerns that need more research: first, the convergence of findings without optimization; and second, the capacity to adapt to changing external variables, especially for varied graph topologies, which are essential for attaining the suggested architecture.

For example, in the current research work, indexing techniques will be used to facilitate queries. For example, the current algorithm needs more time and thus will reflect negatively on larger graphs.

6. Recommendations

The integration of Geographic Information Systems (GIS) for the development of spatial predictor drivers and performing spatial analysis of the findings offers a means to lower the cost of analysis for short route discovery. For ANN training, it is essential that the patterns also specify the range of allowable output values. In order to generate an output map from the interpretation supplied by the trained ANN, the result must be converted back into GIS (often as a polygon coverage). Using this map, Using the neural network algorithm in a program that combined geographic information in version 10.8, when using an image of the base map and identifying the data on this map, an ideal program was designed to determine the nearest point to the target or reach it in the shortest time and at the lowest cost. Despite the absence of nationwide internet connectivity in Iraq, regular communication towers are utilized to connect the country's hospitals, police stations, military bases, and emergency medical care hubs. Coverage is approved, and the site is sent from the mobile phone to the information center to cover the case. The purpose of the method is to increase public awareness, facilitate access to emergency situations, establish special projects to contract with the competent authorities to provide service, and establish a private sector for geographic information systems, which is the first of its kind in Iraq. The idea behind this research is to create an integrated service center using geographic information systems. The system uses geographical maps and adopts the road network analysis technique to find the best and fastest route between two modern sites intended to deliver assistance to the site in need. The proposal aims to improve security and medical services, provide assistance to those in need, and reduce time and cost.

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