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Network Analysis for Finding Shortest Path in Hospital Information System

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Abstract:As the population increases, the transport network becomes complicated and massive. Finding desired location is becomes difficult task. After finding a location people gets confused to reach that location because of the routes comprised a different mode. This problem is even more important for people who may need to visit unfamiliar parts of the metropolis. In case of the hospitals sometimes it is difficult to find the specialized hospital and its shortest path to reach hence takes more time to reach it. In this study, we tried to solve this problem by representing the shortest path facility for finding the nearest location of the hospitals from user's location. We used the ArcGIS software and the Dijkstra's algorithm to provide the shortest path from one location to another.

Keywords: Closest path facility, GIS, Service area analysis, Shortest path analysis

I. INTRODUCTION

A geographic information system (GIS) is a computer system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data[1]. The acronym GIS studies to refer to the academic discipline or career of working with geographic information systems and is a large domain within the broader academic discipline of Geo-informatics [2]. GIS has been used in several areas such as retail site analysis, transportation [3], emergency services, fire, petrol station mapping, and health care planning for the measurement of physical accessibility [4] [5] etc.
The shortest path problem is a problem of finding the shortest path or route from a starting point to a final destination. We use graphs to represents the shortest path problems. it is a mathematical abstract object. It contains sets of vertices and edges. Edges connect pairs of vertices. It is possible to walk by moving from one vertex to other vertices along the edges of a graph. The graph can be a directed graph or an undirected graph. Thelengths of edges are often called weights. Weights are normally used for calculating the shortest path from one point to another point. In order to represent a map we can use a graph, where vertices represent cities and edges represent routes that connect the cities.

II. STUDY AREA- AURANGABAD CITY

Aurangabad is a city located in the Maharashtra State (Fig 2.1). The total geographic area of Aurangabad city is 135.75Sq.Km. It is also called as the city of 54 Gates and the strong presence of these can be felt as one drives through the city. The city is located between 19°53'0"N Latitude and 75°20'00"E Longitude. The city is surrounded with the famous historical places and natural resorts like Ajanta and Ellora Caves (which are UNESCO World Heritage Sites), Bibi-Ka-Maqbara, Panchhakki etc. It is the tourist area where the people around the world come here because of the exotic tourist locations and nature. Aurangabad is one of the fastest developing cities in Asia and it tops the chart among the developing cities. Aurangabad has been declared as Tourism Capital of Maharashtra. By population it is the 5th largest city in Maharashtra, after Mumbai, Pune, Nagpur and Nashik. [6]

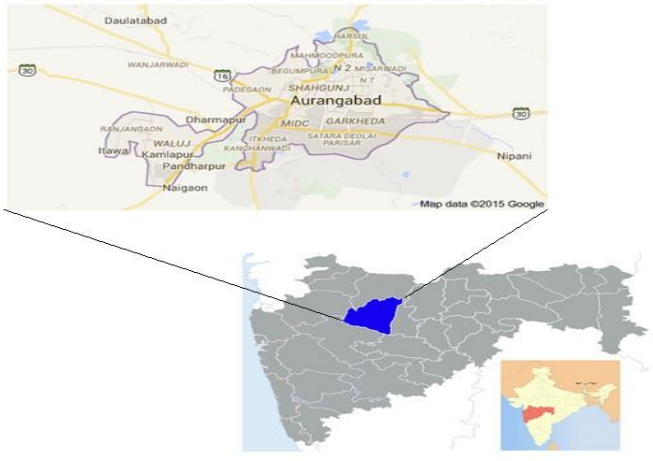

Fig. 2.1:Location of Aurangabad city

III. LITERATURE REVIEW

Md. TaufikLokhmanet. al, in 2012, works on health care facility for Joharbahru city, Malaysia. A network dataset is created from the feature source or sources that participate in the network. It incorporates an advanced connectivity model that can represent complex scenarios, such as multimodal transportation networks. Preparation of the network analyst such as the Shortest Route using Shortest Path tool: the closest facilities using closest facility tool [7].

Tao Peng and Xiaowen Wang, in 2012, [8] works on the project where they used the mobile based navigation web application system. The authors basically works on hinder factors like hospitals, schools, residential areas, traffic lights and the user-controlled factor of traffic and driving speeds for proving route plan, which finds the shortest path and shows he result as online map via web GIS application. The main aim of the project was to use the web GIS and GNSS technology with open source data and tools, to combine web GIS and mobile phones with GPS module for designing and developing a web base application which provides intelligent vehicle navigation system. Authors used Dijkstra's algorithm to find the shortest path.

Ke Huang, Mingqing You (2010) works on the health care information system for china. They proposed a system which works for the coordination of governmental work and promotion of public participation. The technical theories presented in this paper provide a technical solution to the management of environmental health information system. [9]

IV. DESIGN AND DEVELOPMENT

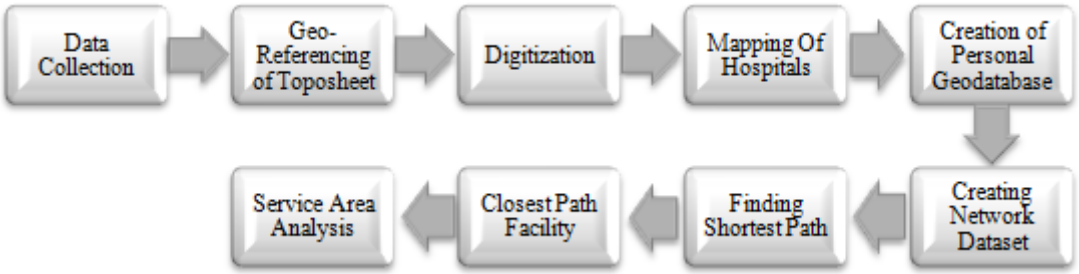

Fig. 4.1: Process Flow Diagram

4.1Data Collection

A. Base Map

It is the first and important step towards the completion of the project. For this work Aurangabad city (19°52′59″ N and 75°19′59″ E) is considered as the study area which is situated in the Maharashtra State of India. Toposheet of Aurangabad city is obtained from the "Government office of Survey of India, Pune", having "Scale 1:50000" traced and scanned, which is considered as the base map for further work (Fig 4.2).

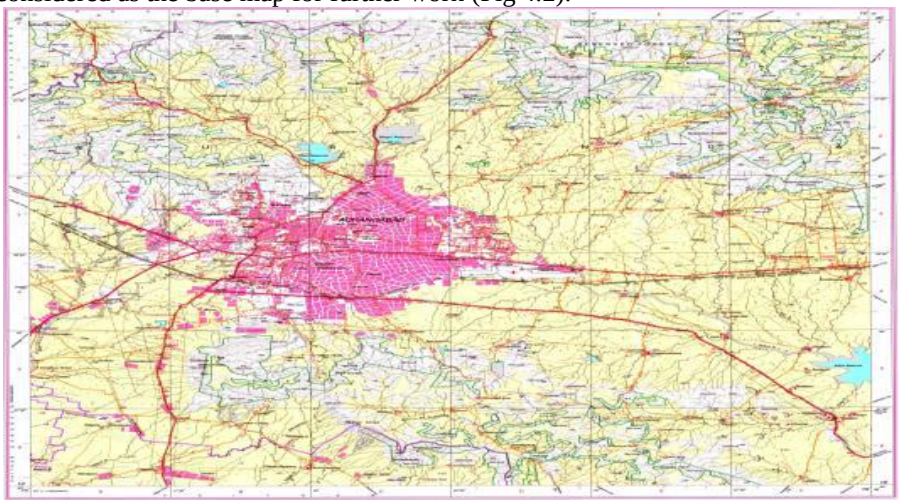

Fig 4.2: Toposheet of Aurangabad City

B. Hospital Data

The hospitals information can be obtained by visiting the desired hospital and taking the important information about the facilities provided number of beds and the specialty of hospitals etc. The attribute data like name of hospital, contact number specialty, site address etc., are need to be stored in the separate database.The data required is in the form of spatial and attribute data. Spatial data required is road network and the hospitals. This spatial data is obtained through the process of digitizing base map of the Aurangabad city.

Attributes taken for Hospitals such as Name, Address, Facilities, Departments, Contact number, Type of the health care provided, email id etc. were collected by surveying of each hospital (Table 4.1). The coordinates of the health care were taken by using Global Positioning System (GPS). For hospitals spatial data, it must be connected to the information services provided at each hospital. Attribute data that need to be stored in the database are roads' name and length and name of hospital and their facilities.

Table 4.1: Hospital Information

Id	Longitude	Latitude	Hospital Name	Type	Address
1	75°20'52.39"E	19°52'09.04"N	DrHedgewarRug nalaya	Multispeciality	GarkhedaRoad,Aurangabad, Maharashtra, 431085
2	75°18'53.44"E	19°51'06.25"N	Kamalnayan Bajaj Hospital	Multispecialty	SataraParisar, Aurangabad, Maharashtra - 431001
3	75°23'16.56"E	19°52'20.55"N	Seth NandlalDhoot Hospital	Multispecialty	MIDC,Chikhalthana Aurangabad-Maharashtra - 431210
4	75°20'52.24"E	19°52'34.92"N	Kodlikeri Memorial's Hospital	Multispecialty	Raghuveer Nagar,Jalna Road, Aurangabad, 431 001
5	75°21'15.06"E	19°52'38.15"N	MGM Hospital	Multispecialty	Mahatma Gandhi Mission (MGM) Aurangabad-431003.
6	75°20'50.65"E	19°52'53.10"N	Apex Super Specialty Hospital	Multispecialty	Basayye Nagar Aurangabad Maharashtra – 431001
7	75°20'41.2"E	19°52'40.8"N	Kodlikeri Memorial Hospital	Multispecialty	8, Manjitnagar, , Aurangabad - 431001

4.2 Georeferencing of Toposheet

Geo referencing process allows registration of the digitized Toposheet on the earth surface[10]. This is very critical stage as the accuracy of the map depends upon georeferencing.

4.3 Digitization

Digitizing converts paper map features into digital format.In this step road network is extracted from Toposheet [11]

4.4 Mapping of hospitals

In this step the coordinates of the hospital is taken by doing field survey. And based upon that coordinates the hospitals are placed on the map as a point feature

4.5 Creation of Personal Geodatabase

Geo-database has been created by integrating actual positions of health care centers (i.e. longitude and latitude values taken GPS) with the health care data collected as shows in Fig 4.3

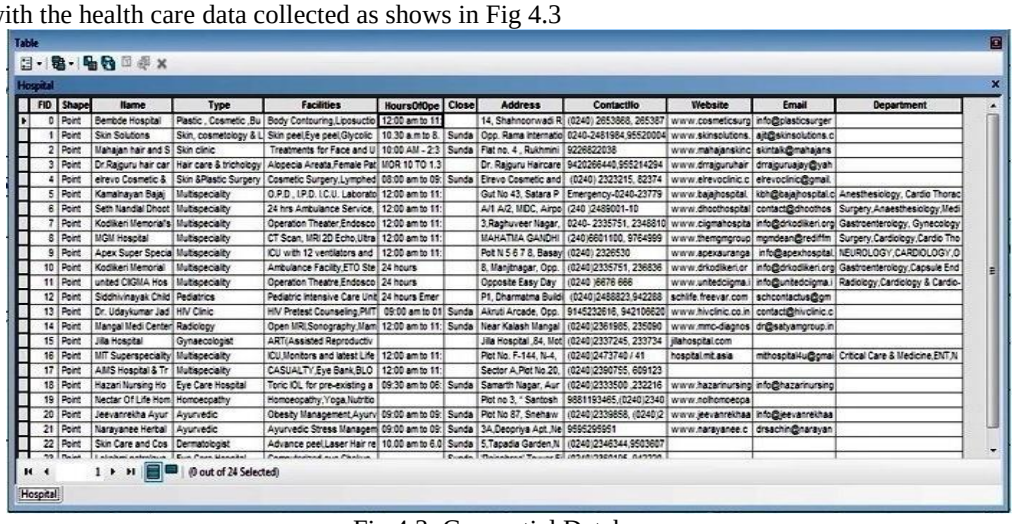

Fig 4.3: Geospatial Database

V. IMPLEMENTATION

For implementation of the project, we used following

1. ArcGIS
2. Dijkstra's algorithm

After the data collection it is important to locate it in the map. The hospital location is carried out using the ArcGIS tool. After hospital location is done it is important to draw a road map. It is also done using the ArcGIS. The Fig. 4.2 shows the Toposheet of the Aurangabad city. When creating a network routing system, specific spatial data were collected for the accurate completion of the network. For example, a complete road network, where all the roads within the network are connected, is significant because it allows connection throughout the system.

5.1 Network Analysis

ArcGIS Network Analyst is a powerful extension of ArcGIS that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis. ArcGIS Network Analyst enables users to dynamically model realistic network conditions, including turn restrictions, speed limits, height restrictions, and traffic conditions at different times of the day.

For the network analysis and finding shortest path we use the Dijkstra's algorithm.ArcGIS Network Analyst allows you to solve common network problems, such as finding the best route across a city, finding the closest emergency vehicle or facility, identifying a service area around a location, servicing a set of orders with a fleet of vehicles, or choosing the best facilities to open or close.

Dijkstra's algorithm is a graph search algorithm that solves the single source shortest path problem for a graph with non-negative edge path costs, producing a shortest path tree. This algorithm is often used in routing and as a subroutine in other graph algorithms. For a given source vertex (node) in the graph, the algorithm finds the path with lowest cost (i.e. the shortest path) between that vertex and every other vertex.

Dijkstra's Algorithm:

```
1.  function Dijkstra(Graph, source):
2.  dist[source]  := 0  // Distance from source to source
3.  for each vertex v in Graph:  // Initializations
4.  if v ≠ source
5.  dist[v]:= infinity    // Unknown distance function from source to v
6.  previous[v] := undefined    // Previous node in optimal path from source
7.  end if
8.  add v to Q            // All nodes initially in Q
9.  end for
10. while Q is not empty:          // The main loop
11. u := vertex in Q with min dist[u]  // Source node in first case
12. remove u from Q
13. for each neighbor v of u:   // where v has not yet been removed from Q.
14. alt := dist[u] + length(u, v)
15. if alt <dist[v]:   // A shorter path to v has been found
16. dist[v]  := alt
17. previous[v]  := u
18. end if
19. end for
20. end while
21. return dist[], previous[]
22. end function
```

VI. EXPERIMENTAL RESULTS

The following assumptions were made:

(i) Traffic congestion not considered
(ii) Calculations were based on road distances and
(iii) State of the road not considered

6.1 Creation of Map for Healthcare Facilities

Based upon thecoordinates taken by using GPS (Fig 4.3), locations of the hospitals are mapped accurately on map. Fig.6.1 shows the map created using geodatabase and the location of the hospital.

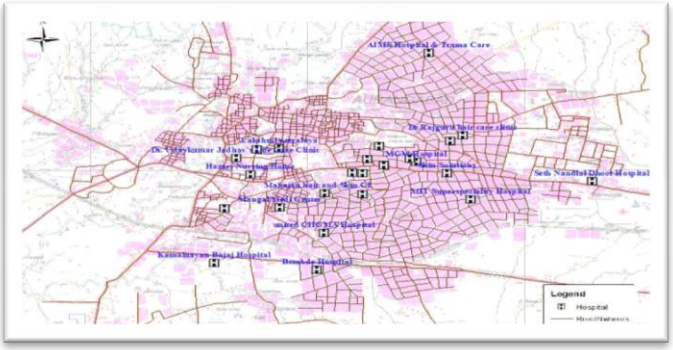

Fig 6.1: Map Created Using Geodatabase

6.2 Creation of Shortest path

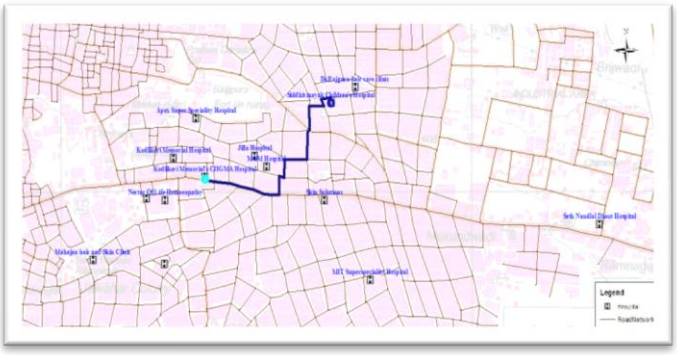

Fig 6.2: Shortest Path between Two Locations

System will generate the shortest path between two locations by calculating the distance based on road length. This will help the user to reduce the traveling time to reach a particular hospital [12]. Fig. 6.2 shows the shortest distance from MangalMedi Center, Osmanpura, Aurangabad to Dr. Raj guru Hair Clinic, Baja rang Chouk, Aurangabad

6.3 Closest Path Facility

When user decides the hospital, it finds calculates its distance from different routes. After this, it takes minimum distance and shows route in the map. Fig. 4 shows the closest facility available near the user's location.

Fig. 6.3: Closest Facility available for given location

6.4 Service Area Analysis

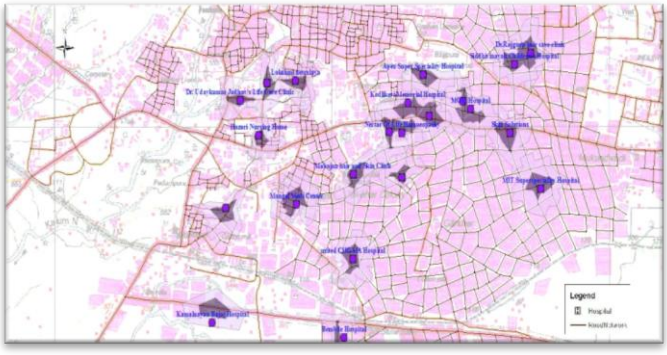

Fig 6.4: Service Area Analysis

In this project the service area is created around the hospital point for finding that how many other facilities are present within 500 m area. So that in any case the particular hospital is closed user can immediately find out the other one within the accessible area. Service area analysis is as shown in Fig 6.4.

VII. CONCLUSION

This study finds the shortest path from the user location to hospitals selected. It uses the ArcGIS and the Dijkstra's algorithm for implementation. ArcGIS is used to digitize the map into road network.

Network Analysis is carried out for all the network related problems.This will help the user to find the shortest path from their location to the health center. Also the user can able to find all the closest present within their area dynamically, which is helpful in terms of reducing their travel time and finding appropriate hospital immediately.

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