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Planning Efficient Transportation through Network Analysis: A Case of Faridabad City

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Abstract

The main challenge that most of the populous satellite cities are facing is traffic congestion that leads to many social, economic, and environmental issues deteriorating the life of the inhabitants. One of the major necessities to deal with this traffic congestion is a good public transportation system. The lack of an appropriate public transportation system leads to problems like deterioration of lifestyle and congestion of traffic which affects the accessibility of people and goods. Accessibility to the important facilities and vehicular mobility are the major concern of the major satellite cities in India. This study focuses on the planning of easy accessibility to the maximum facility locations and its wayfinding through the road network of the case study with the help of the network analysis in geographic information system. The study deals with finding the service area, closest facility, and an optimal route between two locations to improve the accessibility of facility locations in the study area.

1. Introduction

Accessibility refers to how easily the facilities present in that particular location will be used for the planning of easy accessibility transportation systems of any particular location plays a very vital role [8]. A transportation network consists of a system of linked components that show potential paths from one place to another, such as linking junctions (points) as some places and edges (lines) as some roads and streets of any particular area. To find out the shortest path between two points is the most popular work of network analysis in geographic information system. As an appropriate transportation network is the basic need of any smart city, various technologies like Geographical Information System (GIS), Remote Sensing, Global Positioning System (GPS), and Internet of Things can help to maintain the same [7]. To measure accessibility in terms of various impedances like travel time, distances etc. on the network, network analysis can be done.to evaluate the accessibility of the location, one simpler way is to find by creating buffer distance around the location. By using the metaverse as equivalent to the populous cities, the barriers for environmental economic and social sustainability can be explored [1]. A network analyst helps to determine the most optimal route between the two selected locations or between multiple places. Using points in an existing feature class or feature layer, putting points on the screen, or inputting an address can all be used to interactively specify the positions [9]. Wayfinding

is the identification of one location with respect to the other surroundings and finding out the optimal route from that one location to another [10-11]. A network dataset is an important model of any road system as it contains not only the locations but also the attribute table related to the roads and provides all the information about the roads, how they connect to each other and related to each other and what kind of turns are present on these connected roads. It also possesses a rich network attribute which consists of various kinds of impedances, restrictions and the hierarchy of the network system. The optimal route can be found for the user-specified order of places if there are more than two stops to visit [2]. As an alternative, network analysts can solve the optimal order in which to visit the locations, and also find out the closest facility to represent the accessibility of any location and also used to find out the service area of any location. The distance between the locations frequently travelled known by an object having route knowledge [3]. The objective of this study is to find out the shortest path, closest facility around the facilities and the service of that facility. This objective was planned to be achieved by the development of transportation network dataset system:

- The development of the network of roads for wayfinding.
- To find out accessibility of maximum facility locations through the network analysis.

2. Research Methodology

2.1 Development of Road Network

To create the road network of New Industrial Town of Faridabad District, Haryana, India taken as the case study, ArcGIS 10.8 software is used for this study.

2.2 Digitization of Road Network

With the help of Google Earth Pro, an aerial image of New Industrial Town, Faridabad was obtained and placed over the created TIN file. Using second order polynomial transformation equations, the six control points of identical quality of the aerial image of the new industrial town Faridabad were used to georeferenced to quantify accuracy, , by using the same units as the data frame spatial reference the forward residual error was utilized. The accuracy was measured using the formed residual error in the same units as the data frame spatial reference. All residual errors were nearly null, indirectly improved accuracy and a suitable root mean square error value. To check accuracy by comparing its length on the screen to the real length measured using a tape measure along the centre line of a few roads segments, digitized road network was used. Network connectivity was preserved through the use of snapping environments. As new road features are added to already digitized features, the geometric coincidence is guaranteed.

2.3 Building a Network Dataset

The network of the road for the analysis of roads in ArcGIS 10.8 Network analyst extension is used to create a new network dataset. This tool of ArcGIS enables the creation of a network dataset from the linear features set for performing a variety of analysis purposes. The road network of the new industrial township, Faridabad was included in a shape file which was used to create the network dataset for this study. A network dataset establishes connectivity, builds network elements, and gives values to predefined attributes. A point feature class that includes every junction and the network dataset itself are added when a new object is formed. In a network dataset, three different kinds of network elements include turns, junctions, and the edges [6]. The pieces that join intersections over which traffic moves are known as edges. Junctions help make it easier to navigate between edges by connecting them. In a network dataset, junctions are formed from a point feature class and edges from a linear feature class. To maintain a record of the movement across two or more edges, turn elements are used. A network dataset's basic structure is built of junctions and edges. Turns are optional components that serve to record details about a specific turning motion, such as the restriction of a right turn to travel from one edge to another [5].

2.4 Wayfinding

To determine the best route to take in order to get from one location to another is a frequently known issue. Graph exploration techniques are employed in traditional ways to identify an optimal path within networks. [8] The optimal route is being found through a significant improvement in network analysis in GIS. Dijkstra's algorithm is used by the Network Analyst extension of ArcGIS to determine the most optimal route (including distance and travel time) between given locations [4]. The approach works under the assumption that a road network is given, with a set of edges representing roads and a set of nodes representing

destinations, origins, and permanent landmarks.

2.4.1 Route Between Selected Locations

Best routes means different things in the different conditions as it varies with the selected impedance like time constraints, distance constraints which will represent the shortest path or the quickest path etc. If the selected impedance is the time constraint then the result will be the quickest route or the shortest path. To find out the optimal route between one locations to another, a road network dataset was used. Figure 1 shows the shortest route between the hospital and the residential area.

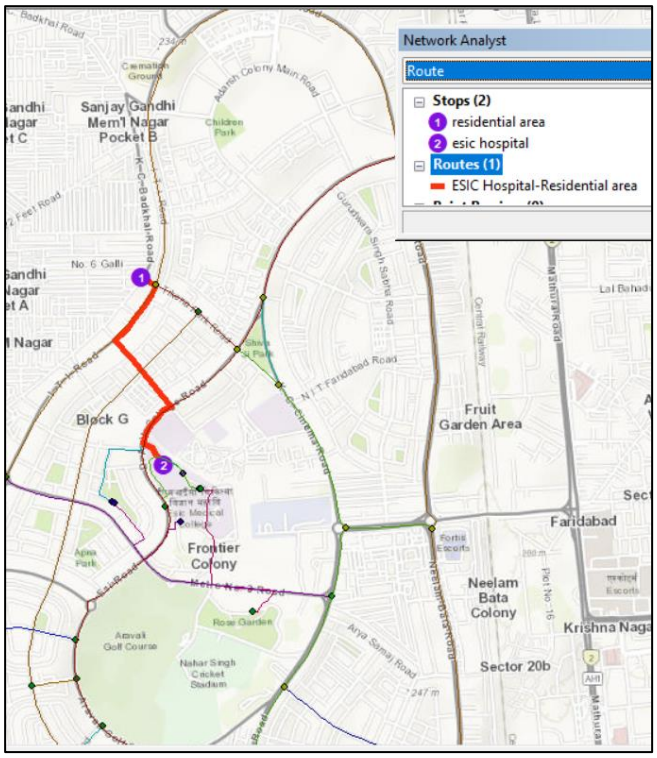

Figure 1 Shortest Route between the Residential Area and the Hospital

2.5 Analysis on Network

The digitized road accuracy can be verified by comparing the actual length measured with the help of the tape along the centre line of the road and the screen length. In network analysis, the places and junctions are shown as the point class features while the streets and the roads are represented by the line feature class and the service area are represented with the help of the polygon class feature.

2.5.1 Closest Facility Analysis

To find out one or more facilities which are nearest to an incident based on impedances like travel time or distances and represents the optimal route between the locations and the closest facility around the location. The layers in the closest facility solver include all the inputs, parameters and results. To find out the closest hospital to the residential area in new industrial township area, closest food corner to the hospital, or closest park to the main hospital are one of the examples of closest facility of network analysis. The use of developed network dataset to find closest facilities that may display optimal route to or from identified facility. Figure 2 shows distance between the selected locations of hospital and nearest food corners available in New Industrial Township, Faridabad.

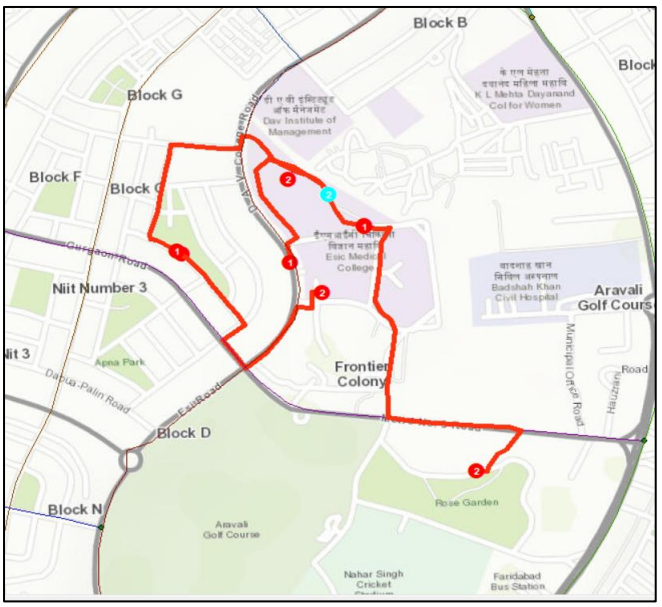

Figure 2 Distance between the Selected Locations of Hospital and Nearest Food Corners

2.5.2 Service Area Analysis

To create the service area is similar to buffering a location as buffering point.it is generally a model of the movement of inhabitants and the things to move along the networks of road. All accessible length of roads that are within the specified impedance like time and distance from any specified location, such region are considered as the service area. Any length of road that is reachable and falls inside a given impedance from a given location is referred to as a service area. For example, a thirty minute service area for a location includes all road length which can be reached within thirty minutes from the selected location. It also helps to identify the area in NIT Faridabad that can be served from a selected location within the specified time. Figure 3 shows a

service area around the hospital in NIT Faridabad that can be served within one minute.

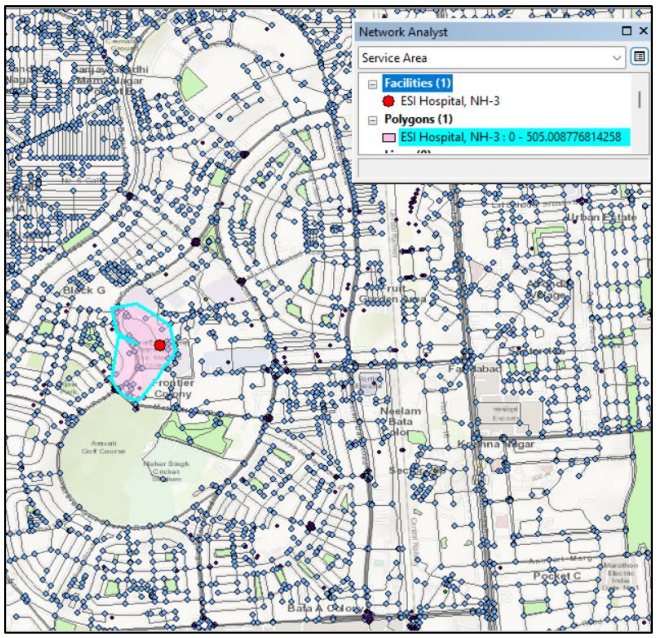

Figure 3 A Service Area around the Hospital to Be Served In One Minute

3. Results and Discussion

The optimal path between the residential area and the hospital was found with the help of the best route network analysis. This will provide the most optimal path at the time of requirement. The accessibility to the maximum facilities location is also find out by the closest facility solver which represents the various facilities to use within the minimum time and the service area around the hospital is also find out with the help of service area solver of the network analyst extension which represent the area to be accessible with in one minute from the selected location. As in the current study the service area of all the hospitals are also found out and as there is overlapping in the service area polygons of various hospitals shows the lack of proper mixed land use and it also decreases the accessibility of the whole area. To make any city more sustainable the accessibility should cover all the areas instead of overlapping these service areas. If those free spaces between the case study are provided with proper hospital facilities it will be more accessible to the inhabitants and can have a more efficient transportation system to improve the lifestyle. Figure 4 shows the service area around all the hospitals in the case study area to be served within one minute and the overlapped service areas.

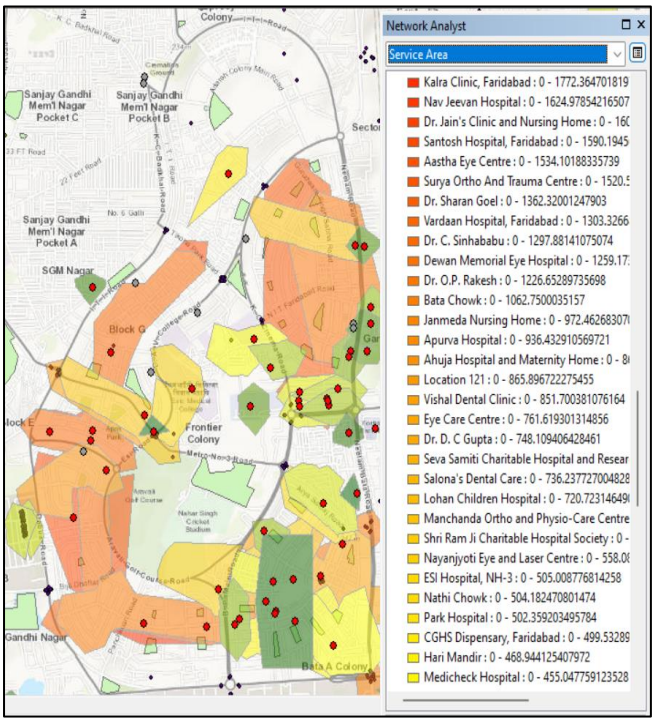

Figure 4 Service Area around All the Hospitals in the Case Study Area to Be Served With In One Minute

Conclusion

The network analyst extension of network analyst tool consists of various kinds of solvers which are used in this study help us to analyse various kinds of problems like optimal path ,service area and, closest facility problems for different times of any day and the results will also vary according to the given conditions. The network analysis layers generally consists of six layers names as route analysis layer, vehicle routing problem layers, location allocation analysis layers, closest facility analysis layer and service area analysis layer which can be used to fulfil the objectives like the planning of easy accessibility to the maximum facility locations and its wayfinding through the road network of the case study with the help of the network analysis in geographic information system. These analyses can be used to create an efficient transportation system and to improve the accessibility and mobility of the area.

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