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GIS BASED APPROACH FOR DYNAMIC ROAD SEGMENTATION

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Abstract

Dynamic segmentation has been used as a method to view linear assets on a geographic information system (GIS) map. The principle being that, continuous segments with homogenous condition can be viewed as a single segment. These segments are viewed as a line with unique attributes. There are several methods of dynamic segmentation, including set banding and tolerance ranges. Each of these has advantages and disadvantages, depending on the desired application. In light of this a new system has been developed, combining these principles that remove many of the disadvantages. As stated, the traditional application of Dynamic Segmentation is in the field of GIS. This very often limited the segmentation to one attribute of the network.Dynamic road segmentation (DRS) data model finds maximum application in GIS Transportation (GIS-T) studies and analysis serving as a data model that splits linear features into new set of segments wherever its attributes change. Attempt has been made by this research to carry out the Dynamic road segmentation of part of colony using Arc GIS 10.1 and other field survey acquired data. Geometric data was acquired using Google earth and Open street map while the attribute data was acquired via the social survey approach. A Geo-database was designed and created within the Arc GIS 10.1 version software environment. Analysis and queries were also performed to solve some pertinent issues concerning the route segments. The result highlighted the present road pavement condition of the considered road segments, adjacent land use, and notable potholes. It also shows the length of the particular route along with the shortest available path that can be chosen for travelling from origin to destination.

Keywords: **Geographic Information System, Road Network, Dynamic Segmentation, Network Analysis, Impedance, Shortest Path.**

1. INTRODUCTION

The road network in India is huge with more than 3.01 million kilometers of road length with 34608 km of National Highway, 128622 km of State Highway and informal network of 2737080 km, operated in vastly different social, economic and climatic environments. The planning and management of such a huge network in the country has been primarily done at two levels i.e. national and local level. The national level planning in the country is broad based and is done using some macro level data like area, gross domestic product etc., whereas local level planning is problem specific and confined to a vicinity of a few metropolitan cities. The road network planning based on the travel demand requirements in the country could not be adopted merely due to lack of relevant data needed for it.The adoption of newly emerging technologies such as Geographic Information System (GIS) can help to improve the decision making process in this area for better use of the available limited funds. Geographical Information System (GIS) are becoming more widely used in transportation planning agencies, especially among metropolitan transportation organizations.The use of GIS for transportation applications is widespread. Typical applications include highway maintenance, traffic modelling, accident analysis, and route planning and environmental assessment of road schemes. Additional information concerning general topography, land cover and land use is pertinent to the consideration of the impact of construction. The lack of appropriate data for GIS remains a chronic problem. GIS describes a world in terms of longitudes and latitudes and other projection systems consisting of a hierarchical structure of graphical objects. The typical GIS represent the world as a map. The major requirements and issues surrounding GIS management technology are building and maintaining a database, selecting and upgrading hardware and software, using the technology to solve problems.Using GIS as the tool for maintaining and monitoring road network system will open up a wide range of possible applications, such as increase in traffic and road condition data acquisition and processing. This will ensure quick andconvenient access of relevant and necessary information requisite for planning, design costing and execution of road network projectthereby proffering solution to thelingering multivariate problems that are associated with road transportation especially in third world countries like India.Using

GIS-T as a tool, this paper seeks to map out and analyse the road pavement condition, nature of adjacent land use, notable pothole areas within the study area.

2. GIS FOR TRANSPORTATION ENGINEERING

Geographic Information System (GIS) represents a new paradigm for the organization of information and design of information systems, the essential aspect of which is use of the concept of location as the basis for the structuring of information systems. The application of GIS has relevance to transportation due to the essentially spatially distributed nature of transportation related data, and the need for various types of network level analysis, statistical analysis and spatial analysis and manipulation. Most transportation impacts are spatial. At GIS platform, the transport network database is generally extended by integrating many sets of its attribute and spatial data through its linear referencing system. Moreover, GIS will facilitate integration of all other socio-economic data with transport network database for wide variety of planning functions.The advantage of using GIS is its ability to access and analyze spatially distributed data with respect to its actual spatial location overlaid on a base map of the area of coverage that allows analysis not possible with the other database management systems. The main benefit of using the GIS is not merely the user-friendly visual access and display, but also the spatial analysis capability and the applicability to apply standard GIS functionalities such as thematic mapping, charting, network-level analysis, simultaneous access to several layers of data and the over laying of the same, as well as the ability to interface with external programs and software for decision support, data management, and user-specific functions.

3. STUDY AREA

The study area is a colony in Hyderabad city, Telangana state, India is shown in Figure 1. It lies between Latitudes 17.3372° N and Longitudes 78.4968° E has a land mass area of about 160,600 hectares with population of 73,729 thousand people.The parameters investigated for the selected study area are physiography, adjoining land use,available potholes and length of the lanes are presented. Once the study area is identified a wide range of spatial and non-spatial data may be require which constitutes of satellite images, road map data, location of origin and destination points etc.

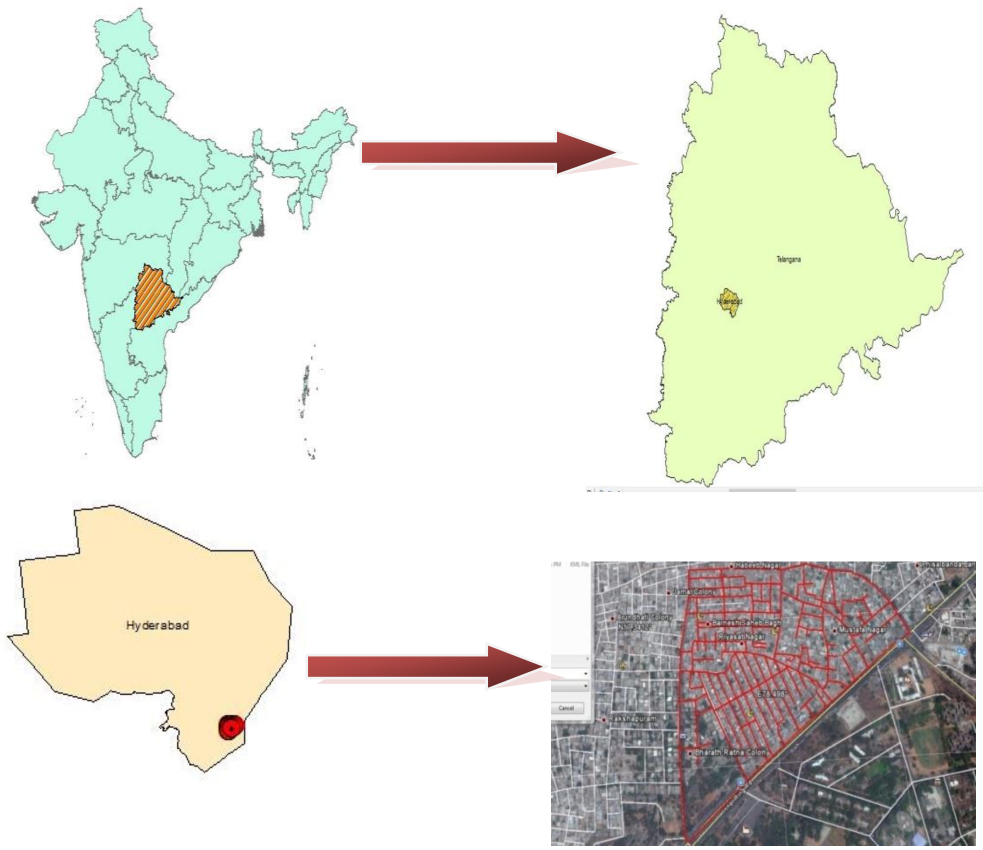

Figure 1 Study Area

4. DATA COLLECTION

The present study is mainly concerned with the network connectivity of colony places but there is a lot of scope to extend this study up to the road network of a city. GIS design and application for network analysis help users to calculate the origin and destination time and cost impendence. Indian Remote Sensing Satellite (IRS) P6 LISS-IV satellite data was used to prepare the road network and places of interest, while attribute data was acquired through social survey (visualization, direct interviews and questionnaire). Various points were coordinated on the image which were used for geo-referencing purpose. The X and Y coordinate of other notable points (such as notable road features such as potholes, etc.) were acquired using mobile phone GPS receivers application.ArcGIS and Google earth software were used for the analysis and database creation. Google earth software was used for geometric correction of satellite data / images and ArcGIS was used to generate spatial data. The ArcGIS network analyst extension was used for carrying out network analysis.

5. DATA PROCESSING

The Road network, ATM'S, stores, and other simple locations were considered for route identification for network analysis of colony. It was based upon the impedance. Impedance is a cost attribute of road network. It may be time or length which can be chosen by the user. However no restrictions were used between the origin and destination points. Analysis was carried on the basis of estimated travel time and distance (based on time and length as impedance). In network analyst, there is ability to calculate the shortest andquickest route between different origin and destinations and also to generate route direction. By clicking on the points, images of particular place can be obtained, viewed, analyzed and printed. In the study, the road network has been prepared for origin and destinations in terms of time and length impedance (cost attribute). Route may be fastest/ quickest, depending upon the impedance chosen by the user.The road network data extracted from satellite image was converted into shape file in Arc GIS. The road network details such as speed, length of the road, road characteristics and time were added in attribute after adding the required data the network analysis process was done through network analyst tool bar in arc GIS. Using the network analysis the shortest route between two points(origin and destination) were calculated. Using network we can find the quickest route between two points and the traveler can select the desired route depending on the requirement of their journey. The shortest route in the road network is shown in the Figure 2.

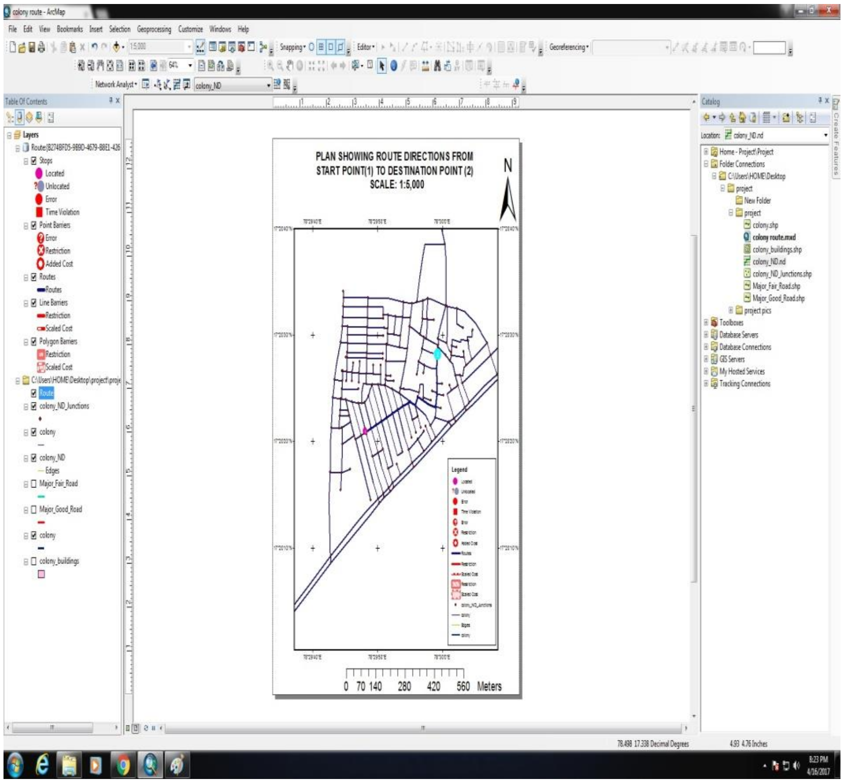

Figure 2Screen Shot of Shortest Route

The network analysis in GIS, are used for more than just finding the shortest routes like origin-destination matrix, closest facility, service area and vehicle routing problem. There are four components required in order to perform a routing in the ArcGIS Network Analyst Extension. These elements are termed as Network Dataset, Network analysis Layer, Network Analysis Classes, and Network Analysis Objects. Each of these elements possesses attributes required in the routing process.***Network Dataset:*** Network dataset is a model of the transportation network. The analysis of the ArcGIS network analyst has happened on a network dataset. Network analysis always works on network dataset which contains information of the network analysis layer like route. The necessary information of route creation is marked or stored here. ***Network analysis Layer:*** It manages or stores the inputs, properties and results of a network analysis. The network analysis layer is displayed in a network analyst window.***Network Analysis Classes:*** It provides classes of network layer for example stop barrier and route are the classes of route layer.***Network Analysis Objects:*** It is a record contains in network analysis classes.

As shown in the fig. 4. Stops, point barriers, routes etc comes under network analysis objects. Therefore, it provides the tabular data for the route analysis.***Testing of Database:*** It involves ensuring the overall workability of the data base in terms of preservation of data, integrity during storage and/or retrieval process.(Oguntade, 2005). This was done by designing a sample query and running the query to see if the desired result is achieved. ***Queries*****:** Queries were designed for the purpose of retrieving information from the designed database. It is a way of obtaining specified information from the database using appropriate commands or syntax. Spatial query and analysis for this paper was carried out on features with certain characteristics related to the study area. The queries performed were based on the available database to answer certain generic questions asked from the database.

Single Criterion Query: Itwas carried out where one condition is used for the design query and is presented in Figure 3.

Query 1:

Type of analysis: Single criterion. Syntax modal: "road quality"="fair condition"

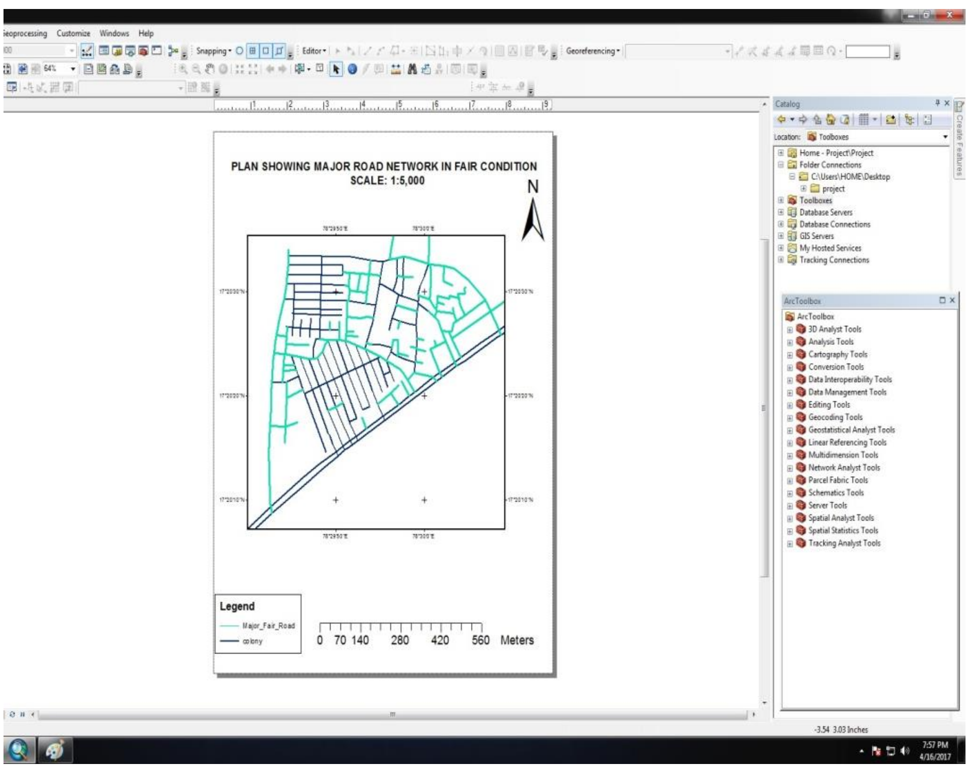

Figure 3 Screen Shot of road quality in fair condition

Multiple Criteria Query:This is the situation where two or more conditions are imposed in a query operation. Here, the two conditions imposed include the road class (major roads) and the road pavement condition (fair condition) as shown in Figure 4.

Query 2:

Type of analysis: multiple criteria query.Syntax model: "road quality"="good".

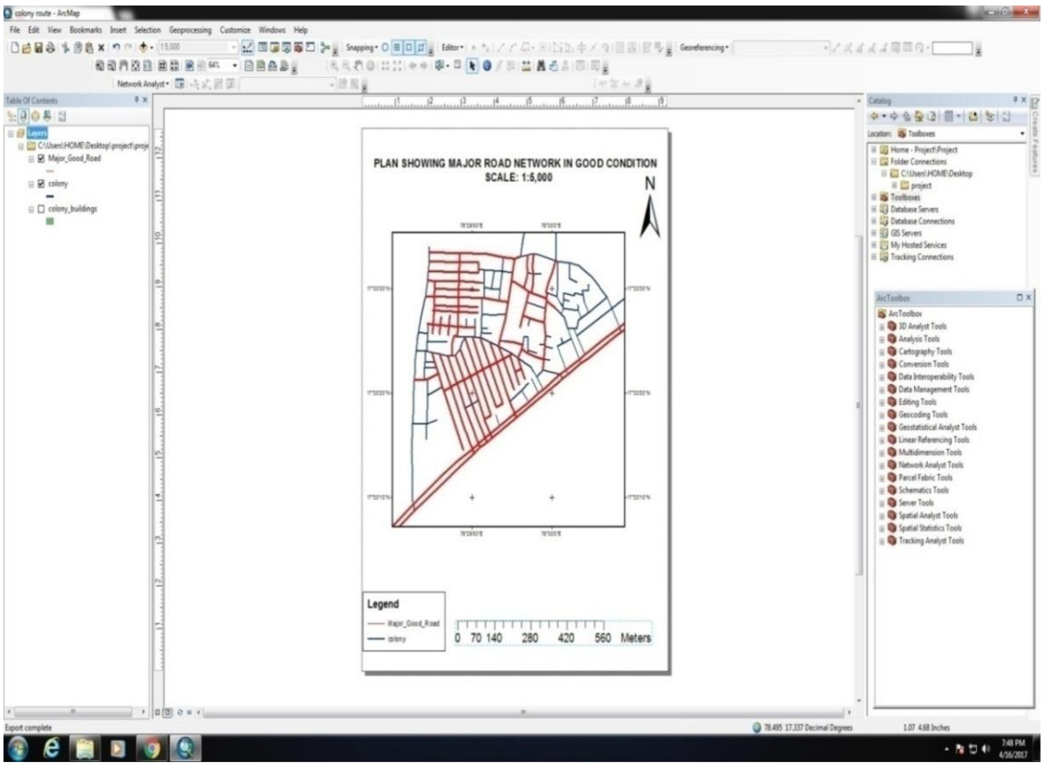

Figure 4 Screen Shot of road quality in goodcondition

6. OD- COST MATRIX ANALYSIS

Estimation of travel time between a set of origins and a set of destinations (i.e., O–D travel time matrix) through a transportation network is a common task in spatial analysis. To list a few, spatial interaction modeling uses travel time between any pair of interacting places (Fotheringham and O'Kelly 1989); traffic demand forecasting relies on an accurate estimation of travel time among locations in various land uses (Black 2003); trade area analysis needs the travel time between each store and each residential area to define a store's customer base (Huff 2003); and accessibility measurement requires the travel time data between supply and demand locations (Luo and Wang 2003).These simple distance measures only need the input of geographic coordinates of origins and destinations and use simple mathematical formulas to calibrate, but are primitive indices of travel impedance.The process begins with building the network dataset in Arc Catalog, where a user chooses the settings for connectivity, modeling turns, and others and specifies the network attributes such as length, travel time, and others. Then, in Arc Map, the user activates the Network Analyst extension and its OD Cost Matrix function. After loading the pre-defined network data set to the active project, various network parameters (impedance, distance unit, etc.) need to be defined. In the Network Analyst window, one can use the origins feature to define ‘Facilities’ and the destinations feature to define ‘Incidents’ and then choose the OD Cost Matrix tool to solve the problem and save the result which is shown in Figure 5.

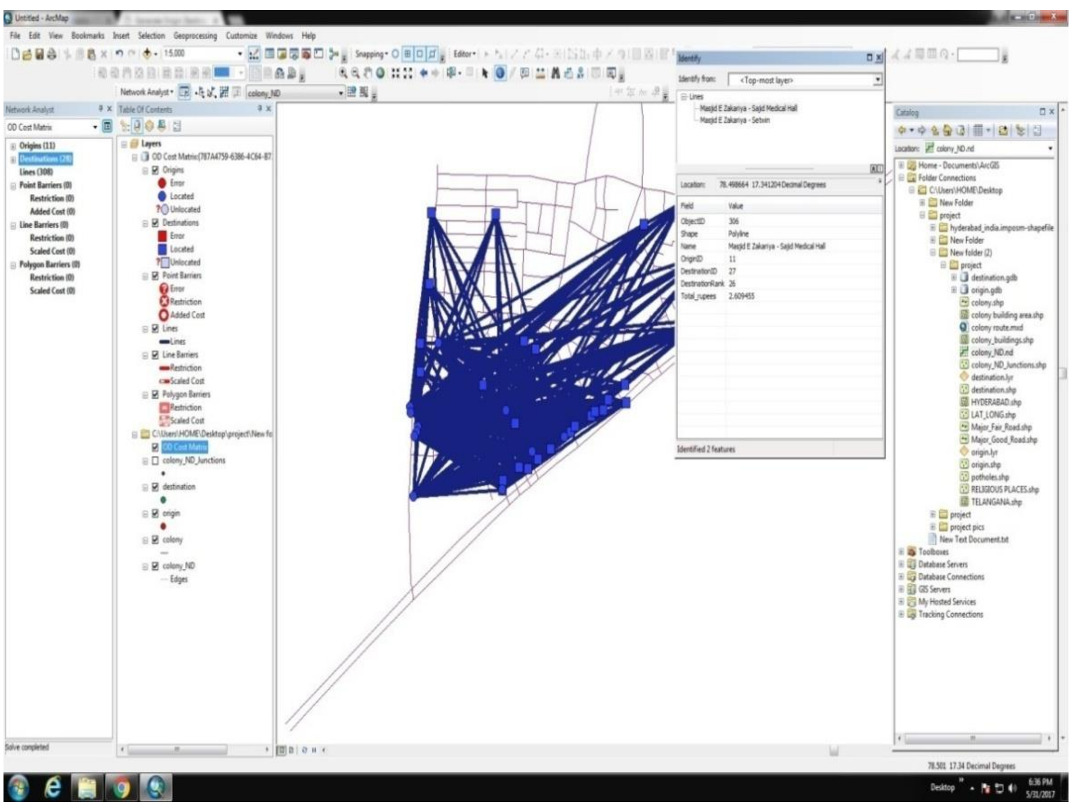

Figure 5 Screen shot of O-D Cost Matrix

7. RESULTS AND DISCUSSION

The result of the single and multiple queries performed on the database are presented as Figures 5 and 3 respectively. The first query seeks to highlight the segments of the road that are in good condition while the second query attempts to highlight the segments of the major road that needs to be repaired or which is in a fair condition. The result of the network analysis is presented in Figure 4 is the travel time estimation process map Figure 5 presents the OD- cost matrix analysis map showing the cost impendence from each origin and destination locations.

CONCLUSIONS

The objective of this research was to observe, record, and analyze changes to routes and travel/response-times of vehicles due to variations in traffic flow related on certain days of the week and times of day. It was believed that dynamic routing based on cost attributes derived from travel-time data and applied to network edges could help response vehicles avoid congested areas and improve travel times.This research was able to utilize the shortest path algorithms in ESRI's Network Analyst to calculate the shortest, fastest, and the most optimal routes by applying various cost attributes.The project was overall a success and the following research objectives were met 1) On the average, a greater portion of the pavement of study area can be said to be in good condition 2) The most prominent adjoining land use along the considered road segments is the residential land/commercial use 3) Network Analyst workflow was created with the road network data extracted from Google Earth and 4) created a cost matrix from multiple origins to multiple destinations from the available road network data.The technique offers an improved method of spatial data analysis and presentation, it considerably increases the ease of spatially displaying road management data and it is applicable to all linear features (node-to-nodes, node-to arcs, etc.), though road network has been experimented in this research using manual intervention.

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