Development of Spatial Information System for Transportation Planning of Calicut Urban Area

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Abstract

GIS is one of the fastest growing technologies of present time. It has emerged as powerful and sophisticated means to manage vast amounts of geographic data. It provides a mechanism by which information on location, spatial interaction and geographic relationship of various facilities can be assessed and viewed in moments. It provides an opportunity to effectively view and access geographic data and thus to improve decision making process. This paper summarises the attempt to develop a computerized spatial data base system for Calicut city and to use that for identification of missing links in the road network based on travel demand.

1.0 Introduction

Traffic and transportation problems in medium sized cities of many developing countries have become grave matters of concern to the governments. Along with the growing population concentration, the rapid increase in the heterogeneous motor traffic and provision of limited transport infrastructure facilities have become the prime reasons for these problems. While the problems of larger metropolitan cities are at least taken note of, those of medium sized are not even recorded. A strategic planning of transport systems will alleviate these problems to a greater extent. Transportation planning process consists of analysis of interaction between supply in the form of existing facilities and the demand in the form of traffic load. It also involves forecasting for the future and evaluation of the alternatives arrived at the planning stage.

Information about land use, demographic and economic characteristics, existing travel facilities and travel characteristics is required at various stage of transportation planning process. Transportation planning deals with large amounts of data, which are inherently spatial in nature. The process is data intensive and causes overwhelming resource strain of map and data manipulation. Also the informations will be collected and maintained by a variety of public and private agencies and hence, it is very difficult to get the necessary data in time. Tools that facilitate easy storage, maintenance and retrieval of large volumes of graphic/non-graphic data and that permit simultaneous sharing of data by many users will be highly useful for transportation planning.

The major concern of the authorities is efficient operation and management of road network. This requires frequent decision making to tackle various types of problems, which are not always structured. The information on variables such as traffic flow and accident particulars on individual links, total travel, zonal details such as population, employment, etc. are required in decision making process. The data retrieval will be quicker and easier if they are maintained in digital form rather than as records, graphs and pictures on papers.

GIS is one of the fastest growing technologies of present time. It has emerged as powerful and sophisticated means to manage vast amounts of geographic data. It provides a mechanism by which information on location, spatial interaction and geographic relationship of various facilities can be assessed and viewed in moments. It provides an opportunity to effectively view and access geographic data and thus to improve decision making process.

This paper summarises the attempt to develop a computerized spatial data base system for Calicut city and to use that for identification of missing links in the road network based on travel demand. The various stages of the work are development of spatial information system of traffic zones and road network, estimation of minimum travel paths, estimation of travel demand though indirect approaches, estimation of link volumes, preparation of desire line diagrams, identification missing links, formulation of alternative road network improvement strategies, evaluation of alternative networks.

2.0 Calicut City - An overview

Calicut city is situated on the West-Coast of India, at a latitude of 11^0 15" N and longitude of 75^0 47" E. It is considered as the commercial capital of Malabar Region. The city has a history of long years and the growth of city has not taken place in a planned manner. While Calicut is connected to many of the important cities of India by rail, within its own hinterland, the connection is restricted mainly to road network.

The city is constrained between the Arabian Sea in the west and the hills in the east and thus takes a linear form. Three National Highways NH 17, NH212 and NH213 pass through the heart of city, which cater to the main activity system of the city. NH17 runs longitudinally through the city acting as spine. The broad gauge railway line Mangalore to Shoranur runs parallel to the NH 17 and forms a barrier between the east and west parts of the city.

The area in the city can be categorized as residential, commercial and industrial based on the activities. Most of the area in Calicut can be classified as residential except for the commercial agglomeration in the Big Bazaar, SM Street, Palayam, Kallai & Puthiyara. Industries are mainly concentrated in Feroke, Cheruvannur, West Hill and on the banks of Kallai river.

3.0 Development of Data Base

The data required for the study include zonal details of study area, road network details of study area and traffic volumes on selected links. These data can be classified as graphic and non-graphic data.

3.1 Graphic Data

Presently the graphic data of traffic zones and road network are available in paper form. These paper drawings have been converted into digital maps adopting the following procedure.

The paper maps, which are large in size, were scanned using the setup available in the laboratory. The setup consisted of video camera interface with a computer through a frame grabber card. The map was kept in front of the video camera such that it is perpendicular to the axis of the camera. Using the software for operating the frame grabber card, the image of the map was captured and stored in *jpeg* format. To have good clarity of captured images, the paper drawings were first traced with thick and dark ink pen. The zonal map and road network map were captured separately.

These captured images were imported into the GIS software MAP, a product of AutoDesk in raster form and were then converted into digital form. For converting raster drawings into digital form the tools or utilities available in MAP were used. Using these utilities three types of objects, nodes, lines and polygons, can be digitized. The raster drawing was kept in one layer and the objects were traced into another layer. After the objects were traced from raster image, the layer consisting of raster image was put off and the file was saved as GIS file. The zonal map and road network were traced into separate layers. The maps of the traffic zones and road network are shown in Fig. 1 & 2 respectively.

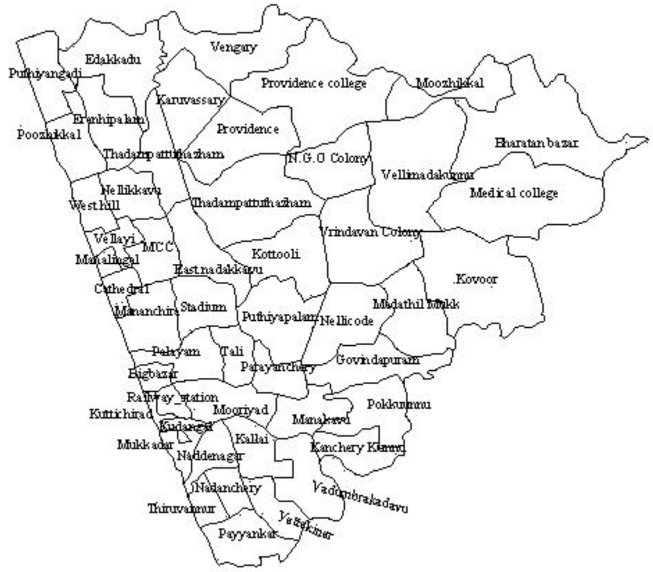

Fig. 1 Zonal Map of Calicut City

Fig 2 Road Network Map of Calicut City

During the process of digitization many types of errors crept in. These errors were corrected using the clean up tools available in MAP, such as duplicate objects, erase short objects, break crossing objects, extend undershoots, erase dangling objects, simplify linear objects, snap cluster nodes, dissolve pseudo nodes and edge matching. Thus the graphic data consisting of two layers, one representing zones and the other road network, was developed. In the zonal map each zone was represented as polygon and the road links in road network were represented as linear objects.

3.2 Non-Graphic Data

The non-graphic data consisted the details of traffic zones and the road network. The non-graphic database was created using the inbuilt data base utilities. The database of traffic zones, which are the electoral wards of Calicut city, consisted of the population, number of employees, area, and road length per sq.km. of area. The non-graphic data of the road network consisted of the information like link number, starting node number, ending node number, length and volume for each link. These data were stored in separate data tables in the database that do not have any relation with the graphic objects until the connection is established.

3.3 Linking Database

It means that after the database is created with all the details regarding the graphic objects, a connection should be established between the database and the graphic file. There is one option in MAP called Link Path Name (LPN) to establish the relation between the database and graphic file. The link path name consists of the name and location of database file and establishes the connections as and when the graphic data file is opened. The next step in linking database is to establish the connections between the objects in graphic data file and the information contained in database. This is done by selecting a record in the data sheet and attaching it to the corresponding graphic object.

3.4 Minimum Path Tracing

Minimum paths between zones based on selected criteria are required for estimation of travel demand and obtaining the link volumes. The MAP software does not have any utilities to trace the minimum path along the links of the road network. A program was written in 'C' based on Moore's algorithm was used to obtain the minimum paths between the zones based on distance as the criteria.

3.5 Traffic Volumes on Selected Links

Another input required for estimation of travel demand through indirect approaches is traffic volumes on selected links. Traffic volumes on 23 selected links were obtained by manual methods.

4.0 Estimation of O-D Matrix

The knowledge about the travel pattern between various zones in study area is required for transportation planning and management activities. This information about the travel pattern between every origin-destination pair in an area is organized in the form of a matrix called trip matrix or Origin-Destination Matrix. Estimation of O-D matrices is one of the major issues transportation planning process. The O-D matrix can be estimated using techniques such as home interview survey, roadside interview survey, work place interview, etc. But, conduct of surveys involves large amounts of resources and thus these methods are expensive and time consuming. To overcome these difficulties, O-D estimation through simple link volume modeling philosophy has been adopted.

The model proposed by Vanzyulen and Willumsen (1980)based information minimization approach was used for estimation of O-D matrix from link volume information. The estimated O-D matrix was assigned was assigned on to the existing road network using all or nothing assignment technique.

5.0 Preparation of Desire Line Diagram

In desire line diagram the travel between various pairs of zones is represented by bands, whose width is proportional to the travel, drawn between the centroids of the zones. The desire line diagram is very useful in understanding the travel pattern in a study area and carrying out the capacity sufficiency or deficiency studies of the road network. Desire line diagram has got important application in this study. The MAP does not have any tools for preparation of desire line diagram. A macro '*desire*' was written in AutoLISP to prepare the desire line diagram taking the travel information from the data file and graphic details of the zones from the graphic data file of the traffic zones. A desire line diagram prepared using the macro '*desire*' is shown in Fig. 3.

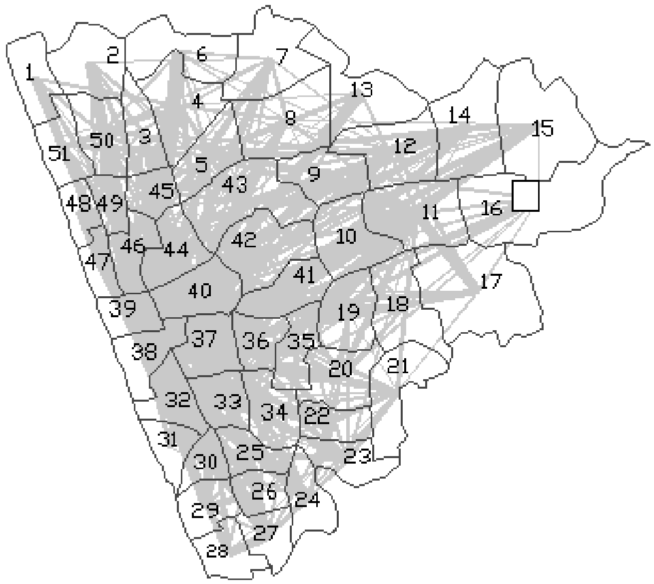

Fig. 3 Desire Line Diagram

6.0 Identification of Missing Links

The road links that are required to carry the traffic between two places but missing in the existing road network are called missing links. Because of the missing connections between places the traffic takes a circuitous route resulting in heavy congestion on the few available links. By providing new roads along the desired direction of travel or between places of major traffic generators the traffic situation can be improved to a great extent. For identifying the missing connections between zonal pairs the prepared desire line diagram was superimposed over the existing road network. The superimposed maps were observed closely along the major O-D pairs and were checked whether direct links between those O-D pairs are available or not. If a direct connection is not available, it means that by adding one or more new links a direct connection can be established resulting in considerable reduction in travel distance between zones. The desire line diagram superimposed over the minimum path diagram was carefully observed and a few sets of missing links were identified, which are shown in Fig. 4.

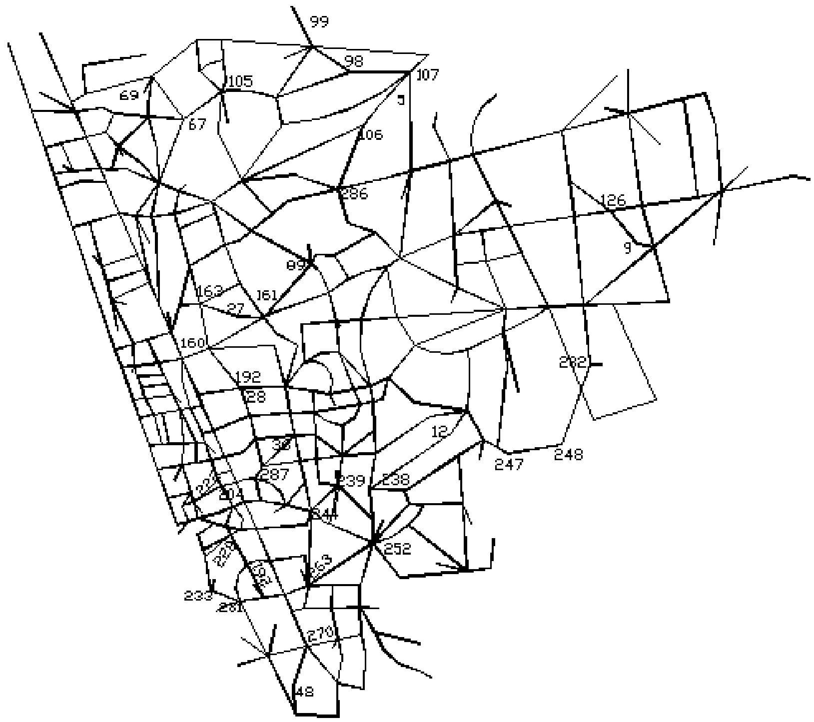

Fig. 4 Missing Links

7.0 Evaluation of Various Alternatives

The various identified missing links were grouped into different sets and were evaluated. The evaluation of the various alternatives was carried out by considering the changes in traffic volume on links and network indices. For this purpose each set of the identified missing links was added to the existing network and the estimated O-D matrix was assigned on to the network to get the volumes on various links of the network. These estimated link volumes were compared with the volumes on the links of the existing network and the difference, either increase or decrease, was taken. The network indices, circuity index, Betti index, alpha index, beta index, gamma index, accessibility index were also estimated for comparing the various alternatives. Other parameters considered for comparison are total minimum path distance (total of minimum path distances considering all pairs of zones) and total travel in terms of trip-kilometers. The various alternatives prioritized based on Accessibility index are given in Table 1. The information system was used to prepare thematic maps based on selected characteristics of the zones.

Table 1 Comparison of Various Alternatives

Alternative	TMD	Circuity	Betti	Alpha	Gamma	Beta	MDI	AI	TTK
Existing	12968.56	1.57	597.00	1.05	1.03	3.07	12.41	6480.14	280992.8
21	12855.18	1.56	599.00	1.05	1.03	3.08	12.35	6420.74	278454.3
23	12860.71	1.56	599.00	1.05	1.03	3.08	12.33	6426.21	278328.0
3	12865.41	1.56	601.00	1.05	1.03	3.08	12.39	6426.83	278457.3
10	12874.32	1.56	599.00	1.05	1.03	3.08	12.37	6435.06	279316.7
16	12883.82	1.56	601.00	1.05	1.03	3.08	12.21	6438.49	279269.4
18	12893.16	1.56	601.00	1.05	1.03	3.08	12.25	6446.36	279580.2
8	12900.94	1.56	601.00	1.05	1.03	3.08	12.42	6446.76	279413.3
22	12903.22	1.57	599.00	1.05	1.03	3.08	12.45	6448.39	279507.0
15	12915.13	1.57	599.00	1.05	1.03	3.08	12.30	6456.10	279932.7
20	12916.35	1.57	599.00	1.05	1.03	3.08	12.39	6456.25	279966.8
13	12919.94	1.57	599.00	1.05	1.03	3.08	12.37	6455.40	280185.8
17	12931.29	1.57	599.00	1.05	1.03	3.08	12.33	6462.82	280338.3
6	12951.19	1.57	599.00	1.05	1.03	3.08	12.39	6471.70	280655.5
9	12953.64	1.57	599.00	1.05	1.03	3.08	12.40	6473.02	280823.3
12	12954.05	1.57	599.00	1.05	1.03	3.08	12.40	6472.85	280441.8
11	12954.05	1.57	599.00	1.05	1.03	3.08	12.40	6472.85	280441.8
14	12954.39	1.57	599.00	1.05	1.03	3.08	12.37	6467.89	280719.8
19	12955.99	1.57	599.00	1.05	1.03	3.08	12.40	6474.63	280842.9
2	12968.56	1.57	599.00	1.05	1.03	3.08	12.41	6480.14	280992.8
7	12968.56	1.57	599.00	1.05	1.03	3.08	12.41	6480.14	280992.8
1	12968.56	1.57	597.00	1.05	1.03	3.07	12.41	6480.14	280992.8
5	12968.56	1.57	599.00	1.05	1.03	3.08	12.41	6480.14	280992.8
4	12968.56	1.57	599.00	1.05	1.03	3.08	12.41	6480.14	280992.8

TMD - Total Minimum Path Distance; MDI - Mean Dispersion Index; AI - Accessibility Index;
TTK - Total Travel Kilometers

8.0 Summary

This paper has described a procedure for GIS based information system application for the creation of transportation related database for Calicut city. It also has described a procedure for estimation of origin-destination travel demands and identification of missing links in the network to suit the travel demand, making use of the database.

References

1. AutoCAD MAP 3 User's Guide, Autodesk Inc.

2. Vanzyulen H.J. and Willumsen L.G. (1980), The Most Likely Trip Matrix Estimation from Traffic Counts, Transportation Research, 14 B, pp. 281-293.