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Geospatial Path optimization for Hospital: a case study of Allahabad city, Uttar Pradesh

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Abstract: *The problem of identifying the shortest path along a road network is a fundamental problem in network analysis, ranging from route guidance in a navigation system to solving spatial allocation problems. Since this type of problem is solved so frequently, it is important to craft an approach that is as efficient as possible. Determination of optimal path in a time-dependent transportation network is a challenge. Our main endeavor is to create a GIS based transport system which assist fastest, shortest and safest route to reach hospitals within Allahabad city. In this research Arc GIS 9.3, Network Analysis tool which is based on Dijkstra's algorithm has been used to find out the shortest and fastest path to reached SHIATS to different Hospital at Allahabad.*

Key words: *GIS, Network Analysis, Shortest path analysis, SHIATS.*

I. Introduction

Path optimization for hospitals is an important and challenging assignment because hospital transportation needs to be safe, reliable and efficient mode of journey. Transportation of a patient to emergency hospital seems quite simple but in actual it is quite difficult and gets more difficult if shortest path of hospital is unknown. Therefore determining the optimal path in a time dependent transportation network is challenging task. Minty (1957) suggested a format for solving the shortest path problem using a network represented as a web of strings and knots. Ford (1956) developed an algorithm to solve the shortest path problem in the presence of some negative arc lengths. In 1959 Dijkstra followed the work of Minty and Ford and suggested an algorithm for finding the shortest path.

The algorithm of Dijkstra remains to this day one of the best approaches for optimally solving the simple shortest path problem where all arcs have nonnegative lengths (*Zeng and Church, 2008*). Network analysis in geographic information system (GIS) provides good decision support for users interested in shortest or optimal route, finding the nearest facility and determining the service area. Searching shortest or optimal path is an essential analysis function in GIS. It is also one of the most important functions in GIS network analysis (Pahlavani. P, Samadzadegan. F, et al. 2006). Geographic information system has not only made it easy but powerful tool for the analysis of both spatial and non-spatial data for solving important problems of transport networking.

The main characteristics of GIS that differentiate from other information systems are its spatial data and geo-statistical analyses (*Li et al 2002, Alivand et al 2008*).

II. Study Area

Allahabad is among the largest cities of the state of Uttar Pradesh in India. The study area is located in the southern part of the state, at Latitude 25°45′ N and Longitude 81°85′ E and stands at the confluence of the mighty rivers, Ganga and Yamuna. It has an area of about 65 km^2 and is 98 m/340 ft. above sea level. The geographical location map of study area is shown in Figure 1.

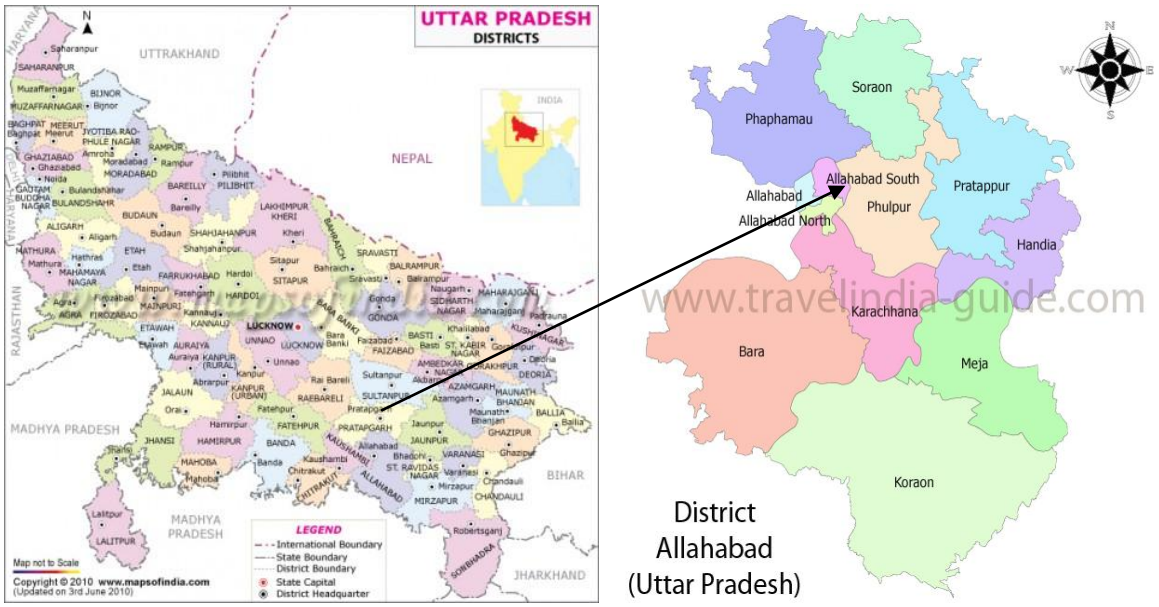


Fig.1 Location map of study area

III. Materials And Methods

Survey of India (SOI) topographic of 1:250,000 and 1:50,000 scales, Google earth data (11.4), LISS-IV data (5.8m), GPS has been used to extract information of road network and location of hospital. Database has been prepared in GIS domain which is not only makes easy to process, analyze and combine spatial data but also make it easy to organize and integrate spatial processes into larger systems that model the real world. ArcGIS Network Analyst tool has been used in this study to find out the shortest and fastest route to reach the hospitals from SHIATS. Network Analyst tool allow users to dynamically model realistic network conditions, like turn restrictions, speed limits, height restrictions, and traffic conditions, at different times of the day (Elizabeth Shafer 2005). ArcGIS Network Analyst based on the well-known Dijkstra's algorithm for finding shortest paths.

Dijkstra's algorithm

Dijkstra's algorithm, named after its inventor, has been influential in path computation research. It works by visiting nodes in the network starting with the object's start node and then iteratively examining the closest not-yet-examined node. It adds its successors to the set of nodes to be examined and thus divides the graph into two sets: *S*, the nodes whose shortest path to the start node is known and *S'*, the nodes whose shortest path to the start node is unknown. Initially, *S'* contains all of the nodes. Nodes are then moved from *S'* to *S* after examination and thus the node set, S, grows. At each step of the algorithm, the next node added to *S* is determined by a priority queue. The queue contains the nodes *S',* prioritized by their distance label, which is the cost of the current shortest path to the start node. This distance is also known as the start distance. The node, *u*, at the top of the priority queue is then examined, added to *S*, and its out- links are relaxed. If the distance label of *u* plus the cost of the out- link *(u, v)* is less than the distance label for *v*, the estimated distance for node *v* is updated with this value. The algorithm then loops back and processes the next node at the top of the priority queue. The algorithm terminates when the goal is reached or the priority queue is empty. Dijkstra's algorithm can solve single source SP problems by computing the one-to-all shortest path trees from a source node to all other nodes. The pseudo-code of Dijkstra's algorithm is described below.

Function Dijkstra (*G*, *start*)
1) d [*start*] = 0
2) $S = \emptyset$
3) $S' = V \in G$
4) While $S' \neq \emptyset$
5) do u = Min (S')
6) $S = S \cup \{u\}$
7) for each link (u, v) outgoing from u
8) do if $d[v] > d[u] + w(u, v)$ // Relax (u, v)
9) then $d[v] = d[u] + w(u, v)$
10) Previous[v] = u

IV. Result

There are ten Veteran Hospitals at different location of Allahabad city, has been taken for this study. Viz: Chiranjeev Hospital, Jeevan Jyoti Hospital & Arpit Test Tube Baby Centre, Swaroop Rani Hospital, Srijan Hospital, Yash Hospital, Heartline Hospital, Nazareth Hospital, Tej Bahadur Sapru Hospital, TLM Community Hospital & Parvati Hospital. Distance and time spend to reach these hospitals from SHIATS has calculated using ArcGIS Network Analyst tool which is based & directed by Dijkstra's algorithm. The detail of total time consumption, distance of each hospital from SHIATS and shortest Path followed has been shown in Table1 and figure 2(a) to 2(j).

Table 1: Total Time taken & Total Distance from: SHIATS to different Hospitals

S_NO	SOURCE	DESTINATION	TIME TAKEN	DISTANCE
1	SHIATS NAINI ALLAHABAD	CHIRANJEEV HOSPITAL	8 MIN	5.7 KM
2	SHIATS NAINI ALLAHABAD	JEEVAN JYOTI HOSPITAL	10 MIN	7.4 KM
3	SHIATS NAINI ALLAHABAD	SWAROOP RANI HOSPITAL	12 MIN	8.4 KM
4	SHIATS NAINI ALLAHABAD	SRIJAN HOSPITAL	16 MIN	8.9 KM
5	SHIATS NAINI ALLAHABAD	YASH HOSPITAL	16 MIN	10.6 KM
6	SHIATS NAINI ALLAHABAD	HEART LINE HOSPITAL	16 MIN	10.8 KM
7	SHIATS NAINI ALLAHABAD	NAZARETH HOSPITAL	15 MIN	9.6 KM
8	SHIATS NAINI ALLAHABAD	TEJ BAHADUR SAPROO HOSPITAL (**BELY HOSPITAL**)	17 MIN	10.8 KM
9	SHIATS NAINI ALLAHABAD	TLM COMMUNITY HOSPITAL	04 MIN	2.4 KM
10	SHIATS NAINI ALLAHABAD	PARVATI HOSPITAL	12 MIN	7.8 KM

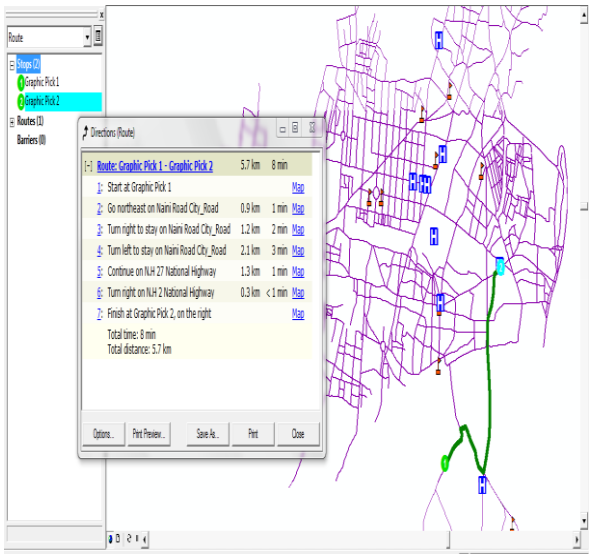


Fig.2(a) SHIATS to Chiranjeev Hospital

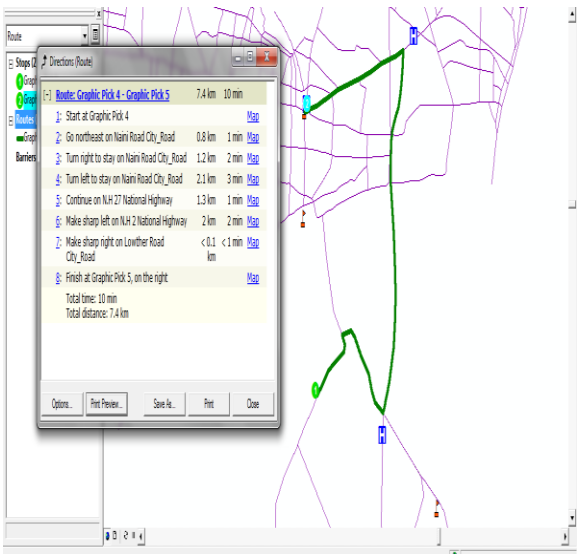


Fig.2(b) SHIATS to Jeevan Jyoti Hospital

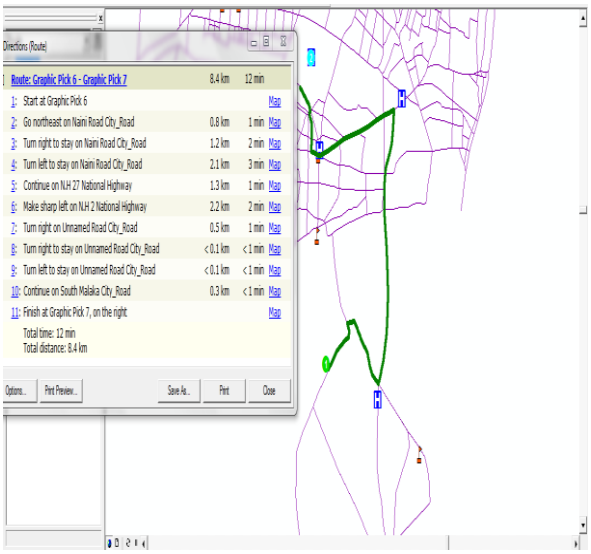
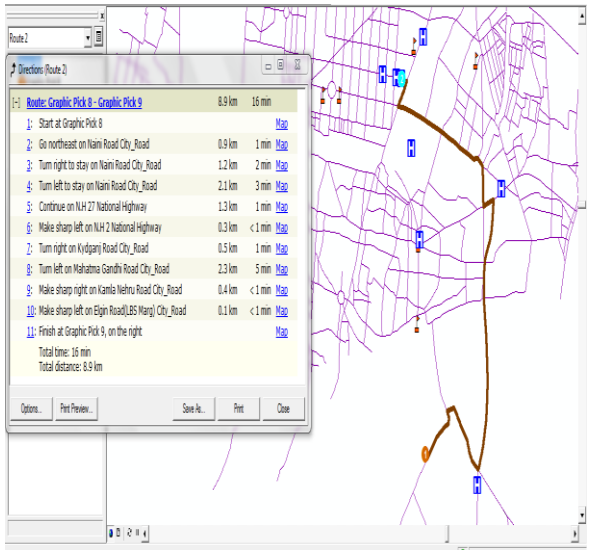


Fig.2(c) SHIATS to Swaroop Rani Hospital



(d) SHIATS to Srijan Hospital

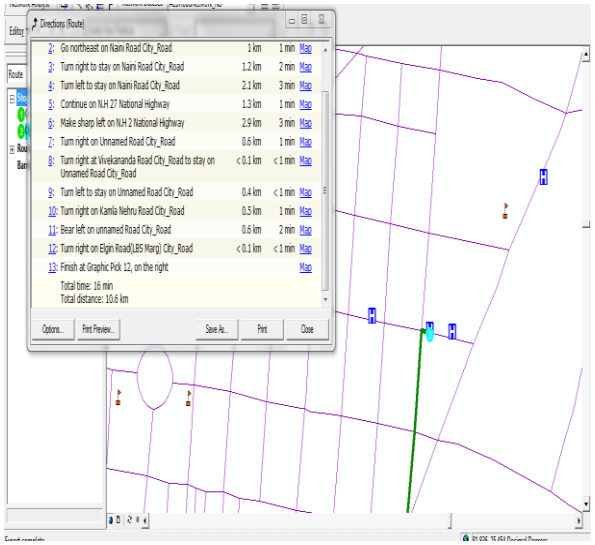


Fig.2(e) SHIATS to Yash Hospital

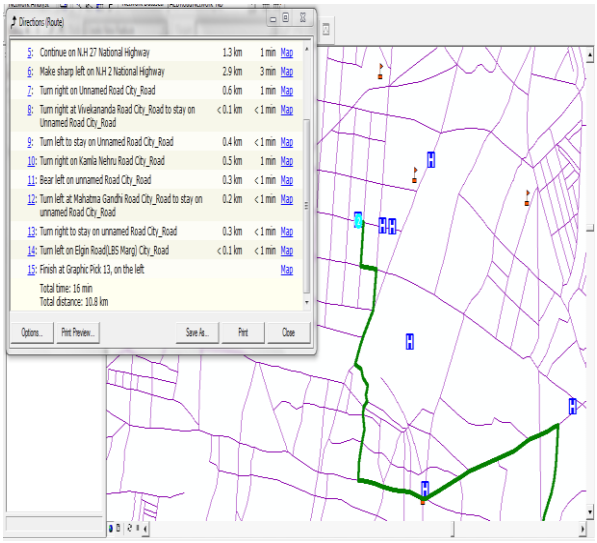


Fig.2(f) SHIATS to Heartline Hospital

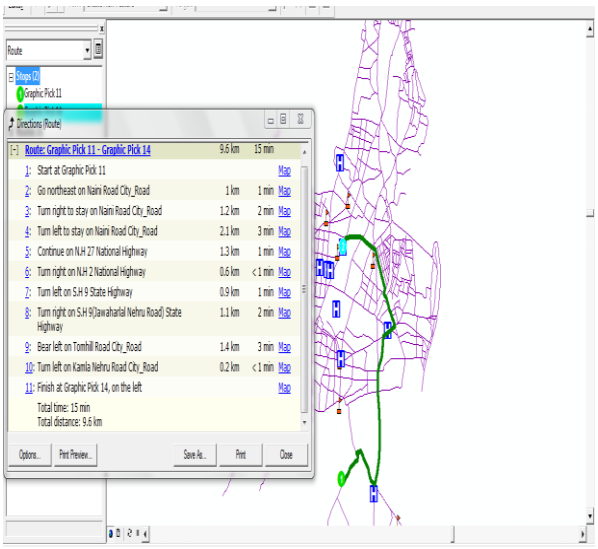


Fig.2(g) SHIATS to Nazareth Hospital

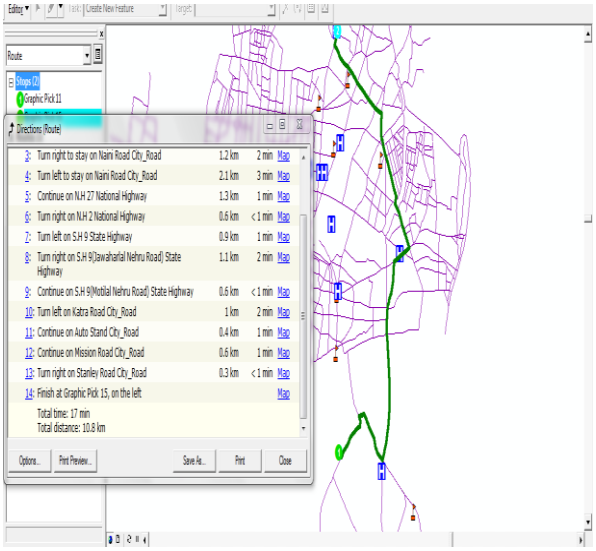


Fig.2(h) SHIATS to Beli Hospital

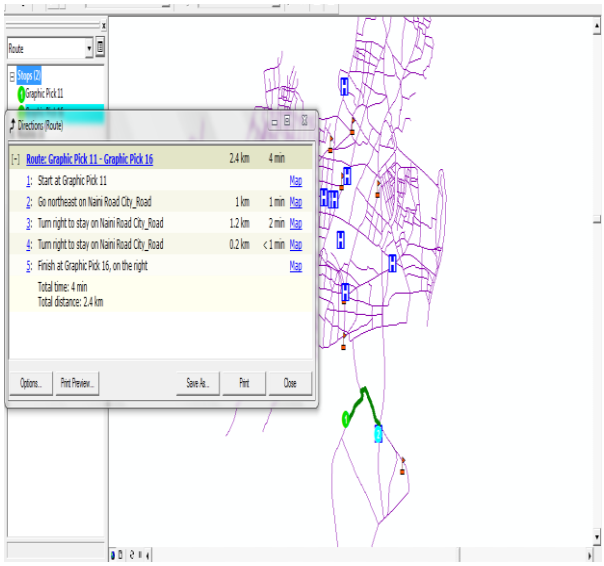


Fig.2(i) SHIATS to TLM Community Hospital

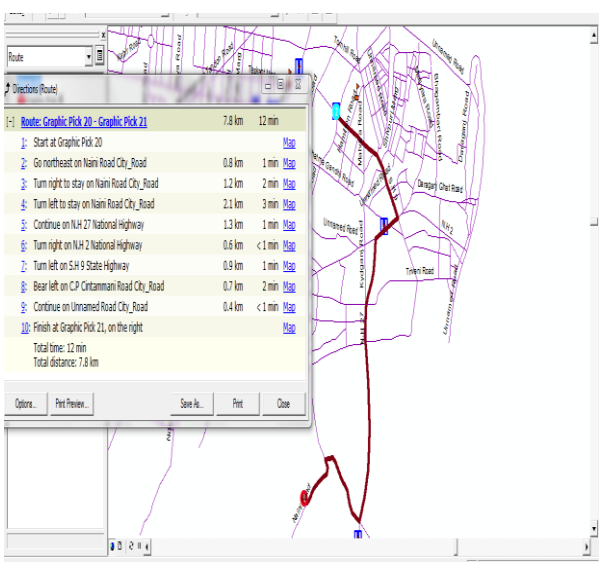


Fig.2(j) SHIATS to Parvati Hospital

Table 2: Observed Vs Estimated Time

Calculated Time(Min)	Estimated Time(Min)
12	8
13	10
15	12
18	16
16.2	16
18.2	16
17.2	15
17.36	17
5	4
13	12

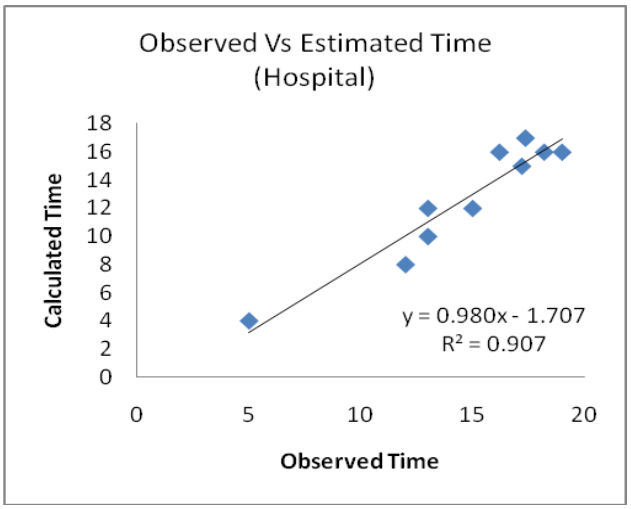


Figure 4.b Observed Vs Estimated Time regression

V. Conclusion

Optimal path finding in road networks is one of the most important analyses in GIS. Traffic congestion changes in road networks both in space and time; so, the solution is affected by time in addition to location. The cost of traveling is changing continuously due to traffic variants. So, it is inefficient to use static approaches for calculating the optimal path in dynamic networks. However, this study addresses the problem of determining shortest path in traffic networks, in Allahabad city. The research has developed a hospital routing from SHIATS in Allahabad, Uttar Pradesh. The study helps the Hospital transportation management to design shortest and fastest routes which will result in decreasing the fuel consumption and save time. Also this study proposes a routing system which is based on the integration of ArcGIS and road distance. Using ArcGIS Network Analyst tool based on Dijkstra's algorithm is user friendly interface which allows the visualization of the road map and traversal of shortest route between two selected junctions. Results of these studies show that these technologies may be very useful in space-time for solving shortest path problem. Although it is possible to determine the fastest & shortest route using GIS based network analysis but it not always work as link on a real road network in a city tends to possess different levels of congestion during different time periods of a day.

REFERENCE

[1]. Andre, M. & Villanova, A. (2004) 'Characterization of an urban bus network for environmental purposes', Science of The Total Environment, Vol. 334-335, 85-99.

[2]. Anthony, A. S. (2001) 'Model for Determining Optimum Bus-Stop Spacing in Urban Areas', Journal of Transportation Engineering, Vol. 127, No. 3, pp. 195-199.

[3]. Arthur, J. S & Wilson. B. (1984) 'Scheduling Buses', Management Science, Vol. 30, No. 7, pp. 844-853.

[4]. W Zeng & R.L. Church (2008) Finding shortest paths on real road networks: the case for A* International Journal of Geographical Information Science, Vol. 23, Nos. 3-4.
[5]. Baxter, P., Gauthier, C., Green, J. (2005) 'Point of View: Addressing Security Risks in Transportation', Transportation Research Board, TR News, Issue Number: 237, ISSN: 0738-6826, pp. 26-27.
[6]. Belcher, J., Britt, D., Granade, S., Powell, L., & Schlessinger, P. (2005) 'Bus routing algorithms: Application to a rural district', ACCLAIM Working Papers 27
[7]. Berry, K. J. (2000) 'Optimal Path Analysis and Corridor Routing: Infusing Stakeholder Perspective in Calibration and Weighting of Model Criteria', Available online at www.innovativegis.com. (Accessed 27 April 2008).
[8]. Boarnet, M. G., Anderson, C. L., Day, K., Mcmillan, T., Alfonzo, M. (2005) 'Evaluation of the California Safe Routes to Legislation Urban Form Changes and Children's', American Journal of Preventive Medicine 28 (2S2) (2005): 134–40.
[9]. Braca, J. J., Bramel, B. P., Simchi-Levi, D., (1994) 'A Computerized Approach to the New York City Bus Routing Problem', IIE Transactions, Volume 29, Number 8. pp. 693-702.
[10]. Cevik, E., Topal T. (2003) 'GIS-Based Landslide Susceptibility Mapping for a Problematic Segment of the Natural Gas Pipeline', Hendek (Turkey), Environmental Geology. Volume: 44, pp: 949-962.
[11]. Chabini, I.,1998. Discrete Dynamic Shortest Path Problems in Transportation Applications, Department of Civil and Environmental Engineering, MIT, USA
[12]. Cheng, M.Y., Chang, G.L. (2001) 'Automating Utility Route Design and Planning Through GIS', Automation in Construction, Volume: 10, N: 4, pp. 507-516.
[13]. Chuck Reider 2006, Fixing high-crash locations, Nevasa DOT geospatially enables traffic safety.
[14]. Cropper, M. (2003) 'GIS in Facility Planning: Modern technology can now aid planners and administrators in district planning. (Technology). (Geographic Information Systems) '. Planning & Management, pp. 56-60.
[15]. Davis, J. & Tanka. S. (2006) 'The Hyderabad Metropolitan Water Supply and Sewerage Board', Harvard University John F. Kennedy of Government. Case No. 1828.
[16]. DIJKSTRA, E.W., 1959, A note on two problems in connexion with graphs. *Nwnerische Mathematik,* 1, pp. 269-27 1.
[17]. Dommety, G., Jain. R. (1996) 'Potential networking applications of Global Positioning Systems (GPS)', Technical Report OSU TR-24, Department of Computer and Information Science, Ohio State University.
[18]. El Shafey, M. & Nasimudheen, M. A. (1997) 'Decision Support System for Vehicle Routing', Proceedings of ESRI User Conference, 1997. San Diego, CA, Available online at: http://gis.esri.com/library/userconf/proc97/proc97/to450/pap439/p439.htm (Accessed 27 April 2008).
[19]. Mohammad Abdul Khader Nayati (May, 2008) " Bus Routing And Scheduling Using GIS" , Department Of Technology and Built Environment, University Of Gavle