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Geospatial School Bus Routing

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----------ABSTRACT----------

Routing of School buses in Allahabad region is reported in present study. This type of transport routing is a great challenge because school bus transportation needs to be safe, reliable and efficient mode of journey. Hence, the research question is to answer how to transport students in the safest, most economical and convenient manner. When so many parameters are to be connected with Transportation network like travel time, speed, road resistance, turning movements, etc. For such a big network GIS proves itself as an efficient tool for solving such a network problems quickly and with a great precision. The GIS Software is determining the optimal routes from one origin to many destinations kind of problem for path routing which assist fastest, shortest and safest route to reach schools with minimizing travel distance and travel time within Allahabad city. In this research ArcGIS 10, Network Analysis tool which is directed by Dijkstra's algorithm, has used for finding the optimal path to reached different Schools in Allahabad region from SHIATS.

KEY WORDS: GIS, Network Analysis, Optimal path analysis, SHIATS

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I. INTRODUCTION

One of the basic problems of network modelling is to find the shortest path from an origin to a desire destination. Transport demand in most Indian cities has increased significantly, due to increases in population as a result of both natural increase and migration from rural areas and smaller towns. Further, due to unavailability of an integrated traveler information dissemination medium in metro cities in developing and transition countries such as India, travelers are not well aware of spatial and temporal variations in traffic and road conditions. Path optimization for school buses is an important assignment because approximately 23 million public school students travel through 400,000 school buses two times daily to go to and from school. In addition, it has been estimated that an additional one to two million students travel in school buses to and from school-related activities every day (National Association of State Directors of Pupil Transportation Services, 1998). The main endeavor of this study is to computes a GIS based network routing which assist to find a fastest, shortest and safest route to reach schools within Allahabad city. The application of GIS to a diverse range of problems in transportation engineering is now well established. It is a powerful tool for the analysis of both spatial and non-spatial data and for solving important problems of network routing. Shortest path analysis is an essential precursor to many GIS operations. Zhan (1996) has worked on this and explored the use of fast shortest path algorithm on extensive road networks. Pathan (1994) has evaluated the possibilities of optimization, in which the optimum routes, travel time, travel distance and cost for defined paths and for the optimum paths was determined for few transport services. Guruswamy (1989) has also evaluated the GIS techniques for route optimization. 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. In 1959 Edsger Dijkstra suggested an algorithm for finding the shortest path in GIS domain. The Dijkstra's algorithm remains to this day one of the best approaches for optimally solving the simple optimal path problem where all arcs have nonnegative lengths (*Zeng and Church, 2008*).

II. STUDY AREA

Allahabad is an ancient & large city of the state of Uttar Pradesh in India. It is consider as educational hub of Uttar Pradesh. 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.

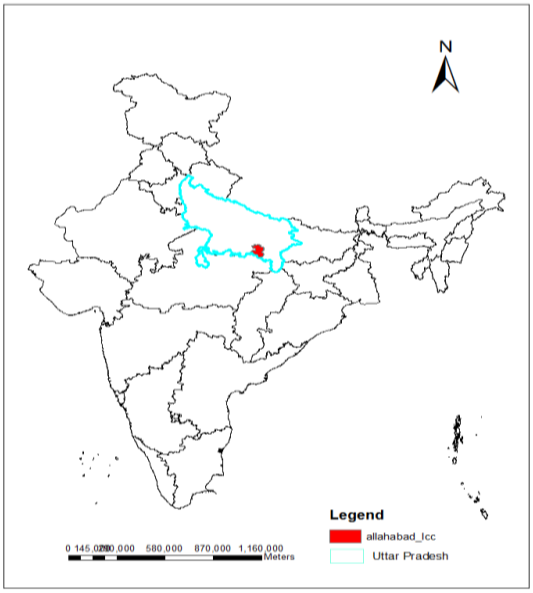

Fig.-1: Location map of study area

III. MATERIALS AND METHODS

Survey of India (SOI) topographic of 1:250,000 and 1:50,000 scales, Google earth data, LISS-IV data (5.8m), Arc GIS 10 & GPS has been used to extract information of road network and location of different schools. Geodatabase has prepared in GIS domain which makes easy to process, analyze and combine spatial data and make it easy to organize and integrate spatial processes into larger systems that model the real world. ArcGIS Network Analyst tool has played a significant role in this study to find out the shortest and fastest route to reach the different schools 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 in a road network.

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 = ∅
3) S' = V ∈ G
4) While S' ≠ ∅
5) do u = Min (S')
6) S = S U {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

Ten famous schools of Allahabad city has been chosen for our purpose of the study in GIS domain, all are situated at different location. They are Modern Public School, Ewing Christian Public Senior Sec. School, Institute of Physiological & Educational Measurement International School, Bishop Johnson School & College, St. Joseph's School & College, Jagat Taran Purva Madhyamik vidhyalaya, Mary Lucas School & College, Kendriya Vidhyalaya Old Cantt, Boys High School and Bethany Convent School. Distance and time spend to reach these schools from SHIATS has calculated using ArcGIS Network Analyst tool, directed by Dijkstra's algorithm. The detail regarding time consumption, distance of each school from SHIATS and the followed suggested shortest path has shown in Table1 and figure 2(a) to 2(j).

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

S_NO	SOURCE	DESTINATION	TIME TAKEN	DISTANCE
1	SHIATS NAINI ALLAHABAD	Modern Public School	7 MIN	4.7 KM
2	SHIATS NAINI ALLAHABAD	Ewing Christian Public Senior Sec School	9 MIN	7.4 KM
3	SHIATS NAINI ALLAHABAD	Institute of Physiological & Educational Measurement International School(**IPEM)**	17 MIN	11.1 KM
4	SHIATS NAINI ALLAHABAD	Bishop Johnson School & College	18 MIN	12.5 KM
5	SHIATS NAINI ALLAHABAD	St. Joseph's School & College	16 MIN	9.9 KM
6	SHIATS NAINI ALLAHABAD	Jagat Taran Purva Madhyamik Vidyalaya	11 MIN	7.9 KM
7	SHIATS NAINI ALLAHABAD	Mary Lucas School & College	15 MIN	10 KM
8	SHIATS NAINI ALLAHABAD	Kendriya Vidyalay, Old Cantt.	18 MIN	12.5 KM
9	SHIATS NAINI ALLAHABAD	Boys High School & College	17MIN	10.3 KM
10	SHIATS NAINI ALLAHABAD	Bethany Convent School	5 MIN	3.5 KM

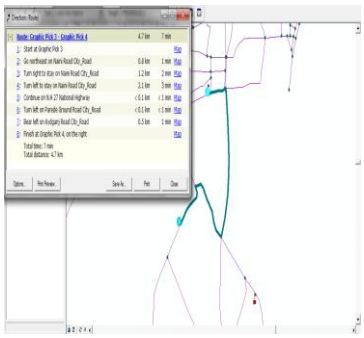

Fig.-2,a:SHIATS to Modern public school

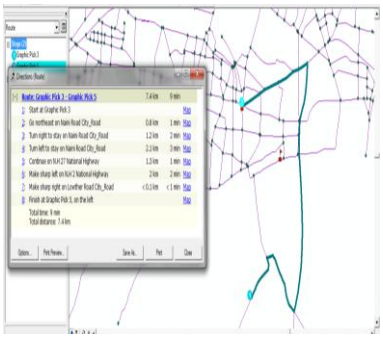

Fig.-2,b:SHIATS to Ewing Christian College

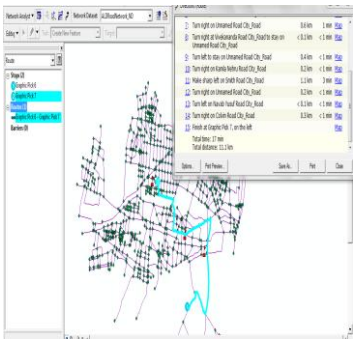

Fig.-2,c:SHIATS to IPEM

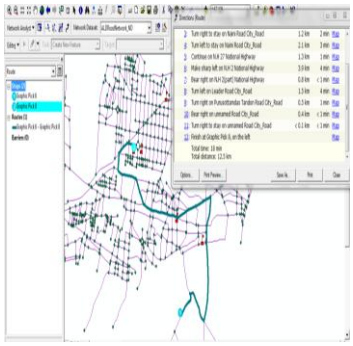

Fig.-2,d:SHIATS to Bishop Johnson School

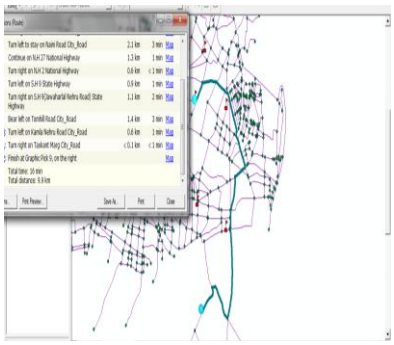

Fig.-2,e:SHIATS to St. Joseph's School

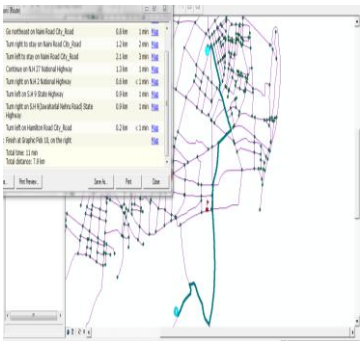

Fig.-2,f:SHIATS to Jagat Taran madhyamik school

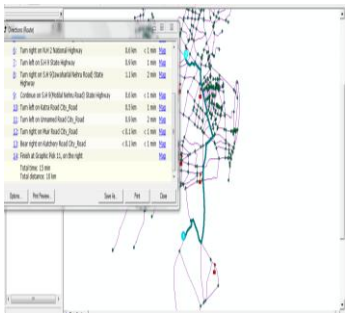

Fig.-2,g:SHIATS to Mary Lucas School

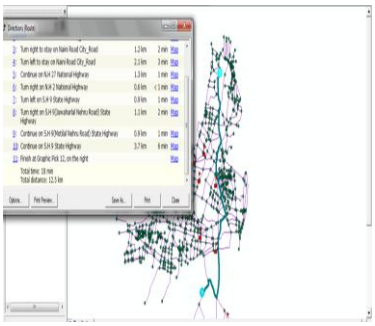

Fig.-2,h:SHIATS to Kendriya vidhyalaya

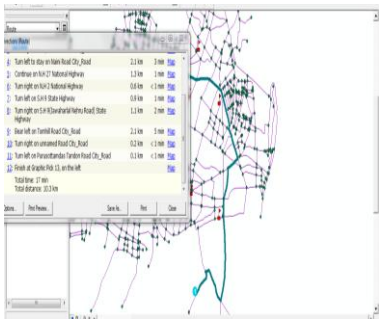

Fig.-2,i:SHIATS to Boys High School

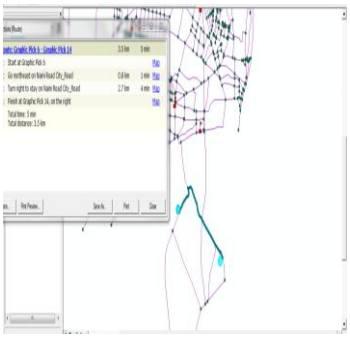

Fig.-2, j: SHIATS to Bethany Convent School

Table-2: Observed Vs Estimated Time

Calculated Time(Min)	Estimated Time(Min)
26	18
25.3	17
13	9
25	17
26.5	18
17	16
14	11
7	5
18	15
24	18

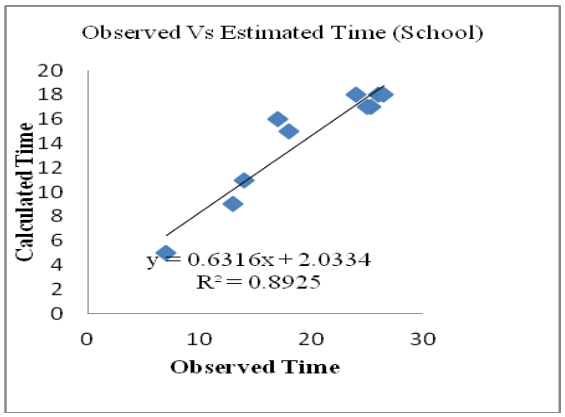

Fig.-3: Observed Vs Estimated Time regression

V. CONCLUSION

The use of GIS based networks and geocoding techniques can greatly facilitate many types of traditional routing problem. This paper provides a systematic approach to aid in the implementation of an optimal School bus routing system that is integrated with GIS technology. The system also assists for school transportation management to design shortest and fastest school bus routes which will result in decreasing the fuel consumption and save time. The system was developed using GIS software ArcGIS 10 and ArcGIS Network Analyst tool, directed by Dijkstra's algorithm is user friendly interface which allows the visualization of the road map and traversal of shortest route between two selected junctions. The study proposes a routing system which is based on the integration of ArcGIS 10 and road distance. Results of these study show that these technologies may be very useful in space-time to solve shortest path problem. The resulted path is a schedule coordinated fastest path for given constraints including origin and destination with a planned departure time or an expected arrival time. Although it is possible to determine the fastest & shortest route using GIS based network analysis but sometime this routing system may not work always as the link on a real road network, tends to possess different levels of congestion during different time of a day.

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