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The Shortest Path Analysis Based on Road Network

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Abstract Rational planning of agricultural product transport route from initial node to destination node can effectively reduce the cost price of agricultural products, and the calculation of shortest path between any two points also affects people's daily travel. Taking Heze Railway Station to Heze College for example, with remote sensing image data as the base map, we conduct vectorization and topological analysis on roads in the target area. With Dijkstra as theoretical basis of shortest path algorithm, we use ArcGIS network analysis method to build road network, and calculate the planning program of the shortest distance path, the shortest path by driving and the shortest path by walking.

Key words Shortest path, Dijkstra's algorithm, Road network model, Network analysis

1 Introduction

With the advance of urbanization, the role of urban road network in people's daily life is more and more important. The level of urban road network construction also reflects the differences in urban scale, urban economic development level and population status. At present, China's large, medium and small cities are facing varying degrees of traffic pressure[1], having a direct impact on the city's economic development and people's travel. At the same time, the quality of agricultural product transport route planning has a direct impact on the cost of agricultural products[2-4]. Space network is the system consisting of lines and points, so building urban road network model and choosing the optimal travel route becomes an effective means. By ArcGIS network analysis tool, we take Heze Railway Station to Heze College for example, and build the urban road network to choose the best travel route and bring forward the solutions to the shortest path problem.

2 Dijkstra's algorithm

Dijkstra's algorithm is an algorithm for finding the shortest paths between nodes in a graph, which may represent, for example, road networks. For a given source node in the graph, the algorithm finds the shortest path between that node and every other. It can also be used for finding the shortest paths from a single node to a single destination node by stopping the algorithm once the shortest path to the destination node has been determined[5-8]. The certain node set at the minimum resource cost is $V_{(i)}$, and the uncertain node set at the minimum resource cost is $S_{(i)}$. At the initial stage, the resistance from source node to source node is known, $V_{(i)}$ includes source node and $S_{(i)}$ includes other nodes. Traversing the nodes from $V_{(i)}$ to $S_{(i)}$, the least resistance path from $V_{(i)}$ to $S_{(i)}$ is generated based on the resource cost ascending order. $K_{(1,j)}$ records the smallest resistance value and path from node i to j until $S_{(i)}$ is the empty set.

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3 Construction of the road network model

The road network model is the abstract representation of traffic network system in the real world. The road is denoted by arc and the road intersection is denoted by node. The correct construction of road network model is the key to searching for the best path. The experiment involved in this paper uses WGS84 coordinates, Gauss-Krüger Projection, 38 belt in 3 degree belt (112.5°E - 115.5°E).

3.1 Road vectorization and grading The electronic map includes bitmap map and vector map. The vector map graphically records the coordinates of each node, which ensures the high accuracy of data. The vector map is divided into point, line and face, and the line type can well match line or net road network[9]. In the road network, the spatial graphics data mainly include points and lines, manifested as nodes and arcs in the entity. Arcs represent the roads and nodes are the connection points in the road network. The state is expressed as resistance magnitude (Table 1). The connection points are divided into the following types: (i) barrier points (traffic prohibition points in road network, such as traffic accidents and road construction); (ii) inflection points (road dividing points in road network, such as bend line limit and turning time limit); (iii) sites (initial node and target point in road network). The vector map in ArcGIS is stored based on layers, and a certain type of thematic information is placed in each layer. The description of each type of thematic information includes two aspects, namely spatial pattern data and attribute information data. On the basis of the acquired raw remote sensing data, it is corrected, the coordinate system is added and projection is defined. After zoning, the remote sensing image is regarded as the base map, and all roads included in ArcGIS environment are vectorized and assigned with attribute value. According to the road width and number of two-way lanes, roads are divided into different types, and the speed is limited based on the standard, as shown in Table 2.

3.2 Topological analysis Factor topology means the relative position between the geographic entity factors in GIS, including 6 relative positional relationships (Table 3). The topological analysis is used to integrate the 6 kinds of spatial relationships and de-

scribe the relative position between the factors. The most important function of topology data structure is topology editing function including polygon connection editing and node connection editing. The creation of topological relations can clearly reflect the logical structure between entity factors, not changing with map projection changes, with good stability, and topological analysis is the premise of network analysis. In ArcGIS environment, under layer-editable state, all road lines are selected, and the topology tool is used for self-intersection between lines and creation of topological relationships between roads. At the same time, the road length attribute information is added and divided according to the road level, and driving and walking time is calculated.

Table 1 Types and attributes of spatial data in road network

Type	Description	Attributes
Points	Node or intersection	Source point, destination node, obstacle point, inflection point and so on
Lines	Arc or road	Road, traffic control, rate-limiting, accessibility and so on
Surfaces	Scope of research	—

Table 2 Road grading

Road level	Running speed//m/min	Walking speed//m/min
Transit road	1000	50
Trunk	670	50
By-pass	340	50
Path	170	50

Table 3 Topological classification

Factor entity	Topological characteristics
Point-point	Adjacency between points
Point-line	Point on line, point not on line
Point-surface	Point on surface, point on the edge, point outside surface
Line-line	Division, intersection, interconnection between lines
Line-surface	Line on surface, line on edge, line outside surface
Surface-surface	Division, intersection, interconnection between surfaces

3.3 Construction of road network The road network model is based on the arc connection, and the road network model is expressed:

$$R_W = (N, R, L_R)$$
$$R = \{(x, y) | x, y \in N, L(x, y)\}$$
$$L_R = \{L_{(x, y)} | (x, y) \in R\}$$

where R_W is road network; N is node set; R is arc set; element (x, y) describes a directed arc from node x to y; L_R is arc length set; $L_{(x, y)}$ is road length from node x to y.

In ArcGIS environment, the new file database is established and the element dataset is created in the file database. The road elements are imported into the element dataset, and on this basis, the network dataset is created on the element dataset. In the creation process, the general turning rules and road network connectivity strategy are set, and road network resource costs and direction are created. The single road section length and time attribute rules are set for road network model, and after the completion of the network, the road network is immediately created so as to form road network. As for the road network constructed, there are a total of 36972 sides, 12325 intersections, 5 single lines and 3 restrictive left intersections.

4 Shortest path analysis based on road network

With remote sensing image of Heze City as the base map, the constructed road network system is used to search for the optimized path with the shortest driving time and walking time and shortest distance between "Heze Railway Station" (initial node) and "Heze College" (destination node). In Network Analyst, by building the new path, the road resistance, driving time resistance and walking time resistance of different paths are set respectively, and the whole path is analyzed. The calculation results are shown in Fig. 1 and the statistical results are shown in Table 4. As can beseen from Fig. 1, the shortest distance path is basically the same as the shortest path by walking but different from the driving path, making a turn in the intersection between Taiyuan Road and Yellow River Road. The shortest distance between Heze Railway Station and Heze College is 7591.592 m; the shortest walking time between Heze Railway Station and Heze College is 156.499 min; the shortest driving time from Heze Railway Station to Heze College is 18.866 min. From the statistical results, it is found that the

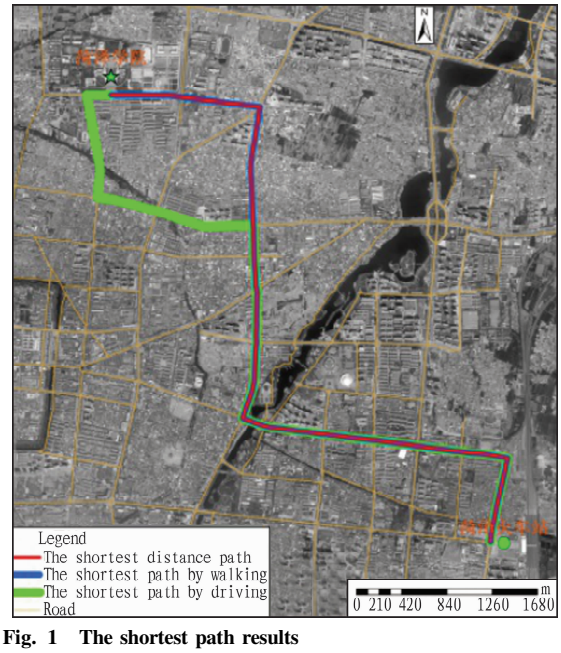

Fig. 1 The shortest path results

shortest path by driving is 7764.602 m, longer than the shortest distance path; since the shortest distance path does not consider traffic lights, intersection turning and other factors, in the total driving time, the driving time for the shortest distance path is shortest, and if considering traffic light resistance and turning resistance, the driving time for the shortest distance path is 19.234 min, namely the driving time for the shortest path by walking; similarly, the shortest total walking time for the shortest distance path is 151.832 min, because it does not consider traffic lights and intersection turning factors, and the total walking time for the shortest distance path is 156.499 min.

Table 4 Statistical results

Path class	Total distance//m	Total driving time//min	Total walking time//min
The shortest distance path	7591.592	14.568	151.832
The shortest path by walking	7764.602	18.866	159.625
The shortest path by driving	7591.592	19.234	156.499

5 Conclusions

The shortest path analysis based on road network is the focus of network analysis in GIS and urban planning. Reasonable planning of agricultural transport routes can also effectively reduce the agricultural prices. The shortest path analysis in this paper can be done to search for the shortest distance path, the shortest path by driving and the shortest path by walking between any two points in the road network, so it is the important application of network analysis in our daily travel, meeting the experimental design requirements.

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4.2 Improving the ability of collecting evidence and standardizing the evidence collection, to solve the difficulty of evidence collection In order to solve the difficulty in collecting evidence for investigation of environmental pollution cases, the investigation organ should take following measures. (i) It is recommended to effectively enhance the ability of the public security organs in collecting evidence. A large number of successful cases create conditions for case handling organizations summing up evidence collection experience and building the evidence system. The Ministry of Public Security should comprehensively establish the evidence system, issue the evidence collection guidance opinion, hold special training classes, disclose typical cases, and promote successful experience. (ii) After receiving and reporting the case, the public security organ should immediately assign personnel to go to the site and make careful investigation. Although it is difficult for the administrative law enforcement organizations to rush to the scene in the first time, it is impossible to obtain the most direct evidence of environmental pollution, but such case has crime scene. According to the experience, the crime scene is the inevitable result of crime activity. In the crime scene, there will be various traces of evidence left by the criminal.

4.3 Including the environmental pollution judicial identification system, and unifying the identification standards, to solve the difficulty in identification In order to enhance the objective and effective judicial identification opinions, we should do a good job in following aspects. (i) It is recommended to include the environmental pollution judicial identification system, and unifying the identification standards, unify the identification technical criteria and regulations. (ii) It is recommended to select a number of professional identification organizations and enhance their credibility. All environmental pollution cases disclosed involve the identification of environmental pollution. (iii) It is recommended to establish and improve the legal system and standardize the identification cycle, to satisfy the demand of case handling. At the national level of legal system, as the legal management organization of judicial identification, the Ministry of Justice should promptly issue departmental rules and regulation, and work out unified regulations on the judicial identification from the legislation, so as to solve the problem of arbitrariness of judicial identification organizations in the identification time limit.

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