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Route Alignment Based on GIS Cost Analysis

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ABSTRACT. *This report uses AHP method to determine the weight of each element, using raster computing to build cost grid, running GIS spatial analysis function to analyse. After that, the cost path between the two provides the basis for route alignment. The GIFFNOCK to DARVEL route alignment is taken as an example to verify this method.*

KEYWORDS: *Geographic information system (GIS), Analytic hierarchy process (AHP), Route alignment*

1. Introduction

The road system is the framework that constructs the city's functions and is the artery that links the cities. According to Dunham’s article, roads are the most common and possible movement routes in cities and the most effective means for the whole city (Dunham, 1960). As an infrastructure to undertake transportation functions, roads also have the ability to open spaces and other resources to show the city's individuality. Route alignment is the basic content of transportation construction. This report is intended to be combined with the AHP method. Improving the Route Alignment method, and take the GIFFNOCK to DARVEL Route Alignment as an example to construct an evaluation system for Route Alignment, making the road construction process more ecological, efficient and economical.

2. DATA

This report based on the AHP to determine the weighting indicators of various impact factors. Then run the GIS raster calculator tool to calculate the multi-factor weight overlap plus, getting the “cost raster” and using the “cost path” tool. Finally, a route alignment plan between the two places will be obtained. Coordinate system used in this report is OSGB_1936_British_National_Grid, and the operating platform is ARCGIS 10.2.

(1) Basic data: The basic data is mainly open data of the Internet, mainly based on raster data, including: 30m precision digital elevation model (Earthdata.nasa.gov, 2019); 30m precision landcover (Data.ess.tsinghua.edu.cn, 2019); satellite imagery, the access method is google earth (Google Maps, 2019), satellite image data is used for decision making.

(2) Coordinate system: Different data have corresponding offsets, the digital elevation model from NASA, its original coordinates are wgs-1984 geographic coordinate system; Landcover data from Tsinghua, its original coordinates are wgs-1984 geography Coordinate system, satellite image from Google Earth, his original coordinates are Wgs_1984_Web_Mercator_Auxiliary_Sphere geographic coordinate system. To complete this research, using GIS projection transformation tool, this report unifies these three data into OSGB_1936_British_National_Grid projection coordinate system.

(3) Single factor: This report mainly uses GIS spatial analysis, buffering, reclassification and other tools. The digital elevation model can derive slope, elevation and undulation data, and the surface cover can extract forest and water plaque data (Jha, 2000; Mamoj K. & Paul Schonfeld., 2004).

3. Results

(1) Factor

Slope: using the GIS platform slope analysis tool to obtain the slope distribution of the study area, set the slope distribution to: 0-5, 5-10, 10-15, 15-20, greater than 20. In addition, the reclassification tool should be used to reclassify the slope value to 5, 4, 3, 2, 1 means that the smoother the slope, the lower the construction difficulty.

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Elevation: the elevation of the area is concentrated in the range of 150-250. In order to avoid large fluctuations on the road, this report takes the average value of 200 as the node and 30m as the fluctuation range. Running the GIS reclassification tool, the elevation raster is used. The assignment is 1, 2, 3, 4, 5, the closer the elevation is to

200 meters, the lower the assignment, indicating that the construction cost is lower.

Relief Degree: The area with higher undulation indicates that the construction difficulty is larger than the earthwork filling amount. The road direction should try to avoid the area with large undulation. According to the undulation raster map, the base undulation range is 0-25m. On the basis of the statistics of fluctuating sample values, the magnitudes of the fluctuations are relatively average, and are standardized at intervals of 5m, and the values are 1, 2, 3, 4, and 5.

Forest buffer: Forests are an important manifestation of the environment in the reaction area, the closer the road is built to the forest, the more severe the disturbance to the forest. This report uses surface coverage data to extract forest patches, using the GIS Euclidean distance tool to obtain forest buffers in the study area, dividing the forest buffer numbers into five stages at a distance of 50 meters. Simultaneously, the reclassification tool will be utilized to expression the values to 5, 4, 3, 2, and 1, representing the farther away from the forest, the less disturbing the forest.

Water buffer: The water body is an important carrier of the landscape and environment of the reaction area. The construction of the road should avoid affecting the water body. The closer it is to the water body, the easier it is to pollute the water body. This report uses surface coverage data to extract water plaques, using the GIS Euclidean distance tool to obtain water buffers in the study area, dividing the water buffer number into five stages at a distance of 200 meters. At the same time, using the reclassification tool to buffer the values are reclassified as 5, 4, 3, 2, and 1, representing the farther away from the body of water, the less disturbance to the body of water.

(2) Cost raster

Ruing YAAHP software, a weight matrix model is established to influence the single factor. The construction cost matrix consistency test CR=0.0752, the model parameters and corresponding weights are as follows:

Table.1 weight matrix

	slope	elevation	relief degree	forest buffer	water buffer	Wi
slope	1	6	5	3	3	0.4666
elevation	1\8	1	1\4	1\6	1\6	0.0351
relief degree	1\5	4	1	1\2	1\2	0.1042
forest buffer	1\3	6	2	1	1\4	0.1438
water buffer	1\3	6	2	4	1	0.2503

For each single factor, multi-factor weight overlap addition, also known as "Millennium Cake Method" (McHarg , 1969). It has been widely used in the field of land evaluation. The conclusions of this part can be generated by Running the GIS raster calculator according to the respective weights of each item. Run the Raster

Calculator tool to weight each element according to Table 1.

Cost raster = slope ∗ 0.46666 + elevation ∗ 0.0351 + relief degreee ∗ 0.1042 + forest buffer ∗ 0.1438 + water buffer ∗ 0.2503

(3) Path selection

According to the GIS path analysis method, it is necessary to determine the road node, that is, the starting point of the road. GIFFNOCK should be chosen as the starting point and DARVEL as the ending point. Finally generate an optimal path calculation are as follows (Fig. 1-3).

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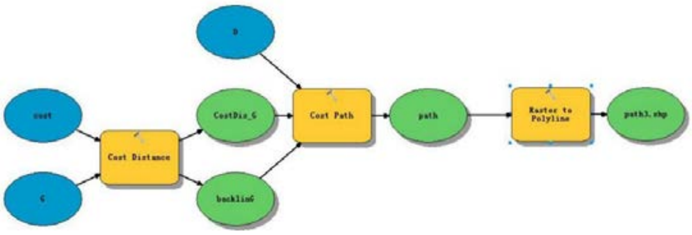

Fig.1 Cost Path Model

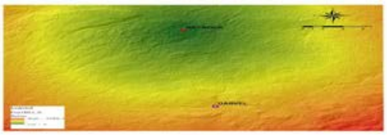

Fig.2 St Distance

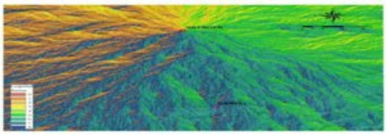

Fig. 3 Cost Back Link

(4) Route Alignment Results and Analysis

The comprehensive factor cost path obtained by determining the weights of the influencing factors by the AHP method results in the path selection between GIFFNOCK and DARVE L (Fig. 4):

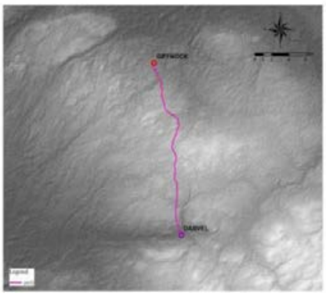

Fig.4 Route Alignment Results

1) The straight line distance between GIFFNOCK and DARVEL is 18.5 km. The selected path length is 20.7 km, which is 2.2 km more than the straight line distance. The average elevation of the Route Alignment is 236M. The selected path is well matched with the terrain, and there is no crossing slope. In steeper areas, the undulation of the road is also kept at a lower level.

2) The road basically does not cross the waters, but has little impact on the waters, but some of them partially invade the forest. The reason is that there are large forest patches in the middle of GIFFNOCK and DARVEL. Due to the weight setting, the economics of Route Alignment and There is a balance between forest disturbances.

4. Reflection on the Conclusion of Road Location

The GIS simulation route alignment scheme is placed on the satellite image basemap for analysis and comparison, and the following conclusions are obtained:

(1) In the area between GIFFNOCK and DARVEL, there are some roads with low grades. The choice of roads between the two places can be extended, concatenated and supplemented by existing roads. Scientifically, it also reduces the damage to the environment.

(2) The main role of the road should be to promote the traffic between the towns of GIFFNOCK and DARVEL, so as to maximize the benefits of road splicing, and the Dijkstra's algorithm itself considers the “node” elements. For the sake of information and time, this report lacks an analysis of this area.

(3) Lack of landscape considerations. Patches such as mountains, rivers, farmland and forests can reflect the heterogeneity of the landscape. The connection of roads should also consider the good viewpoint of the landscape. Therefore, the completion of route alignment in the early stage, the landscape resources of the region should be evaluated.

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