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A Study on the Application of GIS and AHP for the Optimization of Route Selection

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Abstract

In a route plan, the route selection is a complicated problem to consider the spatial distribution and influence through overall related data and objective analysis on the social, economic and technical condition. The developed system in this study was compared and estimated by deciding a practical section for its validity and efficiency. Using Geographic Information System (GIS), the various information required for route selections in database was constructed, the characteristics of subject area by executing three-dimensional terrain analysis was grasped effectively, and the control point through buffering, overlay and location operation was extracted. An optimum route was selected by calculating the sum of alternatives to the sub-criteria weight, and from this result, there is a difference between real route and proposed route according to the prioritization of decision criteria based on the importance. This research could be constructed and applied geospatial information to the reasonable route plan and an optimum route selection efficiently using GIS. Therefore, the applications are presented by applying Analytic Hierarchy Process (AHP) to the decision-making of information needed in route selection.

Key words : geographic information system, analytic hierarchy process, route selection, database construction

1. Introduction

The investigation of route at the time of road planning is made with the system of decision-making to try to choose the most suitable alternative under various judge standards. However, the decision of real route is being made with the intuitional judgement of professional to have much experience in existence due to the lack of all sorts of data and spatial analysis capability.

Route selection process needs the analysis function of GIS to analyze and manipulate a lot of spatial information efficiently, and make decision more reasonably. And the subjective judgment of engineers is the difficult process which plays an important role in such that case.

For the efficient route selection, the route selection model through construction and analysis procedure of position information using GIS were presented, and route selection system linked with AHP was developed. This system is easy to be used and managed for presenting route alignment according to conditions as a Graphic User Interface (GUI) environmental window system by applying three tiers based object-oriented method. Various decision-making factors are considered to have to equip at the time of investigation for maximizing route selection substantially. And, The methods are showed until choosing optimal route after judging the merit and demerit by each alternative systematically through developing it with the module of AHP. Thus, by grafting the approach method of GIS with route selection plan and using AHP, through establishing alternative route and grasping importance degree and seeking systematic and objective decision, feasibility of application of GIS and AHP was showed.

2. Route Plan Process

Route plan is the work to choose most appropriate 1 route in consideration of the various conditions of study area. We may examine the possibility of arrangement of relevant route by constructing and analyzing the database related to route and extracting controlled points so as to link GIS to route selection as is in Fig. 1. In deciding route location, there are the point that route should pass or the point that

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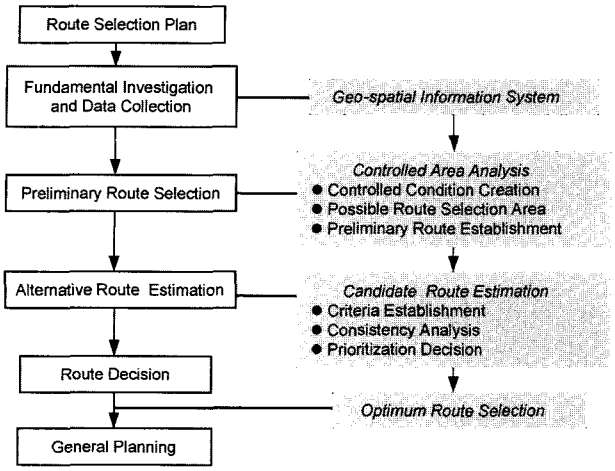

Fig. 1. Geological Map.

route should avoid. This is referred to as controlled point.

The subject area constructed data by utilizing GIS, and constituted route selection model, so that route analysis and estimation etc. may be possible. In addition, we may decide optimum route by setting controlled area condition through the use of overlay analysis and judging the prioritization about preliminary route through the application of spatial analysis function. Optimum route is not to find the route to have short distance, but it means the retrieval of route to satisfy any condition. Optimum route selection level is the stage to judge and choose finally by referring to the weight of decision-making elements.

3. System Construction

3.1 Database

About the acquisition of spatial data about the general map and thematic map of subject area, the subject area digitized through the map scanning and vectorizing work. And, in case of digital map, the subject area set topology after changing data, so that it may be used with MGE module. The subject area established each attribute data related to spatial data by connecting it with relational database(Fig. 2).

3.2 Environment of System Development

The composition of a series of program about route selection system is as is in Fig. 3. This system environment formed whole models to enable one to forecast route selection area by using the analysis function of network in addition to the database for the data management GIS, graphic and the analysis of positional data and to make data management, display and map query by using GeoMedia.

For the addition of user interface development, user

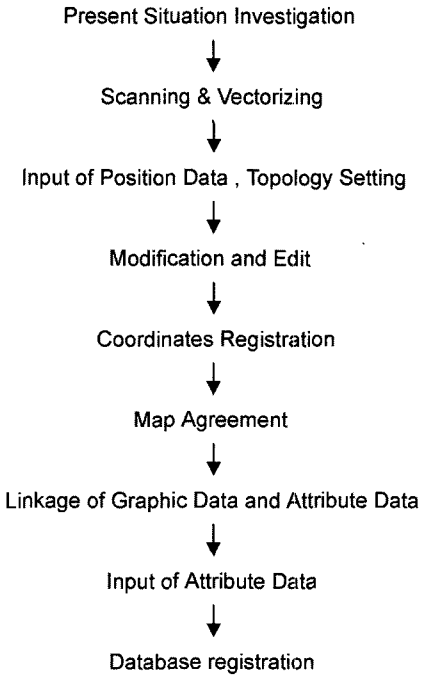

Fig. 2. Database Construction Process.

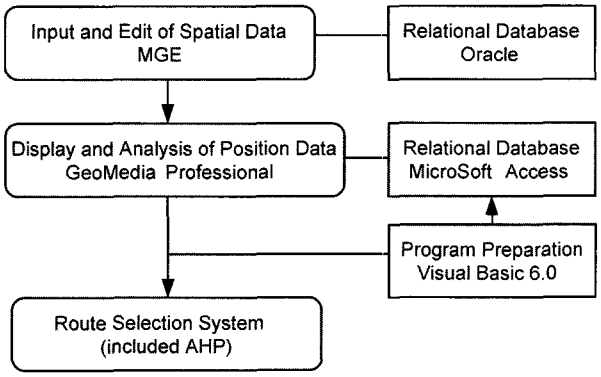

Fig. 3. Framework of Route Selection System Development.

requirement function and the manufacture of user development application, this study used GeoMedia to be standard window development tool such as visual basic. As for development environment, for the application manufacture through the development of user connection or the development of special function and the independent development of user, this study used standard window development tool and Object Linking and Embedding (OLE) technology and constituted with the base structure of Component Object Model (COM). In the saving and management of data, this study simplified the saving of position data and the manipulation of table on the basis of relational data model, as much spatial information should be handled.

The study area are road network between seosan and

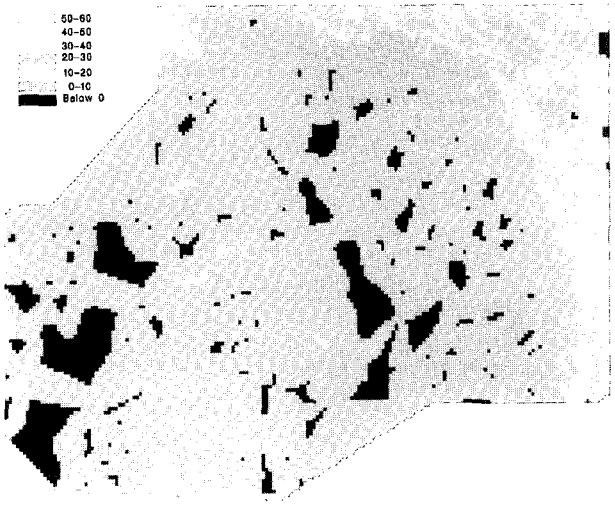

Fig. 4. Slope of Terrain.

Fig. 5. Watershed.

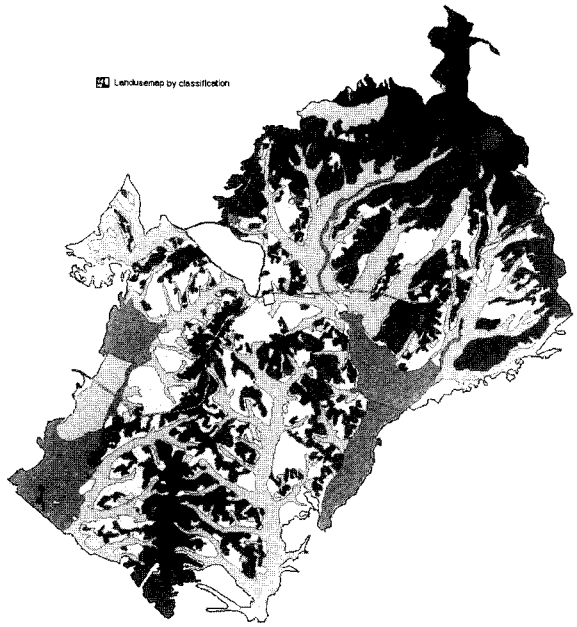

Fig. 6. Land Use Map.

unsan. This study performed precise scanning by using the map scanner (ANAtech Eagle 3640) of high resolution after duplicating the cadastral maps (Scale 1:1000, 1:1200) and forest maps (1:6000) of study area precisely. This study used semi-auto vectorizing to change graphic attribute by designating parcel as occasion demands after displaying the

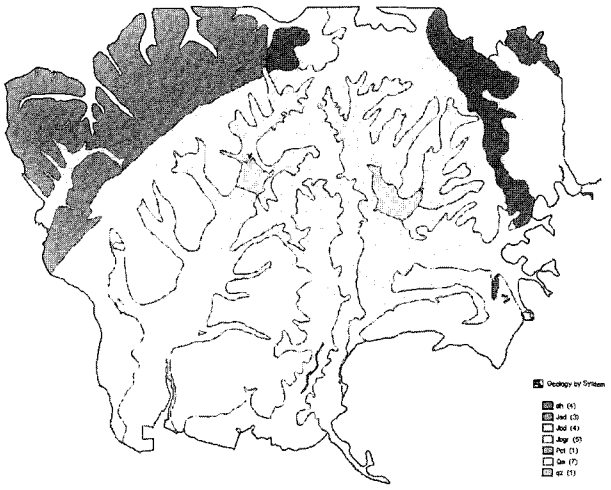

Fig. 7. Geological Map.

Fig. 8. Detailed Soil Map.

Fig. 9. Cadastral and Forest Map of Land.

cadastral maps and forest maps of raster format on monitor. Terrain of subject area from east to west slopes gently down at the sight of terrain as a Fig. 4. Fig. 5 are watershed of stream decided by surrounding of the highest elevation.

This area have much common crops as a Fig. 6. And Fig. 7 represents geological distribution on the subject of area.

Fig. 8 represents a detail soil map. Fig. 9 shows in a graphic form digitized cadastral map and forest map that entered data related parcels into attribute information.

3.3 Extraction of Controlled Point

In this study, this study acquires the information to be suitable for the area that route selection is possible and extracts exclusion area by using the buffering and overlay function of GIS. In addition, this study established the model to be suitable for route selection by introducing expert system and established alternative route through exclusion area analysis. The developed system in this study was compared and estimated by deciding a practical section for its validity and efficiency. Using GIS, the various information required for route selections in database was constructed, the characteristics of subject area by executing three-dimensional terrain analysis was grasped effectively, and the control point through buffering, overlay and location operation was extracted.

By using the spatial database established like this, this study executed the analysis of DTM, thematic map, overlay and buffering and applied spatial query through search and inquiry. This study input the controlled points extracted by the analysis of GIS in the knowledge field of expert as road selection condition like this, and the comparison route came to be extracted by conditions in the route selection system of 3 tier base.

The tier of data is in charge of a class for the exchange, extraction and conservation of data between GeoMedia and application tiers. A route selection algorithm was applied to application tiers, considering all conditions which are necessary for the route selection between a beginning point and an end point, and it was added by module such as data handling, road condition, buffer, clothoid and AHP to select the alternative route followed by new condition. The user tier can express the data acquired by an application tier.

Controlled points means both evasion points and pass points. Evasion points such as residual area, agriculture area, school, apartment complex, road plan boundary, lake, reservoir, and existing building etc are created. In addition, as for pass point, this study used it by inputting bridge location and road intersection etc.

One get to set some plan routes in consideration of the controlled areas chosen with this method. This study applied the points to have to escape out of the conditions used at controlled point jointly. And, this study set the condition, so that route may not pass by, by forming buffering area.

4. Analytical Hierarchy Process

4.1 Decision-making by AHP

Most decision-making problems related to business are showing the form of decision-making problem of multicriteria which should choose optimum alternative under various criteria.

In evaluating route plan, we should choose the evaluation item in consideration of the goal of special plan and the range that the plan may have influence on. And, we may draw conclusion by integrating the influence of each item that units are different respectively through the grasp and forecast of influence by each item. As for the evaluation for route choice, we should consider many quantitative or qualitative evaluation criteria for setting prioritization. Then, what can present the solution about this problem is AHP. The course to apply AHP really in choosing optimum route is as is in Fig. 10.

As for the practice of program, one get to input the relative importance about each evaluation criterion in accordance with the evaluation data of forecast prospective place. Prioritization gets to be decided, as input data are made into measure automatically in system. Data which may not stated in figures are input with qualitative value or they are assumed with same evaluation. In this case, we gets to calculate not by making into measure which is based on value but by preference. Fig. 11 is to show the order dia-

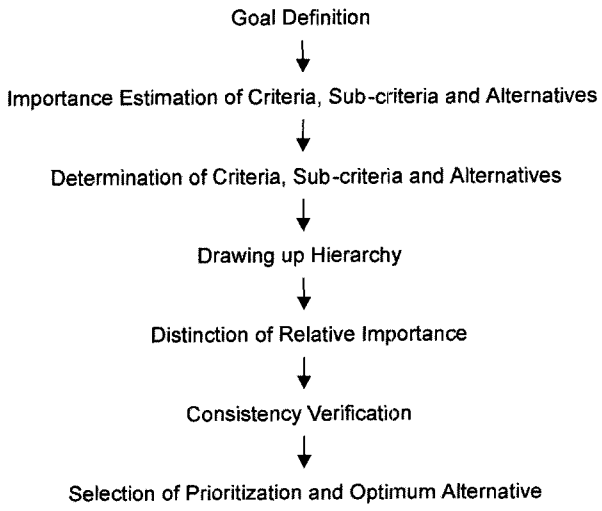

Fig. 10. Performance of Analytical Hierarchy Process.

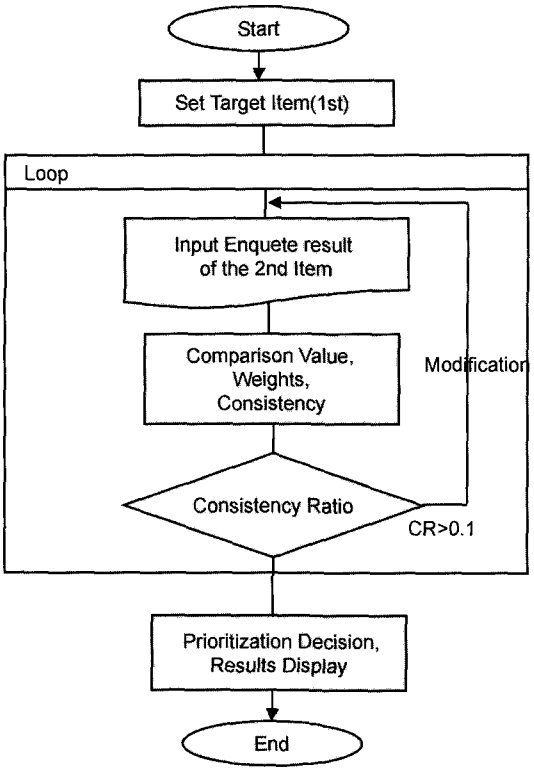

Fig. 11. AHP Program Workflow.

gram to make out the AHP module for choosing the comparison route of road plan.

4.2 Estimation of Route

Three alternative rotutes between a beginning point and an end point inputted by route selection system were selected, and the intensity of importance was derived of nine items from pairwise comparison through expert evaluation by the matrix of level using AHP.

This study used AHP as the route estimation method (Fig. 12). In the realization of the AHP, this study added by making out with one program module of application tier and could present the result to correspond with goal definition by deciding the prioritization of alternative route through the extraction of importance of evaluation criterion. This study quantified the relative importance among the items by asking the opinion of experts about the item to correspond with subcriteria, so as to fill the value of pairwise comparison matrix. To examine the whole weight of decision-making elements finally, it emerged that the 1st route is 0.3503, the 2nd route is 0.3268, and the 3rd route is 0.3229 (Table 1). This study may suggest the 1st plan route as the prospective route of optimum route which is based on the investigation of comparison route of road plan on the basis of above analysis result.

Thus, by grafting the approach method of GIS with route selection plan and using AHP, through establishing alternative route and grasping importance degree and seeking systematic and objective decision, this study tried to present feasibility.

5. Conclusions

For the optimization of more efficient and rational route selection at the time of establishing road plan, this study established and analyzed spatial information by using GIS, and obtained the following conclusions as the result of examining the applicability by developing the route selection system to connect AHP.

In investigating the comparison route at the time of route plan by using GIS, this study could express reference elements by establishing the database to be based on technical, economic, social and environmental factors and

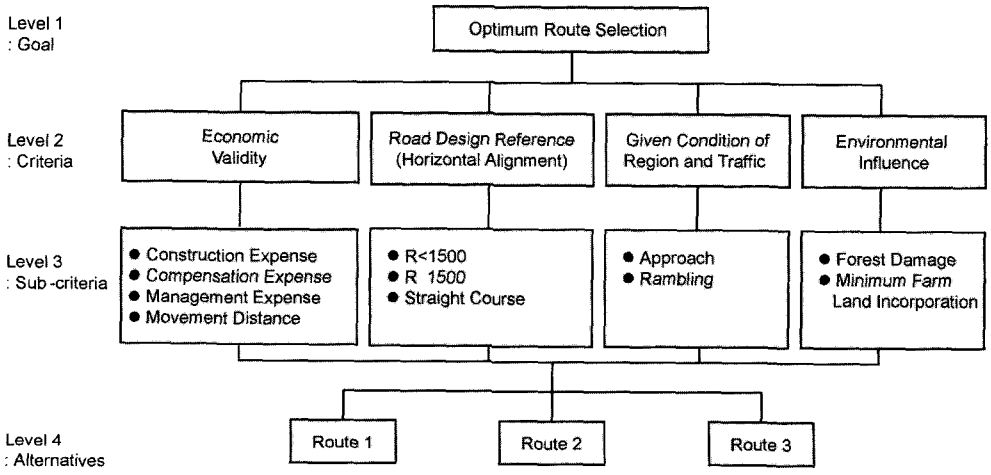

Fig. 12. Hierarchy for the Route Selection.

Table 1. Alternatives Evaluation

Level 1	Level 2	Level 3	Level 4
Optimum Route Selection (1.000) CR : 0.098	Environmental Influence (0.4412)	Forest Damage (0.1614)	Route 1(0.0574)
			Route 2(0.0508)
			Route 3(0.0532)
		Minimum Farm Land Incorporation (0.2797)	Route 1(0.0964)
			Route 2(0.0880)
			Route 3(0.0922)
	Economic Validity (0.2680) CR : 0.0804	Construction Expense (0.1088)	Route 1(0.0350)
			Route 2(0.0359)
			Route 3(0.0379)
		Compensation Expense (0.0845)	Route 1(0.0328)
			Route 2(0.0304)
			Route 3(0.0213)
		Management Expense (0.0413)	Route 1(0.0138)
			Route 2(0.0139)
			Route 3(0.0136)
		Movement Distance (0.0332)	Route 1(0.0114)
			Route 2(0.0110)
			Route 3(0.0108)
	Given Condition Of Region and Traffic (0.1758)	Approach (0.0728)	Route 1(0.0275)
			Route 2(0.0247)
			Route 3(0.0206)
		Rambling (0.1035)	Route 1(0.0377)
			Route 2(0.0315)
			Route 3(0.0343)
	Horizontal Alignment (0.1148) CR : 0.0079	R<1500 (0.0188)	Route 1(0.0119)
			Route 2(0.0038)
			Route 3(0.0032)
		R≥1500 (0.0341)	Route 1(0.0095)
			Route 2(0.0161)
			Route 3(0.0085)
		Straight Course (0.0618)	Route 1(0.0169)
			Route 2(0.0172)
			Route 3(0.0273)

offered the optimum environment of data of evaluation criterion which are necessary for route selection system by comparing and analyzing through the grasp of location relation.

This study developed the route selection algorithm to consider the condition to be necessary for the route setting between beginning point and end point, established with the window system of GUI environment by using visual basic, and facilitated use management, so that the comparison route alignment to be based on conditions may be presented.

By programming the AHP application module to be able to be used as one of decision-making framework at the time of comparing and evaluating route, this study could judge and select similarly relevant decision criteria more effectively.

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