The Research of the Road Alignment Based on the Cloud Model

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ABSTRACT

Road alignment is the core of the road construction plan. The real life working experiences as well as the skills of the designers have been affecting the route selection strategy all the time, due to various uncertain factors. Based on the comprehensive evaluation of the cloud model road alignment, subjective factors can be reduced through adopting the fuzzy mathematics method and establishing the uncertain model transformation of the qualitative and quantitative indicator through AHP and the cloud model theory. The final evaluation result of the road alignment strategy can be drawn by using the comprehensive cloud algorithm in the virtual cloud theory.

1. INTRODUCTION

Road alignment is based on the certain technical standards and finding the most economical and reasonable related zone for the connect lines by combining the topographical, geological conditions and traffic flow. (Liu, et al. 2007.)

As numerous decision-making problems, the decision making process of the road alignment can be divided into three types which are structured type, semi-structured type and unstructured type. This paper is mainly exploring the semi-structured system that would assist the relevant departments to make the right decision. This method has fully taken the ambiguity and the randomness into account. Economical efficiency meets the normal distribution, as a principle, has been taken into use. The decision-making evaluation system of the road alignment is established by using the cloud theory, after the analysis of the main factors as well as the combinations with AHP and the classifications of the factors.

2. CLOUD THEORY

The cloud theory is a new theory which was put forward by Li Deyi academy in 1995 on the basis of traditional statistics mathematics and fuzzy mathematics (Li 2005). The theory established the uncertainty conversion model which is expressed by natural

language values between the qualitative and quantitative concept. The theory fully explained the ambiguity and randomness of the qualitative concept assessment information expressed by experts in natural language. It is a kind of group decision-making with individual preferences based on the natural language assessment information.

2.1 The basic concept of cloud

Take U as a universe in precise value (one-dimensional, two-dimensional or multidimensional), for any one of the elements X in universe, there is a random number with stable tendency $Y = U(X)$, called X to the concept certainty. The distribution of X in the universe is to become cloud model, in short, it is called cloud. Each of (X, Y) is called a cloud droplet. If the universe of discourse U is a n-dimensional space, then it can be to extended to the n-dimensional clouds. (Li 2005)

2.2 The digital feature of cloud

Cloud is formed by a number of cloud droplets and each cloud droplet is a realization of this characterization of the concept in number field of space, with the uncertainties. The digital feature of clouds can be expressed with three values as Ex (Expected Value), En (Entropy), He (Hyper Entropy).

(1) Ex: The value which can fully represent the qualitative concept, it is usually the corresponding x values of the cloud center of gravity, reflecting the corresponding value of information center qualitative concept.

(2) En: Entropy is the measurement of the ambiguity of qualitative concept, its value will directly determine the acceptable number of elements by qualitative concept in the universe, reflecting the "be both this and that" of the qualitative concept.

(3) He: The entropy of the entropy reflected the degree of dispersion of clouds.

2.3 The application of the cloud models in the assessment of the road alignment

The establishment of the road alignment evaluation mode should first fix each factor that may affect the road alignment and then compose all these factors. Thus to weigh its impact extent is the overall objective. After that, we can get the model as well as its digital features for each of the factor by processing the data of each factor. Finally, through combining all the evaluation clouds will generate the comprehensive evaluation clouds for the road alignment.

2.4 The Establishment of the evaluation index system

According to the weighted-table of the comprehensive assessment on road

alignment which was created by 30 representative experts from Taiwan (Table 1)(Zheng and Xu 2005), we mainly pick up three indicators of the benefits on the aspect of the transport, the economy and the society. Set the factor as $U(F,Y,Z)$, F -transport benefits, Y - economic benefits, Z - social benefits. Combine these indicators with Weighting coefficient, transport benefits accounted for 57.7%, economic benefits accounted for 29.7%, social benefits accounted for 12.6%, then W = (0.577,0.297,0.126).

Table 1.Weighted-table

Target group	Evaluation value / Evaluation criterion	Average value	Variation number	Standard deviation	Maximum value	Minimum value
Transport benefits	Road service area	0.245	0.024	0.157	0.465	0.024
	Trip cost	0.098	0.004	0.066	0.233	0.038
	The extent of regional transportation improvement	0.110	0.006	0.078	0.287	0.035
	The convenience of traveling	0.124	0.005	0.08	0.325	0.029
Economic benefits	Building maintenance costs	0.157	0.029	0.169	0.727	0.023
	Operating earnings	0.087	0.010	0.102	0.406	0.009
	Joint development potential	0.053	0.002	0.042	0.128	0.011
Social benefits	The impact on regional development	0.064	0.003	0.050	0.213	0.012
	Residence rights' maintenance	0.030	0.002	0.047	0.199	0.005
	Environmental Impacts	0.032	0.001	0.029	0.009	0.005

2.5 The identification of single-factor cloud model and its digital characteristics

1) To the factor set $U(F,Y,Z)$, the quantitative value of the decision-making problems index, due to a large number of qualitative statements in the evaluation criteria, through the fuzzy theory, by making use of the values between 0 and 1 we are able to define(Du, et al. 2008). This article defines the mark set as: $V=(v_1,v_2,v_3,v_4)$, among them, v_1 (0.9 ~ 1) Excellent; v_2 (0.6 ~ 0.9),good; v_3 (0.4 ~ 0.6),ok; v_4 (0 ~ 0.4) bad(Wang Fan,2009); In the description of the model, the remarks value of each program can define Ex_0. $D_{\min}$ And $D_{\max}$ can be specified by the effective the universe of discourse from 0 to 1. The single factor cloud model as well as its digital features can be acquired by using real data through the reverse-cloud generator. The calculation process is as follows:

Input: The sample points in the valid domain class x_i, i = 1,2,…,n

Output: Digital features which reflects the qualitative concept (Ex_0, En_0, He_0)
Algorithm: Because of the bilateral constraints of the commentary sets (0 to 1), the expected values can be used for each program's comment values. The major active area is the bilateral constraints area which is approximate to the comment values. The cloud parameter's calculation is applying for the following formula:

$$Ex_0 = x \qquad En_0 = (D_{\max} - D_{\min})/6$$

$$He_0 = K \qquad Y_i = e^{-(x_i - Ex_0)^2 / 2En_0^{\ 2}}$$

K is a constant. It can be specifically adjusted according to the reviews' own fuzzy degree(Liu and Yan 2009).

2) After determining the Ef_0, Ey_0, Ez_0 and the corresponding En_0, He_0(Liu, et al. 2008). We will get the comprehensive assessment of cloud model for the road traffic alignment, (w is weight)by using the virtual could theory and integrating the cloud algorithm as well as combine every single factors. The calculation formula is as follows:

$$E_{X\,i} = \frac{E_{fi} w_{x\,i} + E_{y_i} w_{y_i} + E_{z\,i} w_{zi_i}}{w_{fi} + w_{y_i} + w_{z\,i}}$$

$$En_i = \frac{w_{f\,i}^{\ 2}}{w_{f\,i}^{\ 2} + w_{y_i}^{\ 2} + w_{zi}^{\ 2}} En_{f_i} + \frac{w_{y_i}^{\ 2}}{w_{f\,i}^{\ 2} + w_{y_i}^{\ 2} + w_{zi}^{\ 2}} En_{y_i} + \frac{w_{z\,i}^{\ 2}}{w_{f\,i}^{\ 2} + w_{y_i}^{\ 2} + w_{z\,i}^{\ 2}} En_{z\,i}$$

$$He_i = \frac{w_{f\,i}^{\ 2}}{w_{f\,i}^{\ 2} + w_{y_i}^{\ 2} + w_{zi}^{\ 2}} He_{f_i} + \frac{w_{y_i}^{\ 2}}{w_{f\,i}^{\ 2} + w_{y_i}^{\ 2} + w_{zi}^{\ 2}} He_{y_i} + \frac{w_{z\,i}^{\ 2}}{w_{f\,i}^{\ 2} + w_{y_i}^{\ 2} + w_{z\,i}^{\ 2}} He_{z\,i}$$

2.6 The analysis of the road alignment

On the basis of the above principals, it generates the relative could model. We can measure the differences and similarities among different clouds based on the three digital feature index. We can also evaluate the advantages and disadvantages of the road alignment in accordance with the differences and similarities among different clouds. We define the differences and similarities among different clouds as the similarities. If the overall similarities between two clouds are less than the given similar threshold Q,

$Q \le \frac{|D_{\max} - D_{\min}|}{2}$,

then we can take the two clouds as the similar ones or almost equivalent; thus, we get

the following definition:

Definition: Suppose there are two adjacent clouds in the universe of discourse, $A_0(Ex_0, En_0, He_0)$ and $A_i(Ex_i, En_i, He_i)$in it, $A_0(Ex_0, En_0, He_0)$ represents each factor cloud with intermediate values that have formed the digital features of the comprehensive assessment clouds. Q_{i-0}= Ex_i - Ex_0 stands for $A_i(Ex_i, En_i, He_i)$ the similarities between the test value and intermediate value. Within the range of the specified valid domain of discourse $[D_{\min}, D_{\max}]$, we can make orders by the size of Q_{i-0} value. The larger the Q_{i-0} value is, the more excellent the program would be.

2.7 Example

Suppose there are five programs for the road alignment design, the indicators to each program are as in table 2:

Table 2. The assessment of the qualitative effects of a regional road alignment

Target group	Evaluation value / Evaluation criterion	Program1	Program2	Program3	Program4	Program5	remarks
Transport benefits	Road service area	No good	ok	Excellent	good	No good	
	Trip cost	No good	ok	good	No good	good	
	The extent of regional transportation improvement	No good	ok	Excellent	good	No good	
	The convenience of traveling	good	good	good	good	No good	
Economic benefits	Building maintenance costs	ok	ok	good	good	ok	
	Operating earnings	No good	Excellent	Excellent	Excellent	ok	
	Joint development potential	Excellent	ok	good	good	good	
Social benefits	The impact on regional development	Excellent	good	good	good	ok	
	Residence rights' maintenance	Excellent	good	ok	Excellent	Excellent	
	Environmental Impacts	good	good	ok	ok	Excellent	

Achieving the transformation from qualitative evaluation to quantitative evaluation ac cording to the commentary set, see table 3:

Table 3. The assessment of the quantitative effects of a regional road alignment

Target group	Evaluation value / Evaluation criterion	Program1	Program2	Program3	Program4	Program5	remarks
Transport benefits	Road service area	0.3	0.5	1	0.7	0.3	
	Trip cost	0.3	0.5	0.7	0.25	0.7	
	The extent of regional transportation improvement	0.3	0.5	1	0.7	0.3	
	The convenience of traveling	0.7	0.7	0.7	0.7	0.3	
Economic	Building maintenance costs	0.5	0.5	0.7	0.7	0.5	

benefits	Operating earnings	0.3	1	1	1	0.5	
	Joint development potential	1	0.5	0.7	0.7	0.7	
Social benefits	The impact on regional development	1	0.7	0.7	0.7	0.5	
	Residence rights' maintenance	1	0.7	0.5	1	1	
	Environmental Impacts	0.7	0.7	0.5	0.5	1	

Road alignment:

We get the valid universe of discourse [0,1] for the road alignment comprehensive assessment clouds on the basis of the above data. The comprehensive assessment clouds for each program are as follows in Figure 1:

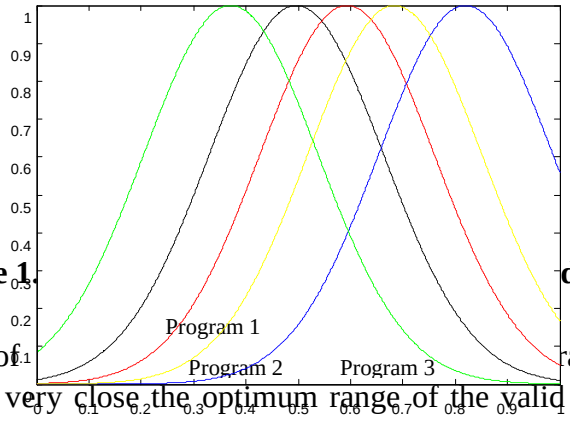

Figure 1. d model

From the features of ram 3, comprehensive assessment clouds is very close the optimum range of the valid universe of discourse. And Q_{i-0} is a maximum, so this program is the optimal alignment program (Lu and Wu 2009).

CONCLUSION

This paper is providing the evaluation and research method for road alignment based on the cloud module. It has clearly explained the fuzziness and randomness which exists in the decision-making process of the road alignment. The assessment indicator system has been created by applying AHP and the qualitative indicators have been quantified through the methods of fuzziness and the optimized modules. This enables us to get the comprehensive assessment clouds for each program in accordance with each

factor and weight; and also confirm the superior optimized program by using the value of Q_{i-0} through introducing the concept of similarities.

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