DOM QUALITY EVALUATION BASED ON MULTI-LEVEL FUZZY COMPREHENSIVE ASSESSMENT OF ENTROPY WEIGHTS

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ABSTRACT:

With the development of RS technology, the evaluation of DOM becomes more important. Multi-level fuzzy comprehensive evaluation is the traditional method for DOM evaluation. But in the process of traditional multi-Level Fuzzy Comprehensive Assessment, the weight of evaluation factor which are subjective is always ascertained by experts. The method can cause evaluation bias because of the subjective weights of factors. In this paper, the external Shannon weight was introduced to integrate with the subjective weights by experts. Then some DOMs were assessed by Shannon weight fuzzy comprehensive assessment. The test proved that the integration of Shannon weight and subjective weight is the combination of subjective and objective factors, it can decrease the bias caused by subjective factors for DOM assessment. The test also proved that evaluation result is external and rational.

1. INTRODUCTION

Our country has finished the conversion from tradition surveying to digital surveying, we are on the way of information surveying era. The surveying production of information surveying era is digital and variety. DOM as one of main GIS product is different from analogue map on form and quality character. It is necessary to understand DOM quality deeply. So it is important to research on the DOM quality evaluation ulteriorly.

Now subjective and external methods are used in image quality assessment. Quantitative descriptions are adopted in external evaluation. But now the quality assessment results by external descriptions are always not accord with the subjective method, so the subjective assessing methods are always adopted now. The subjective assessing method includes defection subtraction method and weighted average method. Those two method are simple and easy to operated, but the evaluation method is coarse and uncertain sometimes. Because of the diversity and complexity of relationship of evaluation factors, numeric limits of evaluation factors are difficult to ascertain, so the factors have fuzzy character. Based on those idea, fuzzy mathematics such as fuzzy comprehensive evaluation method was adopted in DOM quality evaluation by some writers(e.g., Qingguo WANG, Shengwu HU, Zhanhong WANG, Wenzhong SHI), their tests have showed that fuzzy comprehensive method is exquisite compared with traditional methods, so it can be used broadly in GIS product evaluation.

Among all those evaluation methods, the evaluation results are significantly affected by weights of evaluation factors. During the existed evaluation process of fuzzy comprehensive assessment, the weights are always determined by experts. This kind of weight is purely subjective and those always bring bias in assessing result. Some writers have putted forward the deepening problem of determining of the weights.

In this paper, external factors were introduced in the determining of weights in order to avoid the bias arose by pure subjective weights.

Shannon weight is kind of external weight. The weights are determined by analyzing the relationship and contents of information of the original information in the Shannon weight method. This kind of weight can avoid bias bring by the pure subjective weights in a certain extent. Shannon weights were introduced in this paper based on the similarity between the DOM quality evaluation and those evaluation mentioned above. In the paper the weights of the fuzzy comprehensive assessment were determined by combination of external Shannon weights and the subjective weights by experts. Experiment of Fuzzy comprehensive assessment of Shannon weights adopted twelve DOM in one area has finished.

2. THE METHOD OF ENTROPY WEIGHS

The amount of information acquired by people is one of the factors for evaluation accuracy and reliability. In the information theory, the entropy is the measure index of the disorder of system. If the index is little, the information provided by the index is more, so the index should has more effect during evaluation, the weights should be larger. Therefore the entropy can determine weights for factors.

The entropy weight is determined by the matrix constructed by the monitoring indicators of the factors. The evaluation result can be more objective because the weights of factors can avoid the subjective factor.

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The main process for the determining of entropy weights is shows as follows:

(1) We assume the number of the objects will be evaluated is m, the number of factors of evaluation for every object is n, the judging matrix is

$$R = (r_{ij})(i = 1,2,...,m; j = 1,2,...,n)$$

(2)The judgement matrix R is normalized to B, the factors of B is computed as follows"

$$b_{ij} = \frac{r_{ij} - r_{\min}}{r_{\max} - r_{\min}}$$

(3) the entropy is defined by the tradition method as follows:

$$H_j = -(\sum_{i=1}^{m} f_{ij} \ln f_{ij}) / \ln m (i = 1,2,...,m; j = 1,2,...,n)$$

For avoid meaningless of $\ln f_{ij}$ in $f_{ij} = b_{ij} / \sum_{i=1}^{m} b_{ij}$, so we correct the calculation of f_{ij} and define it is $f_{ij} = 1 + b_{ij} / \sum_{i=1}^{m} (1 + b_{ij})$。

(4)Calculate the entropy weights of the evaluation indicators

$$W = (w_i)_{1*n}$$

$$w_i = (1 - H_i) / (n - \sum_{i=1}^{n} H_i)$$

and $$\sum_{i=1}^{n} w_i = 1$$

(5)In order to shows the importance of evaluation indicators the subjective weight of each indicator are determined by experts

$$W' = (w'_j)_{1*n}, j = 1,2,...,n$$。

(6) the final weighs for factors is the combination of the objective and subjective weights, the combination formula is :

$$A_j = (w_j * w'_j) / (\sum_{j=1}^{n} w_j * w'_j) \; j = 1,2,...,n$$

3. THE TEST OF MULTI-LEVEL FUZZY COMPREHENSIVE ASSESSMENT OF ENTROPY WEIGHTS

In the paper, 12 DOM were evaluated by multi-level fuzzy comprehensive assessment of entropy weights, the test process was as follows:

3.1 Determine the muster of the evaluation factors

Based on the foundation of the principles of completeness, irrelevant and usability, according to the supervision and spot check implementing regulations of the 4D survey product quality drawn up by the national survey service (the paper asking for opinion)and the test approval and quality evaluation of digital survey product published by the State Bureau of Quality and Technical Supervision, combined with the actual situation of present evaluation work, the multi-level appraisal factors of DOM product quality are established. The factors are shows as table 1.

3.2 Construct muster of comment

In order to determine the evaluation result for assessing factors and product quality, muster of comment $V = (V_1 \quad V_2 \quad ,\cdots, \quad V_n)$ need to be constructed. The muster was constructed as V＝{excellent，fine，eligibility，disqualification} based on the real condition of current evaluation.

Basic factors	weight	Band two factors	weights
Mathematic precision	0.30	Reference coordinate system	0.25
		Precision of Marginal points and control points	0.25
		Precision of marginal area	0.2
		precision of planar position	0.2
		precision of edge matching	0.1
Image quality	0.3	resolution	0.3
		image colour tone	0.25
		clarity	0.25
		interim margin,	0.1
		edge matching	0.1
The quality of the data	0.2	The correctness of file Name, data organization and data format	0.5
		The correctness of the Data storage media and specifications	0.3
		Date of production	0.2
Quality of decoration	0.1	The integrity and correctness of annotation	0.6
		Quality of map border decoration	0.4
Quality of accessories	0.1	The integrity and correctness of metadata	0.35
		The integrity and correctness of Documentation Book	0.35
		The completeness of data hand in	0.30

Table 1. The muster of the evaluation factors

3.3 Determine the weights of evaluation factors

The weights were determined by the combination of the Shannon weights and subjective weights from experts.

In the article, five evaluation factor of band two below the image quality was depicted in detail as an example. Firstly, scores of the five factors(resolution, image colour tone, clarity, interim margin, edge matching) for the ten tested DOM were given by some experts, then the average were calculated for each factor of each DOM, so the average matrix of the five factors of band two of ten DOM were finished. The normalization matrix was then calculated for easier calculation. The normalization matrix is shows as follows:

Factor and DOM number	1	2	3	4	5	6	7	8	9	10	11	12
resolution	0.10	0.05	0.10	0	0.10	0.10	0.20	0.10	0.10	0.10	0	0.05
image color tone	0.111	0.06	0.08	0	0.13	0.01	0.18	0.08	0.15	0.09	0.04	0.08
clarity	0.10	0.03	0.10	0.03	0	0.04	0.21	0.15	0.18	0.06	0.03	0.07
Interim margin	0.07	0.04	0.04	0.10	0.04	0.08	0.17	0.11	0.15	0.16	0	0.04
edge matching	0.06	0	0.17	0	0.16	0.08	0.12	0.14	0.05	0.06	0.06	0.10

Table 2. The normalization matrix

Then the Shannon of those five factors were calculated by Shannon formula, it show as follows:

H＝[0.8987 0.9101 0.8809 0.9033 0.8906]
The Shannon weights are w=[0.1961 0.1740 0.2307 0.1872 0.2118]
The subjective weights from experts are w=[0.3 0.25 0.25 0.10 0.10]
The combination of external and subjective weights are: S1=[0.2943 0.2176 0.2885 0.0936 0.1060]

The weights of factors of band two corresponding to mathematics precision, data quality, decoration quality and accessories quality have been calculated by the same process shows as follows:

[0.2517 0.1810 0.1783 0.2301 0.1589];
[0.5895 0.2543 0.1562];
[0.7032 0.2968];
[0.4345 0.3218 0.2437]

The weights of the five band one factors are: [0.3322 0.3125 0.1989 0.0995 0.0569]

3.4 Construct the evaluation matrix

In this paper, the evaluation matrix by expert grade method.
The evaluation matrix of one of the test image show as follows:

$$R_{数学}=\begin{bmatrix}0.30&0.35&0.20&0.15\\0.15&0.40&0.30&0.15\\0.10&0.35&0.40&0.15\\0.20&0.50&0.15&0.15\\0.30&0.35&0.15&0.20\end{bmatrix}\quad R_{影像}=\begin{bmatrix}0.40&0.40&0.15&0.10\\0.20&0.40&0.30&0.10\\0.15&0.35&0.25&0.10\\0.45&0.30&0.15&0.10\\0.30&0.35&0.20&0.15\end{bmatrix}$$

$$R_{数据}=\begin{bmatrix}0.55&0.15&0.15&0.15\\0.30&0.40&0.10&0.20\\0.35&0.30&0.25&0.10\end{bmatrix}$$

$$R_{整饰}=\begin{bmatrix}0.25&0.20&0.25&0.30\\0.20&0.45&0.15&0.20\end{bmatrix}\quad R_{附件}=\begin{bmatrix}0.15&0.45&0.1&0.20\\0.15&0.35&0.25&0.25\\0.20&0.50&0.20&0.10\end{bmatrix}$$

Figure 1. The evaluation matrix

3.5 Select the model of fuzzy comprehensive assessment

$M(\bullet,\oplus)$ was selected as the mathematics model in this paper because it a model that weights is useful.

On the basis of the evaluation matrix shows in figure 1, fuzzy comprehensive assessments were done for each band two factors. Then the transform matrix was made up of those calculated results matrix. After that, the higher comprehensive assessment was made, and at last, the evaluation grade was made.

The highest calculation is shows as follows:

$$B=A_{\text{basic factors}}\circ R$$

＝[0.3322 0.3125 0.1989 0.0995 0.0569] ×

$$\begin{bmatrix}0.2784&0.3709&0.2168&0.1053\\0.2142&0.3936&0.2343&0.1579\\0.4552&0.2370&0.1529&0.1549\\0.2352&0.2742&0.2203&0.2703\\0.1622&0.4300&0.1726&0.1917\end{bmatrix}$$

＝[0.2826 0.3451 0.2074 0.1529]

R is the total evaluation matrix made up of B_{math}, B_{image}, B_{data}, B_{groom}, $B_{\text{accessories}}$

Based on the rule of maximum membership principle, the image was graded as fine.

4. CONCLUSIONS

Twelve DOM were evaluated respectively by the method depicted in this paper. In order to validate the validity Of the Shannon fuzzy comprehensive assessment, the compare was done between it and the traditional fuzzy comprehensive assessment for the same ten DOM, the result is : 11 DOM have the same evaluation grade, 1 DOM was classified to different grade. The test has proved that the integration of Shannon weight and subjective weight is the combination of subjective and external factors, it can decrease the bias caused by subjective factors. The test also proved that DOM evaluation result by Shannon fuzzy comprehensive assessment is external and rational.

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