A Method for Digital Chart Quality Evaluation based on Cloud Model

Caixia Yu 1, Jun Xu 1,2, Wenqian Huang 1,3, Luan Jun 4 and Jinzhong Liu 4
1Dalian Navy Academy, Dalian 116018, China
2Chinese Academy of Surveying and Mapping, Beijing 100830, China
3State Key Laboratory of Geo-information Engineering, Xi’an 710054, China
4Navy Publishing House, Tianjin 300450, China
Email: yucaixiaxj@163.com

Abstract. In order to evaluate Digital Chart objectively, quantitively and reasonably, the paper puts forward a method for digital chart quality evaluation based on Cloud Model. Firstly, synthesized Cloud Model is improved with power factor, secondly evaluating indexes including one-level and two-level and their powers are given according to the digital chart characteristic, and then calculates all levels of evaluating indexes used the improved synthesized cloud model, lastly, presents the ultimate result in the form of the Cloud Model for quality evaluation and its character figure. It is proved that the method is feasible by a test.

1. Introduction
As the important link in chart quality control, digital chart quality evaluation is of great importance for improving chart quality. At present, national chart quality management and evaluation often depend on experience, stronger subjectivity, less definite magnitude index. Because digital chart quality evaluation, one problem of much objective and much content, whose evaluation indexes are qualitative natural language, takes on much stronger randomicity and fuzziness, traditional methods such as, direct evaluation method, indirect evaluation method, general evaluation method [1], and fuzzy general evaluation method mentioned in document [2-4] are hard to solve the problem rationally and perfectly. Cloud Model can do well in the conversion between qualitative concept and quantitative representation, which is the reason why Cloud Model is the key topic in recent year, but the many researches are mainly on theory [5-9]. In the paper, Cloud Model is applied to digital chart quality evaluation, and then a method for digital chart quality evaluation based on Cloud Model is put forward.

2. Cloud Model Summarization
Objective world and its describing language are full of uncertainty, while the traditional methods often separate randomicity and fuzziness only in each different view, ignoring the stronger correlation and synchronism between randomicity and fuzziness, then Cloud Model is put forward in the situation.

2.1. Theory of Cloud Model
U is supposed as one quantitative field showed by exact value, while C is one qualitative concept in U, if \( x \in U \), and it is one random value in C, and then \( C_r(x) \in [0,1] \) is one random value of stable tendency. If \( C_r(x) : U \rightarrow [0,1] \) \( \forall x \in U \quad x \rightarrow C_r(x) \)

Then the distribution of \( x \) is called Cloud, and each \( x \) is called one cloud drop [10, 11].
Numerical characters of Cloud Model, such as Expected value (Ex), Entropy (En), and Hyper entropy (He) reflect the qualitative character of qualitative concept [5, 10]. Three numerical characters of Cloud Model not only integrate randomicity and fuzziness completely, but also draw the cloud shape by thousands of cloud drops, what is the unique of it. It can express one-dimensional normal cloud by these three numerical characters, and record as A=U (Ex, En, He).

2.2. Normal Cloud Generator
Normal Cloud Model is the basic cloud model, including forward cloud generator and backward cloud generator. The specific arithmetic can see the reference [10].

2.3. Synthesized Cloud Model
Synthesized Cloud Model generalizes two or more similar types of child clouds to generate one new high father cloud, and its essence is an advanced concept to synthesize two or more similar types of language to one wider concept language. The specific arithmetic can see the reference [10].

3. Digital Chart Quality Evaluation based on Cloud Model
3.1. Digital Chart Quality Evaluation System
According to reference [1, 2, 10], in the paper, digital chart quality content which is determined by quality character, should include 5 quality indexes as follows, time precision, location precision, attribute precision, content and data, cartography generalization and art, and each quality index includes level 2 indexes. Because different quality indexes play different parts in quality evaluation, then we add weight, seeing table 1.

| Level 1 index          | Weight | Level 2 index                     | Weight |
|------------------------|--------|-----------------------------------|--------|
| Time precision         | 0.15   | Data adopted                      | 0.7    |
|                        |        | Notice correction                 | 0.3    |
|                        |        | Maths base                        | 0.4    |
| Location precision     | 0.3    | Plane precision                   | 0.2    |
|                        |        | Depth precision                   | 0.2    |
|                        |        | Height precision                  | 0.2    |
| Attribute precision    | 0.15   | Features classifications and code correctness | 0.5 |
|                        |        | Attribute correctness             | 0.5    |
|                        |        | Content correctness               | 0.4    |
| Content and data       | 0.3    | Logic interconsistency            | 0.3    |
| Cartography generalization and arts | 0.10 | Data perfection                   | 0.3    |
| Cartography generalization |       | Figure quality                    | 0.4    |

At present, evaluation grade can be divided into the best, better, up to standard, and not up to standard, once there arises one of situations that are mathematical basis is wrong (for instance, coordinate system and its correction, projection, reference parallel or mid-longitude, datum and its correction), or if isolated obstructions, wrecks, shallows, shallow soundings, or the important aids to navigation which may be dangerous for navigation safety are wrong or missed, or if the precision of large-area map don’t fit the specifications, or map load and generalization factors don’t meet specifications, chart product can be passed[12].

3.2. Quality Evaluation System Steps based on Cloud Model
From table 1, we can see that digital chart quality evaluation which is composed of two grades belongs
to multi-layer synthesized evaluation problem, so synthesized cloud is adopted in the paper. Firstly, we calculate the first synthesized evaluation from the second layer, viz. the values of father cloud are calculated by child clouds, and then we used the new calculated value for synthesized evaluation again to get the final evaluation results.

Digital chart quality evaluation based on cloud model includes three sets—index set, power set, and comment set, which are index set \( U = \{ \text{time precision, location precision, attribute precision, content and data, cartography generalization and art} \} \), power set \( V = \{ 0.15, 0.3, 0.15, 0.3, 0.1 \} \), and comment set=\{ the best, better, up to standard, and not up to standard \}, according to ten-grade rule, the best is [9,10], better is [8,9), up to standard is [6,8), not up to standard is [0,6].

The specific steps are as follows,

1. We modify the formula in section 1.2.3, and put power \( W \) to generate cloud model of two layer evaluation index. The specific formula is as follow.

\[
\begin{align*}
En &= \frac{Ex_1 W_1^2 + Ex_2 W_2^2 + \ldots + Ex_n W_n^2}{W_1^2 + W_2^2 + \ldots + W_n^2} \\
He &= \frac{En_1 W_1^2 + En_2 W_2^2 + \ldots + En_n W_n^2}{W_1^2 + W_2^2 + \ldots + W_n^2} \\
E_x &= Ex 
\end{align*}
\]

(1)

2. We used the calculated value as the new evaluation value to get the first-grade evaluation cloud model from formula (1). Then the quality of product can be estimated by \( Ex \), and of course can be visualized by character figure.

3. \( N \) cloud drops are got by calculating \( N \) time, and by analysis we get the numbers of cloud drops distributing to “the best”, “better”, “up to standard”, and “not up to standard”, by which we can further confirm the product quality.

4. Experiment and Analyses

Taking digital chart C12261 for example, fractions of two-layer index by experts are seeing table 2.

According to section 1.3.2, we get the synthesized cloud model from equation (1) as follows, 

\[
\begin{align*}
U1 &= (8.23, 0.066, 0.02), U2 = (8.90, 0.132, 0.02), U3 = (8.85, 0.066, 0.02), \\
U4 &= (8.62, 0.099, 0.02), U5 = (8.31, 0.066, 0.02)
\end{align*}
\]

Table2. Evaluation indexes and their weighting value

| Level 2 index | Fraction |
|---------------|----------|
| Data adopted  | 8.5      |
| Notice correction | 7.6   |
| Maths base    | 9.5      |
| Plane precision | 9.0    |
| Depth precision | 8.5    |
| Height precision | 8.0    |
| Features classifications and code correctness | 9.2    |
Table 2. Evaluation indexes and their weighting value (Continued)

| Attribute                      | Weighting Value |
|--------------------------------|-----------------|
| Attribute correctness          | 8.5             |
| Content correctness            | 9.1             |
| Logic interconsistency         | 8.8             |
| Data perfection                | 7.8             |
| Cartography generalization     | 8.5             |
| Figure quality                 | 8.1             |

By equation (1), we calculate again to get the final synthesized cloud model of the first-layer index-(8.57, 0.48, 0.02), $Ex=8.57$, from which we see that the quality of digital chart is better. According to normal cloud generator, we calculate 1000 times to get the character figure as follows.

![Figure 1. The character figure of C12261 quality evaluation](image)

From Figure 1, we can see that most of the cloud drops fall in [8, 9), which again prove the quality of product is better, others fall in [9, 10] and [6, 8), and the cloud drops in [9, 10] are more than that in [6, 8), which prove that the product is more than better. By calculating 1000 times, the number of “the best” drops is 191, “better” is 698, “up to standard” is 111, and “not up to standard” is 0, so subordinate level of comment set is (0.191, 0.698, 0.111, 0), which prove the product is better, and more than better.

5. Conclusions
Cloud Model can preferably solve the qualitative and quantitative problems of digital chart evaluation, taking each evaluation index and power into account, and make the evaluation result to be much practical and reasonable. So we can apply cloud model into other spatial data quality evaluation to get one more perfect, definite, and comprehensive quality evaluation system. Of course, the result depends on some factors, for example, hyper entropy (He).

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