Journal of Theoretical and Applied Information Technology
15th December 2012. Vol. 46 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

VECTOR MAP WATERMARKING EVALUATION BASED ON CERTAINTY FACTOR

[1]JIANGUO SUN,[2] SONGZHU XIA AND [3]GUOYIN ZHANG
[1]Department of computer science and technology,
Harbin engineering university, Harbin, China
E-mail: [1]sunjianguo@hrbeu.edu.cn, [2]xiasongzhu@hrbeu.edu.cn,
E-mail: [3]zhanguoyin@hrbeu.edu.cn

ABSTRACT

Watermarking appraisement plays an important role in the checking the validity in a watermark system. So far, it is regrettable that there is no any comprehensive appraisement proposed for watermarking technology. In general, test software and methods can only analyze a few factors influencing the watermarking algorithm, which are lacking sufficient credibility. So, a comprehensive watermarking appraisement model based on the theory of certainty factor is proposed in this paper, which firstly discusses the relations of factors and operations contained, which all be assigned weight value. Through reasoning and analysis, every watermark algorithm can be quantified, thus, merits and drawbacks of watermark algorithms are obvious, and it is also easy to achieve the optimal watermark algorithm.

Keywords: *Evaluation, Watermarking, Certainty Factor.*

1. INTRODUCTION

In the past years, digital watermarking is proposed to achieve the copyright safeguard and content authentication for the multimedia information in the networks.

The first stage: determine evaluation method. The evaluation of the digital watermarking algorithm is a comprehensive problem, not only involves the calculation of various performance parameters, the weight coefficients distribution and dynamic adjustment of indicators, but also involves the calculation of the quantitative indicators and the appraisement of the qualitative indicators, so the introduction of the credibility reasoning and set pair analysis theory is necessary.

The second stage: determine evaluation scheme. According to the determined good evaluation methods, need to select the specific evaluation method, mainly including selected attacks type and intensity of watermarking algorithm, need to qualitatively evaluate the expert knowledge source, scale and data conversion of the indicator.

The third stage: evaluate the performance calculation of the indicator. Combined with the evaluation scheme, mainly use the error rate to assess the specific performance calculation results for various types of quantitative indicators. At the same time, use the expert knowledge to comparatively assess the qualitative indicators, such as, the security and visibility of the watermarking algorithm.

The fourth stage: combined with content characteristics and operating characteristics of the digital vector map, according to the influence degree for digital watermarking algorithm performance caused by various indicators calculated by the previous phase and get the ultimate evaluation conclusion. According to this conclusion, analyze and point out the shortcomings and deficiencies of the evaluation watermark algorithm.

The digital map is an important and indispensable resource to the national strategic security and social economic development. Digital vector map as a widely used digital map, because of its multiple features, such as, detailed ground information, accurate positioning, easy and flexible operation, and gradually become mainstream geographic information product, it is also important security resource for geographical surveying and mapping industry, transportation industry and digital national defense construction. At the same time, the cost of digital vector maps is expensive

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

and the economic costs of pre-production and post-updates are extremely high, so the illegal criminal behavior arming at the digital vector map, such as, unauthorized copying, illegal distribution, malicious stealing, come in a continuous stream. In recent years, data security of the digital vector map has attached great importance by our government. At the present, needs to focus on resolving the utility question of digital vector map copyright protection technology, furthermore, the information hiding technology is the basic content of the research areas of the digital vector maps copyright protection.

In the early 1990s, international research work began, took the digital vector map copyright protection technology as an academic branch and cutting-edge technology in the information security field, and took the information hiding technology research of the digital map as a starting point. At the start of the study, the researchers mainly took copyright content directly hidden into the map by modifying map spatial domain coefficient, in order to protect the map copyright. However, similar approaches have great defects in practicality, it is that, information hiding operation changing the geographic coordinate information in itself, and that is a kind of disguised destruction to the digital vector map. As the digital vector map widely applied in the national economy important fields, users clearly put the requirements that any unauthorized operation that change geographic information content should be prohibited. On the other hand, when the information hiding technology based on spatial or frequency domain deal with regular operation, it has weak robustness poor practicability and the embedded hidden information can easily be removed.

In the actual digital vector map watermarking algorithm evaluation work, researchers usually take the following ways:

(1)The evaluation method of generalizing the common index, that is only select the evaluation index that all kinds of digital watermarking algorithm need to attention, such as robustness, capacity, invisibility and algorithm efficiency. This evaluation method directly produces the foregoing theory and highly robustness digital vector map watermarking algorithm. Its biggest defects is: on the one hand, this method can't fully confessed testing background information, such as whether the data scale of embedded carrier is same and whether the embedding quantity of unit carrier space are same, this makes the evaluation conclusion less convincing. On the other hand, not combined with specific practical application field of watermarking algorithm, avoid content characteristics and operation features of digital vector maps, and make evaluation conclusion lack of practical reference value. Some new proposed digital vector map watermarking algorithm will take the similar means.

(2)Considering the data security issues that need to be solved specifically, only select the evaluation methods of a few kinds of specific indicators. The digital watermarking algorithm performance evaluation only concern with a limited number of indicators for testing and analysis. These specific indicators have a crucial effect for the successful application of digital watermarking algorithm in the field. The main problems of this method are: 1) index selection tendency is obvious, researchers usually consciously or unconsciously choose some indicators that can prove the proposed digital watermarking algorithm has a better performance to verify, loss of the objectivity of the evaluation conclusions. 2) reduce the overall performance of digital watermarking algorithm, blind to improve and focus on several performance indicators, but ignore the consideration for the algorithm comprehensive performance, such evaluation conclusion is lack of arguments and is easy to mislead users and other researchers. The early published evaluation literatures about digital watermarking algorithm performance usually adopt such methods.

This paper proposes a general and impersonal appraisement method in digital watermark system. With the theory of certainty factor reasoning, the appraisement matrixes and weight matrixes are established and the appraisement result is quantified, which shows the merits and drawbacks of certain watermarking algorithm.

2. EVALUATION PROCESS

2.1. Watermarking Evaluation

In the current digital vector map watermark evaluation methods, the researchers mainly take the way that selecting several kind of indicators to evaluate quantitatively or qualitatively, this was mainly due to the overall performance evaluation of digital watermarking algorithm requires a combination of a large number of professional surveying and mapping knowledge or computer technology, however this knowledge generally comes from the practice accumulation of experts, and has more subjectivity. Because this knowledge have strong field correlation and uncertainty, therefore, in order to formalize, reasoning and

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

evaluate these uncertainties knowledge, researchers have proposed a digital vector map watermarking algorithm evaluation technology based on credibility reasoning theory and fuzzy set pair analysis theory.

There are several targets or factors proposed to support the validity of a watermarking system. For different applications, the choice of targets also varies. In particular, most targets can not be quantified. Therefore, it is hard that giving a convinced and comprehensive appraisement. So, we propose the watermarking appraisement model (see figure 1).

In this model, we define i targets in watermark system, and for each target, containing different testing operations. E.g. target a_i represents "robustness", and for a_i, we can adopt 2 or 3 attack operations for testing. More detailed explanation about this model will be discussed in the follow-up experiments.

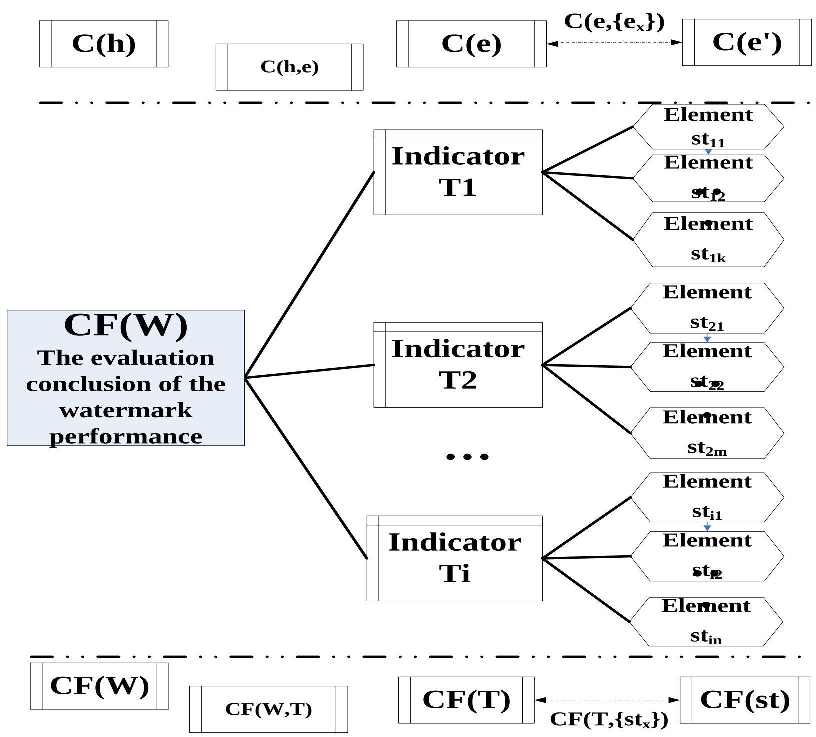

Figure 1 Appraisement Model Of Watermarking

2.2. Certainty Factor

In 2004, Buchanan and Shortliffe in the University of Pittsburgh, put forward the concept of certainty factor. Certainty factor is defined as the believe degree for question really true according to the experience knowledge. In the credibility reasoning process, any evidence has contribution for the conclusion "the problem is true".

The uncertainty of the evidence determined by empirical knowledge, expressed as $CF(e), CF(e) \in [-1,1], e \in E$, E represents a collection of all the factors that have influence to the conclusions, and $CF(e) = -1$, shows that the evidence e must be false.

Evidence corresponding to the various factors affecting the performance of the algorithm, the uncertainty is clear, that is any factor e has a contribution to the performance of watermarking algorithm, so $CF(e) \in (0,1], CF(e) = 1$, if and only if e is certainly true.

Contribution degree that the evidence e is true for the conclusion R, called knowledge, expressed as $CF(R,e)$. Similarly, in the evaluation process, $CF(R,e) \in (0,1]$.

The conclusion is the definition for the degree of the final issue is true, expressed as $CF(R)$, in the expression of the credibility calculation, define $CF(R) = CF(R,E) \times \max\{0, CF(E)\}$. From the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

evidence definition we can see $CF(E)>0$, so $CF(R)=CF(R,E)\times CF(E)$.

In the actual algorithm evaluation process, the evidence is understood as a specific evaluation indicators and the evidence of the evidence is interpreted as a number of factors that affect the evaluation indicator. The traditional credibility reasoning method is generally applicable in the process of uncertain reasoning, applied to the performance calculation aspects of the quantitative indicators. At the same time, using the uncertainty and transmissibility of the evidence, can further clarify the impact degree of various factors on the indicators and the impact right weight of a variety of indicators on the algorithm overall performance.

3. EXPERIMENTAL ANALYSIS

As shown in Figure 2, the digital watermarking algorithm evaluation process based on the credibility of reasoning is as follows:

1)According to the application objectives and evaluation purposes of the digital watermarking system to be evaluated, combined with data characteristics and operating characteristics of the digital vector map, selected specific evaluation indicators and their elements.

2)Combined with the credibility reasoning theory and expert experience, distribute the weight for each evaluation indicators and evaluation elements, and establish weight matrix.

3)According to the credibility reasoning evaluation model, calculate the credibility of the elements and the credibility of their indicators.

4)According to the credibility of the evaluation indicator, calculate the credibility of the whole watermarking system, and give the final evaluation conclusion, point out deficiencies and shortcomings of the digital watermark algorithm performance.

5)Users can selectively improve digital watermarking algorithm based on evaluation conclusions.

Two digital vector map watermarking systems are chosen, which are the performances based on space (A) and frequency (B) domains. The appraisement model of digital vector map watermarking is as follows:

Algorithm A: it changes the geometric coordinate information on the vector map directly according to the certain rules in order to realize the embedding of digital watermark.

Algorithm B: it picks up the information on the vector map to produce a transitional image, and then embed the watermark information by digital watermarking algorithm of image, and finally makes the transitional image which contains the watermark information return into the vector map.

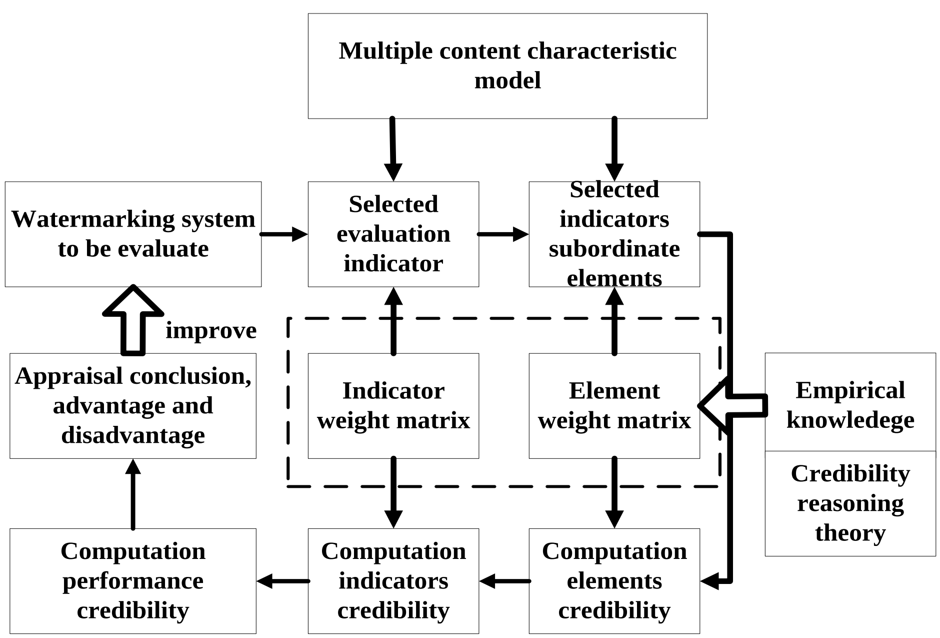

Figure 2 Appraisement Of Digital Vector Map Watermarking

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

The process of digital vector map watermarking appraisement is described in six steps (A-F):

A. For all the operations, following the intervals composed of "most importance", "very importance", "general", in which a score randomly selected will be assigned to each operation. Through the computation and comparison, the operation appraisement matrixes for algorithm A and B are obtained:

$$C_A(V)_{7\times4} = \begin{pmatrix} 0.63 & 0 & 0 & 0 \\ 0.75 & 0.9 & 0 & 0 \\ 0.9 & 0.87 & 0 & 0 \\ 0.73 & 0.83 & 0.76 & 0 \\ 0.14 & 0.89 & 0.9 & 0.7 \\ 0.87 & 0 & 0 & 0 \\ 0.76 & 0.74 & 0.65 & 0.98 \end{pmatrix},$$

$$C_B(V)_{7\times4} = \begin{pmatrix} 0.69 & 0 & 0 & 0 \\ 0.95 & 0.99 & 0 & 0 \\ 0.96 & 0.97 & 0 & 0 \\ 0.8 & 0.76 & 0.81 & 0 \\ 0.37 & 0.81 & 0.89 & 0.82 \\ 0.69 & 0 & 0 & 0 \\ 0.63 & 0.57 & 0.61 & 0.87 \end{pmatrix}$$

B. According to the importance extent of various targets, the weighted matrix is often defined by reasoning:

$$W_T = \begin{pmatrix} 0.1792 & 0.11 & 0.1002 & 0.134 & 0.1206 & 0.176 & 0.18 \end{pmatrix}$$

Values in the matrix above indicate the importance of targets. The result is $C(AR) = \sum T_i \times W_i, W_i \in W_T$, $\sum W_i = 1, i = 1,2,3,4,5,6,7$.

C. Through the analysis and comparison, the weight matrix of operations is as follows:

$$W_{V\,7\times4} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0.3141 & 0.6859 & 0 & 0 \\ 0.5 & 0.5 & 0 & 0 \\ 0.25 & 0.25 & 0.5 & 0 \\ 0.5233 & 0.118 & 0.2092 & 0.1495 \\ 1 & 0 & 0 & 0 \\ 0.1877 & 0.3123 & 0.3123 & 0.1877 \end{pmatrix}$$

D. Obviously, $C_{A,B}(T,V) = 1$ and $C_{A,B}(AR,T) = 1$.

E. In accordance with the theory of CF and steps above, the results of target appraisement for algorithms A and B are:

$$C_A(T) = C_A(T,V) \times C_A(V) \times W_V$$
$$= \begin{pmatrix} 0.63 & 0.85 & 0.885 & 0.77 & 0.471 & 0.87 & 0.761 \end{pmatrix}$$

$$C_B(T) = C_B(T,V) \times C_B(V) \times W_V$$
$$= \begin{pmatrix} 0.559 & 0.977 & 0.965 & 0.795 & 0.602 & 0.69 & 0.7 \end{pmatrix}$$

F. According to rules of calculating in CF, the final results are as follows:

$$C_A(AR) = C_A(AR,T) \times C_A(T) \times W_T$$
$$= 0.746, C_B(AR) = C_B(AR,T) \times C_B(T) \times W_T = 0.731$$

From the matrixes $C_A(T)$ and $C_B(T)$, the merits and drawbacks of algorithms A and B can be concluded as follows (see table 1): "capacity" and "robustness" of algorithm A is better than B, and other targets of algorithm A are inferior to B.

Finally, by the result of this experiment, we can make a decision that algorithm A on the whole is a slightly better than B.

Table.1 Comparisons Of Algorithms A And B

Watermark Targets	[A]	[B]
Anti-compress	Best	General
Cryptic Capability	General	Best
Security	General	Best
Anti-attack Capability	General	Best
Validity	General	Best
Watermark Capacity	Best	General
Robustness	Best	General

4. CONCLUSION

Through above analysis, as long as we reasonably set the weight of the indicators and elements, under the support of the uncertainty transmission mechanism and the credibility reasoning way, a true evaluation conclusion for any kind of digital vector maps digital watermarking algorithm can be obtained.

Although the digital watermarking algorithm evaluation technology based on the credibility reasoning, the above-mentioned advantages can be found. However, there are still some shortages, including, the credibility computing, for the conclusion that some watermarking algorithm performance is better is true, needs that combined with a lot of evidence and knowledge as support. Moreover, the credibility computing for these evidence and knowledge need combine with large

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

number of expert experience knowledge, and the weight distribution also dependents on practical experience.

Too much reliance on empirical knowledge affected the authenticity of the algorithm evaluation conclusions under the credibility reasoning, which leads to the accuracy of the evaluation methods and the size and objectivity of the empirical knowledge closely related, that is, the richer the empirical knowledge, the more objective the expert view is. And the evaluation conclusion would be more credibility.

The ultimate goal of this subject is to solve the critical technologies of the digital vector map copyright protection that the current researchers have not completely solved, and realize the digital vector map copyright protection scheme of comprehensive performance outstanding, namely "lossless for map content, prohibit unauthorized data copying, have the map sources tracking function".

REFERENCES

[1] Tirkel, G.Rankin, R.VanSchyndel, W.Ho,N.Mee, C.Osborne, "Electronic Watermark. Proc".DICTA 1993, pp.666-672.

[2] Wang Dao-Shun, LIANG Jing-Hong, DAI Yi-Qi, LUO Song, QI Dong-XU, "Evaluation of the Validity of Image Watermarking". CHINESEJOURNAL OF COMPUTERS, 2003 26(7), pp.779-788.

[3] Sun Shenghe, Lu Zheming, Niu Xiamu, "Digital Watermarking and Its Applications" M. Beijing:Science Press,2004.

[4] Yin H, Lin C, Qiu F, "A survey of digital watermarking"[J]. Journal of Computer Research and Development, 2005,42(7), pp.1093-1099.

[5] Potdar, V.M., Han,S., Chang E., "A survey of digital image watermarking techniques", 2005 3rd IEEE International Conference on Industrial Informatics,2005, pp. 709-16.

[6] Ling Dan，Zhuang Wan-yu, "A New Method for Partner Appraisement in Dynamic Alliance Based on Certainty Factor", Journal of University of Electronic Science and Technology of China, 2007, 36(2), pp.322-324.

[7] Deng Shujun, Lu liang, Deng Shujun, CheSen, "Research on a Digital Watermarking Algorithm Suitable to Vector Map", Proceedings of the IEEE International Conference on Automation and Logistics, 2007, pp.1236-1240.

[8] Xu De-he, Zhu Chang-qing, Wang Qi-sheng, "A Survey of the Research on Digital Watermarking for the Vector Digital Map" GEOMATICS WORLD, 2007, 12(6), pp.42-48

[9] Wang Lunwei, Liao Xiangke, Wang Huaimin, "Research on Authentication Trustworthiness Theory", Journal of Computer Research and Development, 2005, 42(3), pp.501-506.

[10] Sun Jianguo, Men Chaoguang. Wavelet neural network based watermarking technology of 2D vector maps. High Technology Letters, 2011,17(3):259-262

[11] Davydov A, Kovalev A, Lzyurov K. Distortion measure of watermarking 2D vector maps in the mesh-spectral domain. 17th DSP 2011 International Conference on Digital Signal Processing, 2011:1123-1129 .Corfu, Greece

[12] Zhang Yanqun. Digital watermarking algorithm of vector map based on feature points. 2011 Cross Strait Quad-Regional Radio Science and Wireless Technology Conference, CSQRWC 2011, v 2, 1430-1433

[13] Kim Junqyeop. Vector map digital watermarking using angles. 6th International Conference on Networked Computing and Advanced Information Management, NCM 2010, 417-423

[14] Lee Suk-Hwan, Kwon, Ki-Ryong. Vector watermarking scheme for GIS vector map management. Multimedia Tools and Application, 2011:1-34.