A WATERMARKING ALGORITHM FOR VECTOR GEO-SPATIAL DATA BASED ON INTEGER WAVELET TRANSFORM

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ABSTRACT:

Considering the characteristic of vector geo-spatial data for digital watermarking, this paper presents a new watermarking algorithm for vector geo-spatial data based on integer wavelet transform. By the proposed algorithm, the line and surface coordinate points are decomposed by integer wavelet transform firstly, then watermark is embedded in the low frequency coefficients of integer wavelet transform, and the vector geo-spatial data with watermark is obtained by inverse integer wavelet transform finally. The experiments show that the proposed algorithm can effectively resist the attack of noise, data compressing, points deleting and format exchanging. For integer vector geo-spatial data, the algorithm can restitute the data well.

1 INTRODUCTION

Geo-spatial data are the supporting production of national infrastructure and geoscience's research; it plays a significant role in the national economy and defense construction. The security of geo-spatial data refers to national security, technology cooperation and copyright protection. At present, there must have a credible technology to secure the security of geo-spatial data.

The digital watermarking is a new developed former technology of information security (Sun Shenghe, 2004, Yang Yixian, 2006). There have been many applications for digital watermarking in many fields such as digital images, video, audio and so on. For vector geo-spatial data there were a few studies on the digital watermarking. A watermarking algorithm based on disperse cosine transform was proposed for vector geo-spatial data (M Voigt, 2004). A vector geo-spatial data watermarking algorithm by disperse Fourier transform is developed(V. Solachidis,2000).A watermarking algorithm that plotted out a map to many blocks and embedded watermark to the vertex coordinates of sub-block is proposed. A watermarking algorithm to resist compressing attack was proposed (ZHU Chang-qing,2006). A blind watermarking method based on wavelet transform was developed for vector map(Li Yuanyuan,2004).

For these studies, the results from the algorithms based on transform domain are mainly floating. So when embedding watermark, the precision for integer data will reduce more or less. The lost will influence detecting watermark and make it hard to building the digital watermarking algorithm from which vector geo-spatial data can be restituted well. Considering the essential characteristic of vector geo-spatial data and the new wavelet technology, the paper studies the digital watermarking algorithm for vector geo-spatial data based on integer wavelet transform.

Lifting scheme, based on spatial domain, is said to be the key technology for constructing secondary wavelet. Because lifting scheme does not depend on translation, and not need spectrum analysis tools, it can be used in constructing wavelet on finite area, surface and non-uniform sampling data and so on. Based on lifting scheme, the integer data set can also be integer data set when transforming by wavelet transform. Because the transform coefficients do not need quantize, there is fast algorithm by addition and shift operation and no quantization error in the watermarking algorithm based on integer wavelet transform. The characteristic of Multi-scale in integer wavelet transform which matches the visual characteristic is good for imperceptibility of watermark. Because the coefficients of integer wavelet transform have physics meaning, the embedding and detecting of digital watermark can be convenient.

In general, the vector geo-spatial data is stored to files with the layered form. And contour is a basic and important layer data in vector geo-spatial data. Hence, in the paper, contour is used as the example of vector geo-spatial data. As all known, contour data is composed of the data with position and attribute information. Because attribute data cannot be changed unbending in general, the watermark is embedded in position data of contour in the paper.

A line and surface elements of position data in the vector geo-spatial data are composed of a series of points with coordinate x and y . If the number of points for a line or surface elements is N , the line or surface elements can be represented as $z(n) = x(n) + i \cdot y(n)$, $n = 0,1,\ldots, N-1$. For a line or surface elements, because of the high relativity between the neighborhood points, integer wavelet transform is used to the coordinates of points, and the watermark is embedded into the transform coefficients.

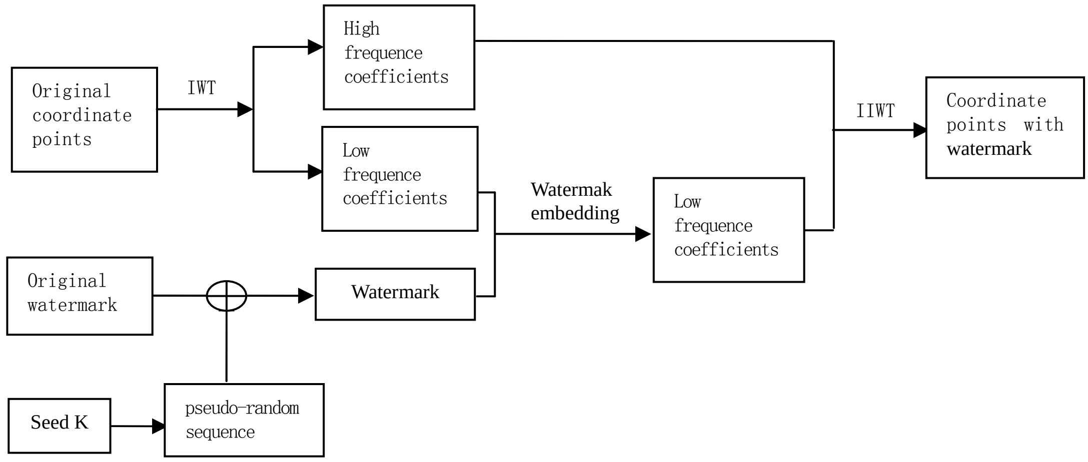

Figure 3. The basic flow of embedding watermark

2 THE CREATING AND PRE-PROCESSING OF WATERMARK

In the paper, the meaning watermark is used. Figure 1 shows the watermark that is an image with 30×130 pixels which will be used as an experimental example in the paper.

Figure 1 the watermark for experiment

By scanning, the watermark can be represented as:

$$M = \{m(k)\}, k = 0,1,\cdots,n-1,\ m(k) = \pm 1.$$

For enhancing the robustness, the algorithm shuffles the watermark before embedding. The pseudo-random sequence based on seed is generated as:

$$P = \{p(k)\}, k = 0,1,\cdots,n-1,\ p(k) = \pm 1$$

The shuffling watermark can be got by bit XOR operation with M and P

$$W = \{w(k) = m(k) \oplus p(k)\}, k = 0,1,\cdots,n-1$$

The shuffling watermark is shown in figure 2.

Figure 2 the shuffling watermark

3 THE EMBEDDING ALGORITHM FOR VECTOR GEO-SPATIAL DATA

The integer wavelet transform can be for x coordinates, y coordinates or both of them (Here is for x coordinates). And the watermark is embedded into the low frequence coefficients of integer wavelet transform. Then the data with watermark is transformed by inverse integer wavelet. Finally the watermark is embedded in the original vector geo-spatial data. The basic flow of embedding watermark for vector geo-spatial data is shown in Figure 3.

The rule of embedding watermark is

$$D[x'(k)] = D[x(k)] + p * w(k) \quad k \in [0, n-1]$$

Where $D[x(k)]$ represents the low frequence coefficients of coordinates by integer wavelet transform, n is the number of bit for the embedded watermark. p is the intensity of embedded watermark and p = 2 in the paper.

4 THE DETECTING ALGORITHM FOR VECTOR GEO-SPATIAL DATA

Detecting watermark is the inverse of embedding watermark in fact. By comparing the low frequence coefficients of the original data and detecting data, watermark W' which is the shuffling watermark can be detected. Further, watermark M can be obtained by inverse shuffling. Finally, by autocorrelation detection, if the vector geo-spatial data have watermark can be judged. The basic flow of detecting watermark is shown as Figure 4

On the comparison of low frequency coefficients, the rule is as follows.

$$c(k) = D[x_d(k)] - D[x_o(k)]$$

$$w_{\mathrm{d}}(k) = \begin{cases} 1, & c(k) \geq 0 \\ -1, & c(k) < 0 \end{cases}$$

Where $x_d(k)$ represents the coordinates need to be detected, $x_o(k)$ represents the original coordinates, $w_{\mathrm{d}}(k)$ represents the detected coordinates.

The normalization correlation detection is used in detecting watermark for enhancing the robustness, and the rule is as follow:

$$c = \frac{\sum_{k=0}^{k=n-1} m(k) * m'(k)}{n}$$

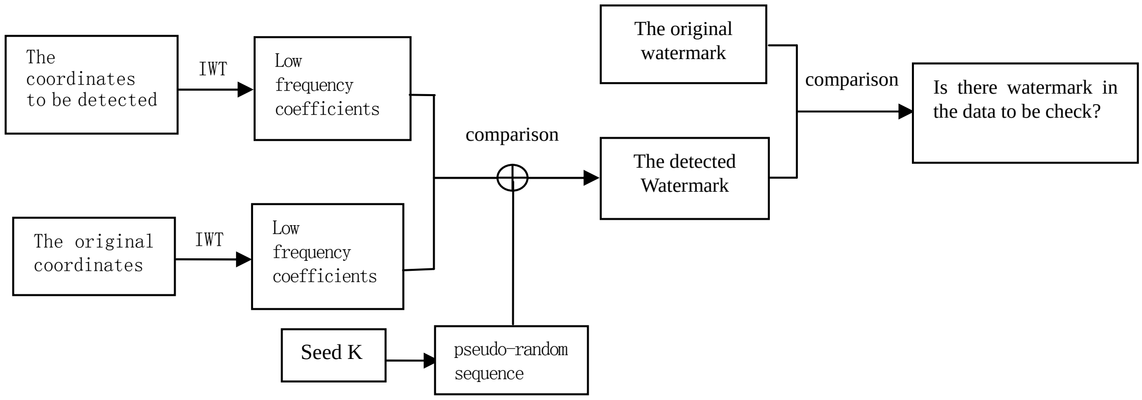

Figure 4. The flow of detecting watermark

Where $m(k)$ represents the original watermark, $m'(k)$ represents the detected watermark, n represents the length of bit for watermark.

Here the original data of coordinate points are needed to record so as to detect the watermark.

5 THE EXPERIMENTS

We now present the experimental results for the proposed watermarking algorithm. The watermark is shown in Figure 1, and the original data to embed watermark is the contour data including 160182 coordinate points with the scale 1:250000.

5.1 Visibility

Figure 5 shows the embedded watermark data overlapped with the original data, where the solid lines is the original contour data and the hidden lines is the embedded watermark data. From the comparison of the two kinds of data in Figure 5, it can be known that the proposed watermarking algorithm is with good imperceptibility.

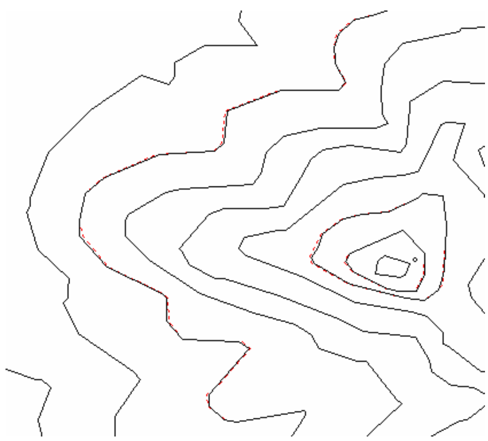

Figure 5 the imperceptibility for the embedded watermark data

5.2 The precision analysis

There are 160182 coordinate points in the original and embedded watermark data. We compare the absolute error between two kinds of data. The comparison results list is in Table 1.

Absolute error C	C=0	C=1	C=2	C>2
Number of points	155024	4204	954	0
Percent	96.78％	2.62％	0.60％	0

Table 1 The error between original and embedded watermark data

From Table 1, it can be known that there is no error for the 96.78% of total data. For the points with the error, the error is allowable (<=2), and the quality of data with watermark can satisfy the actual applications. Hence the proposed watermarking algorithm is with high precision.

5.3 The robustness

In the subsection, the robustness for the embedded watermark data is studies, and the watermark with intensity 1 and max error 2 is detected after meeting the different attack.

(1) No change
If there is no any change for the embedded watermark data, the watermark can be detected wholly.

(2) Compressing
If compressing the embedded watermark data, the watermark also can be detected and the result is shown in Figure 6, where the correlative coefficient is 0.86689.

Figure 6. The detected watermark by compressing

(3) Deleting points
We delete some points randomly from the embedded watermark data, and then detect the watermark from the data. The result is shown in Figure 7, where the percent of deletion is 10% and the correlative coefficient is 0.904580.

Figure 7. The detected watermark by deleting points

(4) Noise attacking
If attacking the embedded watermark data by uniform noise, the watermark also can be detected and the result is shown in Figure 8, where the correlative coefficient is 0.857824.

Figure 8. The detected watermark by noise attacking

(5) Format exchanging

If exchanging format of the embedded watermark data, the watermark also can be detected and the result is shown in Figure 9, where the correlative coefficient is 0.995706.

Figure 9. The detected watermark by format exchanging

6 CONCLUSIONS

Based on integer wavelet transform, this paper proposes a watermarking algorithm for vector geo-spatial data. The experiments show that the proposed watermarking algorithm can resist many attacks such as noise, data compressing, points deleting and format exchanging. The algorithm is with good availability, imperceptibility and robustness, so can be used to secure the security of vector Geo-data widely.

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