The Journal of GIS Association of Korea, Vol. 13, No. 4, pp. 393-400, December 2005

Watermarking technique and algorithm review of digital data for GIS

Jung-yeop Kim* · Sung-Eon Hong** · Yong-Ik Lee*** · Soo-Hong Park****

ABSTRACT

Due to the development of the network and Internet, it is easy to copy and spread digital data. These data has the advantage of being able to be copy without loss. However, this has generated a problem over copyright. The problem occurred in GIS, too. Although GIS data acquisition is the major cost, there is insufficient effort made to protect copyright. For this reason watermarking could be a good method to guarantee owner's copyright. This paper will explain watermarking, and show an overview of watermarking studies connecting image and vector data.

Keywords : Watermarking, copyright, image data, vector data

요 약

네트워크와 인터넷의 발달로 인해, 디지털 데이터의 보급과 확산이 쉽게 이루어지고 있다. 디지털 데이터는 손실없이 복제되고 보급될 수 있다는 장점이 있지만, 저작권 문제와 더불어 데이터의 무분별한 복제 문제가 발생하고 있다. 이러한 문제는 GIS에서도 발생하고 있다. GIS에서 데이터 획득을 위해 큰 비용을 지불하고 있는 반면에 데이터 소유권에 대한 보호 노력은 미흡한 실정이다. 현재 워터마킹은 데이터의 소유권을 보장해 줄 수 있는 좋은 방안으로 대두되고 있다. 이 논문에서는 워터마킹의 기본적인 정의를 설명하고 GIS에서 사용되는 raster 형식의 데이터와 vector 데이터에 대한 워터마킹 연구동향을 분석하여 보고자 한다.

주요어 : 워터마킹, 저작권 보호, 이미지 데이터, 벡터 데이터

*Ph. D. Candidate, Department of Geoinformatic Engineering, Inha University (E-mail : jyfloo@empal.com)
**Full-time lecturer, Department of Welfare · land information, Cheongju University (E-mail : hongsu2005@hanmail.net)
***Master. Course, Department of Geoinformatic Engineering, Inha University (E-mail : a78leekey@naver.com)
****Professor, Department of Geoinformatic Engineering, Inha University (E-mail : shpark@inha.ac.kr)

1. Introduction

The technique of watermark is used in various field, and recently, the need for this in GIS data has increased. GIS data acquisition accounts for approximately 80% of the overall budget. Because the data used in GIS is similar, one solution is to share the data and thereby decrease the overall cost. That is, if an individual(or group) has the right to use the data, he can use the data. If not, he cannot use the data. One of these methods available in this situation is digital watermarking.

Generally, the digital watermarking begins with the rapid growth of network. Advance of network, however, has positive and negative affects. Illegally copied contents has resulted in the offerer losing their will to create. Therefore, it raises demand for copyright protection. One potential solution for protecting media against illegal recording and retransmission is to embed an invisible signal, called a watermark, in digital content. Extraction of the embedded watermark without ambiguity can identify the copyright owner or legitimate recipients to prevent illegal distribution or misuse[1]. A digital watermark is a visible, or preferably invisible, identification code that is permanently embedded in the data and remains present within the data after any decryption process[2]. Figure 1 shows general watermarking embedding/ detection process[20].

Image watermarking is a technique used to hide secret signal into a image. The watermarking should have certain characteristics[1]:

① Imperceptibility: The watermark should be perceptually invisible, or its presence should not interfere with the work being protected.

② Robustness: The watermark must be difficult to remove. In particular, the watermark should be robust in the following area.

· Common geometric distortions(image and video data): Watermarks in image and video data should also be immune from geometric image operations such as rotation, translation, cropping and scaling.

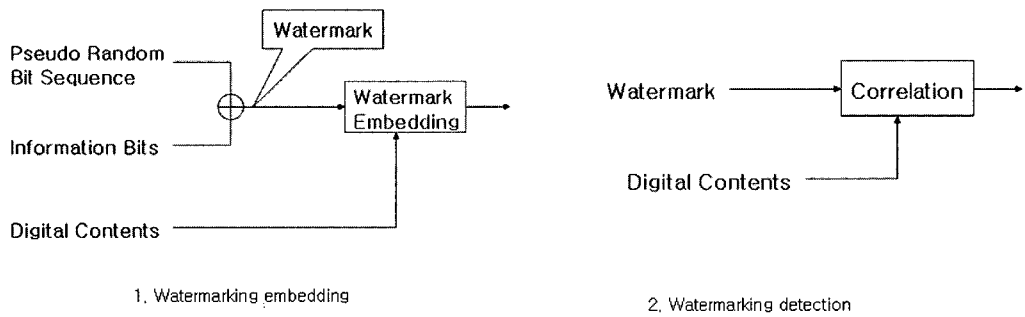

Figure 1. Watermarking embedding/detection process(Source: Adapted from [20])

- Subterfuge attacks: The watermark should be robust to combining copies of the same data set to destroy the watermarks.

③ Security: A watermark should be secure and statistically undetectable. The embedded watermark must not be detected by an unauthorized person but must be retrieved correctly by an authorized user. This requirement can usually be achieved by using cryptographic keys. Since the watermarking algorithm is public, the security of the watermark is then only based on the cryptographic keys.

④ Unambiguity: Retrieval of the digital watermark should unambiguously identify the ownership and copyright.

The features apply in data used in GIS. Figure 2 illustrates general attacks on digital contents[2]. This paper will show an overview of watermarking algorithms that can apply data in GIS.

In chapter 2, we will show and explain watermarking algorithm on raster data. In chapter 3, we will illustrate novel watermarking algorithm on vector data.

2. The raster data

Raster is a typical spatial data format used in GIS. Its main characteristic is that there is a clear order (row, columns) in the data. Satellite imagery as well as aerial photography is delivered in this format. This chapter will present watermarking algorithm on images.

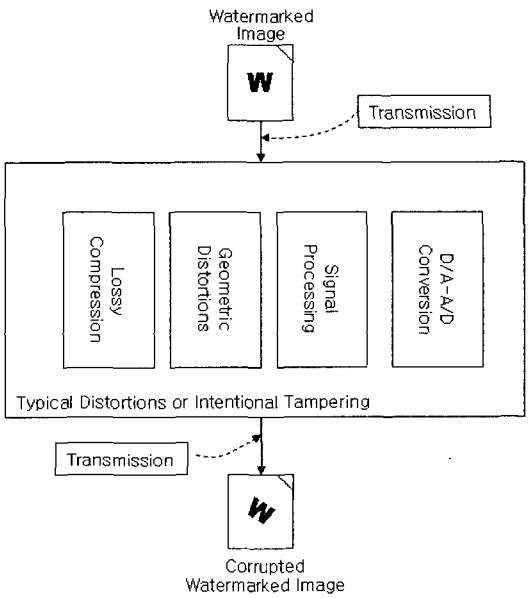

Figure 2. Common processing operation that a media document could undergo (Source: Adapted from [2])

This paper[1] proposed a watermarking algorithm robust to rotation, scale and translation distortion. This algorithm used Fourier transform and Log-Polar transform. Fourier transform has constancy to translation and Log-Polar transform has no relation with rotation and scale. Log-Polar transform, However, induces distortion in digital image. This algorithm used position information in frequency domain of Polar coordinate instead of using direct Log-Polar transform. This study shows that the algorithm has consistency to attacks by rotation, scale and translation distortion.

Jung-Soo Lee et al. [2] proposed a watermarking system for geometric deformation through Fourier transform and watermark. The recomposition of the watermark change original watermark consisted of {-1, 1} into a new watermark of one dimension sequence. After changing it to various size, the resizing watermark reconstructed a round watermark. And the watermark is embedded into a signal obtained by taking the Fourier transform of the image. Detection is performed by the reversing the process. The embedded watermark is robust to scale, cropping and shift.

In this paper, after embedding watermarking according to frequency range, Ki-Hyeok Bae et al [3] studied the robustness of watermark. This paper is done by the following procedure; 1) applying Discrete Fourier Transform (DFT) to the image, 2) dividing the range into three range (high, middle, low frequency). 3) using Cox's way to embed and extract watermark. The watermarking image is attacked by various distortion such as lossy compression, noise, contrast change and brightness change according to three frequency range. After that, the embedded watermark in high and low frequency range is not robust enough to withstand various attacks, but in middle frequency range watermark is robust to attacks.

Hyung-Do Kim [4] used vector quantization (VQ) method to embed and extract watermark. And this paper studied a blind watermarking method. By VQ method, this algorithm embed watermark into most input image vectors. That is, the codeword in the codebook divided into three groups, and then watermark is embedded into a image according to the groups. This algorithm have robustness on the VQ and JPEG compression. Moreover, this algorithm shows that the watermark is evenly embedded in the image.

Ki-Hyuk Bae [5] proposed a blind watermarking algorithm using the visual properties of the subband. The original image divides according to subband by applying Discrete Wavelet Transform (DWT). Then, the watermark is embedded in the position where visual loss is the lowest using 2×2 mask. To extract the embedded watermark, watermarking image are divided into bands by applying DWT. And watermark is extracted through the mask and a certain equation. Although the watermarking image is attacked by clipping, compression, scale change, noise, and filtering, the embedded watermark is rarely impaired.

If watermark is inserted into the whole image

by applying DCT, there will be distortion in no change region. Jae-Wook Shin et al [6] proposed a novel watermarking algorithm that inserts watermark not into the whole image region but only into the interesting regions. To search interesting region, a image is divided into 8×8 size images. Then the subregion can be calculated by using picture information measure(PIM). Watermark is inserted into the subregion that is greater than threshold. The watermarking image is compared to the original image for extracting the embedded bits. The experiment has results that are robust to compression and Gaussian noise.

Myung-Hwan Jang et al [7] proposed the watermarking technique using the feature of wavelet transform coefficients. In this proposed method, the watermark is embedded into the all sub-bands of image which is changed as coefficients of frequency domain. The watermark is embedded by using difference between neighbor coefficient pairs on LL-band, and absolute value of coefficients in other bands(LH, HL, HH). The extraction process can be performed by comparing the original image and the watermarking image with difference and absolute value. The proposed method has better image quality and robustness to the attacks of noise addition, cropping, filtering and loss compression than those of existing Cox's method.

Hyun-Soo Kang et al [8] proposed a novel watermarking algorithm. In general, when people use image data, because there is no the original image, a blind watermarking algorithm is easier than a non-blind watermarking algorithm to extract a watermark. Blind algorithm has, however, a weakness, error rate, on the confidence of extracting watermark due to the interference between the watermark signal and the original signal. To remove the interference, the watermark is divided into M watermark, and the time-average of the sub-watermark are removed. This algorithm is performed by applying DFT and shows that the more M increased, the more error rate decreased.

Traditional watermarking technologies are used by the same key when embedding and detection are done. This symmetric method has shortcomings to attack. De Li[9] have expanded search space of secret key using the solution set of linear simultaneous equations. The complexity of the secret key is raised using an orthogonal matrix to prevent generating the secret key from public key. This algorithm can embed and extract watermark efficiently, and is robust JPEG compression in experiment

This paper[10] presents a secure algorithm for watermarking images. The experiment was performed using Fourier domain method based on the DCT. In order to place a length n watermark into an N×N image, the image is transformed by applying DCT and the watermark is placed into the n highest magnitude coefficients of the transform matrix. In experiments, the watermarking algorithm can extract a reliable copy of the watermark from imagery that is attacked several image processing.

This paper[11] presented a new method of digital image watermarking that embeds the

watermark in an image already compressed via the VQ compression technique. The codewords are divided into several groups according to characteristics. And then the watermark is embedded into the indices generated. To extract the watermark, codebook and the secret key are used. The experiment results show that the watermark exists in both the VQ compressed image and the VQ decoded image and withstand many destructive image processing.

Zhe-Ming LU et al[12] proposed a watermarking algorithm that is to assign each input image block to the nearest codeword labeled the corresponding watermark bit. They performed the watermarking algorithm after dividing the image. The watermark is embedded into image block through comparison with other block. The extraction process can be performed blindly only with the codeword-labeled VQ codebook. Experimental results demonstrate the robustness of the watermarking algorithm

Analyzed studies on watermarking of image data, watermarking methods can be classified into two methods. First, the frequency change methods which have been used in image process which were studied in the early years. The methods perform that watermark is embedded into certain domain where people cannot see it easily. Recently, the vector quantization method that is often used in compression are studied for watermarking algorithm. It is a method that embeds watermark after creating codebook. The method is used in compression. Therefore, it is very robust to compression, and because it can distribute watermark to a whole image, it is good a watermarking method.

3. The vector data

Because vector data have certain properties such as the topological properties and coordinate system, most watermark embedding algorithms and watermark detection algorithm can not be applied directly to vector maps. However, watermark generation algorithms of image data can be easily used for vector map data.[watermarking 2D/3D..)

Solachideis, Nikolaidis and Pitas[13] proposed a blind method and Fourier descriptors for watermarking of vector graphic images. The 2D coordinate (x,y) of each vertex is combined to construct the complex value z = x +iy. After that, DFT can be applied to the vertices of a polyline or polygons to obtain the Fourier descriptors. The watermark can embed with the Fourier descriptors and extract with correlation between the embedded watermark and the watermarked Fourier descriptors. This paper shows that the properties of the Fourier descriptors ensure that the novel watermarking algorithm endures rotation, translatoin, scaling, reflection, change of traversal starting point/ direction and smoothing.

This paper[14] proposes a digital watermarking algorithm for vector digital maps. First, the original data implemented three area subdivision methods. After the subdivision, a watermark is embedded into the map by each bit 0 or 1 in the rectangles. Prior to the extraction, a similarity transformation applied to the

watermarked map is removed. The same rectangles used during the embedding are created through this preprocessing. A message bit is extracted using the algorithm which compares the averaged vertex coordinates among a corresponding pair of rectangles. This paper experimented and analyzed to show the robustness of the attacks such as translation, enlarge, shrink, vertex deletion, additive random noise and cropping.

This paper[15] proposed a novel vector map watermarking algorithm. First of all, the image is partitioned into the blocks with the same area and vertex in a block is changed to a new coordinate value. As the value of the watermark, an area inserted the watermark is changed. To extract the embedded watermark, after dividing the whole image into the block, the bit can be obtained in triangular region. The experiment's result is robust against the noise attack.

Because research on watermarking of vector data is not sufficient, there are not main watermarking methods. We can see that there is watermarking algorithm applying frequency transformation like image watermarking. And there is a method that embeds watermark after dividing vector data into specific region. Vector data watermarking unlike image watermarking has been presented, because vector data have topology and coordinate system.

4. Conclusion

As can be seen above, many studies on watermarking have been presented over the last few decades. In particular, image watermarking has been performed and studied because of usefulness not only in GIS, but also in various fields. Research for vector data watermarking is insufficient compared with image watermarking. Vector data have topology, and can do spatial analysis. And vector data have merits of high accuracy and compression. Vector data have these merits and are widely used in a variety of applications such as GIS, ITS, and mobile computing. Considering this environment, watermarking research for copyright will be needed.

References

[1] D-C Lou, C-H Sung, "Robust Watermarking Technique for Digital Images utilizing the Invariant Relation of Vector Quantization Indices", The Imaging Science Journal, Vol.50, No.4, pp.291-302. 2002

[2] Ingemar J.Cox, Joe Kilian, F.Thomson Leighton, Talal Shamoon, "Secure Spread Spectrum Watermarking for Multimedia", IEEE Transactions on image processing, Vol.6, No.12, pp.1637-1687, 1997

[3] Hyon-Gon Choo, Sam Lim, Whoi-Yul Kim, "Image Watermarking Robust to Rotation, Scale and Translation Distortion", Proceedings of the IEEK Conference, pp.209-212, 2001

[4] Jung-Soo Lee, Jong-Weon Kim, Jong-Uk Choi, "A Study On Image Watermarking Technique against Geometrical Deformation", Proceedings of The 30th KISS Spring Conference, pp.440-442, 2003

[5] Ki-Hyeok Bae, Sung-Hwan Jung, "Comparison

of the Robustness of Digital Image Watermark for Copyright Protection", Proceedings of the KIPS Conference, Vol.8, No.1, pp.851-854, 2001

[6] Hyung-Do, Kim, "Blind Image Watermarking using Codebook Grouping in Vector Quantization", Telecommunications Review, Vol.12, No.5, pp.663-669, 2002

[7] Ki-Hyuk Bae, "Efficient Blind Watermarking using Visual Characteristic", Telecommunications Review, Vol.12, No.5, pp.679-687, 2002

[8] Jae-Wook Shin, "A new watermarking method using entropy-based region segmentation", INHA University, Master paper, 1999

[9] Myung-Hwan Jang, "A Study of Image Watermarking Schema using the Features of Wavelet Transform Coefficients", TAEJON University, Master paper, 2001

[10] Hyun-Soo Kang, Jin-Woo Hong, Kwang-Young Kim, "Enhanced Watermarking Scheme based on Removal of Local Means", Journal of KICS, Vol.27, No.11C, pp1106-1111, 2002

[11] De Li, Jong-Weon Kim, Jong-Uk Choi, "Secure Asymmetric Watermarking Based on Correlation Detection", Korea Information Processing Society Review, Vol.12-C, No.3, pp.379-386, 2005

[12] I.J.Cox, Joe Kilian, F.Thomson Leighton, Talal Shamoon, "Secure Spread Spectrum Watermarking for Multimedia", IEEE TRANSACTIONS ON IMAGE PROCESSING, Vol. 6, No. 12, pp. 1673-1687, 1997

[13] Hsien-Chu Wu, Chin-Chen Chang, "A Novel Digital Image Watermarking Scheme Based on the Vector Quantization Technique", Computers&security, Vol.24, No.6, pp.460-471, 2005

[14] Zhe-Ming LU, Wen XING, Dian-Guo XU, Sheng-He SUN, "Digital Image Watermarking Method Based on Vector Quantization with Labeled Codewords", IEICE TRANS. INF. & SYST., Vol. E86-D, No.12, pp.2786-2789, 2003

[15] V.Solachidis, N.Nikolaidis, I.Pitas, "Fourier Descriptors Watermarking of Vector Graphics Images", In proc. of XIII Brazilian Symposium on Computer Graphics and Image Processing, Vol.3, pp. 9-12, 2000

[16] Endoh. S, Ohbuchi. R, Ueda. H, "Robust watermarking of vector digital maps", In pro. of IEEE International Conference on Multimedia and Expo, Vol. 1, pp. 577-580, 2002

[17] Jong-Uk Choi, Hwan-Il Kang, Kab-Il Kim, "A map data watermarking using the generalized square mask", In proc. of IEEE International Symposium on Industrial Electronics, Vol. 3, pp. 1956-1958, 2001

[18] Hyun-Seung Kim, "Digital Watermarking", Greenpress, 2005

[19] Carlos Lopez, "Watermarking of digital geospatial datasets: a review of technical, legal and copyright issues", International journal of geographical information science, Vol.16, No.6, 2002, pp.589-607

[20] Ho-Hsun Chang, Tsuhan Chen, Kou-Sou Kan, "Watermarking 2D/3D Graphics for Copyright Protection", 2003 IEEE International Conference on, Vol.4, pp.IV_720-IV_723