건축설계도면상에서 꼭지점에 기반한 LINE과 ARC를 이용한 디지털 워터마킹

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A New Digital Watermarking for Architectural Design Drawing Using LINEs and ARCs Based on Vertex

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Abstract

This paper proposed to digital watermarking technique for architectural drawing using LINEs and ARCs based on vertex in CAD system to prevent infringement of copyright from unlawfulness reproductions and distribution. After extract LINEs and ARCs from designed drawing, we embed watermarks using adaptive algorithm in each characteristics. Watermarks robust to various attacks like as geometrical transformation as being embedded in LINE's length and ARC's angle information. Also, the proposed method satisfies enough transparency about watermarked drawing because have suitable embedding strength to each component. By experimental result, we confirmed robustness and invisibility of embedded watermarks in several conversions of architectural design drawing.

Keywords: architectural drawing, CAD, digital watermarking, geometrical attack, copyright protection

I. Introduction

Today, multimedia society has many problems by unlawful reproduction or not admitted distribution from sudden increase of digital contents and multimedia data. To solve such problems, it is possible to hide data (information) within digital medium. The information is hidden in the sense that it is perceptually and statistically undetectable. With many schemes, the hidden information can still be recovered if the host signal is compressed, edited, or converted from digital to analog format and back. This can bear witness to ownership for the owner of the digital media from illegal application. Recently, the watermarking for video, speech and image are developing very actively, and specially, lots of researches for the image watermarking being reported. But, in fact, even so results of these progressed researches, many of them are not used in real world, moreover also studies about its other application are almost not achieved. As development of CAD systems, now almost architectural designs are completed on computer programs. Architectural drawing in CAD system is more detailer, exacter and easier to see. But likewise most of other computer files, CAD files are also easy to copy or circulation. So, sometimes they are exposed to embezzlement or illegal copy. Actually, we often see same modeling at another buildings, and have saw cases about appropriation of architectural design in TV news.

This paper is proposed for prevent from these embezzlements of such architectural design drawings and for stop shrinkage of architectural design techniques. We analysis architectural drawings made by CAD tool for architectural design, then we embed watermarks having transparency using an adaptive algorithm. And finally, develop a robust detection algorithm nevertheless various data handlings treating as attacks. Like as other almost watermarking algorithms, this method must consist in extents that satisfy transparency and toughness [1]. Embedded watermark in architecture design drawing must not be observed by users, and not be damaged or detected by other designers. And, even if it completed itself, because it is possible modifications and distortions without any limit as using CAD programs, it should be have specially robustness about attack on CAD programs.

Swanson *et al.* [2] proposed watermarking method in the DCT

domain using property of human perceptual system. Voloshynovskiy *et al.* [3] proposed adequate stochastic modeling for content adaptive digital image watermarking. The watermarking technique has perceptual characteristics about successive subband quantization and non-stationary Gaussian model in multiwavelet transform domain is proposed [4]. Ohbuchi *et al.* [5] presented method to insert watermark to each vertex there into after divide by rectangles that have vertices of fixed quantity using quadtree way in Vector Digital Map

II. Proposed Watermarking Algorithm

Most of all, we need to consider Vertex based image to achieve watermarking of CAD drawing. Various data transformations of DCT, DFT, DWT, LOG POLA Mapping etc. are available in case of raster based 2-D images, therefore image processing in frequency domains is available. Multimedia watermarking schemes are most consisting in frequency domain, too[1~4]. But, as almost CAD files have a characteristic of vector based image unlike raster based image, it is impossible to transform to frequency domain because they have no relation with neighborhood vertices. Therefore, frequency domain processing or mask processing like as in image watermarking is impossible, but spatial domain processing is only applied. So, there is a characteristic that method to embed watermark in CAD file is limited in spatial domain but have advantage that may not consider attacks in frequency domain.

Fig. 1 is the block diagram of proposed watermarking achievement process. At first time, we acquire and classify components as LINE and ARC in the architectural drawing. Then, we embed watermarks adaptively to length and angle information of the components, because they are most basic components in CAD data, therefore architectural drawings are designed on the basis of these two components, and they are indispensable elements of architectural drawings. The watermark having Gaussian random sequence, is embedded in the architectural drawing, and this algorithm has suitable embedding strength for transparency of the watermark. Watermark is used with position key value to decide embedded position and sign. And, they are composed in original positions again after watermark was embedded. When watermark is detected, it can make to need not whole drawing of original but components that used only when watermark was embedded.

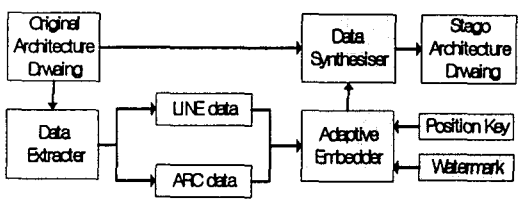


Fig. 1. The block diagram of proposed whole watermarking scheme.

2.1 LINE Watermarking Scheme

2.1.1 LINE Embedding

As one of components that are handled most in design drawing, LINE is consisted of beginning point coordinate (x_1, y_1) and end point coordinates (x_2, y_2). Actually, position that watermark is embedded, is coordinate of this vertex. LINE embedding is performed by mapping to drawing watermarked LINE, after extraction of LINE components from designed drawing. Watermarks should be embedded in coordinates transparently by having distortion index α_L.

We used random sequence of Gaussian distribution as watermark key including binary bit string. This algorithm is to embed one watermark in all coordinates (x_1, y_1, x_2, y_2) to one LINE.

First, place be embedded in one LINE is decided by two position key bits k as (1).

$$P_n = \begin{cases} x_1 & \text{if } k_{n,n+1} = 00 \\ y_1 & \text{if } k_{n,n+1} = 01 \\ x_2 & \text{if } k_{n,n+1} = 10 \\ y_2 & \text{if } k_{n,n+1} = 11 \end{cases}, \quad k_{MAX} = w_{MAX+1} \tag{1}$$

And first key bit also uses to decide sign of original watermarks from (2).

$$s_n = \begin{cases} +1 & \text{if } k_n = 0 \\ -1 & \text{if } k_n = 1 \end{cases} \tag{2}$$

P_n is coordinate value that watermarks was embedded, and n means number of LINE and watermark. As doing this, embedded coordinates are concealed from users or attackers, also minimize visible artifacts, and can detect watermarks by using LINE's length or absolute value. And watermarks are embedded to LINE data by (3).

$$P_n^* = P_n + \alpha_L \cdot s_n \cdot w_n \tag{3}$$

There is distortion index α_L in relation of trade-off between robustness and transparency. Watermarked P_n^* is composed to original CAD data again. Then, compute the LINE's length including embedded coordinate points, finally, get difference value D_n of original LINE's length and watermarked LINE's length. Lastly, this difference $D_{0,1,\cdots,n-1}$ being values that are got as the *Seed Key*, and when detect, they are used to calculate similarity. If $k_{n,n+1} = 01$, numerical formula deciding difference value D_n is (4).

$$D_n = \left\{ \sqrt{(x_2 - x_1)^2 + (y_2 - P_n^*)^2} - \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \right\} / \alpha_L \tag{4}$$

Seed Key value D_n has form of square and distortion index α_L is used as embedding strength. At last, original

CAD data and w_n used to embedding in LINEs, are not necessary in extracting process. It needs only extracted LINE from the original CAD data. The designer gets D_n as key. This method has robust algorithm as long as LINE's length does not change. And, we can get square term's Gaussian distribution similar to w_n as multiplying distortion index α_L to D_n. This algorithm can have robustness in attacks of rotation, translation, cropping and so on, as using length information of LINE by watermark key. Because only one watermark is embedded in 4-coordinate values, it can improve transparency. Also, by binary bit string, users can't know whether watermark embedded in any coordinate point. Because it is no necessity at detection algorithm, binary position key K used in watermark embedding, is removed after whole watermarking scheme.

3.1.2 Watermark Detection Scheme of LINE Data

Because we used length information of LINE when embed watermark to LINE, there is consist as detection process that calculate length of LINE for the first time. And original architectural drawing does not need in watermark detection process. Only, watermark detection is possible if author has extracted LINE information in watermark embedding, users cannot have any information about whole original architectural drawing. Watermark detection achieve as (5).

$$D_n^* = \left\{ \sqrt{(\tilde{x}_2 - \tilde{x}_1)^2 + (\tilde{y}_1 - \tilde{p}_n^*)^2} - \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \right\} / \alpha_L \quad (5)$$

Similarity of detected watermarks is calculated as (6) comparing detected Seed Key D_a^* by (5) with original Seed Key D_n.

$$Sim(D_n, D_n^*) = \frac{D_n^* \cdot D_n}{\sqrt{D_n^* \cdot D_n^*}} \quad (6)$$

3.2 ARC Watermarking Scheme

3.2.1 ARC Embedding

We could confirm robustness about most attacks by LINE watermarking, but because it has complexity of calculation and difficulty of correct abstraction that must calculate the scaling factor for detection similarity about scaling attack, and do resizing again, it has a weakness about scaling. This weakness is supplemented as embedding watermarks to ARC and LINE. Fig. 2 shows ARC Layer's structure that is used in architectural design drawing.

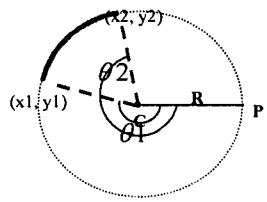


Fig.2. Structure of ARC in architectural design drawing.

Where C is CIRCLE's emphasis that makes ARC, and R is radius from emphasis C to ARC, and P is reference axis of each angle $\theta 1$ and $\theta 2$ that appear to beginning point (x1, y1) and destination (x2, y2) of ARC. ARC consists as such each coordinate points and two angle, and, these angles are stable about geometrical transformation of rotation, scaling, and translation. We achieve watermark embedding that use ARC's angle $\theta 1$ and $\theta 2$ in ARC of Fig. 2 for robust watermarking algorithm. And because human's sight does not recognize delicate change of angle, we can embed watermark transparently. To Embed watermark, after extraction of ARC's information in original drawing, the embedder makes a search for angle $\theta 1$ and $\theta 2$. It selects one angle that watermark being embedded using position key K, because it is embedded one watermark to one ARC. Watermark is embedded by ARC's angle by (7).

$$\theta' = \theta + \alpha_A K w \quad (7)$$

Where θ' and θ are each watermarked angle and original angle, α_A is the distortion index of ARC watermarking, in this method, we decided $\alpha_A = 1$.

3.2.2 Watermark Detection Scheme of ARC Data

Watermark detection consists as extract ARC information again in watermarked drawing. Because watermark is embedded to angle information, detection is available as (8).

$$\omega_A = (\theta 2 - \theta 1) - (\theta 2^* - \theta 1^*) \quad (8)$$

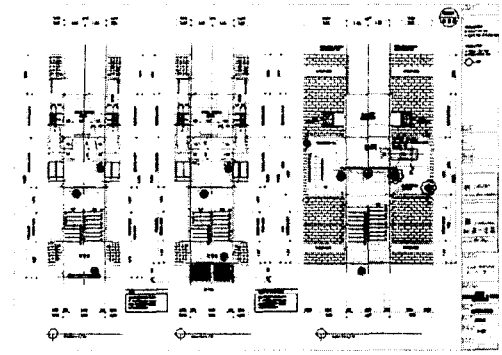
$(\theta 2 - \theta 1)$ and $(\theta 2^* - \theta 1^*)$ express each angles of original drawing and watermarked drawing. Finally, similarity of watermark is calculated by (9) comparing detected watermark ω_A by (8) with original watermark w.

$$sim(w, \omega_A) = \frac{\omega_A \cdot w}{\sqrt{\omega_A \cdot \omega_A}} \quad (9)$$

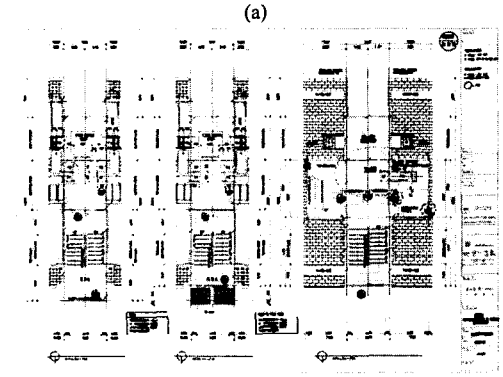
Finally, we calculate similarity about w and ω_A using (9) for ARC watermarking.

III. Experimental Results

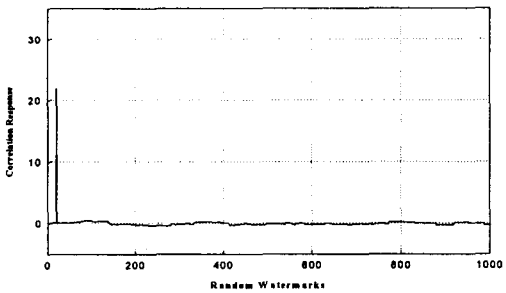
This paper used drawings that are manufactured by 'AutoCAD 2002' tool for an experiment of proposed watermarking algorithm of architectural design drawing, and selected 'building external form drawing' and 'Stair section-detail drawing' drawings to main testing bench for an efficient experiment of proposed method that. After extracted each LINE and ARC, we embedded watermark. Key watermark used 20^{th} seed of 1000 Gaussian random sequence and each α_L and α_A used 0.0001 and 1. We alternated already calculated D_n with the 20th key for the convenience in Line watermarking. And we embedded LINEs and ARCs apart each to two drawings for correct result of experiments. We embedded 1000 watermarks to extracted LINE and 1000 watermarks to extracted ARC in 'Stair section-detail drawing'.



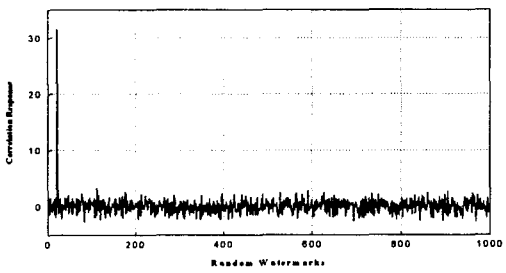
(a)



(b)



(c)



(d)

Fig.3. Correlation responses of watermarked drawing. (a)original drawing, (b)watermarked drawing, (c)correlation response about LINE, (d)correlation response about ARC.

Table 1. Watermark damage by file format conversion.

Format	DXF (2002)	DWG	DWT	DWS	DXF (early)
LINE	21.93	21.93	21.93	21.93	21.93
ARC	31.58	31.58	31.58	31.58	31.58

Table 2. Geometrical attacks of watermarked drawing

Attack		Correlation Response	
		LINE	ARC
Translation		21.93	29.89
Rotation		21.93	27.52
Crop 50%		14.36	17.18
Scaling	enlarge	10.11	29.89
	reduce	10.92	29.89

In spite of extreme enlargement of watermarked drawing, distortion was not recognized in Fig.3. In experimental results, correlation responses of original embedded watermark are each 21.93 and 51.58 at LINE and ARC. Table 1 and 2 show embedded watermark's correlation responses after attacks. We confirmed watermark's robustness against file format conversion, translation, rotation, cropping, scaling attack.

IV. Conclusion

In this paper, we proposed a robust watermarking algorithm in geometrical attacks using LINE, ARC and CIRCLE in architectural drawing. In experiment result, perceptually artifact by watermarks embedded from proposed method did not recognize anyone, as confirmed before, we could know that watermark was showed robust characteristics under various kinds condition be regarded as geometrical or another attacks. These results can help to have copyright about building design technology is not protected by intellectual property entirely. As this, we expect that is going to ready minimum protection standard in copyright protection of exposed architectural drawing shieldlessly. And we expect that may apply to watermarking for more 2-D image based on vertex.

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