

The Research of Print-scan Resistant Watermarking Based on two-dimension code

Zhang Lei¹ Lu Liang² Lu Peng³

(1 Jiangsu Provincial Key Lab of Pulp and Paper Science and Technology, Nanjing Forestry University, Nanjing 210037 2 Beijing Application and Development Center of Round-the-World Information, Beijing 3 University of Shanghai for Science and Technology, Shanghai 200093) ¹

Abstract. This paper applied two-dimension code in image watermarking, according to the high recognition performance and robustness of two-dimension code, the digital watermarking information was converted into the two-dimensional code and embedded in original image, after attacking watermark-image, the attacked image was printed and scanned, then, extracted the watermark information from scanned image, did the research of print-scan resistant watermarking based on two-dimension code.

Keywords: Digital watermarking, Two-dimension code, Print-scan resistant

1 Introduction

The print-scan resistant digital watermark algorithm was according to the design and research of robust feature, and protected the printing works right, so it played an import role in copyright protection of printing works. In the printing and scanning process, the image would be attacked from D/A and A/D conversion, rotation, scaling and noise, etc. These attacks would disturb the watermark information during the printing copyright protection^{[1][2][3]}. The print-scan resistant watermarking based on two-dimension code in this paper would resist these attacks, so, the technology would be used in printing copyright protection.

¹ Zhang Lei (1985-), female, PhD. candidate, Nan Jing Forestry University . Research on: Printing image and text information processing, Image watermarking technology. Foundation: Research Innovation Program for Graduate Student of Jiangsu province (No. CXZZ12_0528)
Email: zhanglei6126@163.com

Tan Lunzheng presented a blind detection watermarking algorithm for document image to hide information against print-scan process, the watermark information was embedded by modulate the count of the positive and the negative of each detail sub-band^[4]. Sun Wenwen proposed a watermarking algorithm which is used in anti-counterfeiting. In order to distinguish the true or the false of the watermarked image, watermark is robust to the first PS (print and scan) and fragile to the second PS^[5]. Han Tianmin proposed a digital image watermarking algorithm applied in printing surveillance system, modulate the amount of positive and the negative coefficients in high-frequency sub-band according to the adaptive coefficients being transformed in each order, so as to achieve watermarking embedding, and extracted the watermarking by unequal weight^[6]. Niu Xiamu proposed a information hiding technique 2D barcode, by modifying the width of each unit of PDF417 barcode, information was hidden into the barcode, the experimental results showed that the algorithm features robustness, security, and high capacity of information hiding etc^[7]. The two- dimension could applied in digital watermarking was a new try, in this paper, we researched print-scan resistant watermarking based on two-dimension code.

2 Digital watermark embedding and extraction algorithm

2.1 Watermark embedding algorithm

The embedding algorithm was based on Harr Wavelet transform and SVD (Singular Value Decomposition) transform^{[8][9]}, the concrete steps were as follows:

(1) Two level wavelet transform was proposed to original image, and obtained LL₂ low frequency matrix C_2 . According to the theory of wavelet transform, the size of two level wavelet transform matrix was one sixteenth of original image.

(2) SVD decomposition was did in low frequency matrix C_2 and obtained singular value matrix H, S, V, S was the singular value matrix of LL₂.

(3) SVD decomposition was did in watermark image, and obtained singular value matrix U_w, S_w, V_w, S_w was singular value matrix of original watermark image.

(4) The two singular value matrix S, S_w was weighted as formula 4, and k was weighting coefficient, so embedded the watermark.

$$S_c = S + k \times S_w \quad (1.1)$$

(5) The inverse SVD transform was did to S_c and got matrix C_2' with watermark information, as formula 5.

$$C_2 = U \times S_c \times V' \quad (1.2)$$

(6) The inverse transform was did to C_2' and two level wavelet, and got embedded watermark image Y .

2.2 watermark extraction algorithm

The extraction algorithm was the inverse transform of embedding algorithm, the concrete steps were as follows:

- (1) Two level wavelet transform was proposed to detecting image, and obtained LL_2 low frequency matrix C_{w2} .
- (2) SVD decomposition was did in low frequency matrix C_{w2} , and obtained singular value matrix.
- (3) According to original image singular value matrix S and weighting coefficient k , extracted the watermark image singular value matrix S_w' .
- (4) The inverse SVD transform was did to S_w' , and got watermark image .

3 Experiments

3.1 Experimental considerations

In order to test the print-scan resistivity of watermark algorithm, the text watermark information was transformed to two-dimension code, then embedded the two-dimension code into original image, attacked the embedded watermark image, after ink jet printing and scanning, extracted the watermark from attacked image.

3.2 Experimental procedure

In this paper, the original image was the picture of Lena in grey style, the size was 512×512 pixels, the text watermark infection were “南京林大”, transformed to two-dimension code, the size was 128×128 pixels. The pictures were shown as follows:



Fig1:Original image



Fig 2:Two-dimension code watermark image

The style of ink jet printer was HP7908, the style of scanner was EPSON GT-X970.

Experimental procedure were shown as follows:

- (1) Embedded the two-dimension code watermark into original image;



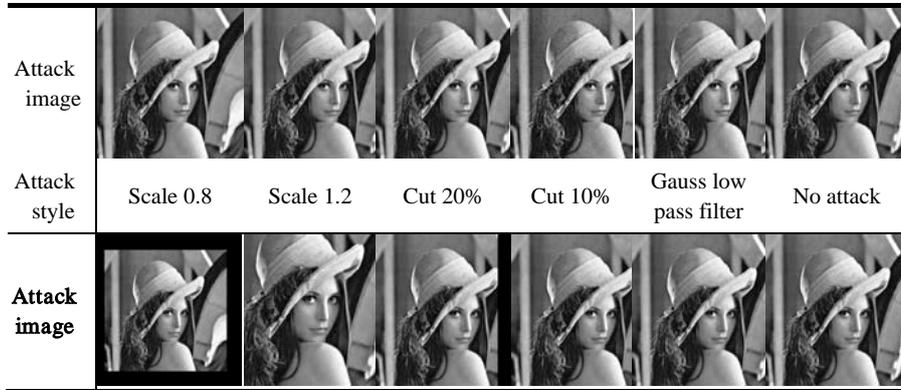
Fig3:Embedded watermark image

- (2) Attacked the embedded watermark image, the styles were rotating, scaling, compressing, cutting and noise;

The attracted styles and images were shown in following table:

Tab.1 Experimental results of different attacks

<i>Attack style</i>	<i>Rotate 3°</i>	<i>Rotate 7°</i>	<i>Rotate 15°</i>	<i>Rotate 30°</i>	<i>Rotate 45°</i>	<i>Rotate 90°</i>
Attack image						
Attack style	JPEG compress 30%	JPEG compress 50%	JPEG compress 70%	Gaussian noise	Salt and pepper noise	Poisson noise



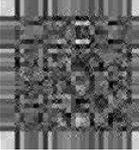
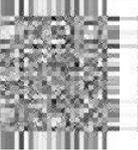
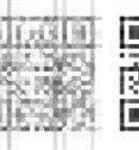
- (3) Printed the attacked images and scanned them;
- (4) Extracted the two-dimension code watermark.

3.3 Experimental results

Through the experiments, the results were shown in following table:

Tab.2 Experimental results of extracted QR code image

Attack style	Rotate3°	Rotate 7°	Rotate15°	Rotate 30°	Rotate45°	Rotate90°
Extracted two-dimension code image						
Result	✓	✓	✓	✓	✓	✓
Attack style	JPEG compress 30%	JPEG compress 50%	JPEG compress 70%	Gaussian noise	Salt and pepper noise	Poisson noise
Extracted two-dimension code image						
Result	✓	✓	✓	✓	✓	✓
Attack style	Scale 0.8	Scale 1.2	Cut 20%	Cut 10%	Gauss low pass filter	No attack

Extracted two-dimension code image						
Result	×	√	×	×	√	√

Footnote: “√” means that the watermark information can be read correctly from the extracted two-dimension code image, “×” means that the watermark information can not be read from the extracted two-dimension code image.

Through the experiments we can see:

- (1) The two-dimension code watermark could be extracted and read correctly in rotating attacks;
- (2) The two-dimension code watermark could be extracted and read correctly in Gaussian noise, Salt and pepper noise, Poisson noise and Gauss low pass filter attacks;
- (3) If the scaling factor was bigger than 1.0, it could be extracted and read correctly in scaling attack, if the factor was smaller than 1.0, it could not;
- (4) The two-dimension code watermark could not be extracted and read correctly in cutting attacks;

4. Conclusion

In this paper, the two-dimension code was applied in image watermarking algorithm. In print-scan resistant experiments, the two-dimension code watermarking algorithm could resist rotating, noise, JPEG compressing attacks; in scaling attack experiment, if the scaling factor was bigger than 1.0, it could be extracted and read correctly; the watermark images could not be extracted and read correctly in cutting attacks. Through these experiments, the application of two-dimension code in digital image watermarking algorithm was robust to print-scan resistant, and there was certain application value in copyright protection of printing works.

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