Advanced Science and Technology Letters
Vol.120 (DCA 2015), pp.753-758
http://dx.doi.org/10.14257/astl.2015.120.149

Rotation-Invariant Image Watermarking Scheme Based on Radon Transform

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Abstract. In this paper, we propose a rotation-invariant image watermarking scheme based on Radon transform. Rotation invariance is achieved using the translation property of the Radon transform. The radon transform emphasize and detect the linear characteristic to calculate the angle of image rotation. The image watermarking scheme used hologram quantization to spread the watermark information and analyses the cover image detail. The watermark is a hologram generated by quantization based on the cover image. The hologram is transformed by a discrete fractional random transform (DFRNT) with a random seed β to make the watermark security. Our method belongs to the blind watermark, because we do not need the original image during detection. The proposed method includes encryption techniques for security, and uses discrete wavelet transform (DWT) domain. DWT domain watermarking is robust to signal processing attacks and watermark synchronization gets rid of the effect of geometric attacks. In rotation attack 0~5 degree, we detect the watermark with 0~0.18% bit error rate (BER). We have performed an intensive simulation to show the robustness of the proposed method.

Keywords: rotation invariant, image, digital watermarking, radon transform, hologram, discrete wavelet transform, discrete fractional random transform, image normalization

1 Introduction

Recently, the problem of illegal distribution has become a social issue. Due to the development of digital technologies, many high-performance multimedia devices are produced and it produce high definition multimedia products. Thus we have developed a corresponding technique. Furthermore, people's awareness of copyright has increased dramatically. To prevent this phenomenon, copyright protection technologies are required.

Digital watermarking is an efficient solution for copyright protection, which inserts copyright information into the contents. [1-2] Ownership of the contents can be established by retrieving the inserted watermark. Watermarking methods are vulnerable to various attacks. Among them, geometric attack such as rotation, scaling and translation (RST) is known as one of the most difficult attacks to resist. Geometric attacks can defeat many watermarking schemes when they introduce synchronization errors between the watermark and the cover image. As a result, the

ISSN: 2287-1233 ASTL

watermarking schemes resistant to geometric attacks have been the subject of quite much research. The existing schemes can be classified into: non-blind scheme [3], invariant domain embedding [4], template based synchronization [5] and feature-based synchronization [6].

2 Related works

2.1 Hologram

Holograms employ a technique that allows the light scattered from an object to be recorded and later reconstructed, so that when an imaging system is placed in the reconstructed beam, an image of the object will be seen even when the object is no longer present. The image changes with the position and orientation of the viewing system in exactly the same way as if the object were still present, thus making the image appear three-dimensional. The hologram recoding itself is not an image; it consists of an apparently random structure of varying intensity, density or profile. Holograms were first proposed by Gabor in 1948 [7], and coherent light interference holograms, which use two separate off-axis holograms, were released by Leith and Upatnieks in 1962 [8].

2.2 DFRNT

Recently, it has been established that a DFRNT can be formulated from a discrete fractional Fourier transform (DFRNT) [9]. The randomness is generated by a random matrix. The overall process is quite similar to that by which the transform matrix of the DFRNT is obtained. The DFRNT can be defined by a diagonal symmetric random matrix. Also it is linear, unitary, index-additive and energy conserving. However, its kernel transform matrix is random, and this affords high security in information security applications such as digital watermarking.

2.3 Edge Detection

Edge Detection

For detecting the edge of an image, we must find the boundaries of the area. It is the brightness changes rapidly taking place in image. It offers important clues in the recognition with easy calculation.

Several algorithms exists, and in this paper we are focusing on a particular one developed by John F. Canny (JFC) in 1986. Even though it is quite old, it has become one of the standard edge detection methods and it is still used in research.

The Process of Canny edge detection algorithm can be broken down to 5 different steps:

1. Apply Gaussian filter to smooth the image in order to remove the noise.
2. Find the intensity gradients of the image.
3. Apply non-maximum suppression to get rid of spurious response to edge detection.
4. Apply double threshold to determine potential edges.
5. Track edge by hysteresis: Finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

2.4 Radon Transform

The Radon transform in two dimensions, named after the Austrian mathematician Johann Radon, is the integral transform consisting of the integral of a function over straight lines. The transform was introduced in 1917 by Radon. [10]

The Radon transform is widely applicable to tomography for the creation of an image from the projection data associated with cross-sectional scans of an object.

3 Proposed Method

The proposed watermarking method is termed a blind algorithm, as it does not require a copy of the original image or any other characteristics, for extraction. Our scheme uses image normalization resistant against rotation attack. The watermark is generated from a hologram using a QR code and quantization is performed based on the cover image. The hologram is transformed using a DFRNT with a random seed β to form the watermark. The generated watermark is embedded into the subband of a discrete wavelet transform (DWT), and the cover image is used for the hologram quantization.

3.1 Image normalization

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Our scheme uses image normalization resistant against rotation attack.

Step 1: Detect the edge of the original image using canny detect operator.

Step 2: Linking the edge with thickening operation.

Step 3: Calculate the rotation angle and normalize image.

3.2 Embedding Scheme Image normalization

Step 1: Transform the watermark message using a DFRNT with seed β, and generate the hologram. (Figure 2 shows the process of the embedding scheme.)

Step 2: Normalize the original image and get the maximum value of radon transform.

Step 3: Rotate the hologram by angle θ. And get the new matrix.
Step 4: Generate blank matrix and combine with Step3.
Step 5: Transform them by two-depth Inverse DWT.
Step 6: Add original images and Step 5.

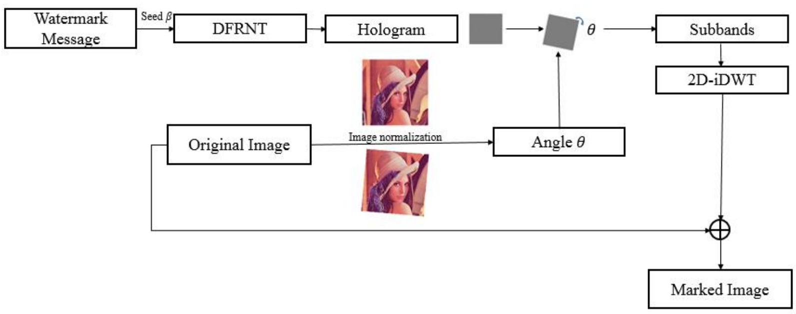

Fig. 1. Watermark embedding process

3.3 Extraction Scheme

The extraction process is the reverse of the embedding process, and uses the same seed β in the DFRNT. (Fig. 2. shows the process of the extraction scheme.)

Step 1: Normalize the marked image. And get the new matrix.

Step 2: Transform the matrix using a two-depth DWT, and select the subbands that will incorporate information.

Step 3: Add the subbands to obtain the new matrix.

Step 4: Transform them by DFRNT with seed β.

Step 5: Restore them with ReHologram, and extract the watermark message.

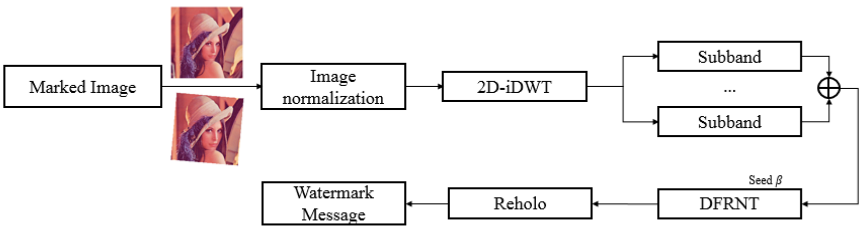

Fig. 2. Watermark extraction process

4 Experiments and Results

In this paper, we use a QR code for the watermark message. QR codes consist of black modules arranged in a square pattern on a white background. Using hologram quantization, we can restore the QR code.

The performance of the proposed watermarking scheme was measured using the several cover images with a 512×512 image size. The size of the QR code was 21 × 21.

Table 1 lists the PSNRs and BERs corresponding to the cover images with several rotation attacks. Using the proposed method, we obtain BERs of 0–1.8%.

Table 1. PSNR and BER values for various cover images

Image	PSNR(dB)	Angle θ	BER (%)
Lena	45.78	0	0.23
		3	0.45
		5	0.90
Plane	46.91	0	0
		3	0.23
		5	0.90
peppers	43.12	0	0
		3	0.90
		5	1.80

5 Conclusion

In this paper, we proposed a digital watermarking scheme using image normalization. Image normalization is efficient in rotation attack and produces better results. We used a DFRNT with the random seed β for security. It was embedded after transforming by the iDWT. To evaluate the performance of the proposed method, watermark information was embedded in the wavelet-transformed domain. In rotation attack 0~5 degree, we detect the watermark with 0~0.18% BER. Experimental results showed that the proposed method gives robustness under rotation attacks.

Through the image normalization experiment after removing the boundary caused by the rotation, image watermarking can be more robust in cropping or other geometric attacks. It is worth researching the advanced methods

Acknowledgments. "This research is supported by Ministry of Culture, Sports and Tourism(MCST) and Korea Creative Content Agency(KOCCA) in the Culture Technology(CT) Research & Development Program 2015"

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