RST Invariant Image Watermarking based on Invariant Contents

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Abstract

An image watermarking scheme resisting RST (rotation, scaling, translation) based on RST invariant square region is proposed in the paper. Two SIFT (scale-invariant feature transform) feature points are selected to determine the position, size, direction of the region. The watermark embedding and detection is completed in the square region with quantization, which could guarantee blind detection. A binary image is employed to be the watermark due to the improvement of watermark capacity. Experimental results show that the proposed scheme can effectively resistant geometrical attacks as well as common signal processing.

Key words *feature points, geometrical attack, square region*

1. Introduction

With the rapid development of computer and internet technology, the copy and transmission of multimedia data are becoming easily. The new technology makes people life convenient but brings some copyright protection problems at the same time. Watermarking is an effective way to solve the problems[1-3]. Rotation, scaling, translation operating on an image can destroy the watermark information, which is difficult to settle down for image watermarking.

Several methods have been proposed focus on geometrical attacks. They belong to one of the four follow classes. The first class is that transform the image to the geometric invariant domain to embed and detect watermark, the typical example is Fourier-Mellin[4] transform. Interpolation error is introduced into the image in transforming and inverse transforming, which degrades the image quality and loses watermark information. Embed a template into original image while embedding watermark[5] is a typical algorithm of the third class. However, watermark detection depends on template detecting. The third class based on image histogram[6], which modify the pixel value based on the pixel statistical property. It can resist liner attacks as well as nonlinear attacks , but its capacity is limited. The Fourth kind is the most studied recently, which selected some regions based on some key points[7-9] to be the watermark region, the watermark synchronous depends on the key points.

The methods in literature[7,9] generated some circle regions to be watermark regions based on SIFT feature points, the region areas were small due to several regions generated, which lead to the limitation of the watermark capacity. The region's size depended on the scale factor of the SIFT point, which may be inaccurate. We proposed a scheme to determine a square region based on two SIFT points, whose size and direction can be derived accurately.

2. Watermarking framework

The watermark embed process is shown in Fig.1.The scheme depends on SIFT feature points, in order to improve the robustness of the points, we first detect the points of original image and its rotation version. Then select two distinct points from the matched points, one is employed to determine the region position, the other assist to derive the region direction. At last quantize the pixel in the region, the watermarked image can be derived after all pixel processed.

The watermark detection process is shown in Fig.2. The success of watermark detection depends on the success of watermark region determined. So we should find the corresponding points of the two original points, then derive the position, direction, size of the region according the two new points. At last extract the watermark from the region.

3. Watermark embedding and extraction

(a) SIFT selection

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Scale-invariant feature transform[10] feature points could keep high matching ratio when operate on an image with rotation, scaling, translation. We first detect the feature points of original image and its rotation version and match them in order to guarantee robustness. Then two feature points are selected elaborately from the matched points set, one is nearest to the image center called point1, the other one is assisted to compute direction and size called point2. The two points are employed to determine the watermark region.

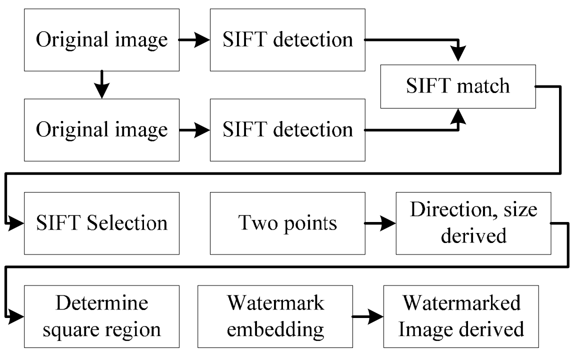

Fig.1 Watermark embed diagram

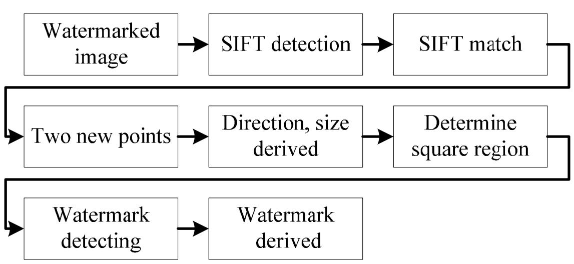

Fig.2 Watermark detection diagram

(b) Region determined

At watermark embedding stage, a square region is determined according to the derived feature points at last section. Whose center is point1 and direction is along with the line between point1 and point2.

At watermark detection stage, we first detect SIFT points of watermarked image, then match them with the two original points to derive two new feature points called point1' and point2' respectively. Next determine the square region as before. We should notice that the square side may be vary with the scaling of watermarked image. Suppose the original square side is , the current square side is , suppose the distance between two points is $\mathrm{dis}(\cdot,\cdot)$. Then

$$\boldsymbol{l}' = \boldsymbol{l} * \mathrm{dis}(\boldsymbol{point1'},\boldsymbol{point2'})/\mathrm{dis}(\boldsymbol{point1},\boldsymbol{point2}) \quad (1)$$

where $\boldsymbol{point1'}$, $\boldsymbol{point2'}$ are matched points, $\boldsymbol{point1}$, $\boldsymbol{point2}$ are original points.

The region position and region direction in original image and their distortion versions are shown in Fig.3, we know that the line direction and circle size guarantee the square region content is invariant to geometrical processing.

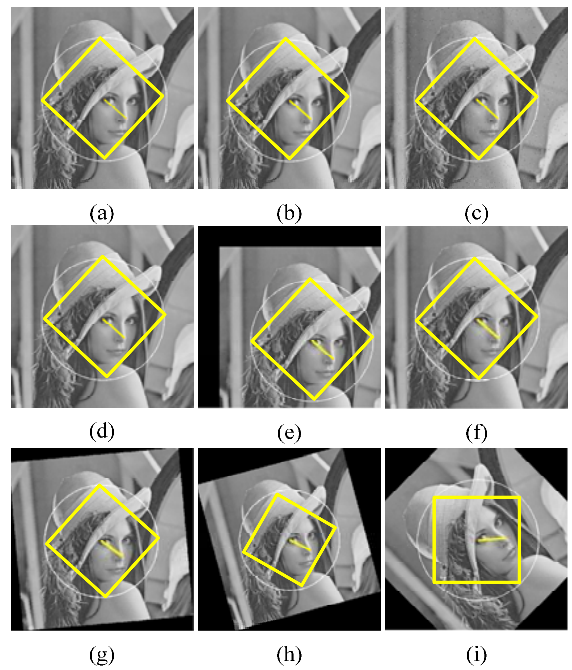

Fig.3 Square region (a) Original image (b) Median filter (c) Noise (d) JPEG compression (e) Translation (f) Scaling 0.8 (g) Rotation 5 deg (h) Rotation 15 deg (i)Rotation 45 deg + Cropping

(c) Quantization

Denote the watermark region as $\boldsymbol{B}$ at embedding, suppose the $\boldsymbol{m} * \boldsymbol{m}$ binary image $\boldsymbol{w}$ as watermark, divide $\boldsymbol{B}$ into $\boldsymbol{m} * \boldsymbol{m}$ sub-block. Suppose the current pixel in the $(\boldsymbol{i}, \boldsymbol{j})$ block as $\boldsymbol{p}$, modify it as follow formulas

$$\lambda = \mathrm{round}(\boldsymbol{p}/\delta) \quad (2)$$

where δ is quantization step, $\mathrm{round}(\cdot)$ is nearest integer operation.

$$\hat{\boldsymbol{p}} = \begin{cases} (\lambda - 0.5) * \delta, & \text{if } \lambda + \boldsymbol{w}(\boldsymbol{i},\boldsymbol{j}) \text{ is odd} \\ (\lambda + 0.5) * \delta, & \text{if } \lambda + \boldsymbol{w}(\boldsymbol{i},\boldsymbol{j}) \text{ is even} \end{cases} \quad (3)$$

where $\boldsymbol{w}(\boldsymbol{i},\boldsymbol{j})$ is watermark bit, $\hat{\boldsymbol{p}}$ is the marked pixel. The marked region $\boldsymbol{B}'$ is generated after all pixels modified.

$\boldsymbol{B'}$ is divided into $\boldsymbol{m*m}$ sub-block as before at watermark detection, Suppose the current pixel in the $(\boldsymbol{i},\boldsymbol{j})$ block as $\hat{\boldsymbol{p}}$,

$$\hat{\lambda} = \mathrm{round}\left(\hat{\boldsymbol{p}}/\delta\right) \tag{4}$$

$$\boldsymbol{w}'(\boldsymbol{i},\boldsymbol{j}) = \begin{cases} 1, \ \mathrm{num}\left(\hat{\lambda} \text{ is odd}\right) \geq \mathrm{num}\left(\hat{\lambda} \text{ is odd}\right) \\ 0, \ \text{else} \end{cases} \tag{5}$$

where $\boldsymbol{w}'(\boldsymbol{i},\boldsymbol{j})$ is the $(\boldsymbol{i},\boldsymbol{j})$ bit in watermark $\boldsymbol{w}'$, $\mathrm{num}(\cdot)$ is the number of operators .

At last, the normalized hamming similarity (NHS) between the extracted watermark $\boldsymbol{w}'$ and original watermark $\boldsymbol{w}$ is computed to decide the presence of the watermark.

$$\boldsymbol{NHS} = 1 - \mathrm{HD}\left(\boldsymbol{M},\boldsymbol{M}'\right)/\boldsymbol{N} \tag{6}$$

where $\mathrm{HD}(\cdot,\cdot)$ denotes the number of bits different in the two binary watermark sequences, and $\boldsymbol{N}$ is the number of watermark bits.

5. Experimental results

The standard 512*512 Lena and Baboon are employed to verify the scheme's effectiveness. A 40*40 binary image is as the watermark. The employed simulation software is Matlab 7.0. The embedding effect is shown in Fig.4. The average PSNR is above 44dB. The edge of the square region is smooth that the invisibility is well.

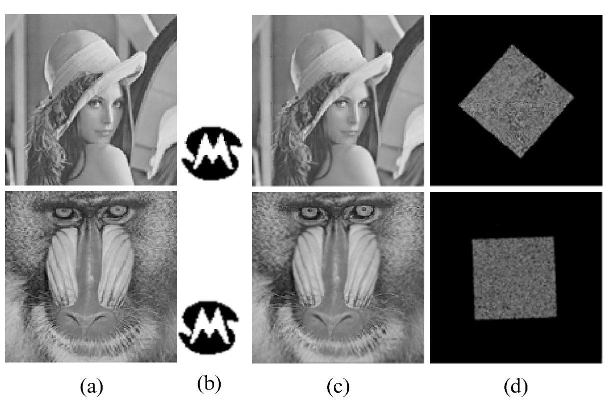

Fig.4 Watermark invisibility (a) Original images (b) watermark (c) Watermarked images (d) Magnified residual images

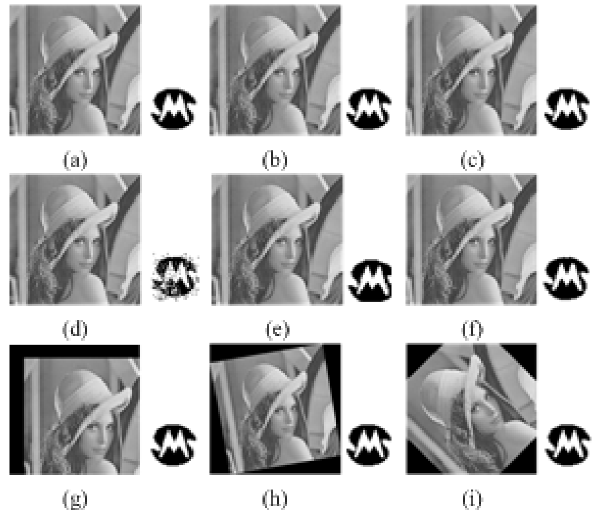

Fig.5 Watermark detection effect (a) Original image (b) Median filter (c) Noised (d) JPEG compression (e) Scaling 1.3 (f) Scaling 0.7 (g) Translation (h) Rotation 15 deg (i) Rotation 45 deg+Cropping

Fig.5 show the watermark detection effect. The watermarked image are manipulated with traditional signal processing and geometrical processing and then detect the watermark, from it we can know the detection effect is ideal.

The similarities between original watermark and detection is shown in table1. Comparing with literature[6] almost all the similarities above that. There should be notice that the detection success can be confirmed from the mark image even the similarity is low. For example, the similarity is 0.6973 when scaling Lena with factor 1.3, the mark image is shown in Fig.4(e), the mark is shown clearly. The low similarity due to the region position is not exactly corresponded.

6. Conclusions

This paper propose a scheme to determine a square region based on two SIFT points, the region content is invariant when the image suffer geometrical attacks. Watermark could resistant RST attacks effectively. Experimental results show the effectiveness of the scheme.

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Table 1 Watermark similarity

Attacks	Similarities			
	Lena		Peppers	
	Literature [6]	Proposed	Literature [6]	Proposed
Median filter	0.729	**1.0000**	0.732	**1.0000**
Noise	0.612	**0.9775**	0.616	**1.0000**
JPEG compression	0.752	**0.8838**	0.770	**0.8488**
Cropping	0.759	**1.0000**	0.779	**1.0000**
Scaling 0.7	0.635	**0.8200**	0.676	**0.8231**
Scaling 0.9	0.753	**0.7688**	0.756	**0.7706**
Scaling 1.1	0.706	**0.7250**	0.769	**0.7256**
Scaling 1.3	0.676	**0.6937**	0.766	**0.6937**
Scaling 1.5	0.722	**1.0000**	0.731	**1.0000**
Rotation 5+Cropping	0.720	**1.0000**	0.760	**1.0000**
Rotation 10+Cropping	0.726	**0.9881**	0.764	**1.0000**
Rotation 30+Cropping	0.709	**1.0000**	0.734	**1.0000**
Rotation 45+Cropping	0.685	**0.9988**	0.704	**1.0000**

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