Image Feature Extract and Performance Analysis Based on Slant Transform

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Abstract. In order to improve the efficient and simple the steps of generation an image hashing, a security and robustness image hashing algorithm based on Slant transform (ST) is proposed in this paper. By employing coefficients of Slant transform, a robust hashing sequence is obtained by preprocessing, feature extracting and post processing. The security of proposed algorithm is totally depended on the user-key which are saved as secret keys. For illustration, several benchmark images are utilized to show the feasibility of the image hashing algorithm. Experimental results show that the proposed scheme is robust against perceptually acceptable modifications to the image such as JPEG compression, mid-filtering, and rotation. Therefore, the scheme proposed in this paper is suitable for image authentication, content-based image retrieval and digital watermarking, etc.

Keywords: Image hashing · Slant transform · Normalized Hamming distance · Encryption keys

1 Introduction

With the rapid development of information-communication and personal computers, copyright protection of digital media as image, video and audio becomes a more and more important issue. Image hash as one of content-based image authentication techniques has become an important research topic recently. An image hash function maps an image to a short binary string based on the image's appearance to the human eye, so it can be used in authentication, content-based image retrieval and digital watermarking.

Security and robustness are two important requirements for image hash functions. By security, it means that one image should have different function values according to the different applications. By robustness, it means that the hash function should keep invariable by common image processing operations such as additive noise, filtering, compression, etc. The underlying techniques for constructing image hashes can roughly be classified into property-based, such as statistics [1]; interaction relation of transform field decomposition coefficients [2]; vision-based feature points [3], etc.; and content-based, such as transform field significantly coefficients [3–5]. Typical case of

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property-based image hash is proposed by Venkatesan et al. [1], which gets statistics by using decomposition coefficients of discrete wavelet transform (DWT). A relation-based technique generates a hash sequence by employing invariant relation of image blocks, which is expect robust to JEPG compression. For sensitive to geometric attacks, the vision-based image hash is inefficacy under common image processing. On the contrary, the content-based algorithm for its super robustness performance became more and more popular, but an expensive search is needed to handle manipulations. Recently, a new kind of robust image hashing algorithms based on non-negative matrix factorization (NMF) [6] is proposed. It is robust against most image processing, minimizes collision probability and identified the tampered place.

In this paper, an image hashing algorithm based on Slant transform (ST) is proposed for certain application. The scheme extracts a robust feature vector to generate a content-based hash sequence, which includes three-step preprocessing, feature generation and post processing. To improve the security of the proposed scheme, the user-keys are used as the encryption keys. Experimental results show that the proposed scheme is robust against common image processing. The remaining of this paper is organized as follows. The concept of Slant transform is briefly introduced in Sect. 2. The framework and the details of the proposed scheme are described in Sect. 3. In Sect. 4, some experimental results and comparison are presented. Security analysis is presented in Sect. 5. A conclusion is drawn in Sect. 5.

2 Slant Transform

The concept of an orthogonal transformation containing Slant basis vector was introduced by Enomoto and Shibata [7, 8]. The Slant vector is a discrete saw tooth waveform decreasing in uniform steps over its length. It has been seen that Slant vectors are suitable for efficiently representing gradual brightness change in a face image line.

Slant Matrix Construction: If $S(n)$ denotes the $N \times N$ Slant matrix ($N = 2^n$), then

$$S(1) = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{1}$$

The Slant matrix for $N = 4$ can be written as

$$S(2) = \frac{1}{\sqrt{4}}\begin{bmatrix} 1 & 1 & 1 & 1 \\ a+b & a-b & -a+b & -a-b \\ 1 & -1 & -1 & 1 \\ a-b & -a-b & a+b & -a+b \end{bmatrix} \tag{2}$$

where a and b are real constants to be determined subject to the following conditions:

(1) step size must be uniform;
(2) S(2) must be orthogonal.

The properties of Slant transform are as follows:

(1) The Slant transform is real and orthonormal

$$S = S^* \tag{3}$$

$$S^{-1} = S^t \tag{4}$$

(2) It is a fast algorithm reducing the complexity to $O(N \log_2 N)$ for $N \times 1$ vector;
(3) It is very good in energy compaction for facial images. Very few coefficients are sufficient for recognizing the stored image of face in database.

The above Slant matrices [9] are used to define the ST as:

$$D_x(n) = S(n)X(n) \tag{5}$$

where $D_x(n)' = [D_x(0)D_x(1)\cdots D_x(N-1)]$, $X(n)' = [X(0)X(1)\cdots X(N-1)]$ and $S(n)$ is $N \times N$ Slant Matrix.

The 2D forward and inverse Slant transform filter bank are shown in Fig. 1.

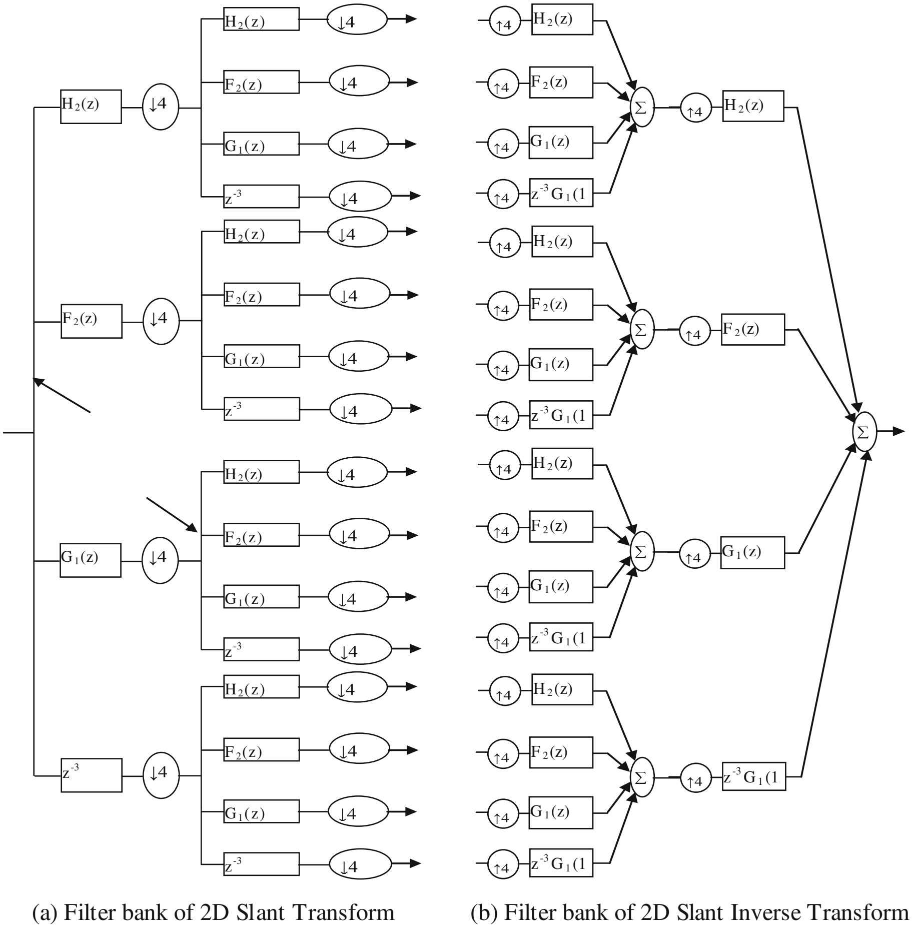

Fig. 1. 2D forward and inverse Slant transform filter bank

3 Proposed Algorithms

For analysis the performance of Slant transform in image hashing algorithm. An image hashing algorithm based on Slant transform is proposed in this paper. The image hash scheme can be constructed by preprocessing, extracting and post processing appropriate image features. In order to improve the property of feature extracting [10–12], the preprocessing of image is always used. The common image preprocessing includes applying a low-pass filter, rescaling, or adjusting the components of image, and so on. But in this paper, for analysis the performance of Slant transform, all the processing of image seemed as attacks to original image. To achieve robustness, security, and compactness, the feature extraction is the most important stage of constructing an image hash. A robust image feature extraction scheme should withstand various image processing that does not alter the semantic content. Various image hashing schemes mainly differ in the way randomized features and extracted. For post-processing, the aim is compression the length of hash sequence and without less the magnitude feature.

In this paper, in order to analysis the performance of Slant transform in image hashing algorithm, a novel robust image hashing algorithm based on Slant transform is proposed. The framework of proposed hashing algorithm is shown in Fig. 2, which includes the following steps:

(1) Block image: block original image to $n \times n$ sub-images. For example, the blocks size is 8×8.
(2) Slant transform: using the Slant transform to every block images.
(3) Feature extraction: selected the middle-frequency coefficients by user-key.
(4) Compression: compression the selected coefficients, and obtain the image hashing finally.

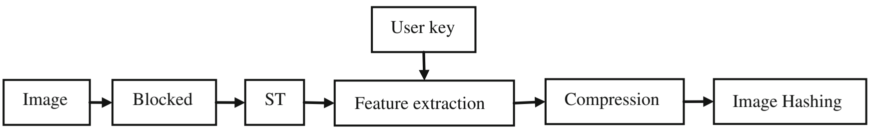

Fig. 2. The framework of proposed hashing algorithm

4 Performance Results

Performance metrics and experiment setup: to measure the performance of image hash, the normalized Hamming distance between the binary hashes is employed. The defined of normalized Hamming distance is:

$$d(h_1, h_2) = \frac{1}{L}\sum_{k=1}^{L} |h_1(k) - h_2(k)| \tag{6}$$

where $h_1(k)$, $h2(k)$ are different image hash sequence values; L is the length of image hash. The normalized Hamming distance d has the property that for dissimilar images, the expected of d is closed to 0.5, else the expected is closed to 0.

Several benchmark images (such as Lena, Baboon, Peppers, F16, Cameraman, etc.) are used to test the performance of the proposed scheme. Images used in this paper are shown in Fig. 3 and Table 1.

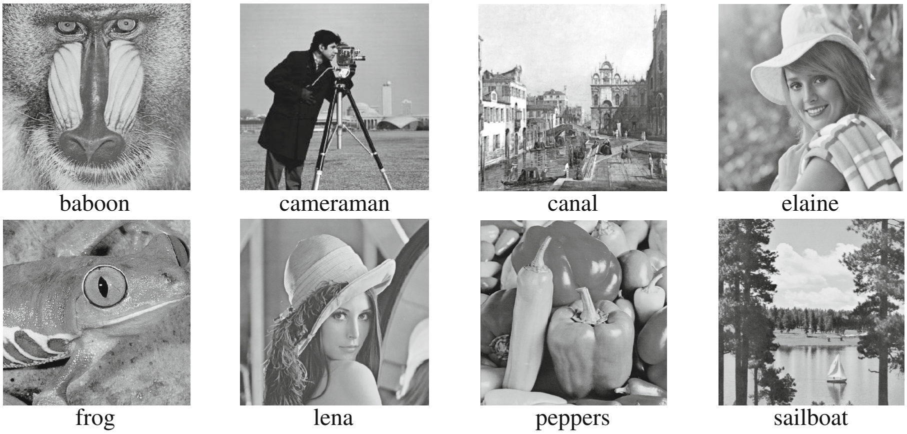

Fig. 3. Several benchmark images

Table 1. Normalized Hamming distances of proposed algorithm between benchmark image

Attacks		Factor	Normalization hamming distance						
Jpeg comp.	2	0.0918	0.0811	0.1182	0.1289	0.1191	0.1182	0.0645	0.0713
	3	0.0869	0.0859	0.1348	0.1338	0.1084	0.1318	0.0586	0.0605
	4	0.0947	0.0977	0.1387	0.1387	0.1104	0.1533	0.0791	0.0742
	5	0.0928	0.0986	0.1523	0.1494	0.1162	0.1543	0.0801	0.0771
	6	0.0928	0.1484	0.1553	0.1611	0.1201	0.2031	0.1396	0.1348
	7	0.0928	0.5010	0.4326	0.4502	0.1094	0.5010	0.4883	0.4775
	8	0.4521	0.4990	0.2021	0.2021	0.1094	0.1611	0.1289	0.1260
	9	0.0928	0.4990	0.5674	0.5498	0.1094	0.4990	0.5117	0.5225
median-filter	3	0.0576	0.0459	0.0615	0.0654	0.0713	0.0703	0.0313	0.0410
	5	0.0723	0.0674	0.0908	0.0908	0.0859	0.0928	0.0479	0.0479
	7	0.0850	0.0684	0.1074	0.1006	0.0977	0.1055	0.0615	0.0527
	9	0.0967	0.0791	0.1162	0.1182	0.1025	0.1094	0.0664	0.0635
Gaussian low-pass	/	0	0	0	0	0	0	0	0
Gaussian noise	0.05	0.0474	0.0495	0.0481	0.0479	0.0479	0.0520	0.0501	0.0499
	0.01	0.0474	0.0495	0.0481	0.0479	0.0479	0.0520	0.0501	0.0499
Peppers and slat noise	/	0.0151	0.0174	0.0396	0.0424	0.0220	0.0277	0.0103	0.0121
Cut	1/8	0	0.0156	0.0156	0.0156	0	0.0117	0.0156	0.0156
Rescaling	0.5	0.0459	0.0898	0.0684	0.0947	0.0811	0.1299	0.0059	0.0459
	2	0	0	0	0	0	0	0	0
Rotation	10^0	0.0818	0.0501	0.0356	0.0364	0.0742	0.0567	0.0384	0.0388
	15^0	0.0765	0.0501	0.0354	0.0368	0.0698	0.0555	0.0394	0.0383

5 Conclusion

In this work, a novel robust image hash scheme for certain application is proposed. The Slant transform is used for constructing robust image hashes, and the user-key are used as the encryption key. The image is first blocked to sub-images, then after the Slant transform of every block image, feature vector is extracted from the transform field coefficients, finally the resulting statistics vector is quantized and the binary hashes sequence is obtained. Experimental results show that the proposed scheme is robust against common image processing such as JPEG compression, mid-filtering, and rotation. Therefore, the scheme proposed in this paper is suitable for image authentication, content-based image retrieval and digital watermarking.

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