KICS The Korean Institute of Communications and Information Sciences

Available online at www.sciencedirect.com

ScienceDirect

ICT Express ▮ (▮▮▮▮) ▮▮▮–▮▮▮

www.elsevier.com/locate/icte

# Robust image hashing using SIFT feature points and DWT approximation coefficients

Lokanadham Naidu Vadlamudi[a,*], Rama Prasad V. Vaddella[b], Vasumathi Devara[c]

[a] *Department of Information Technology, Sree Vidyanikethan Engineering College (Autonomous), Tirupati 517102, A.P., India*
[b] *Department of Computer Science Engineering, Sree Vidyanikethan Engineering College (Autonomous), Tirupati 517102, A.P., India*
[c] *Department of Computer Science Engineering, JNTU College of Engineering, JNT University, Hyderabad 500085, T.S., India*

Received 15 December 2016; received in revised form 4 July 2017; accepted 20 December 2017
Available online xxxx

**Abstract**

This study proposes a robust hashing method using scale-invariant feature transform (*SIFT*) features points and discrete wavelet transform (*DWT*) approximation coefficients for image authentication. Initially, the invariant feature points are computed using *SIFT* from the $L^*$ component of $L^*a^*b^*$ color image. Next, $n$ distinct *SIFT* feature points are utilized to extract image content from the $L^*$ component. Then, *DWT* is applied to extracted content in order to compute approximation coefficients. Finally, the approximation coefficients are normalized to form a binary hash. Experimental results show that the proposed method is robust to various content-preserving operations such as compression, scaling, filtering, additive noise, brightness, and contrast adjustment. In addition, the performance of the proposed method is compared to existing methods using a receiver operating characteristics curve. The comparison results show that the proposed method performs better than the existing methods.


*Keywords:* Image hashing; Image authentication; Scale-invariant feature transform; Discrete wavelet transform; Robustness and anti-collision

## 1. Introduction

The tremendous advancements in multimedia and mobile technologies allow users to create and share multimedia content such as images, audio, and video easily and quickly. Although these advancements enable adversaries to tamper with multimedia content, the visual aspects of these multimedia content are not altered; integrity verification of multimedia content is nevertheless crucial. Various methods are available to verify the integrity of multimedia content [1]. Robust image hashing is a promising approach used to verify the integrity of digital images in extracting robust features such as edges, textures, transformation coefficients, and invariant moments from digital images. Features are then processed with a secret key to generate a secure hash. In addition, the features used in hash generation must be sensitive to malicious attacks and simultaneously insensitive to trivial modifications performed on image content. Moreover, the robust hashing technique should satisfy the following three critical properties: (1) robustness, (2) anti-collision or fragility, and (3) key dependence.

## 2. Prior work

Qin et al. [2] developed an image hashing technique using discrete Fourier transform (*DFT*). The image hash is generated from *DFT* magnitude coefficients. This technique has shown good anti-collision capabilities. Tang et al. [3] proposed a robust image hashing technique using color vector angles and discrete wavelet transform (*DWT*). This technique is robust to content-preserving manipulations and also sensitive to content-changing operations. The hashing method [4] converts the given color image into log-polar space, and then low frequency coefficients of quaternion *DFT* are extracted to generate an

* Corresponding author.
*E-mail addresses:* vlnaidu1982@gmail.com (L.N. Vadlamudi), vvramaprasad@gmail.com (R.P.V. Vaddella), rochan44@gmail.com (V. Devara).
Peer review under responsibility of The Korean Institute of Communications Information Sciences.

https://doi.org/10.1016/j.icte.2017.12.004


Please cite this article in press as: L.N. Vadlamudi, et al., Robust image hashing using SIFT feature points and DWT approximation coefficients, ICT Express (2018), https://doi.org/10.1016/j.icte.2017.12.004.

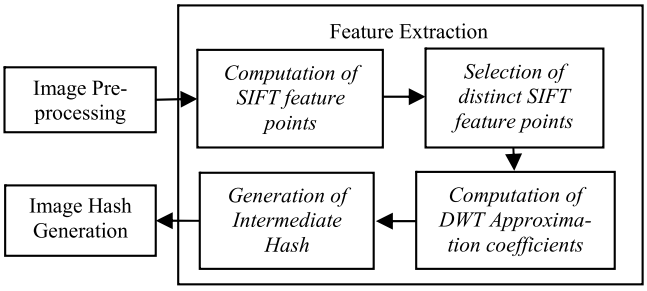


**Fig. 1.** Framework of the proposed hashing method.

(a) (b)

**Fig. 2.** SIFT feature points: (a) $n$ distinct feature points selected on Lena and (b) extraction of overlapped blocks using $n$ feature points.

image hash. Zhao et al. [5] proposed a hashing scheme for detecting image forgeries. This scheme uses invariant Zernike moments and texture information of salient regions in hash construction. The method proposed in [6] constructs an image hash from weighted magnitude and phase features of image using polar complex exponential transform (*PCET*).

In another study [7], the dominant discrete cosine transform (*DCT*) coefficients of an image are used in hash generation. This method has shown good fragility capabilities and the size of the hash is short in length. Chen et al. [8] constructed invariant features from radial moments. The invariant radial features are processed using random gray code to generate a robust hash. Ouyang et al. [9] developed a robust hashing technique by combining scale-invariant feature transform *SIFT* features and quaternion Zernike moments (*QZM*). Xudong and Wang [10] developed an image hashing method based on shape contexts and local feature points. The methods in [11,12] utilized the histogram bin population during hash generation. Tang et al. [13] proposed a novel hashing method using color vector angles and DCT. This method has shown better performance in terms of robustness and discriminative capabilities. Tang et al. [14] designed an efficient image hash technique based on ring partition and nonnegative matrix factorization (NMF). The method in [15] uses color vector angles and edges to generate a robust hash. This method is very robust to common image processing manipulations and outperforms other existing methods.

## 3. Proposed image hashing method

The various stages of the proposed hashing method are illustrated in Fig. 1.

### 3.1. Image pre-processing

In this step, the input *RGB* color image ($I_{RGB}$) is resized to $N \times N$ pixels using bi-cubic interpolation. The resized image is converted to an $L^*a^*b^*$ [16] color image ($I_{lab}$). In addition, the $I_{lab}$ color image is regularized using a Gaussian low pass filter to generate a robust hash.

### 3.2. Feature extraction

The $L^*$ component of the $I_{lab}$ color image is used to extract robust features. The step-by-step feature extraction process is explained as follows.

*Step 1. Computation of SIFT feature points: SIFT* is a computer vision technique [17,18] used to detect and describe invariant features points on digital images. The proposed method computes *SIFT* feature points from the $L^*$ component. These points are denoted as $FP_i$, $1 \leq i \leq t$ where $t$ signifies the total number of feature points. The $i$th *SIFT* feature point is represented as:

$$FP_i(x_i, y_i, \sigma, \theta) \tag{1}$$

where the coordinates $(x_i, y_i)$ denote the location of the feature point on the $L^*$ component, and $\sigma$ and $\theta$ signify the scale and orientation, respectively.

*Step 2. Selection of distinct SIFT feature points:* To select distinct feature points from the list of $t$ points, the points are sorted in descending order based on the scale, and then duplicate points are removed. The first $n$ points are then selected as feature points. The procedure for selection of SIFT key points is also discussed in [9]. The selected distinct points are denoted as $DFP_j$, $1 \leq j \leq n$. The $n = 16$ distinct points selected on the Lena image are shown in Fig. 2(a). The feature points are labeled with numbers.

*Step 3. Construction of DWT approximation coefficients:* In this step, $n$ overlapped blocks denoted as $IB^c_{p\times p}$ $(1 \leq c \leq n)$ of size $P \times P$ pixels are extracted randomly using a pseudo-random procedure from the $L^*$ component by taking a distinct feature point $(x_j, y_j)$ as the center. The extracted blocks from the Lena image using $n$ feature points are illustrated in Fig. 2(b). In addition, the approximation coefficients are computed for each block separately using 2D *DWT*. The *DWT* approximation coefficients are robust against content-preserving modifications and also sensitive to malicious modifications. The approximation coefficients of the $c$th block are represented as:

$$LL_l{}^c(u, v), 1 \leq u, v \leq P/2^l \tag{2}$$

where the variable $l$ denotes the level of *DWT* decomposition. Then, the approximation coefficients of $n$ blocks are arranged into a two-dimensional matrix of size $Q \times R$, where $Q = n \times (P/2^l)$ and $R = P/2^l$ is given in the following equation.

$$AC_{Q\times R} = [LL_l^1; LL_l^2; \cdots, LL_l^c; \cdots; LL_l^n]_{Q\times R} \tag{3}$$

*Step 4. Generation of Intermediate Hash:* The intermediate hash (IH) vector is generated by computing the row-wise

Please cite this article in press as: L.N. Vadlamudi, et al., Robust image hashing using SIFT feature points and DWT approximation coefficients, ICT Express (2018), https://doi.org/10.1016/j.icte.2017.12.004.