Robust Image Hashing Using NMF and Ring partition for Image Analysis

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Abstract: Image hashing is an efficient technique for indexing and can be effectively used in image retrieval .This paper uses image hashing with a ring partition and a non-negative matrix factorization(NMF),which provides rotation robustness and good discriminative capability respectively. The aim of ring partition in image hashing is to construct a rotation invariant secondary image for dimensionality reduction. In addition, NMF coefficients are linearly changed by content-preserving manipulations so as to measure hash similarity with correlation coefficient. Our approach is efficient in producing hash code for images which gets stored in the database for image retrieval.

Keywords: Image Hashing, non-negative matrix factorization, ring partition, correlation coefficient.

I. INTRODUCTION

In the information era, the increasing availability of multimedia data in digital form has led to tremendous growth of tools to manipulate digital multimedia. To ensure trustworthiness, multimedia authentication techniques have been emerged to verify content integrity and prevent forgery. While we are enjoying our life increasingly with multimedia products ,there are still many challenging problems faced by academia and industries tampering, much easier than ever before, assurance of multimedia content security has been an important concern to multimedia community .These real demands lead to an emerging multimedia technology known as image hashing.

Image Hashing not only allows us to quickly find image copies in large databases, but also can ensure content security of digital images. Image Hashing maps an input image to short string, called image hash, and has been widely used in image retrieval, image authentication, digital watermarking, image copy detection, tamper detection, image indexing, multimedia forensics, and reduced reference image quality assessment. There are some cryptographic hash functions,e.g.,SHA-1 and MD-5,which can convert input message into a fixed size string. However, they are sensitive to bit level changes and cannot be suitable for image hashing. This is because digital images often undergo normal digital processing, such as jpeg compression and image enhancement in real applications without changing visual contents of images. The proposed hashing has two basic properties of image hash function, known as perceptual robustness and discriminative capability.

II. RELATED WORKS

Hashing algorithms based on discrete wavelet transform used statistics of wavelet coefficients to construct image hashes. This method is resilient to jpeg compression, median filtering and rotation within 2^0,but fragile to gamma correction and contrast adjustment. Secure image hashing scheme for authentication by using DWT and SHA-1 can be applied to tamper detection, but fragile to some normal digital processing. Hashing algorithms using DCT coefficients is robust against normal processing but sensitive to image rotation. Radon Transform uses auto correlation of each projection in the RT domain to design image hashing. A Scheme RASH method designed by dividing an image into a set of radial projections of image pixels, extracting RAdial Variance (RAV) vector from these radial projections, and compressing the RAV vector by DCT. The RASH method is resilient to image rotation and rescaling but its discriminative capability needs to be improved. Image Hashing techniques with DCT is resilient to several content-preserving modifications, such as moderate geometric transforms and filtering. RT combining with DWT and DFT to develop image hashing is robust against print scan attack and small angle rotation. Our proposed hashing algorithm uses non-negative matrix factorization that is applied on viewed images and attacks as a sequence of linear operators , and to calculate hashes using singular value decompositions. This method ,called SVD-SVD hashing, is robust against geometric attacks ,e.g., rotation, at the cost of significantly increasing misclassification. Our proposed hashing applied NMF to some sub images, used the combination coefficients in the matrix factorization to construct a secondary image, obtained its low rank matrix approximation by using NMF again, and concatenated the matrix entries to form an NMF-NMF vector .To make a short hash, the inner product between NMF-NMF vector and a set of weight vectors is calculated. The NMF-NMF-SQ hashing is resilient to geometric attacks but it cannot resist some normal manipulations. The invariant relation existing in the NMF coefficients matrix are used to construct robust hashes .This method is robust against jpeg compression, additive noise and watermark embedding, but also fragile to image rotation.

III. PROPOSED IMAGE HASHING

Our image hashing consists of three steps. Initially the original images are processed and their hash codes are stored in the database. In Pre-processing, the input image is converted to a normalized image with a standard size. In second step, the normalized image is partitioned into different rings, which are then used to construct a secondary image. In third step, NMF is applied to the secondary image and image hash is finally formed by NMF coefficients. The image hash of modified image is compared with the hash values in the database and original image is retrieved.

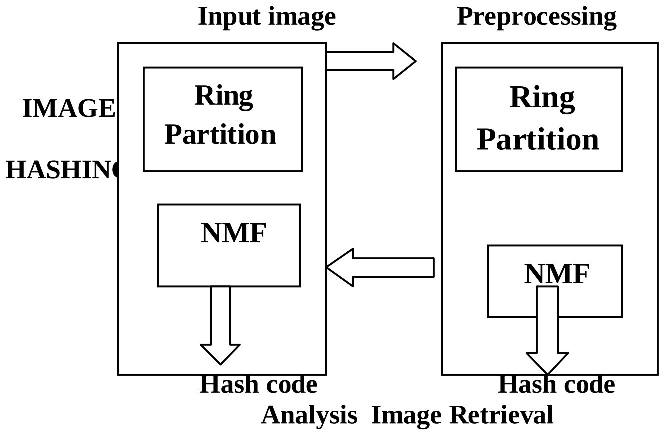

Fig.1 Block Diagram

A. RING PARTITION

In general, rotation manipulation takes image centre as origin of coordinates. To make image hash resilient to rotation, we can divide an image into different rings and use them to form a secondary image invariant to rotation. Let the size of square image be m _ m; n be the total number of rings, and R be a set of those pixel values in the K^{th} ring (k ¼ 1; 2; ...;n). In here, we only use the pixels in the inscribed circle of the square image and divide the inscribed circle into rings with equal area. This is because each ring is expected to be a column of the secondary image. The ring partition can be done by calculating the circle radii and the distance between each pixel and the image centre. The pixels of each ring can be determined by two neighbour radii except those of the innermost ring. Suppose that r_k is the k-th radius (k=1,2,3…..,n),which is labelled from small value to big value. Thus, r_1 and r_n are the radii of the innermost and outermost circles respectively. Clearly, r_n =[m/2] for the m $\times$ m images.To determine other radii ,the area of the inscribed circle A and average area of each ring μ_A are firstly calculated as follows.

$$A=\pi r_n^2$$

$$\mu_A=[A/n]$$

So r_1 can be computed by

$$r_1=\sqrt{\frac{\mu_A}{\pi}}$$

Thus, other radii r_k can be obtained by following equation

$$r_k=\sqrt{\frac{\mu_A+\pi r_{k-1}^2}{\pi}}$$

Let P(x,y) be the value of the pixel in the y-th row and x-th column of the image ($1\le x,y\le m$).Suppose that (x_c, y_c) are the coordinates of the image centre.

Fig.2 Ring Partition

B.   NMF

NMF is an efficient technique of dimensionality reduction, which has shown better performance in learning parts-based Representation . In fact, NMF has been successfully used in face recognition, image representation, image analysis, signal separation , data clustering, and so on. A non-negative matrix **V**=(*Vi*,*j*) is generally viewed as a combination of *N* vectors sized *M*1. NMF results of **V** are two non negative matrix factors, i.e., **B**=(*BM*×*Ni*,*j*)*M*×*K* and **C**=(*C*, where *K* is the rank for NMF and *K*<min(*M*, *N*). The matrices **B** and **C** are called the base matrix and coefficient matrix.
They can be used to approximately represent **V** such that:

$$\mathbf{V} \approx \mathbf{BC}$$

In literature, various algorithms have been proposed to achieve NMF. In this paper, we employ the multiplicative update rules to find **B** and **C** as follows.

$$\begin{cases} B_{i,k} \leftarrow B_{i,k} \dfrac{\sum_{j=1}^{N} C_{k,j} V_{i,j} / (\mathbf{BC})_{i,j}}{\sum_{j=1}^{N} C_{k,j}} \\ C_{k,j} \leftarrow C_{k,j} \dfrac{\sum_{i=1}^{M} B_{i,k} V_{i,j} / (\mathbf{BC})_{i,j}}{\sum_{i=1}^{M} B_{i,k}} \end{cases}$$

$$i = 1, \ldots, M;\ j = 1, \ldots, N;\ k = 1, \ldots, K$$

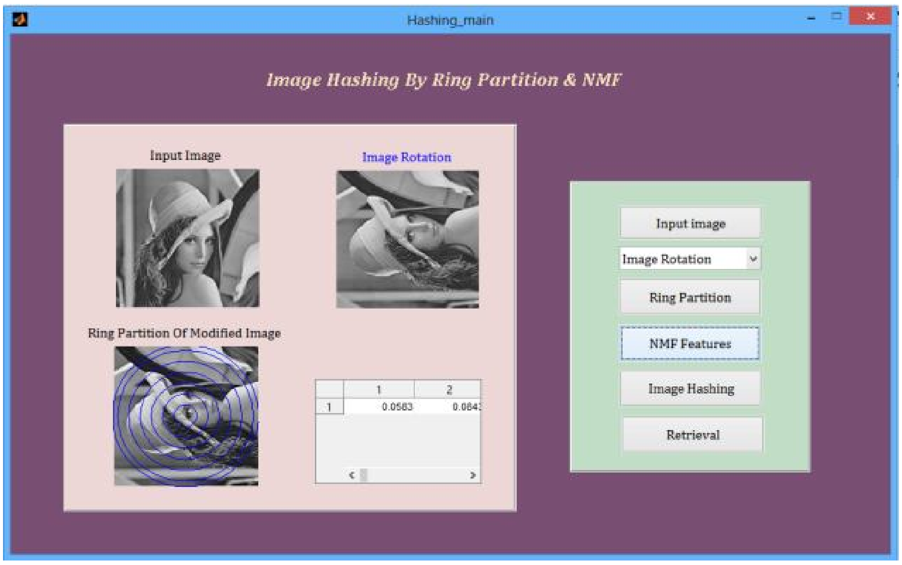

Fig.3   NMF Features

C. IMAGE HASHING

Apply NMF to **V** and then the coefficient matrix **C** is available. Concatenate the matrix entries and obtain a compact image hash. Thus, the hash length is *L=n K*, where *n* is the number of rings and *K* is the rank for NMF. The image hash produced for the modified or pre-processed image is compared with the hash values of the original images previously stored in the database. The hash value which is very similar to this hash will be retrieved along with the corresponding image from the database.

EFFECT OF NUMBER OF RINGS AND RANK FOR NMF

Receiver operating characteristics (ROC) graph was exploited to visualize classification performances with respect to the robustness and the discriminative capability under different parameters. Thus, both true positive rate (TPR) *P* TPR
and false positive rate (FPR) *P* can be calculated as follows.

$$P_{\text{TPR}} = \frac{n_1}{N_1}$$

$$P_{\text{FPR}} = \frac{n_2}{N_2}$$

where n_1 is the number of the pairs of visually identical images considered as similar images, *N* is the total pairs of visually identical images, n_2 is the number of the pairs of different images viewed as similar images, and *N* is the total pairs of different images. Obviously, TPR and FPR indicate the perceptual robustness and the discriminative capability, respectively. For a fixed number of rings, a bigger rank will make better hashing performances. This is because a bigger rank means more elements in the hash, which not only preserve the perceptual robustness, but also improve the discriminative capability. In fact, hashing performances are related to hash length. Generally, a short image hash will have good robustness, but makes poor discrimination. As hash length increases, discriminative capability is strengthened while perceptual robustness slightly decreases.

IV. CONCLUSIONS

In this paper, we have proposed a robust image hashing based on ring partition and NMF, which is robust against image rotation and has a desirable discriminative capability. A key component of our hashing is the construction of secondary image, which is used for the first time in image hashing. The secondary image is rotation-invariant and therefore makes our hashes resistant to rotation. Discriminative
Capability of the proposed hashing is attributed to the use of NMF, which is good at learning parts based representation. The ROC curve comparisons have indicated that the proposed hashing is better than some well-known hashing algorithms in classification performances between the perceptual robustness and the discriminative capability.

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