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Fingerprint Compression based on Sparse Representation: A Review

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Abstract— **Recognition of people by means of their biometric characteristics very popular among the society. Among this, fingerprint recognition is an important technology for personal identification due to its unique structure. Large volume of fingerprint are collected and stored everyday in a wide range of applications. In this context, the compression of these data may become imperative under certain circumstances due to the large amounts of data involved. This paper compare different compression standards like JPEG,JPEG-2000,WSQ,K-SVD etc. A new compression standards based on sparse representation also introduced. The experiments demonstrate that this is efficient compared with several competing compression techniques especially at high compression ratios.**

Keywords— ***Compression; JPEG;JPEG 2000; K-SVD;WSQ***

INTRODUCTION

Large volumes of fingerprints are collected and keep daily in an exceedingly big selection of applications, including forensics, access management etc., and fingerprint square measure evident from the information of Federal Bureau of Investigation (FBI) . Fingerprint identification is commonly employed in forensic science to support criminal investigations, and in biometric systems such as civilian and commercial identification devices. Since giant volume of information consumes additional amount of memory, the data contained in fingerprints should, therefore, be compressed by extracting solely visible components. Fingerprint pictures exhibit characteristic high energy in bound high frequency bands ensuing from the ridge-valley pattern and alternative structures . The *DCT* [2]-based encoder is thought as compression of stream of 8X8 little blocks of pictures. This transform is adopted in *JPEG*[3]. the *JPEG* compression theme has several benefits like simplicity, catholicity and availability. However, it has a bad performance at low bit-rates mainly due to the underlying block-based *DCT* scheme. For this reason, as early as 1995, the *JPEG*-committee began to develop a wavelet-based compression for still images, specifically *JPEG 2000*[5].

Targeted at fingerprint images, there are special compression algorithms. The most common is *Wavelet Scalar Quantization(WSQ)*[6]. It became the FBI standard for the compression of 500 dpi fingerprint images. Inspired by the *WSQ* algorithm, a few wavelet packet based fingerprint compression schemes have been developed. But, these algorithms have a common problem, namely without the ability of learning the fingerprint images can't be compressed well now. So a novel approach based on sparse representation is given [1]. Here features are extracted and represent them as dictionary atoms. In most Automatic Fingerprint identification System (AFIS), the main feature used to match two fingerprint images are minutiae (ridges endings and bifurcations). Therefore, the difference of the minutiae between pre- and post-compression is considered in the paper.

I. RELATED WORKS

In this section, we compare the proposed method with existing fingerprint compression algorithms like JPEG,JPEG-2000,WSQ,K-SVD etc.

A. JPEG

For the past few years, a joint ISO/CCITT committee known as JPEG (Joint Photographic Experts Group)has been working to establish the first international compression standard for continuous-tone still images. To meet the differing needs of many applications, the JPEG standard includes two basic compression methods i.e. a DCT-based method is specified for "lossy''compression, and a predictive method for "lossless'' compression. JPEG has undertaken the ambitious task of developing a general-purpose compression standard to meet the needs of almost all continuous-tone still-image applications..

The JPEG compression scheme has many advantages such as simplicity, universality and availability. However, it has a bad performance at low bit-rates mainly because of the block-based DCT scheme. For this reason, as early as 1995, the JPEG-committee began to develop a new wavelet-based compression standard for still images, namely JPEG 2000.

B. JPEG 2000

In 1996, the JPEG committee began to investigate possibilities for a new still image compression standard to serve current and future applications. The desire to provide a broad range of features for numerous applications in a single compressed bit-stream prompted the JPEG committee in 1996 to investigate possibilities for a new compression standard that was named JPEG-2000.

In JPEG 2000,DCT of JPEG is replaced with *DWT(Discrete Wavelet Transform)*[3]. The DWT-based algorithms include three steps: a DWT computation of the normalized image, quantization of the DWT coefficients and lossless coding of the quantized coefficients. Compared with JPEG, JPEG 2000 provides many features that support scalable and interactive access to large-sized image. It also allows extraction of different resolutions, pixel fidelities, regions of interest etc.

C. WSQ

The above algorithms are for general image compression. Targeted at fingerprint images, there are special compression algorithms. The most common is Wavelet Scalar Quantization(WSQ). It became the FBI standard for the compression of 500 dpi fingerprint images.

The WSQ class of encoders involves a decomposition of the fingerprint image into a number of sub bands, each of which represents information in a particular frequency band. The sub band decomposition is achieved by a discrete wavelet transformation of the fingerprint image .Each of the sub bands is then quantized using values from a quantization table. The quantized coefficients are then passed to a Huffman encoding procedure which compresses the data. Huffman table specifications must be provided to the encoder.

D. K-SVD

K-SVD[9](Single value decomposition) is an iterative method that alternates between sparse coding of the examples based on the current dictionary, and a process of updating the dictionary atoms to better fit the data. The update of the dictionary columns is combined with an update of the sparse representations, thereby accelerating convergence. The K-SVD algorithm is flexible and can work with any pursuit method (e.g., basis pursuit, FOCUSS, or matching pursuit). We analyse this algorithm and demonstrate its results on both synthetic tests and in applications on real image data.

The k-svd is not effective when the dictionary size is so large.

So a new compression standard based on sparse approximation is introduced.

II. PROPOSED METHOD

The above algorithms have a common shortcoming, i.e, without the ability of learning, the fingerprint images can't be compressed well now. So, a novel approach based on sparse representation is given in this paper.

The proposed method has the ability by updating the dictionary. The specific process is as follows: construct a base matrix whose columns represent features of the fingerprint images, referring the matrix dictionary whose columns are called atoms; for a given whole fingerprint, divide it into small blocks called patches whose number of pixels are equal to the dimension of the atoms; use the method of sparse representation to obtain the coefficients; then, quantize the coefficients; last, encode the coefficients and other related information using lossless coding methods.

Given a new fingerprint, slice it into square patches which have the same size with the training patches. The size of the patches has a direct impact on the compression efficiency.The algorithm becomes more efficient as the size increases. In addition, to make the patches fit the dictionary better, the

mean of each patch needs to be calculated and subtracted from the patch. After that, compute the sparse representation for each patch by solving the *l0* problem. Those coefficients whose absolute values are less than a given threshold are treated as zero. For each patch, four kinds of information need to be recorded. They are the mean value, the number about howmany atoms to use, the coefficients and their locations. For improving algorithm,Use Orthogonal matching pursuit instead of Matching pursuit for constructing the dictionary.

Algorithm

1. For a given fingerprint divide it into patches.
2: For each patch its mean is calculated and subtracted from the patches.
3.Update the fingerprint dictionary by means of *MP(Matching Pursuit)*[7] method.
4:Those co-efficient whose absolute value less than a threshold is treated as zero.
5: Record the remaining coefficient

We can enhance the algorithm by using OMP(Orthogonal Matching Pursuit)algorithm instead of MP(MatchingPursuit) algorithm. In OMP dictionary atoms taken once never taken again; there by reduces the total algorithm complexity.

Compared with general natural images, the fingerprint images have simpler structure. They are only composed of ridges and valleys. In the local regions, they look the same. Therefore, to solve these two problems, the whole image is sliced into square and non-overlapping small patches. For these small patches, there are no problems about transformation and rotation. The size of the dictionary is not too large because the small blocks are relatively smaller.

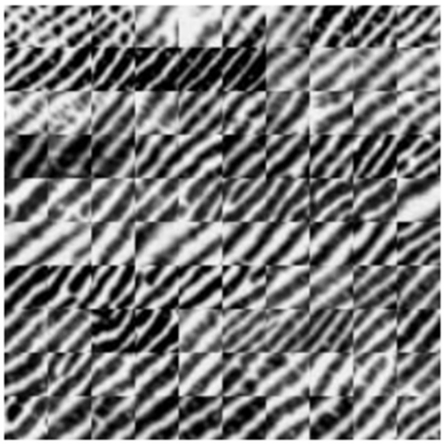

Fig1.100 patches with size 20*20

Fig.1 shows the sample of 100 patches with size 20*20 .

Fig.2 shows the architectural diagram of the proposed standard.

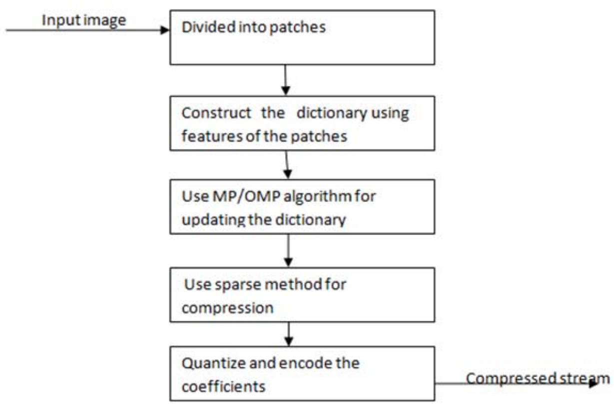

Fig:2 Architectural diagram

III. EXPERIMENTS

In this section, the effects of different dictionaries on fingerprint compression is studied. There are three methods to construct the dictionary.Here, the first is to randomly select some patches and arrange them as columns of the dictionary called *Random-SR*[8] . The second is to select patches according to orientations called Orientation-SR . See Fig.1, they are 100 patches with orientation 45 and size 20×20. The third is to train the dictionary by K-SVD method (K-SVD-SR in short).

In this section, we compare the proposed method with existing fingerprint compression algorithms. We use three different image compression algorithms, JPEG,JPEG 2000 and WSQ, which have been extensively described before. The standard JPEG is a part of almost any image processing tool we do not give further reference on it. The wavelet-based JPEG 2000 we use is provided by the Mat lab. The WSQ algorithm is provided by a software downloaded on the Internet.

There are 2 groups of fingerprint images (referred to as DATABASE 1& DATABASE 2) are tested in the experiments.

DATABASE 1: 50 fingerprints that are used to compare various compression technologies.

DATABASE 2: the public fingerprint database, including 80 fingerprints with size 300 × 300, which are used to compare existing compression technology.

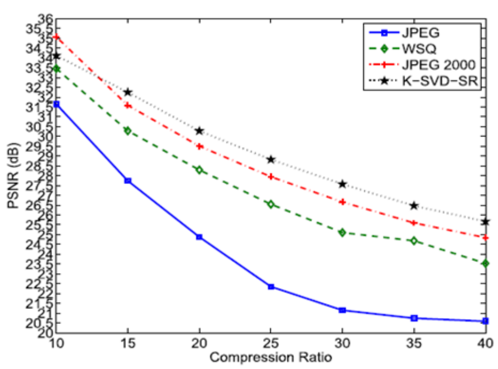

Fig:3 Average performance of proposed algorithms JPEG,JPEG 2000 and WSQ at various compression ratios, on DATABASE 1.

Here KSVD-SR(K-means single value Decomposition using Sparse Representation) have high PSNR value at compression ratio 20:1. The figure shows that the sparse algorithm outperforms the JPEG 2000 algorithm when the compression ratios are high.

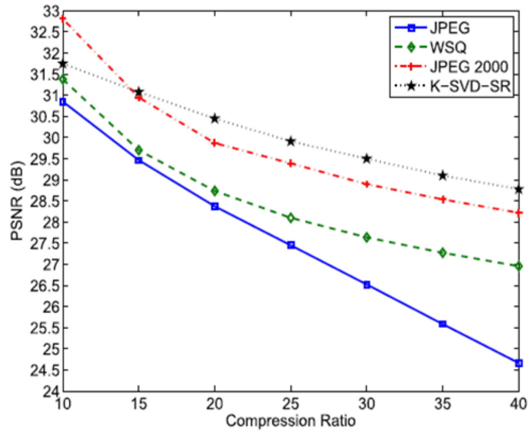

Fig:4 Average performance of proposed algorithm, JPEG, JPEG 2000 and WSQ at various compression ratios, on DATABASE 2.

Fig.4 show the average performances of the proposed algorithms, JPEG, JPEG 2000 and WSQ on DATABASE 2. The results on DATABASE 2 are roughly consistent with the results on DATABASE1. Compared with JPEG and WSQ, proposed method's PSNR and JPEG 2000's PSNR are consistently higher. At compression ratio 15: 1, the performance of sparse method is as good as that of JPEG 2000. At higher compression ratio, our algorithm outperforms the JPEG 2000.From the figure, we can see that the curve of our algorithm is the most flat. This means the rate of decay of our algorithm's PSNR is the slowest as the compression ratio increases.

IV CONCLUSION

The different compression techniques adapted to compress the fingerprint image is reviewed and compared their Performance especially at high compression ratios. A new compression algorithm based on sparse approximation is also introduced. Two groups of fingerprint images are tested. The experiments show that sparse algorithm is efficient than competing compression techniques like JPEG, JPEG 2000, WSQ,K-SVD etc, especially at high compression ratio and can hold most of the minutiae robustly during the compression and reconstruction. However, the algorithm has higher complexities due to the block-by-block processing mechanism. Optimization of code of the different compression techniques has to be improved to reduce the complexity.

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