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A Novel Fingerprint Compression Method Based On Sparse Representation

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Abstract: Recognition of people by means of their biometric features is very popular among the society. There are a variety of biometric techniques including fingerprint recognition, face recognition and eye detection that are used for the privacy and safety purposes in different applications. In current years there has been an increasing interest in the learning of sparse representation of signals. Using an over completeglossary that contains prototype signal-atoms, signals are illustrated by sparse linear combinations of these atoms. Among several biometric recognition technologies, fingerprint compression is very popular for personal identification. One more fingerprint compression algorithm based on sparse representation is introduced. In the algorithm, first we construct a dictionary for predefined fingerprint photocopy patches. For a new given fingerprint images, suggest its patches according to the dictionary by computing l^0-minimization by MP method and then quantize and encode the representation. This paper compares dissimilar compression standards like JPEG, JPEG-2000, WSQ, K-SVDetc.The experiments demonstrate that this is often cost-effective compared with many competitive compression techniques particularly at high compression ratios.

Index Terms: Fingerprint Compression, JPEG, JPEG 2000, WSQ, SPIHT, K-SVD, PSNR.

I. INTRODUCTION

Huge volumes of fingerprints are collected associated remain daily in an passing wide selection of applications, together with forensics, access management etc., and fingerprint unit of measurement evident from the data of Federal Bureau of Investigation (FBI) . In the world today we are identified by the various biometric characteristics such as fingerprint recognition and in this paper we explain the fingerprint recognition based on sparse representation. Because in recent years there will be growing interest in the field of sparse representations of signals. Applications that use sparse representation are many that include compression, regularization in converse problems, feature extraction, and more. Among various biometric recognition technologies, fingerprint compression is very popular for personal identification due to the uniqueness, universality, collectability and invariance [1].

Large volume of data requires the large amount of memory. Fingerprint compression is a key technique to solve the problem.Compared with general normal images the fingerprint images contain simpler configuration. They are only composed of ridges and valleys. In the local regions, they seem to be the same. Therefore, to solve these two problemsthe pre-processing,pre-aligned the whole image is sliced into square and non-overlapping small patches.

Generally, compression technologies can be classed into lossless and lossy. Lossless compression is a type of image compression algorithms that allows the original data to be perfectly reconstructed from the compressed data. Typical image file formats of lossless compression are like PNG or GIF. Lossless compression is used where it is necessary that the original and the decompressed data be one and the same, or where deviations from the original data could be deleterious. Lossless compression methods may be classified according to the category of data they are designed to compress.

Lossy compression technologies usually transform an image into an additional domain, quantize and encode its coefficients. These methods are used to reduce data size for storage, handling, and transmit content. The amount of data reduction achievable using lossy compression is often much higher than through lossless techniques. In lossy transform codes, samples of image are taken, chopped into small segments, transformed into a new basis space, and quantized. The resulting quantized values are then encoded using entropy coding. There are transform-based image compression methods have been implicitly researched and some principles have appeared. Two most universal options of transformation are the Discrete Cosine Transform (DCT) [2] and the Discrete Wavelet Transform (DWT)[3].

The DCT-based encoder can be considered as compression of a stream of 8 × 8 small block of images. This transform has been used in JPEG [4]. The JPEG compression theme has several benefits likesimplicity, catholicity and accessibility. On the other hand it has abad performance at low bit-rates mainly due to theunderlying block-based DCT format. For this motive, asearly as 1995, the JPEG-committee begins to develop a new wavelet-based

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compression for still images, especially JPEG 2000[5]. Targeted at fingerprint images, there are specialcompression algorithms. The most common is WaveletScalar Quantization (WSQ)[7]. It became the FBI standardfor the compression of 500 dpi fingerprint images. Motivatedby means of the WSQ algorithm, a few wavelet packet basedfingerprint compression schemes such as Contourlet Transform (CT) have been developed. But,these algorithms have a familiarlimitation namely, without the ability of knowledge. The fingerprint images can't be compacted well now. They will not be compressed well later. In this paper, ainnovative approach based on sparse representation is given [8]. The proposed method has the ability by updating the dictionary. In most instances, the evaluation of compression performance of the algorithms is restricted to Peak Signal to Noise Ratio (PSNR) computation. The effects on authentic fingerprint matching or recognition are not investigated. In this paper, we will take it into consideration.The effects on actual fingerprint matching or recognition are not examined. In this paper, we will take it into contemplation. 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 among pre- and post-compression is considered in the paper.

II. RELATED WORKS

In this section, we describe the various image compression techniques and also we compare the proposed method with existing fingerprint compression algorithms like JPEG, JPEG-2000, WSQ, K-SVD etc. Generally, compression technologies can be classed into lossless and lossy.

The most common techniques for transformation of images include Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) [3]. Discrete Cosine Transformation has been used in JPEG [4]. DCT basedencoder compress the given image by partitioning the full image into 8*8 small blocks. DCT converts the information contained in these blocks of pixels from spatial domain to the frequency domain. Based on the applications, 1-D and 2-D DCT[10] are performed on the images. JPEG compression has many advantages like simplicity, availability and universality. But its performance degrades at low bit rates due to block-wise approach. Image files that use JPEG compression are generally called "JPEG files", and are stored in variants of the JIF image format. The term "JPEG" is an acronym for the Joint Photographic Experts Group.

To overcome the limitations present in the JPEG format, JPEG-2000 was proposed with the Discrete Wavelet Transform (DWT) [6]. A multi resolution image representation is inherent to DWT along with full frame transformation unlike block-wise approach of DCT. There is a modest increase in compression performance of JPEG 2000 compared to JPEG; the main advantage of JPEG 2000 is the significant elasticity of the code stream. The DWT-based algorithms consist of three steps: a DWT computation of the normalized image, quantization of the DWT coefficients and lossless coding of the quantized coefficients. The detail can be found in [15] [14] and.This full frame nature of transformation décor relates the images across a large scale and eliminates blocking artifacts at high compression ratio. DWT filters have been used in JPEG 2000 that allows support for both lossy and lossless compression within a single compressed bit stream. Therefore, improving the compression efficiency at low bit rates. Both JPEG and JPEG 2000 are similar except the different approaches used for the transformations for JPEG DCT is used instead of DWT.

Several other algorithms that use DWT includes set partitioning in hierarchical trees (SPIHT) algorithms [13]. These algorithms are basically used for general images. In most Automatic Fingerprint identification System (AFIS), the main feature used to match two fingerprint images are minutiae (ridges endings and bifurcations). Specifically for fingerprint images, there are many other special compression algorithms such as wavelet Scalar Quantization (WSQ)[12], Contourlet Transform (CT). WSQ technique is a loss compression technique which is basically used for grey scale fingerprint images [14]. The WSQ compression technique developed by the FBI and alternative entities was designed to compress fingerprint pictures between ratios of 10:1 and 20:1[11].

Contourlet Transform consists of two major phases that are sub band decomposition and the directional transform. The first phase uses the Laplacian Pyramid (LP) and the second phase makes use of the directional filterbanks (DFB). Quincunxes are the building blocks of DFB.Both these algorithms have limitations that they are without the availability of learning. A novel approach based on the sparse representation has been proposed [16].

There is a new compression technique called K-SVD adapted K-means clustering process.K-SVD is an iterative method that alternates between sparse coding of the examples based on the existing dictionary and a process of updating the dictionary atoms to better fit the data [9]. The update of the dictionarycolumns is grouped with an update of the sparse representations, thereby accelerating convergence. The K-SVD algorithm is expandable and can work with any pursuit method (e.g., basis pursuit, FOCUSS, or matching pursuit). We evaluate this algorithm and express its results both on synthetic tests and in applications on real image data.

III. FINGERPRINT COMPRESSION BASED ON SPARSE REPRESENTATION:

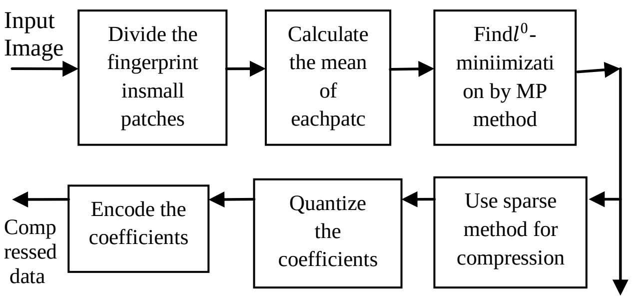

Fig.1. Proposed System Block Diagram.

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The sparse representation methods for image compression which is shown in Figure (1) are specifically used for fingerprint image compression; these are not efficient for general images. The main reason for this is that general images are rich in contents thus, to obtain a dictionary with a modest size, the pre-processing is indispensable. Influenced by transformation, rotation and noise, the fingerprints of the same finger may look very different. What we first think is that each fingerprint image is pre-aligned, independently of the others. The most common pre-alignment technique is to translate and rotate the fingerprint according to the position of the core point. Unfortunately, reliable detection of the core is very difficult in fingerprint images with poor quality. Even if the core is correctly detected, the size of the dictionary may be overlarge because the size of a whole fingerprint image is too large.

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.

The proposed method has the ability by updating the dictionary.In this method, for a given fingerprint, slice it into small patches. For each patch its mean is calculated and subtracted from the patch. For each patch solve the minimization problem by those coefficients whose absolute value are less than a given threshold are treated as zero. Record the remaining coefficients and their locations. Encode the atom number of each patch, the mean value of each patch and the indexes, quantize and encode the coefficients. Output the compressed stream.

IV. PROPOSED SYSTEM IMPLEMENTATION

This paper extends the sparse representation approach of fingerprint compression by performing enhancement with DWT along with SPIHT encoding thinning and binarization at pre-processing stage. This approach can work for both high and low intensity sensors. The modified algorithm is as follows:

Algorithm 1

1. Perform Thinning and Binarization
2. Perform Wavelet decomposition
3. Use SPIHT encoding method
4. Set a threshold. Coefficients having value less than threshold are treated as zero
5. Slice the fingerprint image into equal size patches
6. Foe each patch, mean is calculated and subtracted from the patch
7. For each patch calculate the coefficients by solving minimization problem
8. Record the Non-zero coefficients along with their locations
9. Encode atoms, mean value of each patch
10. Quantize and encode the obtained Coefficients
11. Use SPIHT decoding method
12. Output the compressed stream

In the preceding paragraphs, it is mentioned that the dictionary will be constructed in three ways the first is select the patches at random and arrange them as columns of the dictionary (Random-SR).The second is to select patches according to orientations called Orientation-SR. See Figure (2), there are 256 patches with orientation 45 and size 20×20.

Algorithm 1 summaries the entire compression process. The compressed stream doesn't include the dictionary and the information about the models.

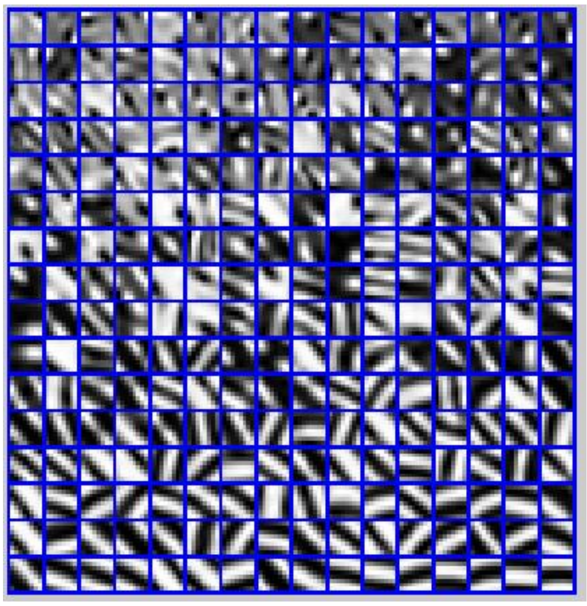

Fig.2. 256 Patches with Size 20*20

It consists exclusively of the encoding of the atom number of each patch, the mean value of each patch, the coefficients and also the indexes. In practice, only the compressed stream needs to be transmitted to restore the fingerprint. In both encoder as well as the decoder, the dictionary, the quantization tables of the coefficients and the statistic tables for arithmetic coding need to be stored.

V. EXPERIMENTAL SETUP

This section explains the experimental details of the proposed work. The proposed algorithm is implemented using MATLAB 2013a. The first step involves the pre-processing of the image that involve feature extraction and perform thinning and binarization on the input fingerprint image. In the next step, DWT is performed on the pre-processed image that output an image consisting of four sections: 1) Original fingerprint image 2) high-pass filtered, downscaled 3) low-pass filtered, up-scaled 4) low-pass filtered, downscaled. In the next step SPIHT encoding is preformed. In the next step, obtained fingerprint image is sliced into equal-size patches. Thenthese patches are used to create dictionary and sparse representation is performed to obtain the coefficients. Then these obtained coefficients are quantized and

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encoded in the same step. In the next step SPIHT decoding is performed. In thenext step, Inverse DWT is performed to reconstruct the image from the sub-bands. Then thecompressed image is stored in the database and matched with the original image to check for the distortion of extracted features.

The experimental results show that the extracted features of the fingerprint image is preserved after compression. Therefore, the technique is successful. The various images were compressed to check the efficiency of the algorithm which ended with positive results. Also, the algorithm works for both high and low intensity sensor image because of the pre-processing of the image done before compression.

The simulation results of proposed algorithms are shown below in figure 3.

Fig.3. Reconstructed image

VI. CONCLUSION

The various compression methods are adapted to compress the fingerprint images are studied and compared their Performance especially at high compression ratios. The proposed work provides algorithm for fingerprint image compression which is done by using SPIHT and K-SVD compression method. The proposed work also provides algorithm for fingerprint image compression which is based on sparse representation which works for high image compression ratio. The main difficulty while designing algorithm for compression of fingerprint is the need for preserving the minutiae which is used for identification. The experimental results shown in the paper ensure the preservation of minutiae during compression and reconstruction. The use of DWT in the pre-processing stage ensures the simplicity of the approach based on sparse representation. Also, for the better compression results, larger number of training set is required. That is, more the number of training set, better is the compression results.

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