International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Fingerprint Compression Technique using Sparse Representation

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Abstract: ***Fingerprint is the most famous biometric that is mostly used in various authentication systems. Fingerprint of human being exhibit certain details marked on it, categorized it as minutiae, which can be used as a unique identity of a person if recognize it in a well manner. Large volume of fingerprint are collected and stored every day in a varied range of applications. In this context, the compression of these data may become commanding under certain circumstances due to the large amounts of data involved. This paper present the characteristics of biometric features of fingerprint image, talk over the necessity of fingerprint compression and present abstract review on different existing fingerprint compression standards such as DCT based JPEG, DWT based JPEG-2000, WSQ, etc. and the proposed method is given which is implementation of fingerprint image compression by using the method of sparse representation.***

Keywords: Fingerprint, JPEG, JPEG 2000, WSQ, Sparse Representation

1. Introduction

Biometric is an automatic technique which is used to distinguish an individual's identity by a unique physiological trait or behavioral characteristic, like fingerprint, retina, face, voice or signature etc. Conventional security systems used either knowledge based methods passwords or pins, and token based methods driver license, passport, ID card and were likely to threat or fraud because passwords or PIN numbers may be forgotten and the tokens may be stolen, missing or copied. So a biometric system is required for robust, reliable, and guaranteed personal identification, authentication systems. Biometric data can't be stolen or guessed in same fashion as of password or token can be guessable. Each individual has unique biometric traits so they can be used to avoid fraud or theft [2].

Among many biometric recognition technologies, the fingerprint recognition is very widespread for personal identification due to their distinctiveness, universality, collectability and invariance [1]

This paper is designed as follows: section 2 discusses the characteristic of fingerprint image and explores the need of fingerprint compression technique. Section 3 gives the abstract description of various existing fingerprint compression technique. Section 4 presents the proposed method for compression of fingerprint image based on sparse representation. Section 5 shows experimental results and finally conclusion is given.

2. Fingerprint Image Characteristics

A fingerprint usually appears as a series of dark lines that represents the high peaking portion of the friction ridge peel, whereas the valleys between these ridges seem as white space and are the low shallow portion of the friction ridge peel. The Figure 1 displays the essential biometric features such as the fingerprint's core, bifurcations and ridge endings [3]. Where the ridge endings are the points at which a ridge stops. Bifurcations are the point on fingerprint image at which one ridge divides into two. And Core is center point of fingerprint pattern.

Figure 1: Biometric features of fingerprint image [3]

Minutiae play a vital role in fingerprint recognition, which are differentiated by some abnormal points on the ridges. There is a variety of minutiae such as bifurcation, independent ridge, termination, lake, spur, crossover and dot. Although there have a variety of minutiae types but two types of minutiae are mainly used and most significant. In which, one is called "termination" which can be characterized as the immediate ending of a ridge and the other one is called "bifurcation" which can be characterized as the point on the ridges where two branches are bifurcated[2]. Islands are ridges somewhat lengthier than dots, occupying the space between two temporarily divergent ridges. Ponds or lakes are the empty spaces between two temporarily divergent ridges. Spurs is a notch protruding from a ridge. Bridges are small ridges joining two longer adjacent ridges and Crossovers are two ridges which cross each other.

The transmission of images consumes a large volume of space. Therefore the Image compression is one of key techniques in solving this problem. Image compression exploits redundancy to achieve reduction in the actual amount of data with or without quality information loss according to certain rules through transform and combination. The overall goal of compression is to represent an image with the smallest possible no of bits, thereby speeding transmission and minimizing storage requirements.

3. Related Work

In this section, we present existing fingerprint compression algorithms such as JPEG, JPEG-2000 and WSQ, with their abstract description.

3.1 JPEG

A joint committee of International standard Organization(ISO) and the Consultative Committee of the International Telephone and Telegraph(CCITT) known as JPEG (Joint Photographic Experts Group) have establish the first international compression standard for continuous-tone still images. To meet the contradictory needs of many applications, the JPEG [10] standard includes two basic compression methods that is first one a DCT-based method is specified for lossy compression, and second is a predictive method for lossless compression. JPEG has started the aspiring task of developing a general purpose compression standard to meet the needs of almost all continuous-tone still-image applications.

The process of JPEG compression is given as following five steps, first step is to divide the image into 8x8 sub images. Second step is Shifting the gray-levels in the range of [-128, 127].Then third step is of applying Discrete Cosine Transform(DCT)[5] on the partitioned image, from this 64 coefficients will be obtained, that is 1 DC coefficient and 63 AC coefficients. Then fourth step is of quantizing the coefficients and the less significant coefficients are set to zero. And lastly order the coefficients using zigzag ordering and the coefficients obtained are in order of increasing frequency.

The JPEG compression scheme provides many advantages such as universality, simplicity and availability. But similarly it arise disadvantage such as it has a bad performance at low bit-rates that is because of the block-based DCT scheme. Therefore in the start of 1995, the JPEG-committee initiated to progress a new wavelet-based compression standard for still images, named as JPEG 2000[7] [11].

3.2 JPEG 2000

In 1996, the JPEG committee initiated to explore opportunities for a new still image compression standard to assist present and future applications. The desire to provide a broad range of features for numerous applications in a single compressed bit-stream encouraged the JPEG committee in 1996 to investigate possibilities for a new compression standard that was named JPEG-2000[7][11].

Over the past several years, the wavelet transform has increased prevalent acceptance in signal processing in general and in image compression research in specific. In various applications wavelet-based structures outperform other coding schemes such as the one based on DCT. Since there is not necessity of blocking the input image and its basis functions have variable length, structures based on wavelet coding at higher compression avoid blocking artifacts. Wavelet-based coding is therefore more robust under transmission and decoding errors and also supports progressive transmission of images. Because of their natural multi resolution nature, wavelet coding schemes are principally appropriate for applications where scalability and tolerable degradation are important.

In JPEG 2000, DCT of JPEG is replaced with Discrete Wavelet Transform (DWT) [6]. The DWT-based algorithms include three steps: first step is a DWT computation of the normalized image, after DWT computation second step is the quantization of the DWT coefficients and finally lossless coding of the quantized coefficients is performed. Matched with JPEG, JPEG 2000 delivers many features that support scalable and interactive access to large-sized images. It also permits extraction of different resolutions, pixel fidelities, regions of interest etc.

3.3 WSQ

The discrete cosine transform based JPEG and discrete wavelet transform based JPEG 2000 is for general images. Especially for fingerprint images, there are special compression standard. And the most common is the Wavelet Scalar Quantization (WSQ) [17]. It has becomes to be the FBI standard for the compression of 500 dpi fingerprint images. WSQ [17] involve two parts namely encoding and decoding. The encoding is composed of three steps as follows. The first step is of wavelet decomposition of the original fingerprint image. Second step is of quantization of wavelet coefficient that is WSQ uses uniform quantization and finally the lossless entropy encoding of the output of quantization is performed. The decoding process is the inverse processing of encoding. From these steps, the quantization step has great impact on the quality of the compressed images. In [18] author proposed an improved WSQ fingerprint image compression algorithm which improve WSQ algorithm in quantization step.

4. Proposed Work

Fingerprint compression using sparse representation has been implemented. Dictionary has been formulated from a set of fingerprint patches. First construct dictionary based on predefined fingerprint image patches. Every finger print image is going to minimize by l0-minimization algorithm. Matching pursuit is one of the greedy iterative algorithms for solving original l0 pseudo-norm problem. Compared with the general natural images, the structure of fingerprint images is modest and it is composed of the ridges and valleys. In the local regions, they appear the same. So the whole image is sliced into square and non-overlapping small patches. These small patches not have problems about transformation and

rotation. The size of the dictionary is not becomes too large because the small blocks are relatively smaller. Coefficients can be quantized by Lloyd's algorithm. Finally all values will be encoded using Arithmetic coding it is a form of entropy encoding used in lossless data compression.

Algorithm 1 Fingerprint Compression Technique based on Sparse Representation [1].

1: For a given fingerprint, slice it into small Patches.
2: For each patch, its mean is calculated and subtracted from the patch.
3: For each patch, solve the l^0 - minimization problem by MP method.
4: Those coefficients whose absolute value is less than a given threshold are treated as zero. Record the remaining coefficients and their locations.
5: Encode the atom number of each patch, the mean value of each patch, and the indexes; quantize and encode the coefficients.
6: Output the compressed stream.

Algorithm 1 outlines the complete process of fingerprint compression based on sparse representation. The compressed stream does not consist of the dictionary and the information about the models. It involves exclusively of the 1.Encoding of the atom number of each patch, 2.The mean value of each patch, 3.The coefficients plus 4.The indexes. In exercise, only the compressed stream needs to be transmitted to restore the fingerprint [1].

5. Results and Discussion

First store the fingerprint images in a directory called the database for performing the various steps of proposed method. The input image is preprocessed using median filter. The median filter identifies the noisy pixel in the image. The pixels neighboring to the noisy pixel were collected and they were arranged in a straight line. The median value is calculated and the noisy pixel is replaced by the obtained median value.

Figure 2: Input and preprocessed image

After preprocessing of an input image is converted into the square patches as shown in the figure 3

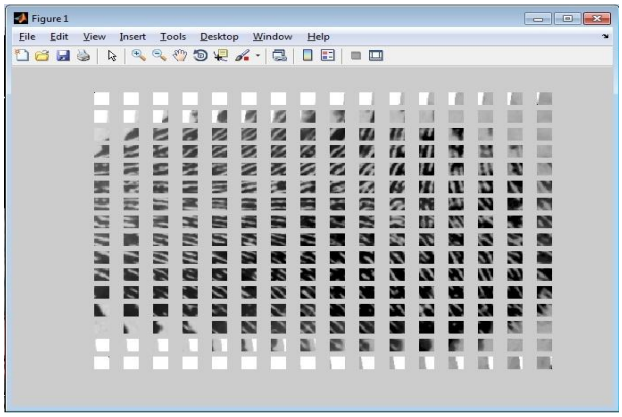

Figure 3: patches generates for image

Before dictionary construction we find mean value for each patch and subtracted from corresponding patches. The dictionary is updated by K-SVD algorithm. In sparse we compute the coefficient matrix using matching pursuit.

If new fingerprint is given make the images into patches of size m x m. To fit the dictionary better, the mean of each patch needs to be calculated and subtracted from the patch. Then compute the sparse representation for each patch by solving the *l*0 problem. From l0 minimization we find mean value, the number atoms to use, coefficients and their locations. Finally we use entropy encoding to encode the values. The reconstruction of the image composed of the exactly the inverse process that we have applied for the compression. The reconstructed image is shown in figure 4.

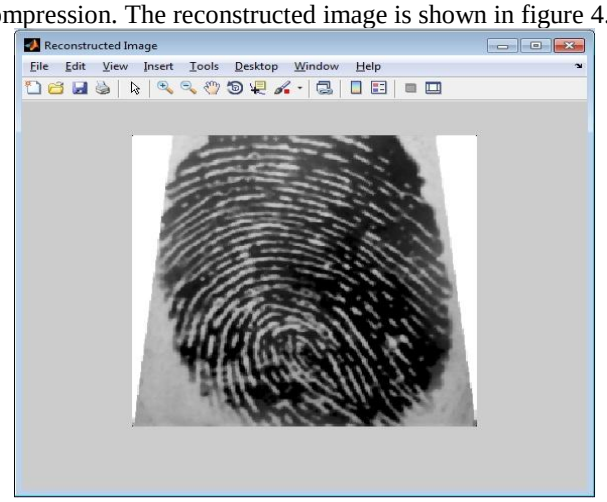

Figure 4: Reconstructed image

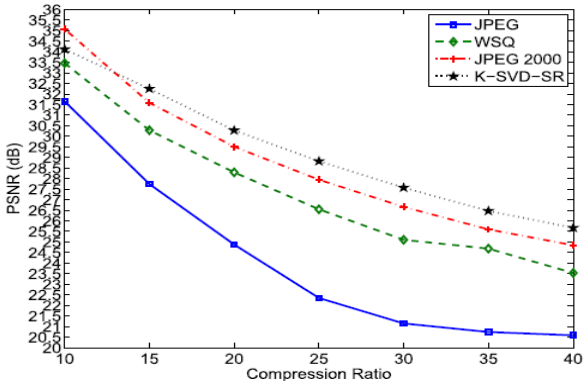

Figure 5: Average performances of the sparse representation algorithms as well as JPEG, JPEG 2000 and WSQ

algorithms, at various compression ratios on database of images [1].

Figure 5 shows average performances of sparse representation algorithms, JPEG, JPEG 2000 and WSQ. Compared with JPEG and WSQ, the JPEG 2000's PSNR and sparse representation method's PSNR are constantly higher. The figure displays that the sparse representation algorithm outperforms the JPEG 2000 algorithm while the compression ratios are high. Though, at compression ratio of 10: 1, JPEG 2000 works well than method of sparse representation. The reason is that the method based on sparse representation can't reflect the details well. This is the shortcoming of the kind of approaches. When the compression ratios are high and the information is not essential, these techniques based on sparse representation have obvious improvement.

6. Conclusion

In this paper, a comparison of different fingerprint compression techniques is presented. The JPEG compression system provides many advantages such as universality, availability and simplicity. But, it has a bad performance at low bit-rates mainly because of the underlying block-based DCT scheme. Compared with JPEG, JPEG 2000 provides many features that support scalable and interactive access to large-sized image. Although the simplicity of sparse representation algorithms for fingerprint compression, it compare favorably with existing more sophisticated algorithms, especially at high compression ratios. The optimization algorithm for solving the sparse representation need to be examined. And the Optimization of code to reduce the complexity of the different compression techniques has to be improved.

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