Fingerprint Compression Based on Sparse Representation

MADANAPALLI TRIVENU¹, M.V. NARASIMHA REDDY², P. PRASANNA MURALI KRISHNA³

¹PG Scholar, Dept of ECE, Dr. SGIET Engineering College, Markapur, AP, India.
²Assistant Professor, Dept of ECE, Dr. SGIET Engineering College, Markapur, AP, India.
³HOD, Dept of ECE, Dr. SGIET Engineering College, Markapur, AP, India.

Abstract: Fingerprint analysis plays crucial role in crucial legal matters such as investigation of crime. But a fingerprint image consists of enormous amount of data. Therefore we have to reduce the amount of its data. To do this, we need some powerful image compression techniques. There are many image compression techniques available. Fingerprint images are rarely of perfect quality. They may be degraded and corrupted due to variations in skin and impression conditions. Thus, image enhancement techniques are employed prior to minutiae extraction to obtain a more reliable estimation of minutiae locations. In this paper, we review various methods of fingerprint compression methods. Finally we discuss a fingerprint compression algorithm based on sparse representation. After the image enhancement, we are constructing a dictionary for predefined fingerprint image patches. For a given whole fingerprint, divide it into small blocks called patches. Use the method of sparse representation to obtain the coefficients then, quantize the coefficients and last, encode the coefficients. Three groups of fingerprint images are tested. The experiments demonstrate that our algorithm is efficient compared with several competing compression techniques. The main feature used to match two fingerprint images are minutiae. Therefore, the difference of the minutiae between pre and post compression is considered.

Keywords: Fingerprint, Compression, Sparse Representation, JPEG 2000, JPEG, WSQ, PSNR.

I. INTRODUCTION

Fingerprints have been used for over a century and are the most widely used form of biometric identification. Fingerprint identification is commonly employed in forensic science to support criminal investigations, and in biometric systems such as civilian and commercial identification devices. Fingerprint identification methods are widely used by police agencies and custom house to identify criminals or transit passengers since the late nineteenth century. ISO standardized the characteristics of the fingerprint files in 2004. However, with tens of thousands of persons being added into the repositories daily, the management of these data becomes a critical issue. Developing fine and delicate methods for fingerprint compression is necessary to both reduce the memory storage and identification time. Among many efforts, the compression technique is considered as one of the most effective solutions. The compression techniques make the database able to store more reference fingerprints, and also help to extract the effective features in improving the accuracy of fingerprint recognition. Because the fingerprint images are frequently sent between law agencies through internet, efficiently compressing the data before transmission is also desirable and necessary. There are many image compression techniques available. JPEG, JPEG 2000, Wavelet Scalar Quantization (WSQ) are the existing image compression techniques. The JPEG, JPEG 2000 methods are for general image compression. WSQ [9] is the commonly used fingerprint compression algorithm. Inspired by the WSQ algorithm, a few wavelet packet based fingerprint compression schemes have been developed. In addition to WSQ, there are other algorithms for fingerprint compression, such as Contourlet Transform. The fingerprint images are rarely of perfect quality. They may be degraded and corrupted with elements of noise due to many factors including variations in skin and impression conditions. This degradation can result in a significant number of spurious minutiae being created and genuine minutiae being ignored. A critical step in studying the statistics of fingerprint minutiae is to reliably extract minutiae from fingerprint images. Thus, it is necessary to employ image enhancement techniques prior to minutiae extraction [16] to obtain a more reliable estimate of minutiae locations. The primary aim of this project is to implement a techniques for fingerprint image enhancement and minutiae extraction. After the image enhancement 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 and encode the coefficients and other related information using lossless coding methods.

II. EXISTED METHODS

In this section, we have a tendency to compare the projected technique with existing fingerprint compression...
algorithms like JPEG, JPEG-2000, WSQ, K-SVD etc. JPEG For the past few years, a joint ISO/CCITT committee referred to as JPEG (Joint Photographic Experts Group) has been operating to ascertain the primary international compression normal for continuous-tone still pictures. To satisfy the differing wants of the many applications, the JPEG normal includes two basic compression strategies i.e., a DCT-based technique is fixed for “lossy” compression, and a prognostic technique for “lossless” compression. JPEG has undertaken the bold task of developing a all-purpose compression normal to satisfy the requirements of virtually all continuous-tone still-image applications. The JPEG compression theme has several benefits like simplicity, catholicity and accessibility. However, it’s a foul performance at low bit-rates in the main as a result of the block-based DCT theme. For this reason, as early as 1995, the JPEG-committee began to develop a brand new wavelet-based compression normal for still pictures, specifically JPEG 2000. JPEG 2000 In 1996, the JPEG committee began to research potentialities for a brand new image compression normal to serve current and future applications. The need to produce a broad vary of options for varied applications in a very single compressed bit-stream prompted the JPEG committee in 1996 to research potentialities for a brand new compression normal that was named JPEG-2000. In JPEG 2000, DCT of JPEG is replaced with DWT (Discrete wavelet Transform)[3]. The DWT-based algorithms embody 3 steps: a DWT computation of the normalized image, division of the DWT coefficients and lossless coding of the quantized coefficients.

Compared with JPEG, JPEG 2000 provides several options that support ascendible and interactive access to large-sized image. It co-jointly permits extraction of various resolutions, constituent fidelities, regions of interest etc. WSQ The on top of algorithms are unit for general compression. Targeted at fingerprint pictures, there are a unit special compression algorithms. The foremost common is wavelet Scalar Quantization (WSQ). It became the Federal Bureau of Investigation normal for the compression of five hundred dpi fingerprint pictures. The WSQ category of encoders involves a decomposition of the fingerprint image into variety of sub bands, every of that represents info in a very explicit waveband. The sub band decomposition is achieved by a distinct wave transformation of the fingerprint image. Each of the sub bands is then quantal mistreatment values from a division table. The quantized coefficients are a unit then passed to a Huffman cryptography procedure that compresses the information. Huffman table specifications should be provided to the encoder. K-SVD K-SVD[9] (Single value decomposition) is associate in Nursing repetitious technique that alternates between thin cryptography of the examples supported the present wordbook, and a method of change the wordbook atoms to higher match the information. The update of the wordbook columns is combined with associate in Nursing update of the thin representations, thereby fast convergence. The K-SVD algorithmic rule is versatile and might work with any pursuit technique (e.g., basis pursuit, FOCUSS, or matching pursuit). We have a tendency to analyze this algorithmic rule and demonstrate its results on each artificial tests and in applications on real image information. The k-svd isn’t effective once the wordbook size is therefore giant. So a brand new compression normal supported thin approximation is introduced.

III. PROPOSED METHOD

The higher than algorithms have a standard disadvantage, i.e., while not the power of learning, the fingerprint pictures can’t be compressed well currently. So, a completely unique approach supported distributed illustration is given during this paper. The projected technique has the power by change the lexicon. The precise method is as follows: construct a base matrix whose columns represent options of the fingerprint pictures, referring the matrix lexicon whose columns area unit referred to as atoms; for a given whole fingerprint, divide it into tiny blocks referred to as patches whose variety of pixels area unit capable the dimension of the atoms; use the tactic of distributed illustration to get the coefficients; then, quantize the coefficients; last, inscribe the coefficients and different connected data mistreatment lossless secret writing ways. Given a replacement fingerprint, slice it into square patches that have identical size with the coaching patches. The scale of the patches incorporates a direct impact on the compression potency. The rule becomes a lot of economical because the size will increase.

![Fig1. Architectural diagram.](image)

Additionally, to create the patches work the lexicon higher, the mean of every patch has to be calculated and deducted from the patch. After that, cipher the distributed illustration for every patch by finding the l0 downside. Those coefficients whose absolute values area unit but a given threshold area unit treated as zero. For every patch, four types of data ought to be recorded. They’re the mean value, the amount regarding how many atoms to use, the coefficients and their locations. For rising rule, Use Orthogonal matching pursuit rather than Matching pursuit for constructing the lexicon. We can enhance the algorithm by using OMP (Orthogonal Matching Pursuit) algorithm instead of MP (Matching Pursuit) algorithm. In OMP dictionary atoms taken once never taken again; there
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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.

IV. IMAGE ENHANCEMENT

Fingerprint images are rarely of perfect quality. They may
be degraded and corrupted due to variations in skin and
impression conditions. Thus, image enhancement techniques
are employed prior to minutiae extraction to obtain a more
reliable estimation of minutiae locations. Enhancement
consists of the following stages. i) Normalization ii)
Segmentation iii) Orientation Estimation iv) Ridge Frequency
Estimation v) Gabor Filtering vi) Binarisation Normalization
is used to standardize the intensity values in an image by
adjusting the range of grey-level values so that it lies within a
desired range of values. Normalization does not change the
ridge structures in a fingerprint; it is performed to standardize
the dynamic levels of variation in grey-level values, which
facilitates the processing of subsequent image enhancement
stages. Segmentation is the process of separating the
foreground regions in the image from the background regions.
The foreground regions correspond to the clear fingerprint
area containing the ridges and valleys, which is the area of
interest. The background corresponds to the regions outside
the borders of the fingerprint area, which do not contain any
valid fingerprint information. When minutiae extraction
algorithms are applied to the background regions of an image,
it results in the extraction of noisy and false minutiae. Thus,
segmentation is employed to discard these background
regions, which facilitates the reliable extraction of minutiae.

In a fingerprint image, the background regions generally
exhibit a very low grey-scale variance value, whereas the
foreground regions have a very high variance. Hence, a
method based on variance thresholding can be used to
perform the segmentation. Firstly, the image is divided into
blocks and the grey-scale variance is calculated for each block
in the image. If the variance is less than the global threshold,
then the block is assigned to be a background region,
otherwise it is assigned to be part of the foreground. The
orientation field of a fingerprint image defines the local
orientation of the ridges contained in the fingerprint. The
orientation estimation is a fundamental step in the
enhancement process as the subsequent Gabor filtering stage
relies on the local orientation in order to effectively enhance
the fingerprint image. The least mean square estimation
method is used to compute the orientation image. In addition
to the orientation image, another important parameter that is
used in the construction of the Gabor filter is the local ridge
frequency. The frequency image represents the local
frequency of the ridges in a fingerprint. The first step in the
frequency estimation stage is to divide the image into blocks.
The next step is to project the grey-level values of all the
pixels located inside each block along a direction orthogonal
to the local ridge orientation. This projection forms an almost
sinusoidal shape wave with the local minimum points

Fig.2. The orientation of a ridge pixel in a fingerprint.

Once the ridge orientation and ridge frequency information
has been determined, these parameters are used to construct
the even symmetric Gabor filter. A two dimensional Gabor
filter consists of a sinusoidal plane wave of a particular
orientation and frequency, modulated by a Gaussian envelope.
Gabor filters are employed because they have frequency-
selective and orientation-selective properties. These
properties allow the filter to be tuned to give maximal
response to ridges at a specific orientation and frequency in
the fingerprint image. Therefore, a properly tuned Gabor filter
can be used to effectively preserve the ridge structures while
reducing noise. The Gabor filter is applied to the fingerprint
image by spatially convolving the image with the filter.

V. METHODS OF IMAGE COMPRESSION

A. JPEG

JPEG is an image compression standard developed by the
Joint Photographic Experts Group. It was formally accepted
as an international standard in 1992. JPEG is a lossy image
compression method. Transform coding method used in JPEG
is DCT. The JPEG encoder consists of the following main
steps:

- Transform RGB to YCbCr and subsample color.
- Perform DCT on image blocks.
- Apply Quantization.
- Perform Zigzag ordering and run-length encoding.
- Perform Entropy coding.

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

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. In JPEG 2000, DCT of
JPEG is replaced with DWT. JPEG 2000 is able to handle up
to 256 channels of information, whereas the current JPEG
The above algorithms are for general image compression. Targeted at fingerprint images, there are special compression algorithms. The most common is 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 DWT 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.

VI. EXPERIMENTS

In this section, the consequences of various dictionaries on fingerprint compression is studied. There are three strategies to build the dictionary. Here, the primary is to every which way choose some patches and organize them as columns of the dictionary referred to as Random-SR[8]. The second is to pick out patches in keeping with orientations referred to as Orientation-SR. See Fig, they're one hundred patches with orientation forty five and size 20×20. The third is to coach the dictionary by K-SVD method(K-SVD-SR in short). In this section, we tend to compare the projected technique with existing fingerprint compression algorithms. We tend to use 3 different compression algorithms, JPEG,JPEG 2000 and WSQ, that are extensively delineated before. The quality JPEG could be a a part of virtually any image process tool we tend to don't offer more reference on that. The wavelet-based JPEG 2000 we tend to use is provided by the Matlab. The WSQ rule is provided by a software system downloaded on the web. There square measure two teams of fingerprint pictures (referred to as info 1& info 2) square measure tested within the experiments. DATABASE 1: fifty fingerprints that square measure wanted to number compression technologies. DATABASE 2: the general public fingerprint info, together with eighty fingerprints with size three hundred × three hundred, that square measure wanted to compare existing compression technology. Here KSVD-SR(K-means single worth Decomposition exploitation distributed Representation)have high PSNR worth at compression magnitude relation 20:1. The figure shows that the distributed rule outperforms the JPEG 2000 rule once the compression ratios square measure high.

A. The Feasibility of Fingerprint Compression Based on Sparse Representation

In this part, we show the patches of fingerprints really have a sparse representation. See Fig. 4(a), 4(b) and 4(c), there are only a few large coefficients, while other coefficients are approximately equal to zero. More amazedly, there is only one large coefficient for many patches, an example shown in Fig. 3. In some special cases, there is no coefficient for some patches, for example, most of the patches from the background of the fingerprint images in DATABASE 1, DATABASE 2 and DATABASE 3. It is good enough to represent these patches using their mean values. These experiments show that the patches can be represented as a linear combination of few columns. The fact makes the proposed fingerprint compression method feasible.

B. Experimental Results on Different Dictionaries

In this section, the effects of different dictionaries on fingerprint compression is studied. As we say in the previous section, there are three different ways to construct the dictionaries. Here, the first is to randomly select 4096 patches and arrange them as columns of the dictionary (Random-SR in short). The second is to select patches according to orientations (Orientation-SR in short). In the experiments, there are 8 orientations. See Fig. 5, they are 100 patches with orientation 450 and size 20×20. The third is to train the dictionary by K-SVD method (K-SVD-SR in short). In the experiment, the test set is DATABASE 2 and the training set is DATABASE 1. The size of dictionary is 144×4096. For grey-level 8-bits per pixel images, the PSNR is computed as
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\[
\text{PSNR}(I, I') = 10 \log_{10} \left( \frac{255^2}{\text{MSE}(I, I')} \right) \quad (\text{dB})
\]

With Mean Square Error (MSE) defined as

\[
\text{MSE}(I, I') = \frac{1}{M \times N} \sum_{i=1}^{N} \sum_{j=1}^{M} (I(i, j) - I'(i, j))^2
\]

where \( M' \) and \( N' \) are the lengths of fingerprint, \( I \) and \( I' \) are the intensities of the original and reconstructed images.

The horizontal axis in Fig. 6 represents the percentage of selected coefficients for each patch and the vertical axis represents the mean values of the PSNR. If the number of the selected coefficients corresponding to the given percentage is not an integer, round it to the nearest integer. The same treatment is adopted in the following experiments. These results show that the K-SVD-SR outperforms two other methods. An additional experiment shows the performance of the K-SVD-SR under the dictionary with 144 × 4096 is still better than that of a dictionary obtained by directly arranging all the patches (26843 patches). The mean values of the PSNR under the dictionary with 144 × 26843 are 21.25dB, 27.75dB, 29.71dB and 30.95dB at 1, 4, 7 and 10 percent of coefficients, respectively. It is concluded that proper training method is necessary and how to construct the dictionary is important. Fig.6 also shows the Orientation-SR almost has the same performance as the Random-SR. Without the process of training, whether the patches are elaborately chosen makes little difference. In the following experiments, the dictionary is constructed in the third way.

VII. CONCLUSION

The different compression techniques custom-made to compress the fingerprint image is reviewed and compared their Performance particularly at high compression ratios. A replacement compression algorithmic program supported sparse approximation is additionally introduced. Two teams of fingerprint pictures are a unit tested. The experiments show that sparse algorithmic program is economical than competitive compression techniques like JPEG, JPEG 2000, WSQ, K-SVD etc, particularly at high compression magnitude relation and may hold most of the trivia robustly throughout the compression and reconstruction. However, the algorithmic program has higher complexities owing to the block-by-block process mechanism. optimisation of code of the various compression techniques needs to be improved to scale back the complexity.

VIII. REFERENCES


Author’s Profile:

Madanapalli Trivenu received B.Tech Degree in Electronics & Communication Engineering from Dr.SGIET Engg College, Markapur in 2013. Currently he is pursuing M.Tech at Dr.SGIET Engg College, Markapur. His research interests
include Fingerprint Compression Based on Sparse Representation.

M.V. Narasimha Reddy M.Tech working as a Assistant Professor in the Department of ECE from last 6 years, Dr.SGIET College, Markapur. He research interests include Fingerprint Compression Based on Sparse Representation.

P. Prasanna Murali Krishna M.Tech (Ph.D) working as an Associate Professor in the Department of ECE from last 13 years, Dr.SGIET College, Markapur. He research interests include Fingerprint Compression Based on Sparse Representation.