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Research Paper

IMPLEMENTATION OF HIGH EFFICIENT COMPRESSION METHOD FOR FINGERPRINT IMAGES

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In all the modern security systems biometric plays an important role. Among the existing biometric methods, fingerprint recognition is easiest and low cost method. The storing of the captured fingerprint images is the main problem. Wavelet Scalar Quantization (WSQ) is the first technique proposed to compress fingerprint images and it provides only low values of compression ratio and also low quality of the compressed image. This paper proposed a unique method called sparse representation to provide better compression ratio and better quality of the compressed image than WSQ technique. In the proposed method, the dictionary is constructed for the predefined fingerprint image patches and are determined by l^1-minimization. These dictionary patches are quantize, encoded and are used for the calculation of patches of new fingerprint images. The pre and post compression factor provides the difference between patches. The performance of the proposed method is evaluated by the computation of PSNR and AFIS. The proposed method is gives better compression ratio and better quality than the existing WSQ method. This method is mainly used for the high quality compression ratio of the fingerprint images.

Keywords: Biometrics, Compression techniques, AFIS, WSQ

INTRODUCTION

Authentication of members by use of biometric characteristics is a vital technique in the society. Among different biometric techniques, fingerprints has an incredibly nature to identify the persons. This technique has many features like individuality, generality, collectability and invariance (Maltoni *et al.*, 2009). In every day of our life, fingerprints have number of applications, which are access management and forensics, etc. In 1995, the Federal Bureau of Investigation (FBI) collected over three hundred million fingerprints with reasonable size. This was slowly increased from 35000 to 50000 new patches per day. This

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information needs more memory to store. A key technique is used to unravel the matter.

Basically, compression technique is classified into lossy and lossless compression models. Lossless compression technique is widely used in comparison of the input and output of any system. The lossless compression model is usually utilized within the output factors of lossy compression. Lossy compression technology typically reworks a picture into the domains. In last three decades, mostly two techniques are fallowed. Those are Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) (Natarajan, 1974; and Gopinath, 1998).

In DCT technique, the encoder compresses the data stream of 8x8 blocks of pictures. This is adopted by a JPEG (Mitchell, 1993). The JPEG has simplicity, availability and universality. However, this technique has a defect for the low bit rates for the basic block by block based algorithm. This problem can be solved by introducing the DWT method. This technique involves three basic steps to avoid the drawback of the JPEG. They are normalization of picture, division of the coefficient factors and lossless cryptography of quantity coefficient (Gormish, 2000; and Christopoulos, 2001). JPEG2000 compression technique has several futures, which are resolution of picture, picture element fidelity, and support to large size picture, region of interest and etc. compared to JPEG compression. The above algorithms are used for the general compressions but the target is to compress fingerprint pictures most effectively.

In last few decades, this problem is solved by a WSQ method (Brislawn, 1993; and Bradley, 1996). This technique is used for picture resolution, areas of interest regions and etc. DWT has several algorithm techniques, like SetPartitioning In Hierarchical Trees (SPIHT) algorithm (Pearlman, 1996). In case of fingerprint compression, a new technique is needed for the good compression factors. Basically WSQ gives 500 dpi for the fingerprint picture. This can be implemented by using new patches, where the new patches are added to WSQ to construct a new technique called as a Countourlet Transform (CT) (Karthiga, 2006). The CT algorithm has a standard algorithm. The main disadvantage of this is that the power factor cannot be evaluated.

As a part of the proposed algorithm, the base matrix, which is called as dictionary, is created first. In that matrix, columns represent features of fingerprint pictures. Thesecolumns are known as atoms. In this case, required fingerprint image can be divided into very small blocks called as a patch, where the number of pixels is equal to the size of the atom. This method is used for obtaining the coefficient factors and quantized factors to get encoding factors.

The compression performance can be evaluated by the computation of PSNR and Automatic Fingerprint identification System (AFIS). A minutia is the main feature in AFIS and this feature is used for matching two fingerprint images by considering the difference of minutiae in between pre and post compression.

PROPOSED METHOD

This section gives the details of compression of fingerprint images by using sparse method.

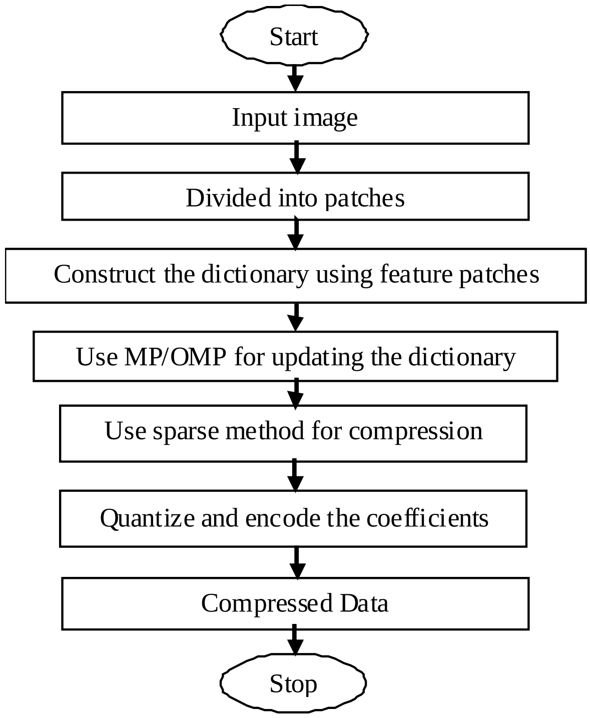
This method consists construction of the dictionary, compression of the given fingerprint, and then quantization and coding analysis of the algorithm complexity

Generally, if the available information is as much as possible, then the dictionary size will be increased to great extent. Therefore, in order to get a dictionary with small size, the preprocessing is essential. The fingerprint of same finger is influenced by the factors, which are rotation, transformation and noise. Initially every fingerprint is pre-aligned without the knowledge of others independently. This pre-alignment, which are translation and rotation, mainly depends on position of the core point. Usually, it is very difficult to detect core of the fingerprint image with low quality. Even though the core is identified correctly the dictionary size is huge because the fingerprint image size is so large.

The structure of fingerprint images, which are composed of valleys and ridges, is simple compared with natural image. In local areas, they look like same. Therefore, in order to solve these two issues, the entire image is sliced into squared and non-overlapping small patches. The problem of rotation and transformation is, therefore, avoided. So, the size of the dictionary is reduced because the small blocks relatively smaller.

The process of sparse representation technique is explained by the flow chart shown in Figure 1.

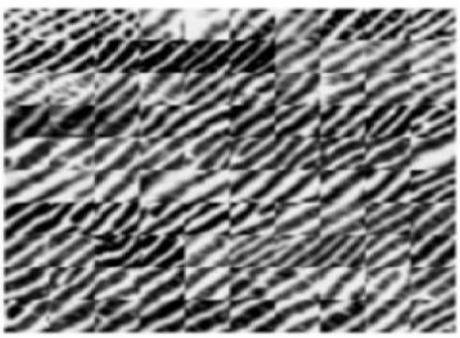
Figure 1: Architecture Diagram of Sparse Representation



Dividing into Patches

The fingerprint image is sliced into patches in square form having the size similar to the training patches. The compression efficiency is dependent on the size of the patches used in the technique. If the size of the patches increases then the algorithm will be more efficient. The mean of the single patch is calculated by making the dictionary better. The sparse method is computed for each patch by evaluating l0mitigation problem. Example for the patches in the fingerprint image is shown in Figure 2.

Figure 2: Sample of 100 Patches with 20*20



Construct the Matrix Using Features of Patches

To construct the matrix from the patches one needs number of images per subject for efficient functioning of the sparse recognition method. The basic thing here is to find the resemblance in facial regions from training sample images. These resemblance regions are used in constructing the matrix-A.

MP Algorithm

MP method helps in comparing the new images with already stored images. If the comparison of the image is affirmative, the new image is stored else the image is used in identifying the individual. For more efficiency another method is proposed named as Orthogonal Matching Pursuit (OMP). The complexity of the OMP is reduced by redundancy of the dictionary atoms. MP method is used to solve the main problem of l^0 minimization.

The steps included in this technique are:

- DC components are quantized, compressed separately. DPCM and Huffman coding methods are used in this method as JPEG does.
- Coefficient based sparse matrix denoted by W is found based on trained dictionary using OMP.
- The real values in the sparse coefficients are rounded off to nearest integer values.
- The position data and the non-zero values of W are categorized into 2 steps. The position values are coded with DPCM and the other by run-length coding and end of block coding. These two are coded with recursive splitting Huffman method.

Sparse Representation

This representation is classified into three sections, which are sparse representation model, greedy algorithm and l^1 minimization.

The Sparse Representation Model: Construct a matrix A = [a1, a2, ..., an] ∈ $R^{M\times N}$, any new sample y ∈ $R^{M\times 1}$ to represent a linear combination of columns from the matrix A, i.e., dictionary. The dictionary is created using Equation (1).

$$y = Ax \quad ...(1)$$

$where\ y \in R^{M\,X\,1}, A \in R^{M\,X\,N}$ and

$$x = [x_1, x_2, x_{3,\ldots\ldots\ldots} x_N]^T$$

In Equation (1), M and N are unknown and are not distinctive. Consistent with the idea, the illustration is thin. For this assumptions, the sparse representation by minimization of the l^0 factor and is given by

$$(l^0): min\ \|x\|_0 \quad s.t. Ax = y \quad ...(2)$$

The Sparse Model by Greedy Algorithm: This algorithm solves l^0 issues straightly. NP-hard method has problem to solve the sparest solution. In order to solve this issue MP method is introduced. This algorithm is ease and effective. The experiment results of this method shows that none zero elements are less.

Sparse Model Solution for l^1-Minimization: The problem raised in above algorithm can be solved by Equation (3).

$$(l^p): \quad min\|x\|_p^p \quad s.t. Ax = y \quad ...(3)$$

In Equation (3), p is nearer to the Equation (2) improvement issues l^0 and l^p. Where p is very small then magnitude of x is not considered. They are analyzed x whether zero or not. Therefore, the value of p is taken as small. However, the drawback (3) isn't rounded as $0 < p < 1$. The consideration of unique for $p = 1$. They get a problems are.

$$(l^1): \ min\|x\|_1 \quad s.t. \quad Ax = y \qquad ...(4)$$

The Equation (4) represents implication of the sparse compression technique. The results of the sparse method are effective when the above three algorithms are included in this method; there by the issues found in Equations (2) and (4) are solved.

Quantization and Coefficients Encoding

The arithmetic coder is used to evaluate number of atoms, mean of the patch, indexes and coefficients. The mean value is coded variously. Coefficients are quantized by use of Lloyd algorithm. The MP algorithm is used to learn the offline coefficients of the training set. The number of coefficients' for each block is produced while quantization. The sample is encoded by using various arithmetic coders. The offline coefficients are obtained from the index of the training set. In this coding, the same arithmetic coders are used throughout process. The primary coefficients produce 6 bits each time and next coefficients produce only 4 bits. Absolute value is taken as zero when the coefficient value is less than threshold level.

Compression Data

The original fingerprint image is divided into small patches and approximated with diagonals, rows and columns as shown in Figure 4. This approximation is helpful for compressing the image with good quality. These patches are reconstructed by using the same method of approximation of the image, where the image has an efficient quality, PSNR ratio and good compression ratio.

Figure 3: Behavior of for Various Values of Pas p Tends to Zero

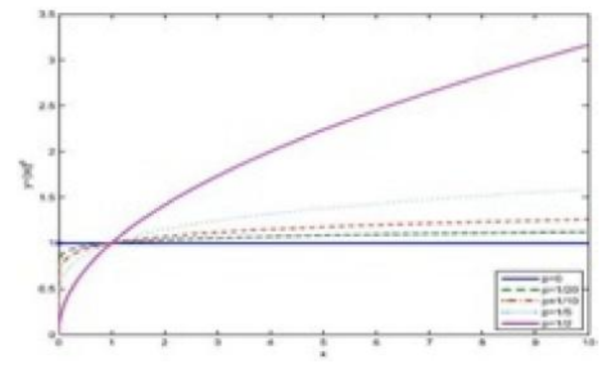
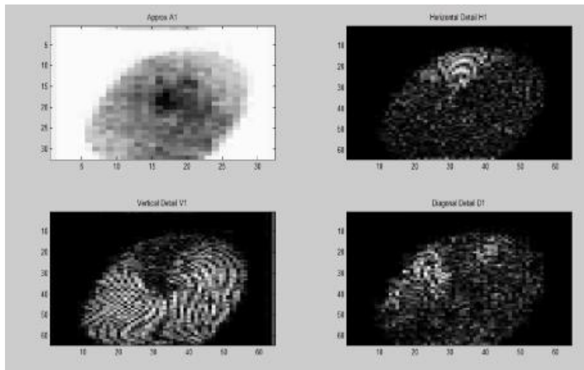


Figure 4: Approximation Image



Analysis of the Algorithm Complexity

This algorithm consists of training process and compression process. The difficulty present in compression process is analyzed because the training process is offline. For example the patch size is m x n then the number patches in dictionary is N. Every block is coded with L coefficients; where L is average number of non-zero elements in the coefficient vectors. In order to represent each patch with respect to the dictionary, every iteration of MP algorithm consists mnN scalar products. LmnN represents total number of scalar multiplication of each patch. The size of fingerprint image is M_1XN_1 pixels. The number of the patches of the fingerprint image is approximately equal to $M_1xN_1/(mxn)$. Therefore, the total number of scalar multination for compressing a fingerprint image is $[M_1xN_1/(mxn)]X$ LmnN namely, LM_1N_1N.

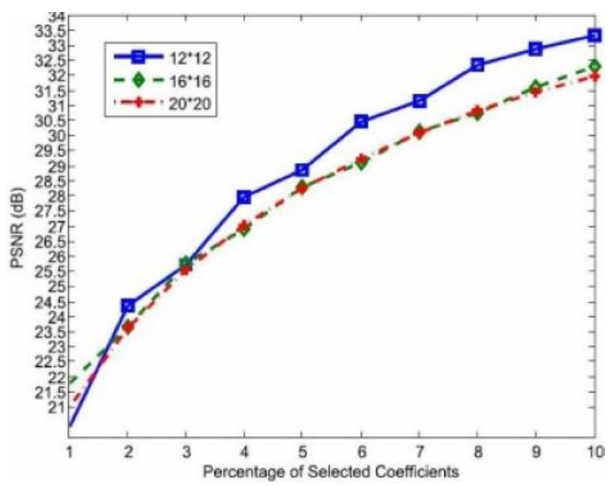
EXPERIMENTAL RESULTS

In this section, the proposed method is compared with the WSQ method and hence proved, the proposed method is effective or not. The Table 1 shows the different factors about the same fingerprint. Not only that, the same image is calculated with the different sizes as shown in Figure 5, where it is clear that, the 12x12 image has a highest PSNR ratio. The basic compression dimension 8x8 is not taken because of the small size. These images are taken from the FBI samples.

Table 1: Comparison of WSQ and SPARSE with Different Factors

Method	Quality Factor in %	Compression Ratio in %	PSNR
WSQ	72	2.6958	29.9136
SPARSE	99	94.83	18.77

Figure 5: Different Compression Sizes



The compression ratio using the DWT technique is achieved about 90 to 98 and sparse method gives in least case 95 and maximum of 100% compression ratio. The Figure 6 shows the compression ratio values for both DWT and sparse method with respect to pixels.

The Figure 7 shows the compression of image size with respect to pixels of both row and column wise by using sparse method. Column pixels are compressed when the size of the column is greater than 30 pixels. Then automatically row pixels are also degraded to half of its original value.

Figure 6: Compression Ratio of the DWT and SPARSE

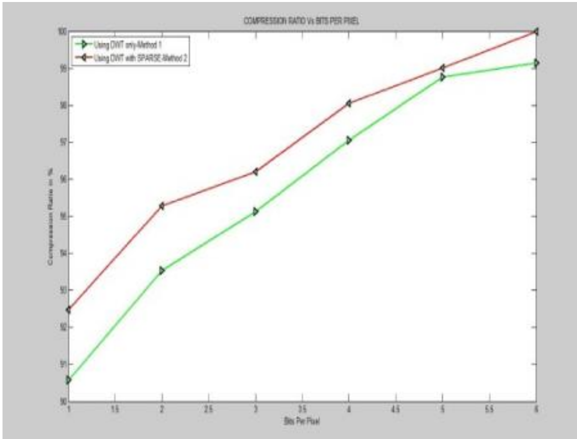
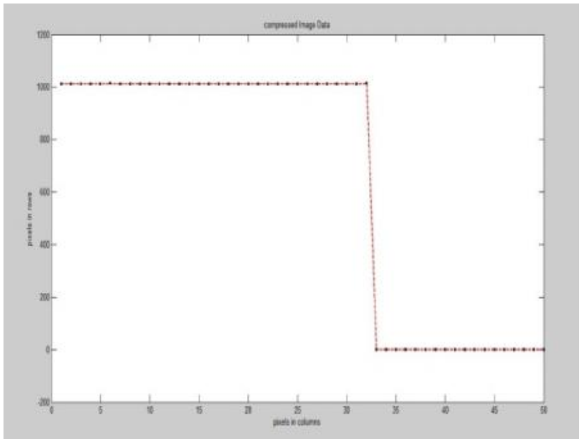


Figure 7: Compression of the Image Data by Sparse



In case of sparse method the compression of the image is 94.83 and PSNR is 18.77 and is shown in Figure 8. The required fingerprint patch can be compressed to approximately 95%. So image is better compressed.

The quality factor of the image can be calculated by the pixels quality with the bit per pixel. The Figure 9 shows the quality factor values of DWT versus sparse. The quality of the DWT has the maximum of 90% but in the case of sparse method, the quality is minimum 90 and maximim 95 Percentage.

Figure 8: PSNR Ratio of the Given Fingerprint

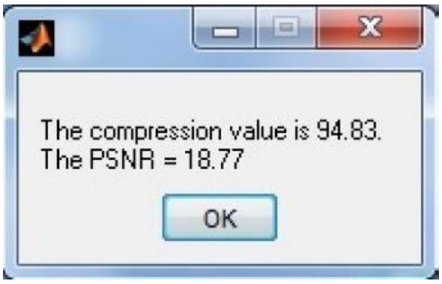
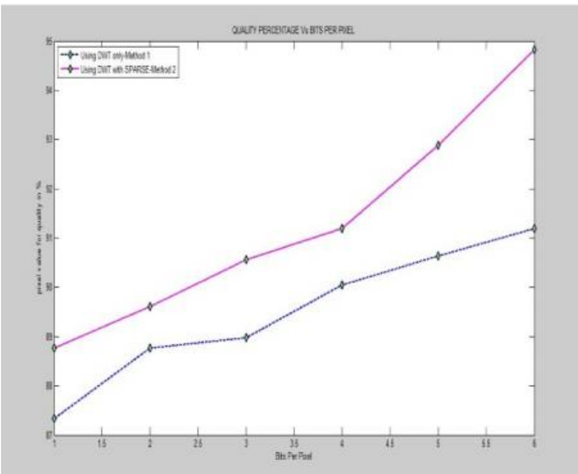


Figure 9: Quality Factor of the DWT and SPARSE



The main feature of most AFIS is minutiae, which is used to match to fingerprint images. By comparing the difference of minutiae between pre and post compression the robustness of the proposed method is explained. Based on recall rate, accuracy rate and their sum, the robustness of proposed algorithm is measured.

The recall rate: RR = Num 1/Num

The accuracy rate: AR = Num 1/Num[1]

The total rate: Total = AR + RR

CONCLUSION

The proposed sparse method is explored and performed on different fingerprint images. In spite of less complexity in our proposed structure, it compresses very effectively compared to existing methods. Moreover at higher compression ratio, better quality of fingerprint images are obtained compared to WSQ method. Not only that, the reconstruction of the compressed image is very simple. The step by step process is introduced to reduce the complexity of the coefficients by using MP algorithm. The different fingerprints are tested and recognized very easily in this method. It is very help to maintain databases. Different compression sizes of the fingerprint can be calculated for good PSNR ratio like 12x12, 16x16 and 20x20. Among these three sizes of the fingerprint a good PSNR is obtained at 12x12 only.

REFERENCES

1. Bradley J N (1996), "FBI Compression Standard for Digitized Fingerprint Images", in Proceedings of SPIE Denver, CO, Vol. 2847, August, pp. 344-355.
2. Brislawn C (1993), "WSQ Gray Scale Fingerprint Image Compression

Specification", Federal Bureau of Investigation, February.

3. Christopoulos C (2001), "The JPEG 2000 Still Image Compression Standard", IEEE Signal Processing, September.

4. Gopinath R A (1998), *Introduction to Wavelets and Wavelet Transforms: A Primer*, 1st Edition, Printice Hall Inc.

5. Gormish M J (2000), "An Overview of JPEG-2000", in Proceedings of IEEE Data Compression Conference, March, pp. 523-541.

6. Karthiga R (2006), "Fingerprint Compression Using Contourlet Transform with Modified SPIHT Algorithm", *Iranian Journal of Electrical and Computer Engineering*, Vol. 5, No. 1, Winter-Spring.

7. Maltoni D, Maio D, Jain A and Prabhakar S (2009), *Handbook of Fingerprint Recognition*, 2nd Edition, Springer-Verlag, London.

8. Mitchell J (1993), "JPEG-Still Image Compression Standard", Van Nostrand Reinhold, New York.

9. Natarajan T (1974), "Discrete Cosine Transform", *IEEE Transactions on Computers*, Vol. C-23, No. 1, pp. 90-93.

10. Pearlman W A (1996), "A New Fast and Efficient Image Codec Based on Set Partitioning in Hierarchical Trees", *IEEE Transactions on Circuits, and Systems for Video Technology*, Vol. 6, June, pp. 1-16.