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A Survey on Fingerprint Compression techniques

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Abstract— Fingerprint recognition is commonly used for personal identification due to its uniqueness .A considerably large amount of fingerprints are collected and stored on a daily basis in a wide range of applications,including forensics and access control.Large amount of such data would consume large amount of memory.The solution for this problem is fingerprint compression.Already there are general image compression techniques like JPEG, JPEG 2000 etc:.Special compression algorithms targeted at fingerprints like Wavelet Scalar Quantization (WSQ) , Contourlet Transform (CT) etc: are mainly used for fingerprint compression.Recently fingerprint compression based on sparse representation has been introduced. This method works efficiently when compared to compression technologies like JPEG, JPEG 2000, WSQ at high compression ratios.

Index Terms— *Fingerprint, compression, sparse representation, JPEG 2000, JPEG, WSQ, PSNR.*

1 Introduction

Using Biometric characteristics for Recognition of persons is an important technology in the Society, as it can't be shared and they represent the individual's unique identity. Fingerprint recognition is very popular for personal identification among the many Biometric recognition technologies, due to the uniqueness, universality, collectability and invariance. Fingerprints which amount to large volume are collected and stored every day in a wide range of applications like the kind of forensics and access control. In 1995, the size of the FBI Fingerprint card archive was increasing at a very fast rate. When there is large volume of data it consumes large amount of memory. The key technique to solve the problems is finger print image compression .

2. COMPRESSION TECHNOLOGIES:

To reconstruct the exact original images from the compressed data we go for Lossless compression.Used in cases where it is important that the initial and decomposed data are identical like file transfer. Avoiding distortion restricts their compression efficiency,while being used in image compression slight distortion is acceptable. Lossless compression techniques are often applied in the output coefficients of Lossy compression.Here in Lossy compression, it transforms an image into another domain, quantize and encode its coefficients.Here, some data is lost, for example in the case of video transfer.

2.1 Transform based compression technologies

Discrete Cosine Transform (DCT) :The DCT-based encoder can be thought of as compression of a stream of 8×8 small block of images .This transform has been adopted in JPEG.JPEG has advantages such as simplicity, universality and availability .It shows bad performance at low bit-rates mainly because of the underlying block-based DCT scheme.
Discrete Wavelet Transform (DWT) **:**new wavelet-based compression standard for still images, namely JPEG 2000.The DWT-based algorithms include three steps: 1)a DWT computation of the normalized image 2)quantization of the DWT coefficients 3)lossless coding of the quantized coefficients . JPEG 2000 is wavelet based

3. SPECIAL COMPRESSION ALGORITHM:

The algorithms mentioned above are for general image compression. Targeted at fingerprint images, there are some special compression algorithms. The most common is Wavelet Scalar Quantization (WSQ) . It became the FBI standard for the compression of 500dpi fingerprintimages.In addition to WSQ, there are other algorithms for fingerprint compression, such as Contourlet Transform (CT) .Disadvantage is that these algorithms have a common shortcoming, namely, without the ability of learning. The fingerprint images can't be compressed well now.

Now,we'll see the various compression techniques in detail:

3.1 JPEG:

Here in [1], its described that the DCT-based JPEG compression is a lossy compression method. There are 3 different kinds of errors in the compression and decompression procedure. The quantization error, which exists in the compression process.The main steps of JPEG compression and decompression process are shown in Figs. 1 and 2, respectively. A colour image can be approximately considered as multiple grayscale images. Without loss of generality, we suppose that the pixel values of the image in the spatial domain are represented by the integral numbers in the range [0-255]. After applying inverse DCT (IDCT) to the dequantized JPEG coefficients, the obtained float numbers need to belong to the region[0,255] in spatial domain. In order to reconstruct the image data, the values that do not belong to [0,255] would be truncated to 0 or 255, respectively. The disadvantage of this method is the bad performance at low bit-rates mainly because of the underlying block-based DCT scheme.

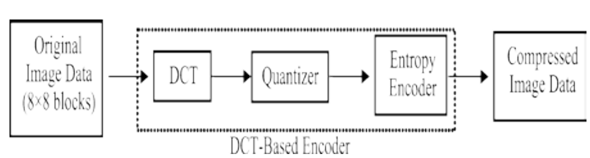

Fig 1. DCT based encoder

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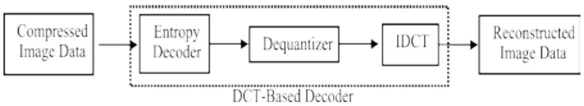


Fig 2. DCT based decoder

3.2 JPEG 2000

Here in [2], it is described that, goal of this method is to avoid the need for different compression standards for lossless and lossy compression.
ARCHITECTURE:

Component Transform**:** The component transform provides decorrelation among image components (R, G, B). This improves the compression and allows for visually relevant quantization

Wavelet Transform: Two wavelet transforms possible in the standard.Both transforms provide lower resolution images and spatial decorrelation of the images to enhance compression.The 9x7 filter produces the highest compression, **5x3** filter yields lower complexity and grants lossless compression.

Quantization : The trade-off between rate and distortion is acquired by quantization.Wavelet coefficients can be divided by a different value for each subband. Alternatively, portions of the coded data can be eliminated (decreasing rate and quality).

Context Model: This splits the bits of the quantized wavelet coefficients into groups with similar statistics so the arithmetic coder can productively compress them. Each bit plane of a coefficient is processed by one of three coding passes as narrated in Fig 3**.**

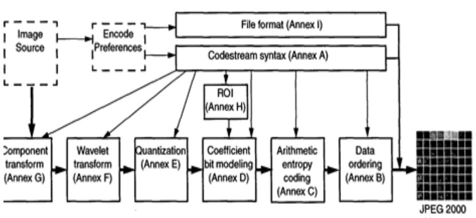


Fig 3 JPEG 2000

Arithmetic coder :JPEG 2000 uses the MQ binary arithmetic coder to provide lossless compression of each coding pass of quantized wavelet coefficients.
Bitstream Ordering: Portions of coded data (output coming from the arithmetic coder)are collected into packets. These packets have a compressed header.While the codestream syntax permits data to be accessed in almost any order, there must be some order to the data.Various orders are possible to permit progression by resolution, or quality, or location, or some combination of these.

3.3 WSQ

Here in [3] an overview of WSQ is given. Wsq consists of 2 parts encoding and decoding: 1)Wavelet decomposition of the initial fingerprint image 2)Quantization of wavelet coefficients 3)Loseless entropy encoding of the output of quantization. Decoding is the inverse of encoding.The quantization step has great impact on the quality of compressed images.Compression ratio around 20:1.Disadvantage:here in paper[4] ,the disadvantages are described.They are: 1)Wsq cannot control the compression ratio.2)Its performance on fuzzy images is poor.

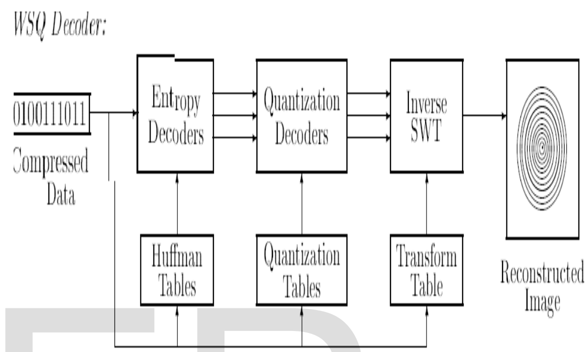
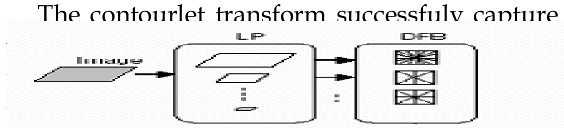


Fig 4 WSQ Decoder

3.4 CONTOURLET TRANSFORM

Here in [5] this is briefly described.The wavelet transform (WT) has shown its high capability to compress natural images that have smooth regions with definite boundaries .This type of transform, on the other hand, is not very useful with contours. Textured images are not suitable for application of wavelet. Due to the mentioned shortcomings of the wavelet transform other transforms are proposed such as bandelet, curvelet , and contourlet . The contourlet transform (CT) , is a geometric transform which preserve features such as contours and textures. Two main parts of the contourlet transform are Laplacian pyramid (LP) and directional filter bank (DFB). This transform has a redundancy ratio of less than 4/3 . In NLA algorithms after performing an orthogonal transform of the image, ͵m larger coefficients are stored and the rest of the coefficients are eliminated. The reconstructed image will be an approximation of the original one and is formed using the M stored coefficients.

The contourlet transform successfuly capture smooth con- ... ges. In con- ... dissolving ... filter banks analyze each detail image as illustrated in Fig 5.



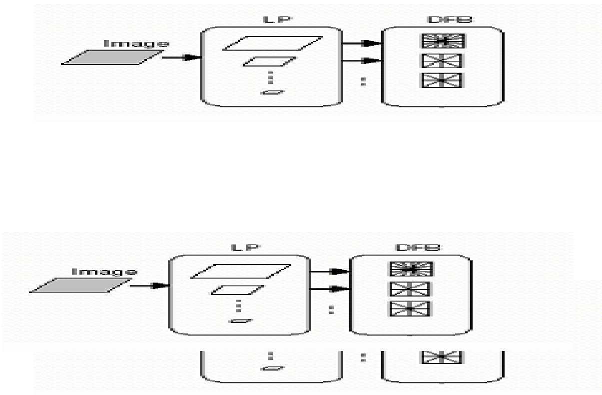


Fig 5 A flowgraph of the contourlet transform

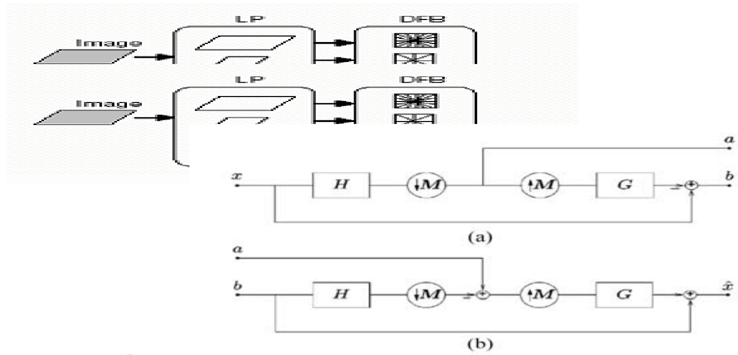


Fig 7 Laplacian pyramid scheme (a) analysis, and (b)reconstruction

Double filter bank structure in Fig 6, in which at first the Laplacian pyramid (LP) is used to secure the point discontinuities, and followed by a directional filter bank (DFB) to link point discontinuities into linear structures .The overall result is an image expansion with basis images as contour sectors, and thus it is named the contourlet transform. The combination of this double filter bank is named pyramidal directional filter bank (PDFB).

Directional Filter Bank

The directional filter bank is a critically sampled filter bank that can decompose images into any power of two's number of directions. The DFB is efficiently implemented via a *l*-level tree structured decomposition that leads to '2*l*' subbands with wedge-shaped frequency partition.

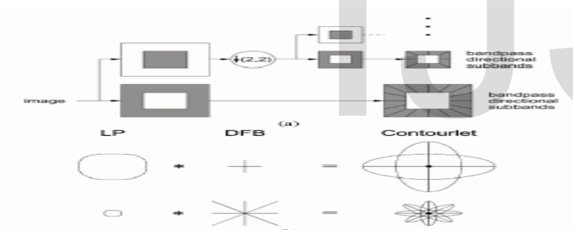
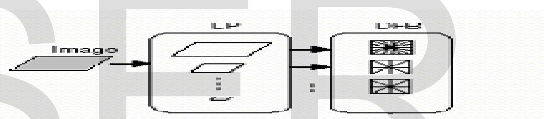


Fig. 6 (a) Block diagram of a PDFB, and (b) Supports for Contourlets

Laplacian Pyramid :

This achieves a multiscale decomposition .The LP decomposition at each level generates a down sampled low pass version of the original and the difference between the original and the prediction, resulting in a bandpass image as shown in Fig. 7(a). In this figure, 'H' and'G' are called analysis and synthesis filters and 'M' is the sampling matrix. The process can be repeated on the coarse version. In Fig. 7(a) the outputs are a coarse approximatio'a' and a difference 'b' between the initial signal and the prediction. The process can be iterated by decomposing the coarse version iteratively. In this figure, 'H' and'G' are called analysis and synthesis filters and 'M' is the sampling matrix. The process can be iterated on the coarse version. In Fig. 7(a) the outputs are a coarse approximation 'a' and a difference 'b' between the initial signal and the prediction. The process can be iterated by decomposing the coarse version repeatedly . Fig 7 (b) shows the reconstruction.



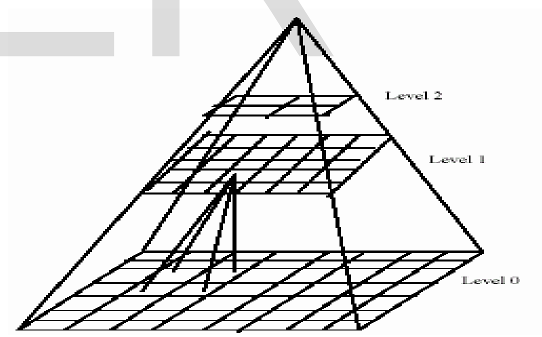


Fig 8 Laplacian pyramid structure

4 Fingerprint Compression Based on Sparse Representation

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 [6].

Here in [6], a method sparse representation is proposed for fingerprint compression.

A. Construction of the Dictionary

Dictionary will be constructed in 3 ways.The first method: choose fingerprint patches from the samples that are trained at random and arrange these patches as columns of the dictionary matrix. The second method: in generic, patches from foreground of a fingerprint have an position while the patches

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from the background don't have,this fact can be used to make a dictionary. Divide the interval [00, . . . , 1800] into equal-size intervals.Here each interval is represented by an position (the middle value of each interval is chosen).

B. Compression of a Given Fingerprint

The algorithm becomes more efficient as the size of patch increases. However, the complexity of computation and the size of the dictionary also increase rapidly to make the patches fit the dictionary better, the average of each patch needs to be calculated and subtracted from the patch.

C. Coding and Quantization

Entropy coding of the atom number of each patch, the average value of each patch, the coefficients and the indexes is carried out by static arithmetic coders . The quantization of coefficients is performed using the Lloyd algorithm.

D. Analysis of the Algorithm Complexity

The algorithm has two parts, namely, the training process and the compression process.Training process is off-line,so only the complexity of compression process is analyzed. Size of the patch is $m \times n$,number of patches in the dictionary is N, the total number of scalar multiplications for compressing a fingerprint image is($M1 \times N1/m \times n) \times LmnN$,namely, $LM1N1N$.

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) method.
4. Those co-efficient whose absolute value less than a threshold is treated as zero.
5. Record the remaining coefficient

5 Conclusion

Here, the different compression techniques adopted to compress the fingerprint image is reviewed. A new compression algorithm based on sparse representation is introduced. The experiments show that sparse algorithm is efficient than rival compression techniques like JPEG, JPEG 2000, WSQ,CT etc, especially at high compression ratio and can hold most of the minutiae powerfully during the compression phase and reconstruction phase. However, the algorithm has higher complexities due to the presence of block-by-block processing mechanism. Experiments show that block effect encountered is less serious than that of JPEG.Improvements can be made by thinking about optimization algorithms for solving the sparse representation.Optimization of code of different compression techniques has to be enhanced to reduce the complexity.

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