



IRIS IMAGE COMPRESSION USING DIFFERENT ALGORITHMS

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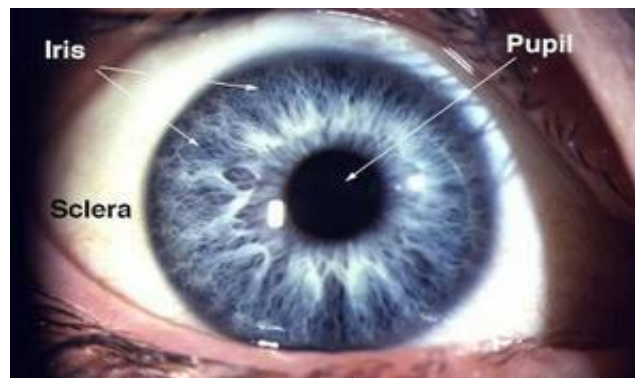
Abstract : With the increasing use of multimedia technologies, image compression requires higher performance as well as new features. Many compression standards are in place. But still there is a scope for high compression with quality reconstruction. One such application is Iris recognition, which is gaining popularity as the method of choice for biometric authentication in society today. This paper analyses three wavelet – based image compression schemes – SPIHT (Set Partition in Hierarchical Trees), Modified SPIHT and JPEG2000 and compares them on the basis of parameters like the compression ratio, signal to noise ratio and average bit rate.

I. INTRODUCTION

In a modern world, biometric recognition is a common and reliable way to authenticate the identity of the person. Biometric identification or verification of identity is currently a very active field of research and finds scope in many critical applications that require some degree of confidence concerning the personal identification of the people involved such as banking, computer network access or physical access to secure facility. A higher degree of confidence can be achieved by using unique physical characteristics to identify a person.

II. IRIS RECOGNITION

Iris recognition is an automated method of biometric identification that uses mathematical pattern-recognition techniques on video images of the irides of an individual's eyes, whose complex random patterns are unique and can be seen from some distance. The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye.



Iris has 400 identifying features and the probability of matching two different iris is $1: 10^{78}$ having a misidentification rate of $1/1200000$. Due to these properties of iris, it is the most powerful tool in biometrics. The various steps involved in an iris recognition system are - Iris Localization, Iris Normalization and Image Enhancement.

- **Localization-** Both the inner boundary and the outer boundary of a typical iris can be taken as circles. But the two circles are usually not co-centric. Compared with the other part of the eye, the pupil is much darker. We detect the inner boundary between the pupil and the iris. The outer boundary of the iris is more difficult to detect because of the low contrast between the two sides of the boundary. We detect the outer boundary by maximizing changes of the perimeter- normalized along the circle. The technique is found to be efficient and effective.
- **Normalization-** The size of the pupil may change due to the variation of the illumination and the associated elastic deformations in the iris texture may interface with the results of pattern matching. For the purpose of accurate texture analysis, it is necessary to compensate this deformation. Since both the inner and outer boundaries of the iris have been detected, it is easy to map the iris ring to a rectangular block of texture of

a fixed size.

- **Enhancement-** The original image has low contrast and may have non-uniform illumination caused by the position of the light source. These may impair the result of the texture analysis. We enhance the iris image reduce the effect of non-uniform illumination.

Commercial iris systems are used in such applications as access to secure facilities or other resources, even criminal / terrorist identification. The enrolment of an individual into a commercial iris system requires capturing one or more images from a video stream. Typically, the database for such system does not contain actual iris images, but rather it stores a binary file that represents each enrolled iris. A template called an IrisCode, is generated in such systems. The template is stored as 512 bytes per eye. Once the template is created, the iris image is discarded. These templates are relatively small compared to the size of the iris image from which they were created (307,200 bytes for a 640x480 grayscale image). This means that the speed with which they may be compared using a very large database has to be real fast, and the storage requirements of such a database is very high. This is where image compression becomes critical.

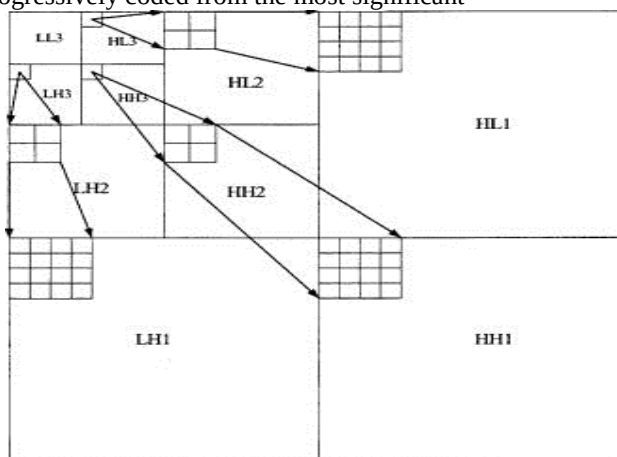
III. SET PARTITIONING OF HIERARCHICAL TREES (SPIHT)

SPIHT is a codec which works on bitmap images. SPIHT works on the Discrete Wavelet Transform (DWT) of the image. In DWT, information of an image gets concentrated in the upper left corner, while the information content goes on reducing as we move towards the bottom right corner. As a result, pixels having maximum information content get compressed first, which leads to an accurate image reconstruction after decompression. The basic principle is: a progressive coding is applied, processing the image respectively to a lowering threshold. This is an idea that takes bounds between coefficients across subbands in different levels into consideration. The SPIHT algorithm first converts the image into its wavelet transform and then transmits information about the wavelet coefficients. If there is a coefficient in the highest level of transform in a particular subband considered insignificant against a particular threshold, it is very probable that its descendants in lower levels will be insignificant too, so we can code quite a large group of coefficients with one symbol. Thus, SPIHT progressively compresses and decompresses the image which means that compression and decompression can be done to desired level. It allows trade-off between size and quality.

IV. SPIHT ALGORITHM

SPIHT makes use of three lists – the List of Significant Pixels (LSP), List of Insignificant Pixels (LIP) and List of Insignificant Sets (LIS). These are coefficient location lists that contain their coordinates. After the initialization, the algorithm takes two stages for each level of threshold – the sorting pass (in which lists are organized) and the refinement pass (which does the actual progressive coding transmission). The result is in the form of a bitstream.

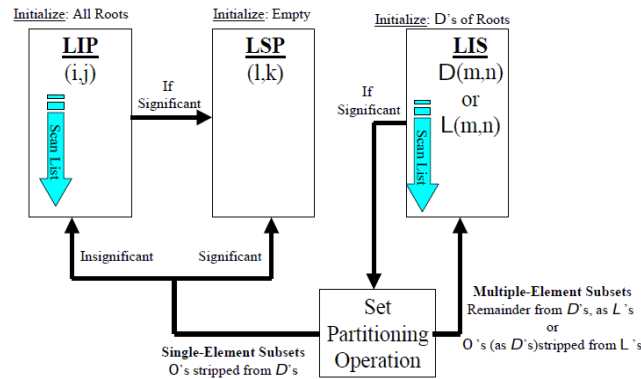
In the SPIHT algorithm, the image is first decomposed into a number of sub bands by means of hierarchical wavelet decomposition. The sub band coefficients are then grouped into sets known as spatial-orientation trees (SOT), which efficiently exploit the correlation between the frequency bands. The coefficients in each spatial orientation tree are then progressively coded from the most significant



bit-planes (MSB) to the least significant bit-planes (LSB), starting with the coefficients with the highest magnitude and at the lowest pyramid levels. The algorithm in each sorting pass calculates a threshold value 2^n which determines the pixel that will correspond to the lists. The value of threshold in each step is given by 2^n where n is-

$$n = \lfloor \log_2 (\max_{\forall (i,j) \in I} |c_{ij}|) \rfloor$$

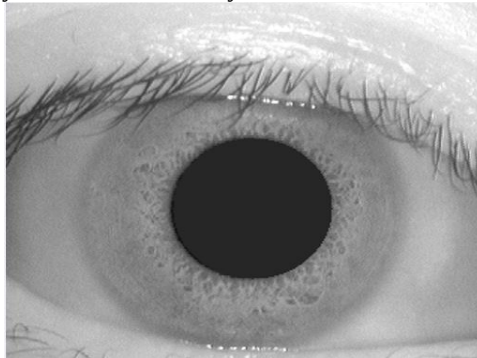
where c_{ij} is a wavelet coefficient at location (i, j) , and $\lfloor x \rfloor$ is the nearest integer $\leq x$. For subsequent steps the value of n is reduced by 1.



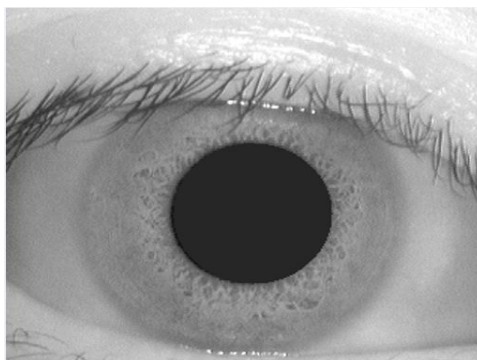
where,

$O(i,j)$: set of coordinates of all offspring of node (i,j) ;
 $D(i,j)$: set of coordinates of all descendants of node (i,j) ;
 $H(i,j)$: set of all tree roots (nodes in the highest pyramid level);
 $L(i,j)$: $D(i,j) - O(i,j)$ (all descendants except the offspring)

The algorithm has several advantages. The first one is an intensive progressive capability – we can interrupt the decoding (or coding) at any time and a result of maximum possible detail can be reconstructed with one-bit precision. This is very desirable when transmitting files over the internet, since users with slower connection speeds can download only a small part of the file, obtaining much more usable result when compared to other codec such as progressive JPEG. Second advantage is a very compact output bitstream with large bit variability – no additional entropy coding or scrambling has to be applied. It is also possible to insert a watermarking scheme into the SPIHT coding domain and this watermarking technique is considered to be very strong regarding to watermark invisibility and attack resiliency.



AN EXAMPLE IMAGE FROM CASIA DATABASE (DIMENSIONS: 512 X 512, SIZE: 266240 B)

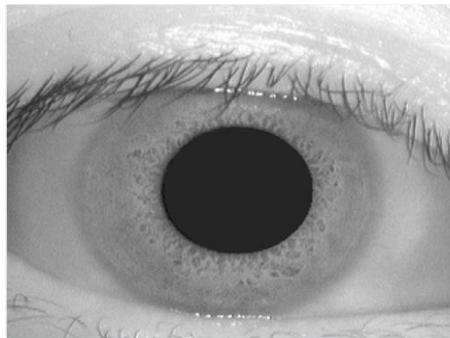


SPIHT RESULT (SIZE = 241766 B (0.3 bpp, 1:1.10), PSNR = 43.26 dB)

But we also have to consider disadvantages. SPIHT is very vulnerable to bit corruption, as a single bit error can introduce significant image distortion depending of its location. Much worse property is the need of precise bit synchronization, because a leak in bit transmission can lead to complete misinterpretation from the side of the decoder. For SPIHT to be employed in real-time applications, error handling and synchronization methods must be introduced in order to make the codec more resilient.

V. MODIFIED SPIHT

In SPIHT, the use of three temporary lists is a powerful way to improve the codec's efficiency. However, they are quite memory consuming, a circumstance that is a major drawback for the SPIHT algorithm. In addition, during coding, we often insert or delete the elements in the lists. These frequent operations will greatly increase the coding time with the expansion of the lists. In order to realize the implementation of the SPIHT algorithm in real-time for mobile communications, a successful fast and low-memory solution must be provided. In the MSPIHT algorithm, the sorting pass and the refinement pass are combined as one scan pass to reduce the execution time.



MSPIHT RESULT (SIZE = 29176 B (0.3 bpp, 1:8.2), PSNR = 0.42 dB)

In addition to having the advantages of less working memory, the MSPIHT algorithm is more suitable than SPIHT for incorporation into a plug-in program for an Internet browser owing to faster coding and decoding. Since MSPIHT requires less memory during coding and decoding and has a comparably lower complexity of the source code, the program footprint is relatively smaller than that of SPIHT. From the user's point of view, this feature is clearly beneficial.

The main improvement of MSPIHT in comparison to SPIHT is the CPU time in seconds. For a 512 X 512 grayscale image, the encoder is 2 times faster than SPIHT at a bit rate of 0.3 bpp. On the other hand, the decoder is 3 times faster for the same image at the same bit rate. Taking advantage of the absolute zerotree structure, the MSPIHT algorithm reduces the number of entries in the LIS, thus improving the execution time for coding and decoding. It satisfies the common requirements of real-time imaging for wireless channel. MSPIHT is faster than SPIHT in CPU time; therefore, MSPIHT has less computational complexity and depends on the number of mathematical operations in the entire algorithm, including addition, subtraction, division, multiplication, and shift operations. Usually, more complex compression algorithm takes a longer time to execute. Because MSPIHT takes less time to code and decode than arithmetic-coded SPIHT, it is clear that this algorithm is less complex and perfect for real-time mobile communications.

Bit rate	CPU time in seconds			
	<i>MSPIHT</i>		<i>SPIHT</i>	
	code	decode	code	decode
0.0075	0.1094	0.0313	0.50	0.28
0.0154	0.2813	0.0781	0.52	0.27
0.0380	0.2969	0.0938	0.54	0.28
0.045	0.5060	0.1509	0.55	0.32
0.055	0.5581	0.2500	0.55	0.32

Comparison of SPIHT and Modified SPIHT in terms of run time

VI. JPEG 2000

JPEG 2000 is an image compression standard and coding system. It was created by the Joint Photographic Experts Group committee in 2000 with the intention of superseding their original discrete cosine transform-based JPEG standard (created in 1992) with a newly designed, wavelet-based method. The standard has multiple parts dealing with a variety of applications, from basic image compression to volumetric imaging and wireless applications. In particular the JPEG 2000 algorithm has been very effective in the compression of large high-resolution images.

The JPEG standard has been in use for almost a decade now. It has proved a valuable tool during all these years, but it cannot fulfil the advanced requirements of today. Today's digital imagery is extremely demanding, not only from the quality point of view, but also from the image size aspect. Current image size covers orders of magnitude, ranging from web logos of size of less than 100 Kbits to high quality scanned images of approximate size of 40 Gbits. Digital imaging has become an integral part of the Internet and JPEG 2000 is a powerful new tool that provides power capabilities for designers and users of networked image applications. The JPEG 2000 standard provides a set of features that are of importance to many high-end and emerging applications by taking advantage of new technologies. It addresses areas where current standards fail to produce the best quality or performance.

Some of the features of JPEG 2000 are

- 1) Superior low bit-rate performance
- 2) Continuous-tone and bi-level compression
- 3) Progressive transmission by pixel accuracy and resolution
- 4) Region-of-interest (ROI) coding
- 5) Open architecture
- 6) Robustness to bit errors
- 7) Protective image security

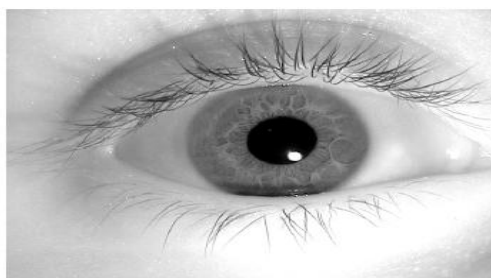
At the encoder, the discrete transform is first applied on the source image data. The transform coefficients are then quantized and entropy coded before forming the output code stream (bit stream). The decoder is the reverse of the encoder. The code stream is first entropy decoded, de-quantized and inverse discrete transformed, thus resulting in the reconstructed image data. Although this procedure looks like the one for the conventional JPEG, there are radical differences between them.

A. ENCODING PROCEDURE

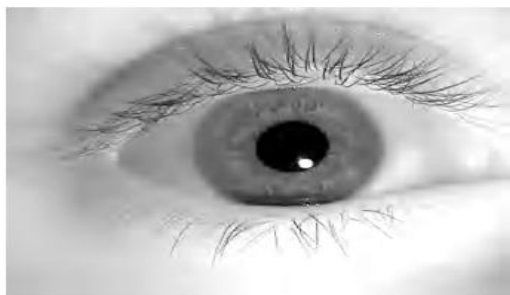
To recapitulate, the encoding procedure is as follows -

- The source image is decomposed into components.
- The image and its components are decomposed into rectangular tiles. The tile-component is the basic unit of the original or reconstructed image.
- The wavelet transform is applied on each tile. The tile is decomposed in different resolution levels.
- These decomposition levels are made up of subbands of coefficients that describe the frequency characteristics of local areas (rather than across the entire tile-component) of the tile component.
- The subbands of coefficients are quantized and collected into rectangular arrays of "code-blocks".
- The bit-planes of the coefficients in a "code-block" are entropy coded.
- The encoding can be done in such a way, so that certain ROI's can be coded in a higher quality than the background.
- Markers are added in the bitstream to allow error resilience.
- The code stream has a main header at the beginning that describes the original image and the various decomposition and coding styles that are used to locate, extract, decode and reconstruct the image with the desired resolution, fidelity, region of interest and other characteristics.
- The optional file format describes the meaning of the image and its components in the context of the application.

B. RESULT



An example image of ICE 2005 database.



The iris image after compression to 100:1.

Average bit rate (bpp)	PSNR (dB)	RMSE (dB)	Comp. Ratio
0.33	35.7249	3.7969	0.2844
0.19	36.0816	3.6807	0.2724
0.25	36.2061	3.8120	0.2127
0.2	35.5982	4.1335	0.2621

JPEG PARAMETERS.

VII. CONCLUSIONS

We have presented three algorithms that operate on the principles of Discrete Wavelet Transform (DWT). We presented an algorithm that operates through set partitioning in hierarchical trees. This SPIHT algorithm uses the principles of partial ordering by magnitude, set partitioning by significance of magnitudes with respect to a sequence of octavely decreasing thresholds, ordered bit plane transmission and self-similarity across scale in an image wavelet transform.

Modified SPIHT is a fast, efficient, low-memory real-time image-compression algorithm. It also preserves most of the merits of SPIHT (such as simple computation, effective compression, and embedded coding), thereby showing great promise for real-time applications. The solution in this paper not only is suited for the implementation of the SPIHT algorithm but also can be used in the majority of applications where the acquisition, compression, and storage of images are needed.

JPEG 2000 is very powerful and efficient compression technique. Iris database could be reduced in size using this algorithm possibly by compression rate of 5 to 6 or even higher.

In general, when images are not compressed, images that have higher quality will generate higher recognition accuracy, as expected. When the images are compressed, the original image patterns will be suppressed and some new artificial compression artifacts/patterns will be added. This decreases the recognition accuracy. As the compression rate increases, the recognition accuracy decreases. However, when using a small database, this effect may not be reflected in the recognition results. For some images in a small database, the compression process could introduce some stable unique patterns, which in some cases can increase the recognition accuracy. That is why we see the fluctuations in recognition accuracy across different compression rates, as well as fluctuations in the number of bits compared. When large amounts of data are used, more images will have similar artificial patterns due to the compression process, and the recognition accuracy decreases.

In addition, different iris images would have different “reactions” to the compression due to the characteristics of the patterns. The quality of some images may be reduced dramatically due to the compression process, but

some may not be. In general, an iris image that contains smooth patterns will be more affected in compression than an iris image that has a more variability in the iris patterns.

VIII. REFERENCES

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