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Review of Image compression Techniques Based on Orthogonal Transforms

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Abstract:- In this paper, a comprehensive survey on different image compression techniques based on orthogonal transform is presented. The important role played by digital imaging and video, it is necessary to develop a system that produces high degree of compression while preserving critical image/video information. There are various transformation techniques used for data compression. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the most commonly used transformation. DCT has high energy compaction property and requires less computational resources. On the other hand, DWT is multiresolution transformation. Here, we present the different approaches adopted by different authors to compress the image signal based on orthogonal transform such as DCT and DWT. The two fundamental principles used in image compression are redundancy and irrelevancy. Redundancy removes redundancy from the signal source and irrelevancy omits pixel values which are not noticeable by human eye. Table summarize the different approaches for the image compression and the effectiveness of different approaches.

Index Terms: **Discrete cosine Transform (DCT), Discrete Wavelet Transform (DWT), Haar discrete wavelet transforms (HDWT).**

I. INTRODUCTION

Image compression is very important for efficient transmission and storage of images. Demand for communication of multimedia data through the telecommunications network and accessing the multimedia data through Internet is growing explosively. With the use of digital cameras, requirements for storage, manipulation, and transfer of digital images, has grown explosively. From last few decays, the increasing demand of storage and transmission of digital images, image compression is now become an essential application for storage and transmission [1]. Demand for communication of multimedia data through the telecommunications network and accessing the multimedia data through Internet is growing explosively [2]. With the use of digital cameras, requirements for storage, manipulation, and transfer of digital images, has grown explosively.

There are many image compression techniques available, but still there is need to develop faster, and more strong and healthy techniques to compress images. Because, main difficulties in developing compression algorithms for image is the need for preserving the minutiae i.e. ridges endings and bifurcations, which are subsequently used in identifications. There are two different types of redundancy relevant to images spatial redundancy and spectral redundancy. By using data compression techniques, it is possible to remove some amount of redundant information. The will save some amount of file size and allows more images to be stored in a certain amount of disk or memory space.

Discrete Wavelet Transform (DWT) [3]-[7] can be efficiently used in image coding applications because of their data reduction capabilities. Unlike the case of Discrete Cosine Transform [6] (DCT) whlch basis is composed of cosine functions, basis of DWT can be composed of any function (wavelet) that satisfies requirements of multiresolution analysis.

Different compression algorithms are Shapiro's embedded zero tree wavelet (EZW) algorithm [9], Said and Pearlman's set partitioning in hierarchical trees (SPIHT) algorithm [10], Servetto et al.'s morphological representation of wavelet data (MRWD) algorithm [11], and Taubman's embedded block coding with optimized truncation (EBCOT) algorithm [12], SOM based vector quantisation [20], arithmetic coding [16], Singular Value Decomposition [19].

This paper present a comprehensive survey on different image compression techniques based on orthogonal transform. There are various transformation techniques used for data compression. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the most commonly used transformation. DCT has high energy compaction property and requires less computational resources. On the other hand, DWT is multiresolution transformation. Here, we present the different approaches adopted by different authors to

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This paper is organized as follows: In Section II, image compression system is presented in detail with general steps of image compression and image restoration. Some application of the image compression system is also presented in section III. Section V, present the comprehensive study of different approaches presented by different authors for the image compression. Finally, a conclusion is made base on this study.

II. IMAGE COMPRESSION

Image compression techniques reduce the number of bits required to represent an image by taking advantage of these redundancies. An inverse process called decoding is applied to the compressed data to get the reconstructed image. The objective of compression is to reduce the number of bits as much as possible, while keeping the resolution and the quality of the reconstructed image as close to the original image as possible.

Image compression systems are composed of two distinct structural blocks: an encoder and a decoder, as shown in Fig. 1. Image f(x,y) is fed into the encoder, which creates a set of symbols form the input data and uses them to represent the image. If we let n_1 and n_2 denote the number of information carrying units in the original and encoded images respectively, the compression that is achieved can be quantified numerically via the compression ratio, $C_R = n_1/n_2$

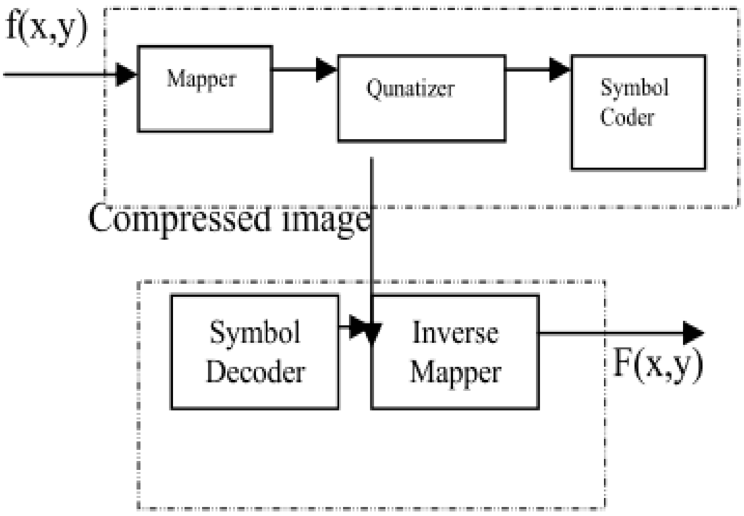

Fig. 1 Image compression

Encoder is responsible for reducing the coding, inter-pixel and perceptual redundancies of input image. In first stage, the mapper transforms the input image into a format designed to reduce inter-pixel redundancies. The second stage, qunatizer block reduces the accuracy of mapper's output in accordance with a predefined criterion. In third and final stage, a symbol decoder creates a code for quantizer output and maps the output in accordance with the code. These blocks perform, in reverse order, the inverse operations of the encoder's symbol coder and mapper block. As quantization is irreversible, an inverse quantization is not included.

A. GENERAL STEPS OF IMAGE COMPRESSION

The usual steps involved in compressing an image are

1. Specifying the Rate (bits available) and Distortion (tolerable error) parameters for the target image.
2. Dividing the image data into various classes, based on their importance.
3. Dividing the available bit budget among these classes, such that the distortion is a minimum.
4. Quantize each class separately using the bit allocation information derived in step 3.
5. Encode each class separately using an entropy coder and write to the file.

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B. GENERAL STEPS OF IMAGE RECONSTRUCTION

Reconstructing the image from the compressed data is usually a faster process than compression. The steps involved are

1. Read in the quantized data from the file, using an entropy decoder.
2. Dequantize the data.
3. Rebuild the image.

III. APPLICATIONS OF IMAGE COMPRESSION

1. Image compression has increased the efficiency of sharing and viewing personal images, it offers the same benefits to just about every industry in existence. Early evidence of image compression suggests that this technique was, in the beginning, most commonly used in the printing, data storage, and telecommunications industries [2]. Today however, the digital form of image compression is also being put to work in industries such as fax transmission, satellite remote sensing, and high definition television, to name but a few.
2. In certain industries, the archiving of large numbers of images is required. A good example is the health industry, where the constant scanning and/or storage of Medical images and documents take place. Image compression offers many benefits here, as information can be stored without placing large loads on system servers. Depending on the type of compression applied, images can be compressed to save storage space, or to send to multiple physicians for examination. And conveniently, these images can uncompress when they are ready to be viewed, retaining the original high quality and detail that medical imagery demands.
3. Image compression is also useful to any organization that requires the viewing and storing of images to be standardized, such as a chain of retail stores or a federal government agency. In the retail store example, the introduction and placement of new products or the removal of discontinued items can be much more easily completed when all employees receive, view and process images in the same way. Federal government agencies that standardize their image viewing, storage and transmitting processes can eliminate large amounts of time spent in explanation and problem solving. The time they save can then be applied to issues within the organization, such as the improvement of government and employee programs.
4. In the security industry, image compression can greatly increase the efficiency of recording, processing and storage. However, in this application it is imperative to determine whether one compression standard will benefit all areas. For example, in a video networking or closed-circuit television application, several images at different frame rates may be required. Time is also a consideration, as different areas may need to be recorded for various lengths of time. Image resolution and quality also become considerations, as does network bandwidth, and the overall security of the system.
5. Museums and galleries consider the quality of reproductions to be of the utmost importance. Image compression, therefore, can be very effectively applied in cases where accurate representations of museum or gallery items are required, such as on a Web site. Compressed images can also be used in museum or gallery kiosks for the education of that establishment's visitors. In a library scenario, students and enthusiasts from around the world can view and enjoy a multitude of documents and texts without having to incur traveling or lodging costs to do so.

IV. COMPREHENSIVE SURVEY ON THE COMPRESSION OF IMAGE SIGNAL BASED ON ORTHOGONAL TRANSFORMS

Table shows the detail of the work done by different authors in the field of image compression based on different transform.

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Year of Publication	Author	Title	Approach	Effects and solution
2005	Bao, P., Xiaohu Ma	Image adaptive watermarking using wavelet domain singular value decomposition [14]	Quantization-index-modulation process	To improve the fidelity and the perceptual quality of the watermarked image and to enhance the security of watermarking, we model the adaptive quantization parameters based on the statistics of blocks within subbands. The scheme is robust against JPEG compression but extremely sensitive to malicious manipulation such as filtering and random noising. Watermark detection is efficient and blind in the sense only the quantization parameters but not the original image are required.
2007	Bhattacharya, C., Mahapatra, P.R.	A Discrete Wavelet Transform Approach to Multiresolution Complex SAR Image Generation [15]	Complex synthetic aperture radar (SAR) images	The lifting scheme of DWT is adapted to handle complex signal approximations and employed to further enhance the computational efficiency. We generate hierarchical approximations of complex SAR signals in the discrete wavelet transform (DWT) domain, where we employ lifting steps for efficient computation.
2008	Jingyu Yang, Yao Wang, Wenli Xu, Qionghai Dai	Image Coding Using Dual-Tree Discrete Wavelet Transform [16]	directional and redundant transform, for image coding	Three methods for sparsifying DDWT coefficients, i.e., matching pursuit, basis pursuit, and noise shaping, are compared. We found that noise shaping achieves the best nonlinear approximation efficiency with the lowest computational complexity. The interscale, intersubband, and intrasubband dependency among the DDWT coefficients are analyzed.
2009	Jingyu Yang, Yao Wang, Wenli Xu, Qionghai Dai	Image and Video Denoising Using Adaptive Dual Tree Discrete Wavelet Packets [17]	Adaptive dual-tree discrete wavelet packets	For denoising the ADDWP coefficients, a statistical model is used to exploit the dependency between the real and imaginary parts of the coefficients. The proposed denoising scheme gives better performance than several state-of-the-art DDWT-based schemes for images with rich directional features.
2010	Chih-Chin Lai, Cheng-Chih Tsai	Digital Image Watermarking Using Discrete Wavelet Transform and Singular Value Decomposition [18]	hybrid image-watermarking scheme based on discrete wavelet transform (DWT) and singular value decomposition (SVD	The watermark is not embedded directly on the wavelet coefficients but rather than on the elements of singular values of the cover image's DWT subbands. The technique fully exploits the respective feature of these two transform domain methods: spatio-frequency localization of DWT and SVD efficiently represents intrinsic algebraic properties of an image.
2013	Farsi, H., Mohamadzadeh, S.	Colour and texture feature-based image retrieval by using hadamard	Feature extraction	A new method based on combination of Hadamard matrix and discrete wavelet transform (HDWT) in hue-min-max-difference colour space. An

		matrix in discrete wavelet transform [19]		average normalised rank and combination of precision and recall are considered as metrics to evaluate and compare the proposed method against different methods.
2013	Kalaivani, K., Thirumarais elvi, C., Sudhakar, R.	An effective way of image compression using DWT and SOM based vector quantisation [20]	vector quantisation	An algorithm based on Kohonen's self organizing maps is proposed in this paper for quantising the image data. This algorithm uses its roots in neural networks based on neighbourhood relationships. Wavelet transform is also a cutting edge technology in the field of image compression.
2013	Malviya, S., Gupta, N., Shirvastava, V.	2D-discrete walsh wavelet transform for image compression with arithmetic coding [21]	DWT (Discrete Wavelet Transform)	Walsh Wavelets transform with arithmetic coding techniques to remove redundancy from images has been presented. In this correspondence, a comparison of different image compression methods given by various authors. The presented Walsh Wavelets transform with arithmetic coding method is capable in effectively restoring the removed regions for good visual quality, as well.

V. CONCLUSIONS

In this paper, a comprehensive survey on different image compression techniques based on orthogonal transform is presented. There are various transformation techniques used for data compression. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the most commonly used transformation. Here, we present the different approaches adopted by different authors to compress the image signal based on orthogonal transform such as DCT and DWT.

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