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IMAGE COMPRESSION METHODS BASED ON TRANSFORM CODING AND FRACTAL CODING

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ABSTRACT

Image compression is process to remove the redundant information from the image so that only essential information can be stored to reduce the storage size, transmission bandwidth and transmission time. The essential information is extracted by various transforms techniques such that it can be reconstructed without losing quality and information of the image. In this research comparative analysis of image compression is done by four transform method, which are Discrete Cosine Transform (DCT), Discrete Wavelet Transform(DWT) & Hybrid (DCT+DWT) Transform and fractal coding. MATLAB programs were written for each of the above method and concluded based on the results obtained that hybrid DWT-DCT algorithm performs much better than the standalone JPEG-based DCT, DWT algorithms in terms of peak signal to noise ratio (*PSNR*), as well as visual perception at higher compression ratio. The popular JPEG standard is widely used in digital cameras and web based image delivery. The wavelet transform, which is part of the new JPEG 2000 standard, claims to minimize some of the visually distracting artifacts that can appear in JPEG images. For one thing, it uses much larger blocks- selectable, but typically 1024 x 1024 pixels for compression, rather than the 8 X 8 pixel blocks used in the original JPEG method, which often produced visible boundaries. Fractal compression has also shown promise and claims to be able to enlarge images by inserting realistic detail beyond the resolution limit of the original.

KEYWORDS: Image Compression, DCT, DWT, Transform Coding, Fractal Coding, Hybrid Transforms.

I. INTRODUCTION

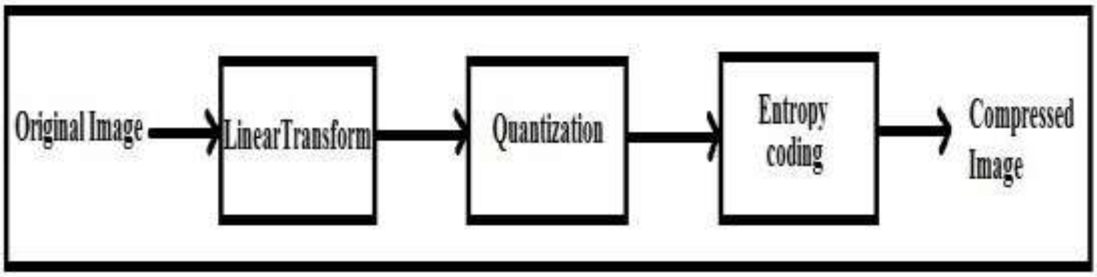
The increasing demand for multimedia content such as digital images and video has led to great interest in research into compression techniques. The development of higher quality and less expensive image acquisition devices has produced steady increases in both image size and resolution, and a greater consequent for the design of efficient compression systems [1]. Although storage capacity and transfer bandwidth has grown accordingly in recent years, many applications still require compression. In general, this research investigates still image compression in the transform domain. Multidimensional, multispectral and volumetric digital images are the main topics for analysis. The main objective is to design a compression system suitable for processing, storage and transmission, as well as providing acceptable computational complexity suitable for practical implementation. The basic rule of compression is to reduce the numbers of bits needed to represent an image. In a computer an image is represented as an array of numbers, integers to be more specific, that is called a digital image. The image array is usually two dimensional (2D), If it is black and white (BW) and three dimensional (3D) if it is colour image [3]. Digital image compression algorithms exploit the redundancy in an image so that it can be represented using a smaller number of bits while still maintaining acceptable visual quality. A data compression system mainly consists of three major steps and that are removal or reduction in data redundancy, reduction in entropy, and entropy encoding. A typical data compression system can be labeled using the block diagram shown in Figure 1 It is performed in steps such as image transformation, quantization and entropy coding. JPEG is one of the most used image compression standard which uses discrete cosine transform (DCT) to transform the image from spatial to frequency domain [2]. An image contains low visual information in its high frequencies for which heavy quantization can be done in order to reduce the size in the transformed representation. Entropy coding follows to further reduce the redundancy in the transformed and quantized image data. The main advantage of compression is that it reduces the data storage requirements. It also offers an attractive approach to reduce the communication cost in transmitting high volumes of data over long-haul links via higher effective utilization of the available bandwidth in the data links. This significantly aids in reducing the cost of communication due to the data rate reduction. Due to the data rate reduction, data compression also increases the quality of multimedia presentation through limited-bandwidth communication channels, Because of the reduced data rate. Offered by the compression techniques, computer network and Internet usage is becoming more and more image and graphic friendly, rather than being just data and text-centric phenomena. In short, high-performance compression has created new opportunities of creative applications such as digital library, digital archiving, video teleconferencing, telemedicine and digital entertainment to name a few. There are many other secondary advantages in data compression.

II. TRANSFORM CODING

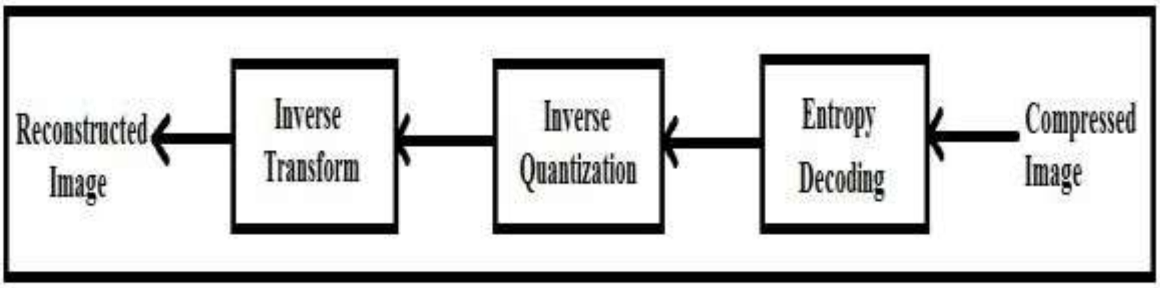
In transform coding, an image is transformed from one domain (usually spatial or temporal) to a different type of representation, using some well known transform. Then the transformed values are coded and thus provide greater data compression. In this research, transforms are orthogonal so that the mapping is unique and reversible. As a result, the energy is preserved in the transform domain that is the sum of the squares of the transformed sequence is the same as the sum of the squares of the original sequence. Thus, the image can be completely recovered by the inverse transform. Transform coding (TC), is an efficient coding scheme based on utilization of interpixel correlation. Transform coding uses frequency domain, in which the encoding system initially converting the pixels in space domain into frequency domain via transformation function. Thus producing a set of spectral coefficients, which are then suitably coded and transmitted [22]. The transform operation itself does not achieve any compression. It aims at decorrelating the original data and compacting a large fraction of the signal energy into a relatively small set of transform coefficients (energy packing property). In this way, many coefficients can be discarded after quantization and prior to encoding. Most practical transform coding systems are based on DCT of types II which provides good compromise between energy packing ability and computational complexity. The energy packing property of DCT is superior to that of any other unitary transform [25]. Transforms that redistribute or pack the most information into the fewest coefficients provide the best sub-image approximations and, consequently, the smallest reconstruction errors. In Transform coding, the main idea is that if the transformed version of a signal is less correlated compared with the original signal, then quantizing and encoding the transformed signal may lead to data compression. At the receiver, the encoded data are decoded and transformed back to reconstruct the signal.

III. TRANSFORM BASED IMAGE COMPRESSION

Transform refers to changing the coordinate basis of the original signal, such that a new signal has the whole information in few transformed coefficients. The processing of the signals in the transform domain is more efficient as the transformed coefficients are not correlated [22].



(a) Encoder



(b) Decoder

Figure 1 Block Diagram of transform based image coder (a) Encoder (b) Decoder

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IV. FRACTAL IMAGE COMPRESSION

Fractal coding is a new method of image compression. The main principle of the fractal transform coding is based on the hypothesis that the image redundancies can be efficiently exploited by means of block self-affine transformations. By removing the redundancy related to self-similarity in an image. Fractal image compression can achieve a higher compression ratio with high decoding quality. Fractal coding has the advantage such as resolution independence and fast decoding as compare to other image compression methods. So fractal image compression is a promising technique that has great potential to improve the efficiency of image storage and image transmission [23]. Fractal image coding is based on partition iterated function system (PIFS),in which an original input image is partitioned into a set of non-overlapping sub-blocks, called range block (R) that cover up the whole image. The size of every range block is N X N. At the same time, the original image is also partitioned into a set of other overlapping sub-blocks, called domain blocks (D), which size is always twice the size of range blocks. The domain blocks are allowed to be overlapping and need not cover the whole image [26]. Secondly, each of the domain blocks is contracted by pixel averaging or down sampling to match the size of the range block. Next, eight symmetrical transformations (rotations and flips) are applied to all contracted domain blocks to bring out an extended domain pool, which denoted asˆ For each range block, we search the domain pool to get the best matched domain block *D* with a contractive affine transformation. The problem with fractal coding is the highly computational complexity in the encoding process [29]. Most of the encoding time is spent on the best matching search between range blocks and numerous domain blocks (Dˆ) so that the fractal encoding is a time consuming process, which limits the algorithm to practical application greatly. In order to solve this problem, lots of researches were done earlier to speed up the block matching process. Most of these improvements tried to restrict the search space of the domain block pool in order to reduce the computation requirements of the best matching search, hence speeding up the fractal image encoding procession [28].

Advantages and Disadvantages

Fractal image compression has the following advantages:

- Fast decoding process
- High compression ratio
- Low performance device
- Resolution independence
- It can be digitally scaled to any resolution when decoded.
- Image compressed in terms of self-similarity rather than pixel resolution
- Lower transmission time

Disadvantage of fractal image compression

- Long encoding time
- Image quality

DCT requires less computational resources and can achieve the energy compaction property. However, for the higher compression ratio it introduces the blocking artifacts and the false contouring effects while image reconstruction. DWT is the only techniques which has capacity of multi resolution compression. However, it requires higher computational complexity as compared to other techniques. Hence, in order to benefit from each other. Conventional Fractal method circumvents the drawbacks of DCT, DWT, Hybrid (DCT+DWT), but it requires more computational time. A different approach for image compression using fractals is also discussed which uses the mean and variance of range and domain blocks. This approach speeds up the encoding time by reducing the number range- domain comparison with remarkable amount. Each method can be well suited with different images based on the user requirements. The lower value of MSE indicates better picture quality. There is an inverse relationship between MSE and PSNR. Hence, the larger PSNR value gives the better image quality. Compression ratio indicates the efficiency of compression technique, more the compression ratio, less memory space required. Hence, more compression ratio is always desirable without trade off in image quality.

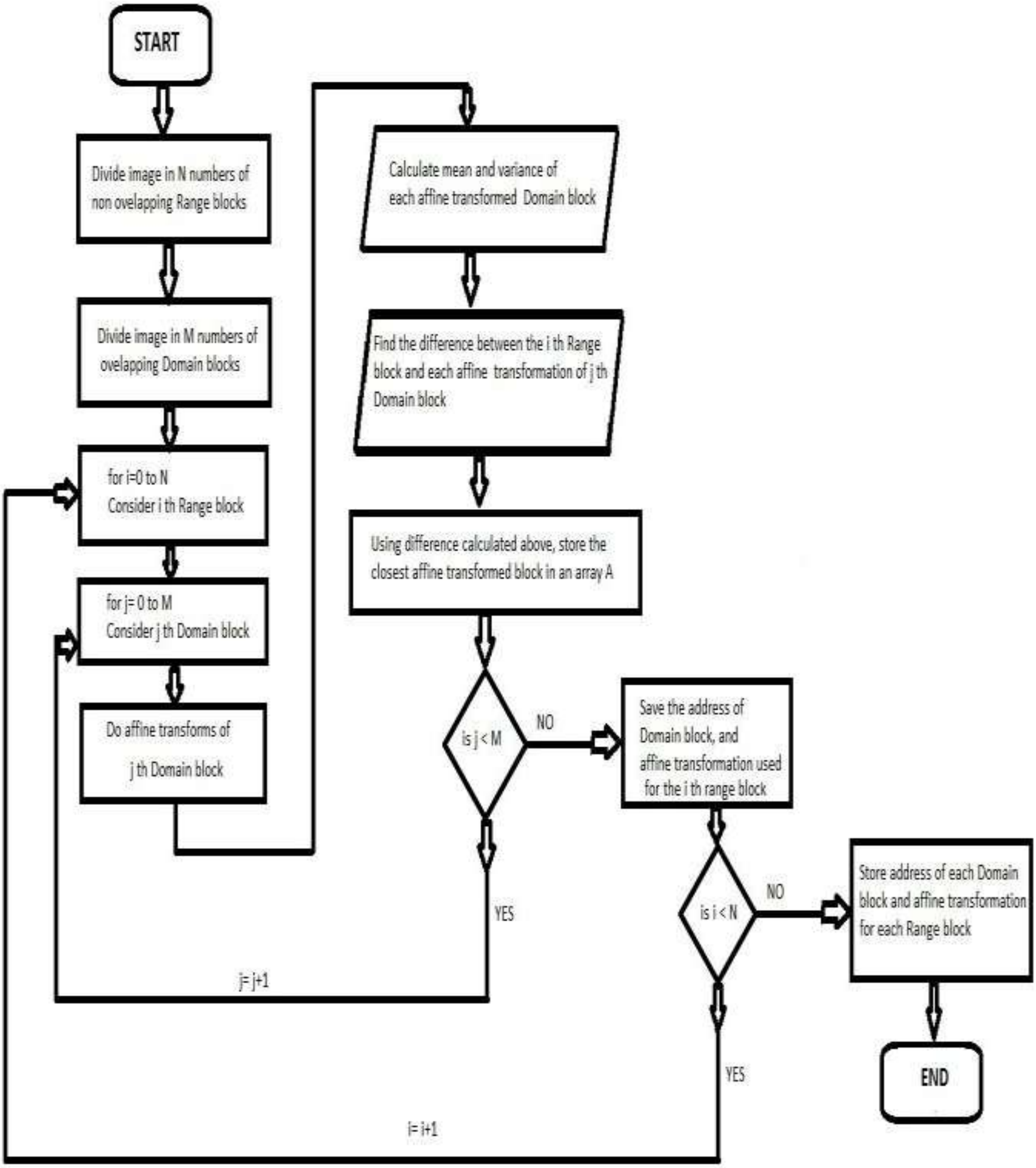

Figure 2 Fractal Coding Algorithm

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V. SIMULATION RESULTS

The studied algorithms are applied on several types of images: natural images, benchmark images such that the performance of proposed algorithm can be verified for various applications. These benchmark images are the standard image generally used for the image processing applications and are obtained from. The results of the meticulous simulation for all images and are presented in this section. The results are compared with the JPEG-based DCT, DWT, Hybrid (DCT-DWT) algorithms and using Fractals. The algorithms were implemented in MATLAB simulation tool. For the DWT and DCT, MATLAB functions ”dwt2” and ”dct2 “ has been considered, respectively. The evaluation parameters (PSNR, CR, MSE and Variance), sub-sampling, quantization and scaling routines were manually programmed in MATLAB. The proposed algorithm is compared with DCT, DWT and Hybrid (DCT-DWT) algorithms. The results are obtained for images of sizes 128x128 and 512x512. Original and reconstructed images are also shown in Figure 3. the compression ratio CR is high for Hybrid transform as compare to standalone transforms. DWT comprises between compression ratio and quality of reconstructed image, it adds speckle noise to the image for improvement in the reconstructed image. Hence DWT technique is useful in medical applications. DCT gives lesser compression ratio but it is computationally efficient compared to other techniques.

Figure. 3 Comparison of visual image quality of reconstructed image for DCT, DWT AND HYBRID (DCT+DWT) for test images.

(a) Original image (b) Decoded image at threshold (c) Decoded image at threshold

Figure 4 : Comparison of visual image quality of reconstructed image from the proposed method at different threshold value.

Thus, analyze the difference between the decoded images. As we can see the quality of decoded image at different threshold level in the above Figure 4

VI. CONCLUSION

In this, various Image compression techniques for different images is done based on parameters, compression ratio(CR), mean square error (MSE), peak signal to noise ratio (PSNR). DWT gives better compression ratio without losing more information of image. Pitfall of DWT is, it requires more processing power. DCT overcomes this disadvantage since it needs less processing power, but it gives less compression ratio. DCT based standard JPEG uses blocks of image, but there are still correlation exits across blocks. Block boundaries are noticeable in some cases. Blocking artifacts can be seen at low bit rates. In wavelet, there is no need to divide the image. More robust under transmission errors. It facilitates progressive transmission of the image (scalability). Hybrid transform gives higher compression ratio but for getting that clarity of the image is partially trade off. It is more suitable for regular applications as it is having a good compression ratio along with preserving most of the information. On the other hand Fractal Image Compression gives a great improvement on the encoding and decoding time. A weakness of the proposed design is the use of fixed size blocks for the range and domain images. There are regions in images that are more difficult to code than others .Therefore; there should be a mechanism to adapt the block size *(R, D*) depending on the mean and variance calculated when coding the block. This type of compression can be applied in Medical Imaging, where doctors need to focus on image details, and in Surveillance Systems, when trying to get a clear picture of the intruder or the cause of the alarm. This is a clear advantage over the Discrete Cosine Transform Algorithms such as that used in JPEG.

VII. FUTURE WORK

The result in this, provides a strong foundation for future work for the hardware design. The algorithm can be realized in hardware implementation as a future work. It can also be a good option for the image processor of the wireless capsule endoscopic system. The research work has been analyzed for high compression ratio. Further research can be performed to relax high compression ratio constraint. This work has been constrained only for the removal of the spatial redundancy by compression of still images.

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