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Image Compression of Radar Signals Using JPEG 2000 and DWT

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Abstract- The JPEG 2000 international standard represents advances in image compression technology where the image coding system is optimized not only for efficiency, but also for scalability and interoperability in network and mobile environments. 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 and provides capabilities to markets that currently do not use compression. The markets and applications better served by the JPEG 2000 standard are Internet, color facsimile, printing, scanning (consumer and prepress), digital photography, remote sensing, mobile, medical imagery, digital libraries/archives, and E-commerce. Each application area imposes some requirements that the standard, up to a certain degree, should fulfill. The introduction of the JPEG 2OOO compression standard has meant that for the first time the discrete wavelet transform (DWT) is to be used for the decomposition and reconstruction of images together with an efficient coding scheme. The use of wavelets implies the use of subband coding in which the image is iteratively decomposed into high- and low-frequency bands. In this paper we try to use Discrete Wavelet Transform (DWT) using JPEG for Image compression of radar signals using MATLAB.

Index Terms- Compression, Discrete Wavelet Transform, Gaussian Filtering, Noise Estimation

I. INTRODUCTION

Digital image processing is electronic data processing on a 2-D array of numbers. The array is a numeric representation of an image. A real image is formed on a sensor when an energy emission strikes the sensor with sufficient intensity to create a sensor output. An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. Digital image processing has the same advantages over analog image processing as digital signal processing has over analog signal processing — it allows a much wider range of algorithms to be applied to the input data, and can avoid problems such as the build-up of noise and signal distortion during processing . Image processing is a subclass of signal processing concerned specifically with pictures. Improve image quality for human perception and/or computer interpretation. The discrete wavelet transform (DWT) is introduced to the new JPEG2000* image compression standard in this document, which includes a information on how to use it. The main idea behind this compression method is to treat a digital image as a matrix, which is an array of numbers. Each image is made up of a vast number of little squares known as pixels (picture elements). Each pixel in a digital image is assigned a whole integer by the matrix. A 256x256 pixel grey scale image, for example, is saved as a 256x256 matrix, with each element of the matrix being a whole number ranging from 0 (for black) to 255 (for white) (for white). Image compression is a technique for reducing the amount of memory required to represent an image. Images frequently require a significant number of bits to represent them, and it is impractical to transmit or store the image without lowering the amount of bits in some way. Every day, we are all affected by the challenge of sending or storing an image. Image transmission is exemplified by television and fax machines, while image storage is exemplified by digital video players and Catherine Zeta-Jones' web photos. A strategy for lowering storage and transmission costs is mage compression. Lossless and lossy compression techniques are the two types of compression techniques that are currently employed to compress picture data. The original digital image is frequently changed using an invertible linear transform into another domain, where it is highly de-correlated by the transform, in lossy compression approaches. Wavelet coding is proven to be a very effective method for picture compression, providing much better outcomes with equivalent computing performance than the JPEG standard algorithm. The Discrete Wavelet Transform (DWT), quantization of the produced wavelet coefficients (either uniformly or using a human visual system weighting scheme), and lossless encoding of the quantized coefficients are the typical processes in such downsizing. The coefficients are typically stored in raster-scan order, while frequent modifications include encoding each sub-block independently or performing vector quantization inside the various sub-blocks.

II. JPEG 2000 Image Compression

JPEG2000 is a wavelet-based image compression standard. It was created by the Joint Photographic Experts Group committee in the year 2000 with the intention of superseding their original discrete cosine transform-based JPEG standard. The JPEG standard has been in use for more than a decade now. It has proved a valuable tool during all these years, but it cannot fulfill 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. JPEG2000 requires far greater decompression time than JPEG and allows more sophisticated progressive downloads, yet averages similar compression rates. JPEG2000 becomes increasingly blurred with higher compression ratios rather than generating JPEG'S "blocking and ringing" artifacts, complicating direct comparison of their respective compression rates. Images machine-judged to be of equivalent quality for both compression schemes often look better to humans in JPEG2000 at low bitrates.

Features of JPEG2000

A. Superior low bit-rate performance*:*

This standard should offer performance superior to the current standards at low bit rates (e.g., below 0.25 b/p for highly detailed gray-scale images). This significantly improved low bit-rate performance should be achieved without sacrificing performance on the rest of the rate-distortion spectrum. Network image transmission and remote sensing are some of the applications that need this feature.

B. Continuous-tone and bi-level compression

It is desired to have a coding standard that is capable of compressing both continuous-tone and bi-level images. If feasible, this standard should strive to achieve this with similar system resources. The system should compress and decompress images with various dynamic ranges (e.g., 1 to 16 bits) for each color component. Examples of applications that can use this feature include compound documents with images and text, medical images with annotation overlays, and graphic and computer generated images with binary and near to binary regions, alpha and transparency planes, and facsimile.

C. Lossless and lossy compression

It is desired to provide lossless compression naturally in the course of progressive decoding. Examples of applications that can use this feature include medical images, where loss is not always tolerated; image archival applications, where the highest quality is vital for preservation but not necessary for display; network applications that supply devices with different capabilities and resources; and prepress imagery. It is also desired that the standard should have the property of creating embedded bit stream and allow progressive lossy to lossless buildup.

D. Progressive transmission by pixel accuracy and resolution

Progressive transmission that allows images to be reconstructed with increasing pixel accuracy or spatial resolution is essential for many applications such as web browsing, image archival and printing.

E. Region-of-interest (ROI) coding

Often there are parts of an image that are of greater importance than others. This feature allows users to define certain ROIs in the image to be coded and transmitted in a better quality and less distortion than the rest of the image.

F. Open architecture

It is desirable to allow open architecture to optimize the system for different image types and applications. With this feature, a decoder is only required to implement the core tool set and the parser that understands the code stream.

G. Robustness to bit errors

It is desirable to consider robustness to bit errors while designing the code stream. One application, where this is important, is transmission over wireless communication channels. Portions of the code stream may be more important than others in determining decoded image quality. Proper design of the code stream can aid subsequent error correction systems in alleviating catastrophic decoding failures.

H. Protective image security

Protection of a digital image can be achieved by means of different approaches such as watermarking, labeling, stamping, or encryption. JPEG 2000 image files should have provisions for such possibilities.

JPEG2000 Compression

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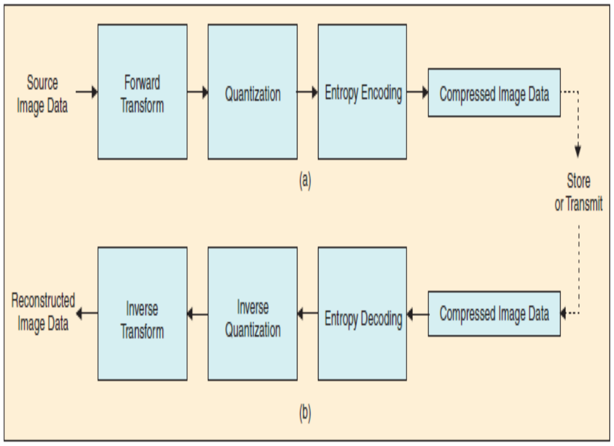

▲ 2. General block diagram of the JPEG 2000 (a) encoder and (b) decoder.

Fig.1. JPEG 2000 Block diagram

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, dequantized, and inverse discrete transformed, thus resulting in the reconstructed image data. Although this general block diagram looks like the one for the conventional JPEG, there are radical differences in all of the processes of each block of the diagram. For the clarity the whole compression engine is decomposed into three parts: the preprocessing, the core processing, and the bit-stream formation part, although there exist high inter-relation between them. In the preprocessing part the image tiling, the dc-level shifting and the component transformations are included. The core processing part consists of the discrete transform, the quantization and the entropy coding processes. Finally, the concepts of the precincts, code blocks, layers, and packets are included in the bit-stream formation part.

Preprocessing

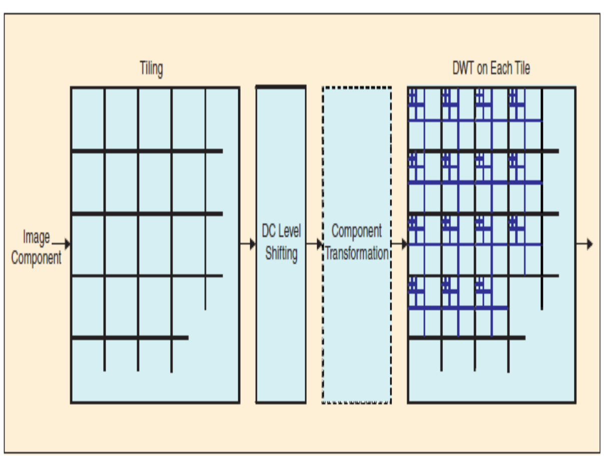

Fig.2: Tiling, DC Level Shifting, color transformation (optional) and DWT of each image component ImageTiling

The term "tiling" refers to the partition of the original (source) image into rectangular nonoverlapping blocks (tiles), which are compressed independently, as though they were entirely distinct images. All operations, including component mixing, wavelet transform, quantization and entropy coding are performed independently on the image tiles. The tile component is the basic unit of the original or reconstructed image. Tiling reduces memory requirements, and since they are also reconstructed independently, they can be used for decoding specific parts of the image instead of the whole image. All tiles have exactly the same dimensions, except maybe those at the boundary of the image. Arbitrary tile sizes are allowed, up to and including the entire image (i.e., the whole image is regarded as one tile). Components with different subsampling factors are tiled with respect to a high-resolution grid, which ensures spatial consistency on the resulting tile components. As expected, tiling affects the image quality both subjectively and objectively. Smaller tiles create more tiling artifacts compared to larger tiles (PSNR values are the average over all components). In other words, larger tiles perform visually better than smaller tiles. Image degradation is more severe in the case of low bit rate than the case of high bit rate. It is seen, for example, that at 0.125 b/p there is a quality difference of more than 4.5 dB between no-tiling and tiling at 64 × 64, while at 0.5 b/p this difference is reduced to approximately 1.5 dB.

Table 1. The Effect of Tiling on Image Quality.

Tiling / Bit Rate (b/p)	No Tiling	Tiles of Size 128 × 128	Tiles of Size 64 × 64
0.125	24.75	23.42	20.07
0.25	26.49	25.69	23.95
0.5	28.27	27.79	26.80

PSNR (in dB) for the color image "ski" (of size 720 × 576 pixels per component)

Fig.3. Image :"ski" of size 720 · 576 (a) original image, (b)-(d) reconstructed images after JPEG 2000 compression at 0.25 bpp: (b) without tiling, (c) with 128 × 128 tiling, and (d) with 64 × 64 tiling

Component Transformations

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JPEG 2000 supports multiple component images. Different components need not have the same bit depths nor need to all be signed or unsigned. For reversible (i.e., lossless) systems, the only requirement is that the bit depth of each output image component must be identical to the bit depth of the corresponding input image component. Component transformations improve compression and allow for visually relevant quantization. The standard supports two different component transformations, one irreversible component transformation (ICT) that can be used for lossy coding and one reversible component transformation (RCT) that may be used for lossless or lossy coding, and all this in addition to encoding without color transformation. The block diagram of the JPEG 2000 multicomponent encoder is depicted in. (Without restricting the generality, only three components are shown in the figure. These components could correspond to the RGB of a color image.)An effective way to reduce the amount of data in JPEG is to use an RGB to YCrCb decorrelation transform followed by subsampling of the chrominance *(C, C) r b* components. This is not recommended for use in JPEG 2000, since the multiresolution nature of the wavelet transform may be used to achieve the same effect. For example, if the HL, LH, and HH subbands of a component's wavelet decomposition are discarded and all other subbands retained, a 2:1 subsampling is achieved in the horizontal and vertical dimensions of the component.

Wavelet Transform

Wavelet transform is used for the analysis of the tile components into different decomposition levels. These decomposition levels contain a number of subbands, which consist of coefficients that describe the horizontal and vertical spatial frequency characteristics of the original tile component. To perform the forward DWT, the standard uses a one-dimensional (1-D) subband decomposition of a 1-D set of samples into low-pass and high-pass samples. Low-pass samples represent a down-sampled, low-resolution version of the original set. High-pass samples represent a down-sampled residual version of the original set, needed for the perfect reconstruction of the original set from the low-pass set. The DWT can be irreversible or reversible. The default irreversible transform is implemented by means of the Daubechies 9-tap/7-tap filter. The default reversible transformation is implemented by means of the Le Gall 5-tap/3-tap filter.

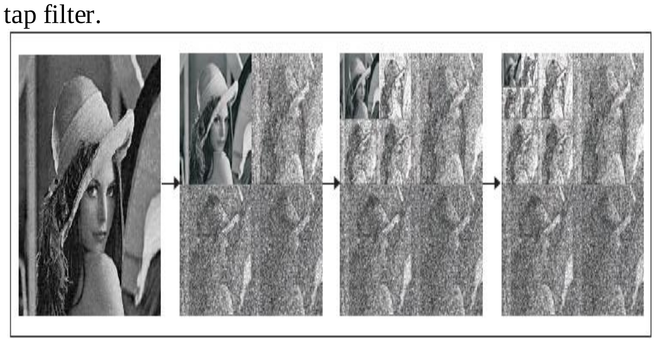

Fig.4. DWT on the image

Traditional wavelet transform implementations require the whole image to be buffered and the filtering operation to be performed in vertical and horizontal directions. While filtering in the horizontal direction is very simple, filtering in the vertical direction is more cumbersome. Filtering along a row requires one row to be read; filtering along a column requires the whole image to be read. The line-based wavelet transform overcomes this difficulty, providing exactly the same transform coefficients as the traditional wavelet transform implementation. However, the line-based wavelet transform alone does not provide a complete line-based encoding paradigm for JPEG 2000. A complete row-based coder has to take also into account all the subsequent coding stages up to the entropy coding.

Proposed Block-Based Noise Estimation Algorithm Using Adaptive Gaussian Filtering

The proposed noise estimation algorithm is based on both block-based and filtering-based approaches. It selects smooth blocks by block-based approach and filters selected smooth blocks using a filtering-based approach.

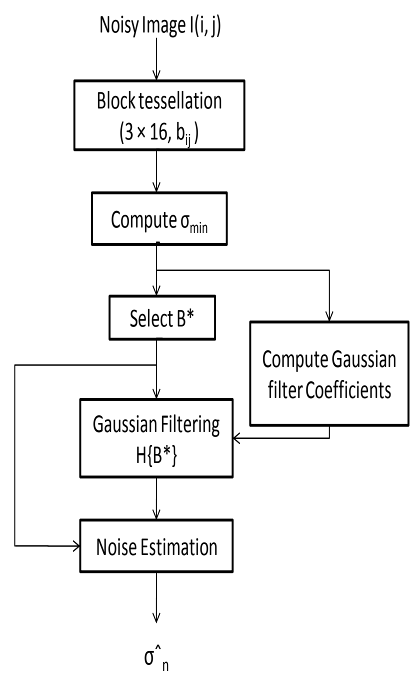

Fig.5. Block Diagram of proposed block-based noise estimation algorithm using adaptive Gaussian filtering

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III. Proposed Work

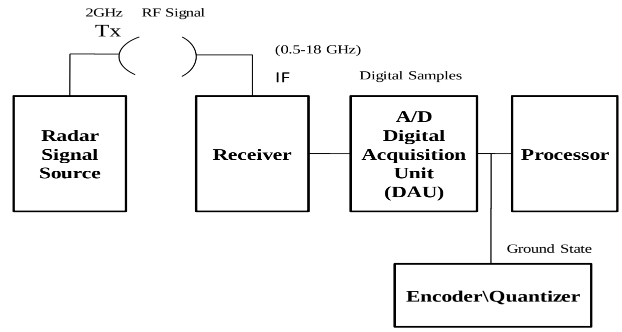
This is the complete architecture of the project setup. First the receiver receives the RF signal in the form of IF signals and converts it to digital samples using A/D converter. This digital data is then compressed using the compression techniques. We use MATLAB Software to debug the compression codes.

Software Details

MATLAB is a high performance language for technical computing. It integrates computation, visualization and programming in an easy-to-use environment where problems and solution are expressed in familiar mathematical notation. Typical values include

- Math and Computation
- Algorithm development
- Data Acquisition
- Modeling simulation and prototyping
- Data Analysis, exploration and visualization
- Scientific and engineering graphics

Application development including graphical user interface MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve any technical computing problems, especially those with matrix and vector formulations, in a fraction of time it would take to write a program in a scalar non-interactive language such as C or FORTAN. MATLAB features a family of add-on applications specific solutions called toolboxes. Very important to most of users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (m-files) that extended the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation and many others.



Test Bench Setup

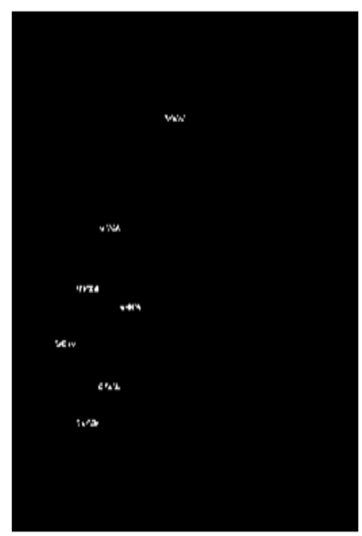
Fig.6. Project Setup

Block Based Noise Estimation Using Adaptive Gaussian Filtering

Original picture "Cameraman.tif

Noisy Image (Gaussian Noise)

IV. Results



Standard Deviations

Esimated Noise

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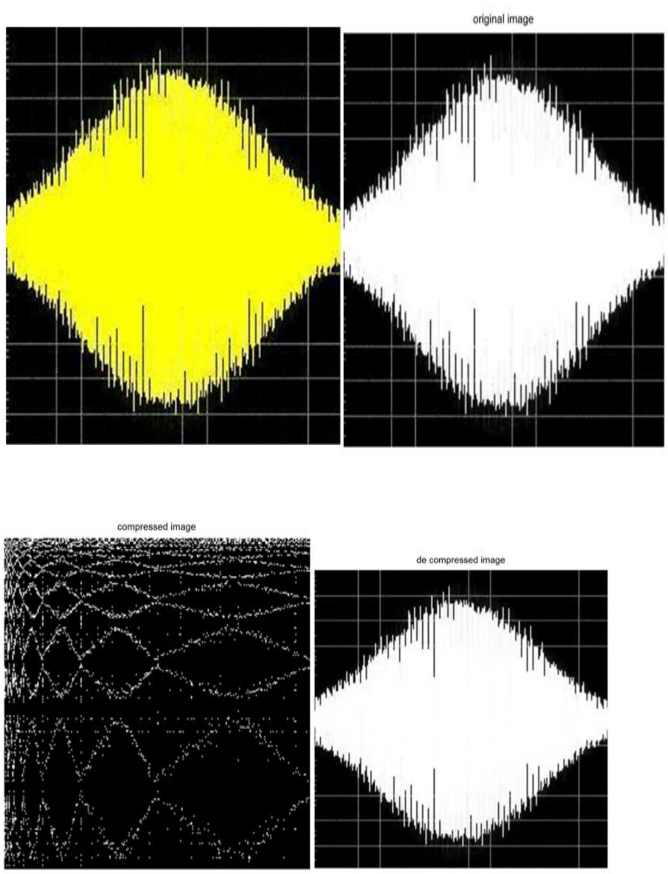
Image compression for colour image using JPEG2000 Data compression using JPEG2000



CONCLUSION

From this we conclude that various compression technique like Discrete Wavelet Transform (DWT) using JPEG 2000 is easy for Image compression of radar signals using MATLAB .Experimental result so that the proposed algorithm use better results.

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