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A Combine Approach of Compression And Encryption For Image Transmission

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ABSTRACT
In recent years, the development and demand of multimedia product is growing increasingly fast. This is a contribution to insufficient bandwidth of network and storage of memory device. When we send any image over the network it consumes more time. This is due to the huge size of the image file as compared to the text file. One more factor, which is security, should be considered while transmission. Compression can reduce the data redundancy to save more hardware space and transmission bandwidth and encryption can provide security.
Compression and encryption algorithms can be classified into two main categories: Independent encryption and compression technique and joint encryption and compression technique. Joint encryption and compression technique is employed to enable faster and secured transmission of image data.

Keywords : Discrete Cosine Transform(DCT), Compression, Encryption, Huffman Algorithm, Discrete Wavelet Transform(DWT).

1. INTRODUCTION

The revolution of multimedia and hyper media has been a driving force behind fast and secured data transmission techniques. Now people are offering web based learning through internet **[1].** In general, image data takes more time in encryption than text due to its large size. Due to this large size, it needs to be compressed and encrypted to avoid security threats and delay.

Uncompressed multimedia (graphics, audio and video) data requires considerable storage capacity and transmission bandwidth. Despite rapid progress in mass storage density, processor speeds, and digital communication system performance, demand for data storage capacity and data transmission bandwidth continues to outstrip the capabilities of available technologies. The recent growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of such signals central to storage and communication technology.

Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios. Image Compression addresses the problem of reducing the amount of data required to represent the digital image. Compression is achieved by the removal of one or more of three basic data redundancies: (1) Coding redundancy, which is present when less than optimal (i.e. the smallest length) code words are used; (2) Inter pixel redundancy, which results from correlations between the pixels of an image; &/or (3) psycho visual redundancy which is due to data that is ignored by the human visual system (i.e. visually nonessential information).

Image compression methods are divided into two classes, lossless or lossy. With lossless image compression **[30],** the reconstructed image is exactly the same as the original one, without any information lost. The entropy, which measures the quantity of information contained in a source, gives a theoretical boundary for lossless compression expressed by the lowest compression bit- rate per pixel. Entropy depends on the statistical nature of the source and ideally an infinite-order probability model is needed to evaluate it. On the contrary, lossy image compression **[23]** would reconstruct the image with a varying degree of information loss.There are several types of redundancy in an image, such as spatial redundancy, statistical redundancy, and human vision redundancy. Basically, removing these types of redundancy is how the process of compression is achieved.

Spatial redundancy **[29]** means that the pixel information could be partially deduced by neighboring pixels. Spatial de-correlation methods, like prediction or transformation, are usually employed to remove the spatial redundancy. Prediction is used to predict the current pixel value from neighboring pixels. For example the differential pulse code modulation (DPCM) method is a typical prediction based technique. Transformation is used to transform the image from the spatial domain into another domain, applying; for example, the discrete cosine transforms (DCT) or the discrete wavelet transform (DWT).

Statistical redundancy **[29]** explores the probability of symbols. The basic idea is to assign short code words to high-probability symbols, and long code words to low-probability symbols. Huffman or arithmetic coding is two popular methods to remove statistical redundancy; they are usually called entropy coding.

Human vision redundancy, when dealing with lossy compression, explores the fact that eyes are not so sensitive to high frequency. Removing human vision redundancy is normally achieved by quantization, with high-frequency elements being over quantized or even deleted.

The revolution of multimedia and hyper media has been a driving force behind fast and secured data transmission techniques. Since the size of graphics data is huge in volume, it needs to be compressed and encrypted to avoid security threats and delay. There are two strategies for this, namely, independent encryption algorithms and joint compression and encryption algorithms. In independent encryption algorithms, both compression and encryption are done independently as two different steps by employing suitable algorithms.

Steps involved in independent encryption **[17]** are illustrated in Fig. 1.1 This strategy consumes more time and memory. When independent encryption algorithms are employed, overall system performance decreases due to the huge computation overhead involved.

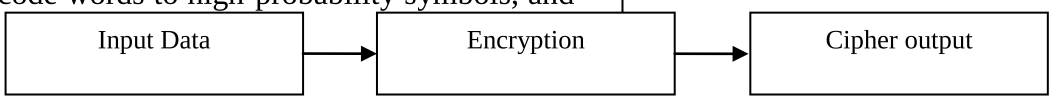

Fig. 1.1: Independent encryption process

But in joint compression and encryption algorithm, both the steps, namely, compression and encryption are integrated together as a single step. There are two approaches for joint compression and encryption algorithm: the first method employs encryption after compression and the second method does encryption before compression. Steps involved in both the approaches are illustrated in Fig. 1.2(a) and 1.2(b).In the first strategy, as encryption is done after compression we get two-fold advantage, namely, reduced data size and time. The second strategy encrypts data without compression and is time consuming. In general, any joint compression and encryption algorithm will provide two levels of security and consumes less time when compared to independent compression and encryption algorithms.

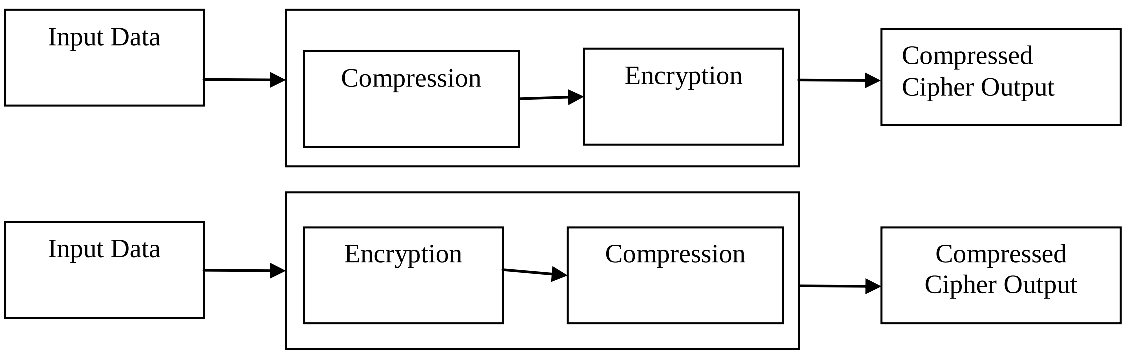

Fig. 1.2: (a) Compression before encryption (b) Compression after encryption

The term data compression refers to the process of reducing the amount of data required to represent a given quantity of information. A common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image. Two fundamental components of compression are redundancy reduction and irrelevancy reduction.

Redundancy reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System (HVS). It is not an abstract concept but a mathematically quantifiable entity. If n_1 and n_2 denote the number of information-carrying units in the two data sets that represent the same information, the relative data redundancy RD of the first data set (the one characterized by n_1) can be defined as:

$$RD = 1 - 1/CR$$

Eq.(1.1)**[10]**

Where CR, commonly called the compression ratio is:

$$CR = n_1/n_2$$

Eq.(1.2)**[10]**

2. RESEARCH METHODOLOGY

Image compression literally means reducing the size of graphics file, without compromising on its quality. Depending on whether the reconstructed image has to be exactly same as the original or some unidentified loss may be incurred. Encryption is used to secure the data during transmission. In this thesis a selective approach is proposed based on Huffman coding of wavelet lower trees and selective encryption Huffman code procedure is based on the two observations. Firstly more frequently occurred symbols will have shorter code words than symbol that occur less frequently. Secondly the two symbols that occur least frequently will have the same length. The Huffman code is designed by merging the lowest probable symbols and this process is repeated until only two probabilities of two compound symbols are left and thus a code tree is generated and Huffman codes are obtained from labeling of the code tree. The second step in Huffman's procedure is to code each reduced source, starting with the smallest source and working back to its original source. The minimal length binary code for a two-symbol source, of course, is the symbols 0 and 1. Huffman's procedure creates the optimal code for a set of symbols and probabilities subject to the constraint that the symbols be coded one at a time.

2.1- DEVELOPMENT OF HUFFMAN CODING AND DECODING ALGORITHM

Step1- Read the image on to the workspace of the mat lab.

Step2- Convert the given color image into grey level image.

Step3- Call a function which will find the symbols (i.e. pixel value which is non-repeated).

Step4- Call a function which will calculate the probability of each symbol.

Step5- Probability of symbols are arranged in decreasing order and lower probabilities are merged and this step is continued until only two probabilities are left and codes are assigned according to rule that :the highest probable symbol will have a shorter length code.

Step6- Further Huffman encoding is performed i.e. mapping of the code words to the corresponding symbols will result in a compressed data.

Step7- The original image is reconstructed i.e. decompression is done by using Huffman decoding.

Step8- Generate a tree equivalent to the encoding tree.

Step9- Read input character wise and left to the table II until last element is reached in the table II.

Step10-Output the character encodes in the leaf and returns to the root, and continues the step9 until all the codes of corresponding symbols are known.

2.2- THE PROCESS

The whole process of wavelet image compression is performed as follows: An input image is taken by the computer, forward wavelet transform is performed on the digital image, thresholding is done on the digital image, and entropy coding is done on the image where necessary, thus the compression of image is done on the computer. Then with the compressed image, reconstruction of wavelet transformed image is done, then inverse wavelet transform is performed on the image, thus image is reconstructed.

Various wavelet transforms are used in this step. Namely, Daubechies wavelets, Coiflets, bi-orthogonal wavelets, and Symlets. These various transforms are implemented to observe how various mathematical properties such as symmetry, number of vanishing moments and orthogonality differ the result of compressed image. Advantages short support is that it preserves locality. The Daubechies wavelets used are orthogonal, so do Coiflets. Symlets have the property of being close to symmetric. The bi-orthogonal wavelets are not orthogonal but not having to be orthogonal gives more options to a variety of filters such as symmetric filters thus allowing them to possess the symmetric property.

Compactly supported wavelets are functions defined over a finite interval and having an average value of zero. The basic idea of the wavelet transform is to represent any arbitrary function f(x) as a superposition of a set of such wavelets or basis functions. These basis functions are obtained from a single prototype wavelet called the mother wavelet ψ(x), by dilations or scaling and translations. Wavelet bases are very good at efficiently representing functions that are smooth except for a small set of discontinuities. For each n, k ∈ Z, define ψn,k(x) by: ψn,k(x) = 2n/2ψ(2nx − k)

Eq.(1.3)**[27]**

Constructing the function ψ(x), L2 on R, such that {ψn,k(x)}n,k∈ Z is an orthonormal basis on R. As mentioned before ψ(x) is a wavelet and the collection $\{\psi_{n,k}(x)\}_{n,k\in Z}$ is a wavelet orthonormal basis on R; this framework for constructing wavelets involves the concept of a multi resolution analysis or MRA.

In the process of image compression, applying the compression to the RGB components of the image would result in undesirable color changes. Thus, the image is transformed into its intensity, hue and color saturation components. In a wavelet transform, we call LH1, HL1 and HH1 to the sub bands resulting from the first level of the image decomposition, corresponding to horizontal, vertical and diagonal frequencies. The rest of image transform is computed by recursive wavelet decomposition on the remaining low frequency sub band, until a desired decomposition level (N) is achieved (LLN is the remaining low frequency sub band).

Algorithm consists of three stages. In the first one, all the symbols needed to efficiently represent the transform image are calculated. During this stage, statistics can be collected in order to compute a Huffman table in a second stage. Finally, the last stage consists in coding the symbols computed during the first one by using Huffman coding.

In the first stage (symbol computation), the entire wavelet sub bands are scanned in 2×2 blocks of coefficients, from the first level to the Nth (to be able to build the lower-trees from leaves to root). In the first level sub band, if the four coefficients in each 2×2 block are insignificant, they are considered to be part of the same lower-tree, being labeled as LOWER_COMPONENT. Then, when scanning upper level sub bands, if a 2×2 block has four insignificant coefficients, and all their direct descendants are LOWER_COMPONENT, the coefficients in that block are also labeled as LOWER_COMPONENT, increasing the size of the lower-tree.

In the second stage, Huffman codes are built with the probability model for the source (the symbols computed in the first stage), once this probability model has been acquired during the first stage. The computed table containing the Huffman codes is output so that the decoder can use it to decode the encoded symbols.

Finally, in the third stage, sub bands are encoded from the LLN sub band to the first-level wavelet sub bands. Observe that this is the order in which the decoder needs to know the symbols, so that lower-tree roots are decoded before its leaves. In addition, this order provides resolution scalability, because LLN is a low-resolution scaled version of the original image, and as more sub bands are being received, the low-resolution image can be doubled in sizeIn each sub band, for each 2×2 block, the symbols computed in the first stage are Huffman encoded using the codes computed in the second stage. Recall that no LOWER_COMPONENT is encoded, and that significant bits and sign are needed, and therefore binary encoded, for each significant coefficient.

2.3- PROPOSED ALGORITHM

The method, considered in this paper, is outlined for grey scale images but can be extended to colour ones also. The image is considered to be a smooth function of *x* and *y*, even though it is not so.

2.3.1- COMPRESSION

The stepwise procedure to compress a given image is as follows:

Step 1

Let us denote the image as a matrix of gray level intensity values and represent it by I.

Step 2

Pass *I* through a high pass filter and name it IHP. The pass band frequency of the high pass filter to be used must be chosen in such a way that the resulting filtered image has enough details; or in other words, the order of the filter is to be decided on the basis of the amount of information to be retained.

Step 3

IHP is divided in square blocks of some size, say 16 × 16. We take [m/16] and [n/16] where [] represent ceiling.

Step 4

For each such block:

1) The gray value at each position (*x*, *y*) is obtained. We have 256 such values one for each pixel position.

2) If not more than half; i.e., 128 (threshold parameter), of these values are zero then the block is marked for Huffman encoding, else it is marked for Huffman encoding of wavelet lower trees.

Step 5

Computations, from now onwards, are carried out on the original image and not on the filtered one. The original image is also divided in 16 × 16 blocks, as the filtered image. These blocks are numbered so that we can keep a track of which block is marked for which type of compression.

Step 6

Each block, starting from block 1, is checked for which method it is marked for in step 3.

Step 7

All the blocks marked for Huffman encoding are placed together row wise in a new image matrix, I-Huff.

Step 8

In I-Huff:

1) For each position, (*x*, *y*), grey value, Gn, is obtained.

2) Number of occurrence of each Gn is calculated.

3) Encode Img-Huff using the above calculated values.

4) This encoded matrix, can be further compressed using LZW or arithmetic coding, is represented as C-Huff.

Step 9

All the blocks marked for Wavelet are placed together row wise in image matrix, ImgWavelet.

1) ImgWavelet is divided into 2 × 2 blocks.

2) For each block Bn

If | Ci,j | < 2rplanes

set si,j =LOWER_COMPONENT

else for each Ci,j € Bn

if |Ci,j| < 2rplanes ^ descendant(ci,j)=LOWER_COMPONENT

set Si,j=LOWER

else

if |Ci,j| < 2rplanes ^ descendant(ci,j)≠LOWER_COMPONENT

set Si,j= ISOLATED_LOWER

else

nbitsi,j = [log2(| Ci,j |)]

if descendant(ci,j)=LOWER_COMPONENT

set Si,j= nbitsi,jLOWER

else

set Si,j= nbitsi,j

3) Build Huffman codes with statistics from *S*

4) Repeat step 8 and the resulted matrix are named C-wavelet.

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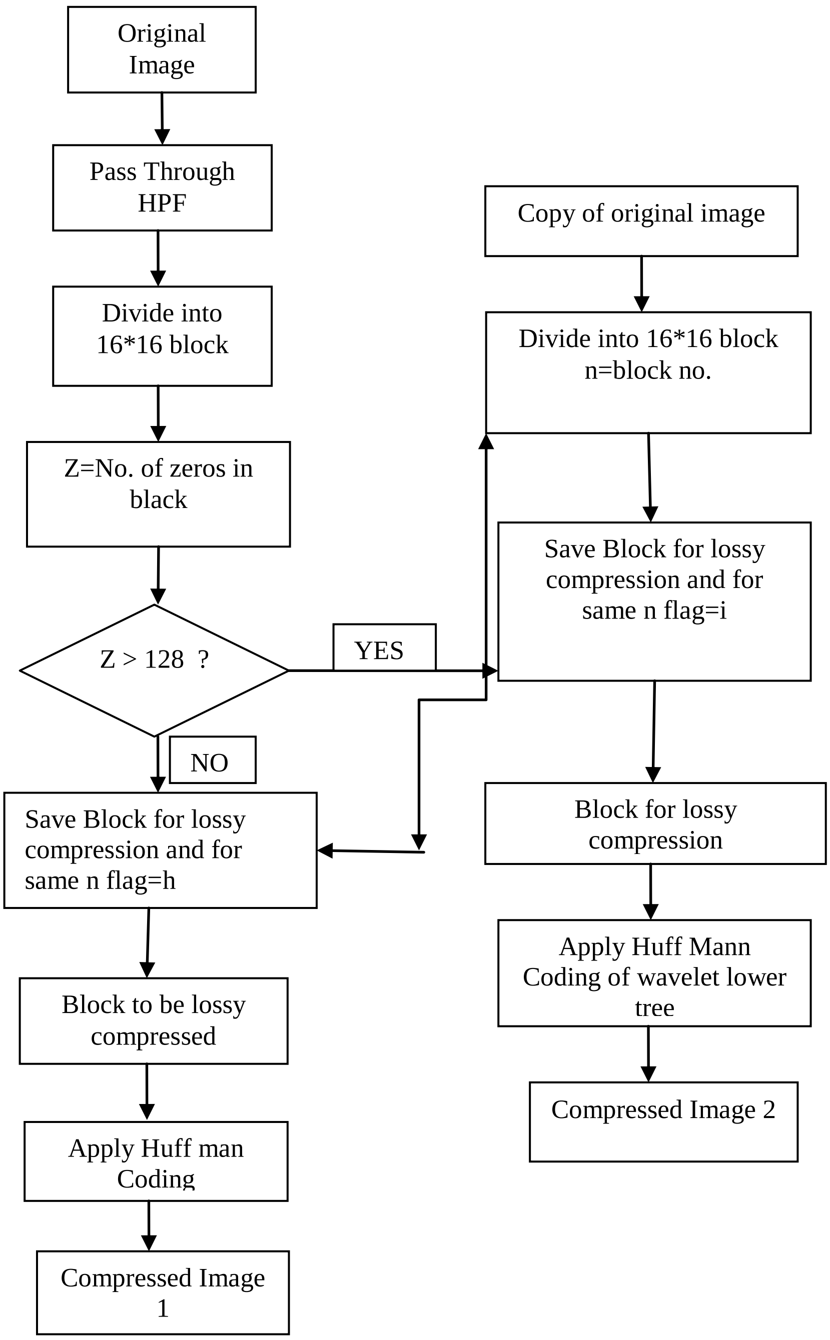

Fig 1.3: Image compression using proposed algorithm

2.3.2- DECOMPRESSION

To reconstruct the original image the two compressed images, C-Huff and C-Wavelet, are considered. The procedure is outlined below:

Step 1

We start with block number 1 and check whether it belongs to C-Huff or C-Wavelet matrix.

Step 2

If the nth block belongs to C-huff

1) It is stored in a new image matrix IHuf1. This is done until all blocks compressed by the Huffman method are stored in IHuf1.

2) IHuf1 is decoded back to original pixel values using Huffman decoding algorithm.

3) The decoded blocks are placed in reconstructed image, say DecomImg, according to their number.

Step 3

If the nth block belongs to C-Wavelet

1) Apply Huffman decoding of wavelet lower trees.

2) This block is placed in reconstructed image, DecomImg, according to its number.

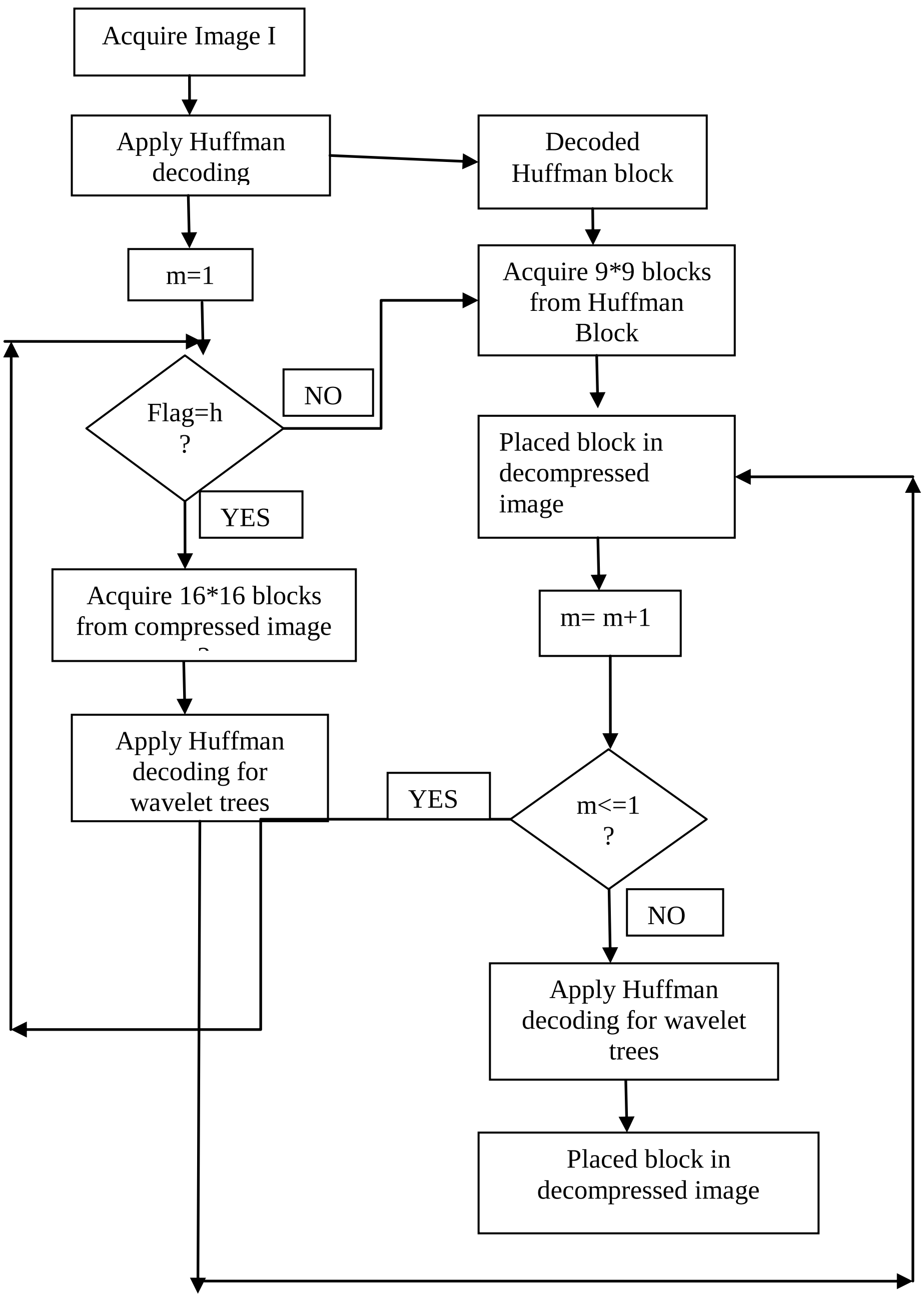

Fig 1.4 : Image decompression using proposed algorithm

3.SELECTIVE ENCRYPTION OF

COMPRESSED IMAGES

In some applications, it is relevant to hide the content of a message when it enters an insecure channel. The initial message prepared by the sender is then converted into ciphertext prior to transmission. The process of converting plaintext into ciphertext is called encryption. The encryption process requires an encryption algorithm and a key. The process of recovering plaintext from ciphertext is called decryption. The accepted view among professional cryptographers (formalized in KIRKHOFF's law) is that the encryption algorithm should be published, whereas the key must be kept secret.In the field of image cryptography, the focus has been put on steganography, and in particular on watermarking during the last years .Watermarking, as opposed to steganography, has the additional requirement of robustness against possible image transformations. Watermarks are usually made invisible and should not be detectable.In applications requiring transmission the image is first compressed, because it saves bandwidth.

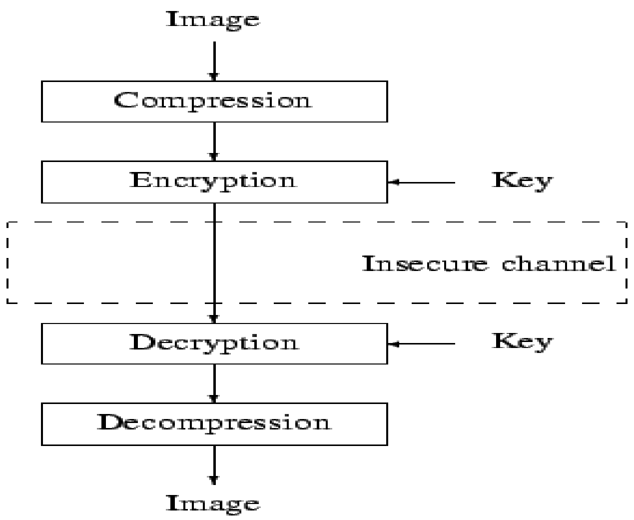

Fig 1.5: Encryption of an image.

The removal of redundancy enhances robustness as it squeezes out information that might be useful to a cryptanalyst. However it also introduces known patterns in the compressed bitstreams, like headers or synchronization stamps (called markers), that eases plaintext attacks on the signal. An alternative would be to compress after encryption, but it would not be as efficient in terms of bandwidth because encrypted information looks random and is therefore hard to compress.

- there are two kinds of information: the image and the key.
- the subjective significance of information contained in the image is ignored. For example, there is no distinction between Most Significant Bits (MSBs) and Least Significant Bits (LSBs).

It is clear that the receiver should decrypt the information before it can decompress the image. This approach has the main drawback that it is impossible to access the smallest part of information without knowledge of the key. For example, it would impossible to search through a general database of fully encrypted images. A way to address this issue is to use a technique called selective encryption.

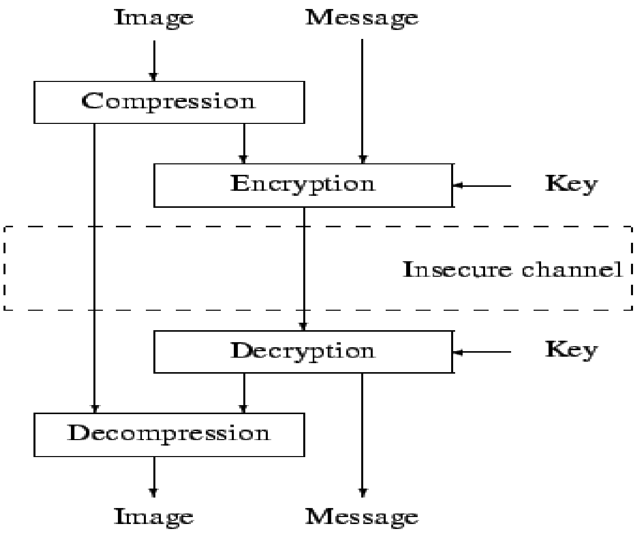

Fig:1.6 Selective encryption mechanism.

The image is first compressed (if needed). Afterwards the algorithm only encrypts part of the bitstream with a well-proven ciphering technique; incidentally a message (a watermark) can be added during this process. To guarantee a full compatibility with any decoder, the bitstream should only be altered at places where it does not compromise the compliance to the original format. This principle is sometimes referred to as format compliance. With the decryption key, the receiver decrypts the bitstream, and decompresses the image. In principle, there should be no difference between a decoded image and an image that has been encrypted and decrypted. However there might be a slight though invisible difference if a watermark message has been inserted in the image.When the decrypting key is unknown, the receiver will still be able to decompress the image, but this image will significantly differ from the original.

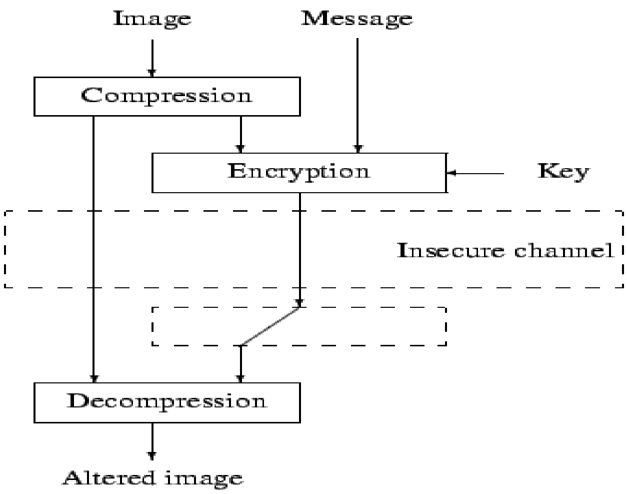

Fig1.7: When the decryption key is unknown to the receiver.

2 Selective encryption of uncompressed images

A very effective method to encrypt an image, which applies to a binary image, consists in mixing image data and a message (the key in some sense) that has the same size as the image: a XOR function is sufficient when the message is only used once. A generalization to gray level images is straightforward: encrypt each bitplane separately and reconstruct a gray level image. With this approach no distinction between bitplanes is introduced although the subjective relevance of each bitplane is not equal.

4.FUTURE SCOPE

A mechanism can be designed to securely transmit the key so that unauthorized person should have no access to it. The performance evaluation factors are PSNR ratio and coding-decoding time for compression and encryption respectively, but the balancing parameter for the combined process is not yet being defined. While currently this approach only focuses on images, and can be applied on audio, text and video as well. A neural network can be used to learn the threshold upon which it can be decided that whether the block has to be compressed lossy or losslessly which can then automate compression technique for any type of image.

5.CONCLUSION

The joint selective compression and encryption technique for image transmission has been proposed which resolves two major issues such as speed and security when confidential image data is sent over the network. It can be observed that it is not computationally complex. Results show that it gives better quality images than JPEG 2000, DCT, DWT for the same compression ratio and also the execution time is being improved.

Through this approach some performance parameters are being concluded. They are as follows:

1) **Performance of Compression:** When compared with independent encryption algorithms, joint compression and encryption algorithms give better compression ratio.

2) **Performance of Encryption:** Joint compression and encryption algorithms are more efficient than independent encryption algorithms. Since the encryption is done after compression, these algorithms provide high encryption speed.

3) **Security:** In joint compression and encryption technique, the compression process involves one or more encryption steps. Additionally a separate encryption process is applied after compression. Thus this scheme provides two level securities.

4) **Execution Speed:** In joint compression and encryption technique, compression and encryption are done as one process due to which it takes less execution time as compared to independent compression and encryption process.

5) **Memory Utilization:** Joint compression

and encryption algorithm are more secured, faster and consume less memory as compared to independent encryption algorithms.

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