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Analysis on Image Compression & Encryption

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ABSTRACT: The change from the cinematographic film to digital image processing and exchange is primarily inspired by the flexibility and ease of handling and processing digital image information. While preparing and developing standards for digital image communication, one has to make absolutely sure that the image quality is improved or maintained, the image is not accessed by unauthorized users, and also the storage capacity and transmission bandwidth, researches on image protection and security through a combination of cryptographic and compression techniques begin to take form. This paper addresses about various image compression and encryption techniques. Basically there are two types introduced lossy and lossless compression techniques and symmetric and asymmetric cryptographic techniques. In present time some other techniques are added with basic method. We analyze different types of existing method of image compression and encryption.

KEYWORDS: Compression, Encryption, Huffman Coding, Lossless, Lossy, Redundancy, Symmetric, Asymmetric.

I. INTRODUCTION

Messaging transmission service through internet media such as e-mail, and social media like Twitter, WhatsApp, Facebook, can also be done. One emerging problem is that a growing size of digital data, particularly still images, is unavoidable due to the need of high-quality images. As a result,there is a need for larger storage spaces . Although storage techniques in digital computers have experienced rapid development, in many situations they require the reduction of digital data storage ,in other words, Compression is the solution.

Compressing an image is significantly different than compressing raw binary data. Of course, general purpose compression methods can be used to compress images.Image compression can be lossy or lossless[1][2].This is because images have certain statistical properties which can be misused by one of the finer details in the image can be sacrificed for the sake of saving a little more storage space or bandwidth. This is lossy compression techniques that can be used. Lossless compression involves with compressing data which, when decompressed, will be an exact replica of the original image. They need to be exactly reproduced when decompressed. On the other hand, images (and music too) need not be reproduced 'exactly'. An approximation of the original image is enough for most purposes, as long as the error between the original and the compressed image is tolerable.

In addition to the speed of data exchange of a growing size, data safety is of utmost concern due to the susceptibility of data sent through communication lines to their being extracted by eavesdroppers[3]. So the need of Encryption occurs.There are basically two types of encryption methods: Symmetric and Asymmetric. Symmetric key cryptography is a common cryptographic technique using the same key at both the transmitter and receiver side. Whereas Asymmetric cryptography uses public and private keys to encrypt and decrypt image[4].Encryption ensures that transmitted data is reliable and integral by converting it from legible into illegible data through an encoding process. Conversely, a compression method seeks to reduce the size of transferred/stored data by finding out and removing duplicate parts of evidence or patterns of data[6]. However, data compression and cryptographic system are deeply connected and mutually useful that they are capable of being employed together. The aims are to generate a smaller size of data; to ensure a quality of data during reconstruction; to speed up data transmission; to reduce bandwidth

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requirement, and to ensure its safety[7].
In this paper, mainly combination of compression and cryptography techniques will be discussed to enhance efficiency in the transmission and safety of image data during the last decade.

II. RELATED WORK

The research work of image compression and encryption is categorised in CE, EC and JCE as follows:.

- Compression followed by Encryption (CE)

In this approach an invader have less cleave to access the image but due to compression followed by encryption the size of the image may be increased.

- Encryption followed by Compression (EC)

In this approach size is not been increased but due to encryption followed by compression an invader can access the image due to more clues.

- Joint Compression and Encryption (JCE)

The procedure of this approach is complicated and is recently used but it is faster as compared to previous two approaches CE and EC.

A. *Research work on CE Approach*

1) Masanori Ito, Ayman Alfaou, Ali Mansour proposed a new encryption and compression technique. The compression is done with the help of DCT. Firstly the image is divided into small squares blocks after this DCT (discrete cosine transformation) is applied and obtain DCT components. Most of DCT components have high energy in low frequency bands; they use low frequency components through a low pass filter which is simple. After compression the small blocks are rotated randomly and the rotation matrix is saved as a key. The encryption technique is inspiration of blind source separation. The compressed and rotated blocks of DCT are mixed together. It is observed that when ratio of compression is between 0.1 to 0.5 the best performance can be achieved. Therefore by using this technique a fast and secure image transmission can be achieved.[8]
2) Ebru Celikel, Mehmet Emin Dalkilic performed experiments on a secure compression algorithm. Results are compared using different compression techniques like Arithmetic coding, Huffman Coding, Lempel-Ziv, Prediction by Partial Matching and Burrows Wheeler. Encryption is performed using symmetric key BBS PRNG. The authors applied algorithm on text file in English and Turkish.
3) Younggap You, Hanbyeori Kim [11] addresses image compression and followed by fault tolerant encryption of continuous video streams such as computer tomography and digital endoscopy for lower data traffic and secure transmission. performed compression using Discrete Wavelet Transform. For encryption Advanced Encryption Standard algorithm AES is used. Algorithm is suitable for Medical video and image.
4) D.Kesavaraja et al. [12] observed that the conventional image compression algorithm run slow therefore they proposed real time implementation of a Distributed Image Compression in Clustering of Nodes. In this security is also more important factor. So, they proposed a Distributed Intrusion Detection System that monitors all the nodes in the cluster. If an invader tries to intrude in node processing then prevention step based on RIC (Robust Intrusion Control) Method is to be taken. This suggested method gives higher efficiency rate than other schemes. The Security Level is high on this Intrusion Scheme Java Cluster. The efficiency ratio of this computation procedure is 91.20.

B. *Research work on EC Approach*

1) V.Radha, D.Maheswari [9] stated that, image encryption algorithm consists of two parts: first,scrambling of plain-image and second,mixing operation of scrambled image using discrete states variables of chaotic maps.The reason of scrambling is to transform, a meaningful image into a meaningless image, disordered and

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unsystematic image to obscure real meaning of image. A secret scrambling increases the computational complexity of potential chosen-plaintext attack, which makes cryptanalysis of image encryption much more complicated.

2) Fawad Ahmed et al. [10] used encryption scheme that relies on some very the properties of orthogonal matrices that contain columns that form a set of orthonormal basis vectors. JPEG is used for performing compression.In this method there is no image format constraint.This scheme has the capability to cover the plaintext-image from the cipher image,it can recover even if the cipher image data is compressed using JPEG lossy compression.Production of cipher-image with varying perceptual distortion can be achieved by adjusting encryption algorithm.

3) Wei Liu et al. [13] focuses on the design of a practical image codec, here the image data undergoes the stream cipher based encryption before the compression.The stream cipher is based on Slepian-Wolf coding for encryption. It is stated to compress the image progressively, such that the decoder can observe a low-resolution image.Also lossless compression is used. Theoretical analysis shows that, despite the inefficiency of channel codes,their scheme can achieve 70% to 90% rate saving of that of the optimal conventional intra-frame coder.

4) Mingyu Li et al. [14] used a RC5 stream cipher based scalable encryption scheme for low complexity transparent transcoding. CCSDS compression method is used which consist of two part DWT and Bit plane coding. Advantage is that Encryption is scalable.

C.*Research work on JCE Approach*

1) Shaimaa A. El-Said et al. [23] proposed algorithm called OMHT (Optimized Multiple Huffman Tables) technique which uses an Optimized Multiple Huffman Tables (OMHT) technique which was proposed to face some compression and security problems found in Multiple Huffman Tables (MHT) technique. OMHT depends on using statistical-model-based compression method which generated different tables from the same data type of videos or images to be encrypted leading to increase security compression efficiency and security of the used tables.The cost of encryption of OMHT is smaller than cryptographic cipher.
2) Maher Jridi, Ayman Alfalou [15] proposed a method that utilizes the Discrete Cosine Transform properties to achieve the encryption and compression simultaneously.This method is to increase the levels of security and to enhance the speed of transmission of secret information over the network, as the basic model of Visual Cryptography is not an efficient tool to hide the secured information.A compression ratio higher than 65% is achievedThe implementation of whole method shows improvement in terms of area and power consumption, throughput.
3) Abraham Jun Jiang Lock et al. [16] performed image compression which is based on fractal image coding with little modification. Private Key cryptography using new method ‗Fractal Encryption' is used.Fractal is used as a "master key" to enable simultaneous generation of "local" or "sequential" keys that are then used to encrypt and decrypt the actual messages. Encryption uses Mandelbrot Set. Fractal compression can provide higher compression ratio and fractal encryption can provide strong protection against the attacks so that no intruder can access it.
4) Yunpeng Zhang et al. [17] Compression is carried out using the feature of JPEG2000 data structure & uses chaotic system to encrypt the coefficient-bit and the context according to the plane coding, in the view of JPEG2000 image compression standard. Since it is carried out at the same time as coding/decoding, the scheme makes the compression ratio influence small and also retains the original compression algorithm's stream elasticity, and also enjoys low cost and high security.It is proved to be an effective encryption/decryption resolution for JPEG2000. So the scheme is well for application

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III.IMAGE COMPRESSION

Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages .There are several different ways in which image files can be compressed. For Internet use, the two most common compressed graphic image formats are the JPEG format and the GIF format. The JPEG technique is usually used for photographs, while the GIF technique is commonly used for images like, line art in which geometric shapes are simple.

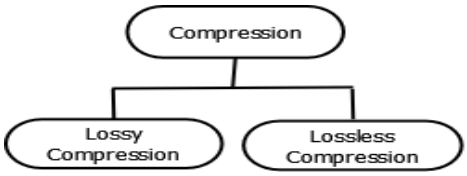

Fig 1. Compression

The issue of reducing the amount of information required to represent a digital image is addressed by Image compression. A compact representation of an image is intended to produce by using image compression, therefore reducing the requirements of image storage transmission. Every image will have some redundant data. Redundancy means duplicate data in any image. Redundancy may be either by repeating pixels across the image or pattern, The pattern which is repeated regularly in the image. The image compression occurs by taking the advantage of redundant information in the image. Reducing the redundancy helps one to achieve a saving of storage space of an image. In image compression there are three basic data redundancies that can be identified and exploited. Compression is achieved by removing one or more of the three basic data redundancies

A. *Inter Pixel Redundancy*

Inter Pixel Redundancy occurs due to the correlation between the neighboring pixels of an image. This type of redundancy is called Inter-pixel redundancy. In image, neighboring pixels are not statistically independent. Inter Pixel Redundancy is also called spatial redundancy. The gray levels are not equally probable. This redundancy can be explored in many ways, one is by predicting a pixel value based on the values of its neighboring pixels. To do so, the original 2D array of pixels is usually mapped in a different format, e.g., an array of differences between adjacent pixels. If the original image [19] pixels can be reconstructed from the transformed data set the mapping is said to be reversible. Individual pixel carries relatively small information. To reduce the inter pixel redundancy the difference between adjacent pixels can be used to represent an image.

B. *Coding Redundancy*

The uncompressed image usually is coded with each pixel by a fixed length. For example, an image with 256 gray scales is represented by an array of 8 bit integers. Code Redundancy occurs due to using variable length code words selected to match the statistics of the original source, that is, the image itself or a processed version of its pixel values. This type of coding is reversible.Using some variable length code schemes such as Huffman coding and arithmetic coding are examples of image coding schemes that explore coding redundancy

C Psycho Visual Redundancy

Psycho visual redundancy arises because of the problem of perception. Our eyes are more responsive to slow and gradual changes of illumination than perceiving finer details and quick changes of intensities. For example intensity variation can be perceived in an area of constant intensity, such phenomena results in the fact that the eye does not respond with equal sensitivity to all visual information .Hence, to what extent we should preserve the details for our perception and to what extent we can compromise on the quality of reconstructed image that we perceive is to be essentially carried out by exploiting the Psycho visual redundancy.

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D *Types of Image Compression*

Image compression schemes can be broadly classified into two categories:

1. Lossless Image Compression

In Lossless image compression, the original image can be recovered exactly from the compressed image. Lossless image compression schemes exploit various redundancies without experiencing any loss of data. Thus, the image prior to encoding and after decoding is exactly the same without any distortion in the reconstruction quality. Therefore, Lossless image compression is exactly reversible.Lossless compression is achieved by exploiting statistical redundancy. For example, if we convert the image into a string of symbols before encoding and then assign shorter code words to more frequently occurring symbols and longer code words to less frequently occurring symbols, then we can say we achieved compression and at the same time ,during decoding the encoding process can be exactly reversed , as there is an one-to-one mapping between the symbols and their codes. Huffman coding, Arithmetic coding ,Variable length coding, , LZW coding, Bit plane coding, Lossless Predictive coding are the most commonly used coding techniques for Lossless Image compression.

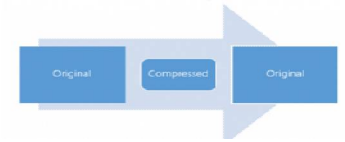

Figure 1. Lossless Compression

Lossless image compression schemes can achieve only limited extent of bandwidth reduction for Image transmission, but it maintains the quality of the image, without suffering from any distortion.

- Advantages: No loss of quality, slight decreases in image file sizes.
- Disadvantages: Larger files than if you were to use lossy compression.

2. Lossy Image Compression

This technique incurs loss of data and hence suffers a loss of quality in reconstruction.In this technique, there is a possibility of achieving significant image compression, but quantization is many-to-one mapping hence it is irreversible and exact reconstruction is never possible. These methods are used where some loss of data is acceptable. Lossy Compression technique essentially exploits the psychovisual redundancy. For example, compressed Video signal is different from the original. However, we can obtain the higher compression ratio than the Lossless compression methods. Some of the common techniques for lossy image compression are Transform coding, Wavelet coding, Lossy predictive coding, Zonal coding,Image compression standard [22].

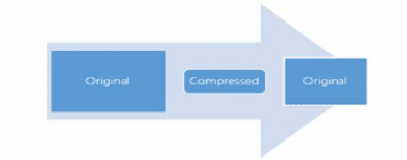

Figure 3. Lossy Compression

Lossy Image compression techniques are very effective at compression than the Lossless methods. Also these techniques provide substantial image compression with very good quality reconstruction. The higher is the compression ratio, the more noise is added to the data [5].

- Advantages:
  1) Very small file sizes and lots of tools, plugins, and software support it.
  2) It significantly reduces the size of the image file.

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- Disadvantages:

1) Quality degrades with higher ratio of compression. Can't get original back after compressing.
2) Compression is achieved with a loss of quality

III. IMAGE ENCRYPTION

Nowadays information security is becoming more important in data storage and transmission. Images are used widely after text in several processes, having secure and reliable means of communication with images and video is becoming a necessity, and its related problems must be carefully considered, so protection of image from the unauthorized users is very important. Encryption is the process of using an encryption algorithm of encoding to transform information or hide data to make it unreadable to the unauthorized users and only authorized people can access or read it. Image encryption have applications in various fields, including multimedia systems, wireless communication, military communication, medical imaging, telemedicine and more different areas. In encryption the image is encrypted using an encryption algorithm, generating the text that is in encrypted format and only read if decrypted [17]. There exists many traditional encryption techniques like DES, AES etc for providing high security to the data that may be in textual or image form.

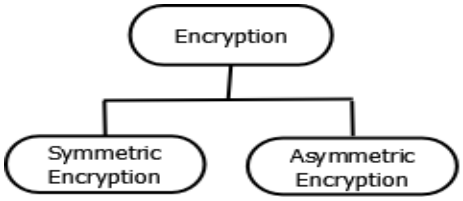

Figure 4. Encryption

Symmetric-key encryption and asymmetric-key encryption are the two primary types of encryption through which we can encrypt our images.

A. *Symmetric Encryption*

In Symmetric algorithm sender and receiver ends use a same cryptographic key (symmetric key) for data transformation. Symmetric key cryptography is also known as shared key cryptography. A cryptographic key is a special kind of information that helps the sender to convert original data into encrypted form and at other end it helps the receiver to access the encrypted data.Symmetric cryptography also provides a degree of authentication because data encrypted with one symmetric key cannot be decrypted with any other symmetric key. Therefore, as long as the symmetric key is kept secret by the two parties using it to encrypt communications, each party can be sure that it is communicating with the other as long as the decrypted messages continue to make sense.

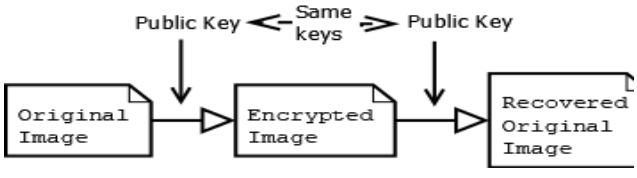

Figure 5. Symmetric Encryption

At sender side the message or data is converted into a special data format called cipher text using various encryption algorithm and secret key. The receiver side performs the same operation but in reverse order. It takes cipher text as input and then converts it into the original message. There are various algorithms for image encryption such as chaotic, blowfish, AES algorithms etc.[19]

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Symmetric key Encryption are valuable because:

- Since there is no key transmitted with the data, the chances of data being decrypted are null.
- A symmetric Encryption uses password authentication to prove the receiver's identity.[20]

The major drawback is

- Secret-key encryption is in exchanging the secret key because any exchange must retain the privacy of the key. This usually means that the symmetric key must be encrypted in a different key, and the recipient must already have the key that will be needed to decrypt the encrypted symmetric-key. This can lead to a never-ending dependency on another key for encryption.

The examples for symmetry algorithm are : DES, Triple-DES (3DES), IDEA, CAST5, BLOWFISH, TWOFISH.

B. *Asymmetric Encryption*

Asymmetric cryptography, also known as public key cryptography, uses public and private keys to encrypt and decrypt data. The keys are simply large numbers that have been paired together but are not identical (asymmetric). One key in the pair can be shared with everyone; it is called the public key. The other key in the pair is kept secret; it is called the private key. Either of the keys can be used to encrypt a message; the opposite key from the one used to encrypt the message is used for decryption.

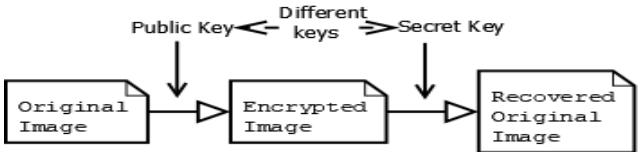

Figure 6. Asymmetric Encryption

For asymmetric encryption to deliver confidentiality, integrity, authenticity and non-repudiability, users and systems need to be certain that a public key is authentic, that it belongs to the person or entity claimed and that it has not been tampered with or replaced by a malicious third party. There is no perfect solution to this public key authentication problem.[21]

Asymmetric key Encryption are valuable because:

- In asymmetric or public key, cryptography there is no need for exchanging keys, thus eliminating the key distributionproblem

The major drawback of

- Asymmetric-key encryption is speed: there are popular secret-key encryption methods which are significantly faster than any currently available public-key encryption method.

V.CONCLUSION AND FUTURE WORK

In the digital world nowadays, the security and storage of digital images has become most important since the communications of digital products over open network occur more and more frequently. Image compression and encryption is attractive area for research in these days because communication with the help of multimedia objects increasing rapidly. In this paper, many of the current important image compression and encryption techniques have been presented and analyzed. The above analysis gives a quick overview of cryptography and compression.

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The best way of fast and secure transmission is by using compression and encryption of multimedia data like images. The research works have been categorized in the following three categories based on the order of the two process viz. CE, EC or JCE. The compression technique observed is either lossy or lossless. Always lossless compression is preferred but to achieve secrecy some image quality degradation is accepted. The encryption technique observed is either symmetric or asymmetric. Symmetric is most used which provides more security during the transmission. In addition to it will explain some of the most used terms in encryption and compression along with a brief description of some popular algorithms to allow the reader to understand the key differences between all of them.
At last, a conclusion is that all examined encryption and compression techniques in this paper, are effective and have their own merits and demerits in respect of speed, storage, transmission and security trade off.

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