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Image Steganography Using Discrete Cosine Transform and Random Pixel Injection

Nivedita Patil
M. Tech Scholar
AITR, Indore
nivedita.patil04@gmail.com

Lakshita Landge
Asst. Professor
AITR, Indore
pcst.lakshita@gmail.com

Abstract: Data hiding or transferring data under the veil of some cover data has long existed and been studied. The technique is referred to as Steganography. The present work uses the Discrete Cosine Transform (DCT) to achieve Image Steganography. Apart from that, the technique proposed uses Random Pixel Injection wherein random pixel values are injected in the Stegano image so as to make it almost infeasible to attackers to break it. The performance of the system is evaluated in terms of Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Correlation and Entropy. It is shown that the proposed system achieves better performance compared to previous work.

Keywords: **Discrete Cosine Transform (DCT), Random Pixel Injection, Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Correlation, Entropy.**

I. Introduction

An **image** may be defined as a two dimensional function *f(x,y)* where x and y are spatial co-ordinates i.e. co-ordinates corresponding to space or location , and the intensity of the image at any point (*x*,*y*) which is also called the gay level of the image is a function of the co-ordinates (x,y). I f it happens so that the values of (x, y), and the gray level [*f(x, y)*] are finite and discrete values, then such an image is called a **digital image**.

A **digital image** is a numeric representation of (normally binary) a two-dimensional image. Depending on whether the image resolution is fixed, it may be of vector or raster type. By itself, the term "digital image" usually refers to raster images or bit-mapped images.

Digital Image Processing

The field of *digital image processing* refers to processing digital images by means of a digital computer. Note that a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as *picture elements*, *image elements*, and *pixels*. *Pixel* is the term most widely used to denote the elements of a digital image. We consider these definitions in more formal terms in Chapter 2.Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception. However, unlike humans, who are limited to the visual band of the electromagnetic (EM) spectrum, imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves. They can operate on images generated by sources that humans are not accustomed to associating with images. These include ultrasound, electron microscopy, and computer-generated images. Thus, digital image processing encompasses a wide and varied field of applications.

II. Image Steganography

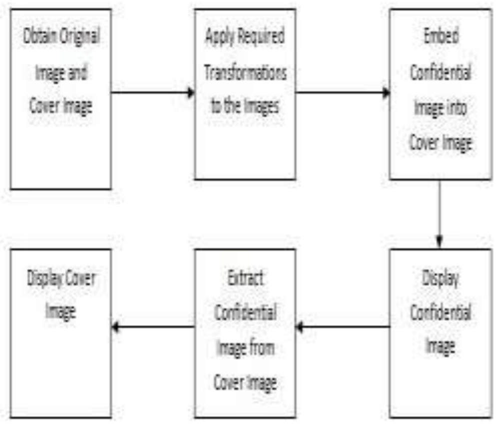

Fig.1: Block Diagram of Image Steganography

It is an art of conveying secret messages and secret images through cover images in a secret way that only the receiver knows the existence of a message. The fundamental requirements of Steganography are:

•**Imperceptibility**: Means that the embedded messages should not be discernible to the human eye.

•**Embedding Capacity:** Means the capacity of embedding the secret image.

•**Security:** Means that the Stegano image should be fool proof and robust.

Any image Steganography model should satisfy the following conditions:

1. It should be able to secure various types of images viz. Photographic Images, Radar Images, Biomedical Images etc.
2. It should render a high amount of randomness to the encrypted data making it infeasible for the adversaries to decrypt by brute force.
3. The key used in the algorithm should change with the state of the images so as to ensure higher levels of security.
4. Finally, it should not be too complex to implement on hardware.

One of the applications that are attacked by the hackers is the E-mail. There are many companies providing the E-mail service such as Gmail, Hotmail and Yahoo mail. These companies need to provide the user with a certain data capacity, speed access, as well as a certain level of security. Security is an important issue that we should consider when we choose Web Mail.

III. The Discrete Cosine Transform

The DCT is defined as:

$$y(k) = w(k)\sum_{i=1}^{N} x(n)\cos\left(\frac{\pi(2n-1)(k-1)}{2N}\right)$$

Here

$w(k) = 1/\sqrt{N}$ for k=1 and

$w(k) = \sqrt{2/N}$ for 2< k<N

Some fundamental properties of the DCT are:

The DCT helps separate the image into parts (or spectral sub-bands) of differing importance, with respect to the image's visual quality. The important advantages of DCT are:

- DCT is a real transform.
- DCT de-correlating performance is very good.
- DCT is reversible (with Inverse DCT).
- DCT is a separable transform.
- DCT has a fast implementation (similar to FFT)

The main benefit that we want to derive out of the Discrete Cosine Transform is the capability to reduce the similarity (correlation) among pixels of the steganographic image. It will make tack by brute force extremely difficult or infeasible. Pixel correlation can be reduced using the separation of image pixels into different frequency bands and then re arranging pixels which show high pixel similarity. Transform coding constitutes an integral component of contemporary image/video processing applications. Transform coding relies on the premise that pixels in an image exhibit a certain level of correlation with their neighboring pixels. Similarly in a video transmission system, adjacent pixels in consecutive frames2 show very high correlation. Consequently, these correlations can be exploited to predict the value of a pixel from its respective neighbors. A transformation is, therefore, defined to map this spatial (correlated) data into transformed (uncorrelated) coefficients. Clearly, the transformation should utilize the fact that the information content of an individual pixel is relatively small i.e., to a large extent visual contribution of a pixel can be predicted using its neighbors.

The objective of the source encoder is to exploit the redundancies in image data to provide compression. In other words, the source encoder reduces the entropy, which in our case means decrease in the average number of bits required to represent the image. On the contrary, the channel encoder adds redundancy to the output of the source encoder in order to enhance the reliability of the transmission. Clearly, both these high-level blocks have contradictory objectives and their interplay is an active research area. However, discussion on joint source channel coding is out of the scope of this document and this document mainly focuses on the transformation block in the source encoder. Nevertheless, pertinent details about other blocks will be provided as required. As discussed previously, the principle advantage of image transformation is the removal of redundancy between neighboring pixels. This leads to uncorrelated transform coefficients which can be encoded independently. Efficacy of a transformation scheme can be directly gauged by its ability to pack input data into as few coefficients as possible. This allows the quantizer to discard coefficients with relatively small amplitudes without introducing visual distortion in the reconstructed image. DCT exhibits excellent energy compaction for highly correlated images.
A DCT operation on these images provides very good energy compaction in the low frequency region of the transformed image. Generally an image contains a number of edges (i.e., sharp

intensity variations) and therefore can be classified as a high frequency image with low spatial content. images with progressively high frequency and spatial content. Consequently, the transform coefficients are spread over low and high frequencies. All studies show periodicity therefore the DCT contains impulses with amplitudes proportional to the weight of a particular frequency in the original waveform. The other (relatively insignificant) harmonics of the sine wave can also be observed by closer examination of its DCT image. Hence, from the preceding discussion it can be inferred that DCT renders excellent energy compaction for correlated images. Studies have shown that the energy compaction performance of DCT approaches optimality as image correlation approaches one i.e., DCT provides (almost) optimal de correlation for such images. A major property, known as separability, has the principle advantage that C(u, v) can be computed in two steps by successive 1-D operations on rows and columns of an image. Another look at the definition of DCT reveals that these operations are functionally identical. Such a transformation is called a symmetric transformation. The de correlation characteristics of DCT should render a decrease in the entropy (or self information) of an image. This will, in turn, decrease the number of bits required to represent the image.

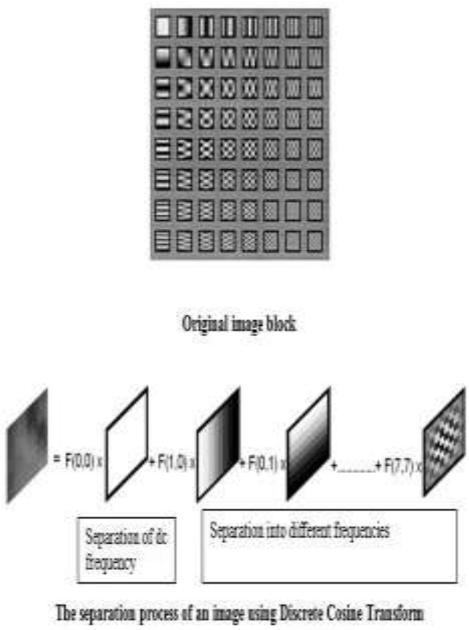

Fig.2: Graphical Illustration of DCT

IV. Proposed Methodology

A. Embedding Algorithm:

- Select the original image and cover image.
- Apply DCT to both images.
- Break both the images into different frequency sub bands after breaking the image into 8X8 blocks
- Obtain the DCT coefficient matrix of both images
- Since DCT coefficients < FFT coefficients, therefore DCT is a faster technique
- DCT coefficients are rounded off so that since it requires more time and space complexity to store and operate upon fractional values
- Embed the DCT coefficient values of Original Image into Cover Image
- Obtain a Stage One Stegno Image

B. Pixel Injection method:-

- Generate a random sequence of Pixels.
- Embed the random pixel values into the Stage One Stegno Image.
- The above step generates Stage Two Stegno Image
- The random pixel injection does not allow the attacker to get back the original image even if he is able to crack the pixel imbedding function of Stage One Stegno Image

C. Extracting the Original Image from the Stage Two Stegno Image

  - Remove the random pixels injected into Stage Two Stegno Image
  - Calculate the Inverse Discrete Cosine Transform (IDCT) of the above image.
  - Calculate the Mean Square Error(MSE) and Peak Signal to Noise Ratio(PSNR)

- Since during the Image Processing Stage, DCT is used and it quantizes the pixel values, therefore some differences arise in the extracted image when compared to the Original Image.

- This is an inherent (inbuilt) limitation of any Image Processing mathematical model or tool like DCT or Wavelet Transform or Fast Fourier Transform.
- The lesser the difference between the Original Image and the Extracted Image, the lesser will be the value of error or mean square error (MSE)
- Peak signal to Noise Ratio (PSNR) tells us about the ration of Original Image Values and the unwanted changes in the image (Noise) i.e. S/N. The lower the value of errors or Noise (N) , the higher the value of PSNR.
- Our aim is to obtain lower values of MSE and Higher values of PSNR compared to previous works.

IV. Performance Indices

Mean Square Error (MSE)

The MSE represents the cumulative squared error between the encoded and the original image. The effectiveness of the algorithm stands in minimizing the mean square error. If F(X, Y) is the original image, and I(X, Y) is the recovered image then MSE is given by

$$MSE=[\Sigma \Sigma \{F(X,Y)-I(X,Y)\}^2]/MN$$

Here M and N are the image indices

A low of MSE indicates that the original and the recovered image are close in characteristics.

Peak Signal Noise Ratio (PSNR)

PSNR represents a measure of the ratio between maximum powers of signal to the power of noise. We are trying to increasing the value of PSNR to the extent possible. PSNR is inversely proportional to the MSE; its unit is in decibel (dB) and is formally defined by the following equation.

$$PSNR=10\log_{10} (MN)^2/MSE$$

A high value of PSNR indicates that the effect of noise has been mitigated.

Entropy

Image entropy tells about the information content in an image. The higher the entropy value, more is the variation in pixel values and overall information content or lack of redundancy in the image.

Mathematically:

$$E = -\Sigma P_i \log_2 P_i$$

Here P_i denotes the probability that the difference between two pixels is equal to i.

Correlation

Image correlation gives an idea about the sectored similarity in images. Mathematically it is defined as

$$C(x, y, x^*,y^*) = \Sigma \text{ mod}[F(x,y)-G(x^*,y^*)]$$

V Results

The entire steganographic process and each of its results has been shown. The parameters computed have also been depicted in a comparative form for ease of comprehension. The various parameters that have been computed are Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Compression Ratio (CR), Image Entropy (E) and Image Correlation (C). The algorithm achieves a compression ratio of 5.96. A comparative analysis with the previously referred work i.e. FMT in DCT has also been given.

Fig.3: Secret Image

Fig.4: Cover Image

Fig.5: DCT of Image

Fig.6: Random Pixel Injection

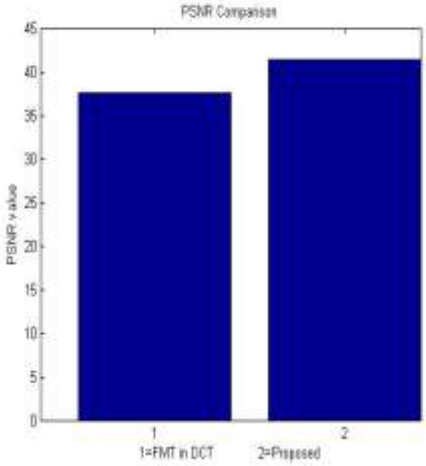

Fig.7: Comparative PSNR Analysis

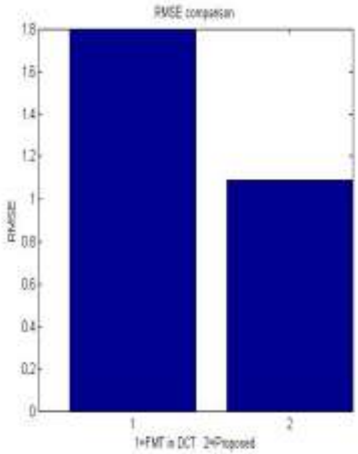

Fig.8: Comparative RMSE Analysis

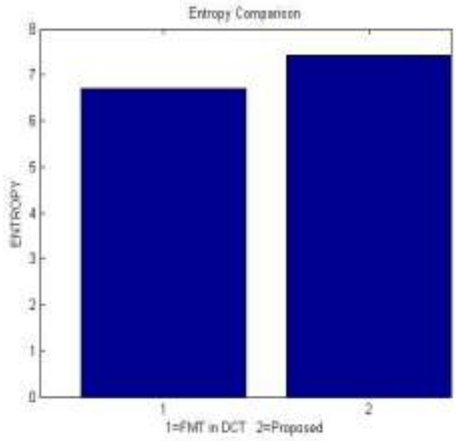

Fig.9: Comparative Entropy Analysis

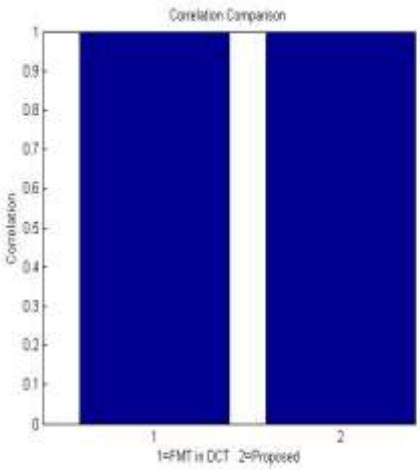

Fig.5.8 Comparative Correlation Analysis

VI. CONCLUSION

The proposed work focuses on the critical aspects of image Steganography i.e. attaining high values of PSNR while trying to reduce the redundancy among pixels by reduction of pixel correlation. It has also been shown that the image Steganography technique proposed here uses a random pixel injection technique algorithm rendering randomness in the process. It has been shown that random pixel injection been used for the design of the encryption algorithm which provides extremely high resistance to brute force attack. It can be concluded from results furnished that the proposed algorithm achieves substantially improved results compared to the previously used techniques. High value of PSNR can be attributed to the Discrete Cosine Transform. Also better values of MSE, Entropy and Correlation are achieved.

References

[1] Nidaa AbdulMohsin Abbas, "Image encryption based on Independent Component Analysis and Arnold's Cat Map",Elesvier ,2015.

[2] Reversibility improved data hiding in encrypted images, by Zang, Kede Ma, Yu Elsevier 2014.

[3] Maniccam S.S., Bourbakis N.G., "Lossless image compression and encryption using SCAN", Pattern Recognition 34 (2001) 1229-1245 Springer 2014

[4] Acharya B, Patra S. K., Panda G., "A Novel Cryptosystem Using Matrix Transformation", Proceedings of SPIT-IEEE Colloquium and International Conference, Mumbai, India, Vol. 4, 92 IEEE 2014.

[5] Gautam A, Panwar M, Gupta P. R., "A New Image Encryption Approach Using Block Based Transformation Algorithm", International Journal Of Advanced Engineering Sciences And Technologies, Vol No. 8, Issue No. 1, 090 – 096 2013

[6] C. H. Kim, "Improved Differential Fault Analysis on AES Key Schedule", IEEE Transactions on Information Forensics and Security, Vol. 7, No. 1, pp. 41-50, 2012.

[7] Zhang X, Feng G, Ren Y, and Qian Z. , "Scalable Coding of Encrypted Images", IEEE Transactions On Image Processing, Vol. 21, No.6, June 2012

[8] Zhang X, "Lossy Compression and Iterative Reconstruction for Encrypted Image", IEEE Transactions On Information Forensics And Security, Vol. 6, No. 1, March 2011

[9] Guo J M and Le T N, "Secret Communication Using JPEG Double Compression", IEEE Signal Processing Letters, Vol. 17, No. 10, October 2010

[10] Kushwaha J, Roy B., "Secure Image Data by Double encryption", International Journal of Computer Applications (0975 – 8887), Volume 5– No.10, August 2010

[11] Liu W, Zeng W, Dong L, and Yao Q, "Efficient Compression Of Encrypted Grayscale Images", IEEE Transactions on Image Processing, Vol. 19, No. 4, April 2010

[12] Yicong Z., Panetta K, Agaian S, Senior Member, "Image Encryption Using Binary Key- images" ,Proceedings of the 2009 IEEE International Conference on Systems, Man, and Cybernetics San Antonio, TX, USA - October 2009

[13] F.Menichelli, R. Menicocci, M. Olivieri and Alessandro Trifiletti, "High Level Side Channel Modeling and Simulation for Security Critical Systems on Chips", IEEE Transactions on Dependable and Secure Computing, Vol. 5, No. 3, pp. 164-175, 2008.

[14] E. Bertino, N. Shang and S. S. Wagstaff, "An Efficient Time-Bound Hierarchical Key Management Scheme for Secure Broadcasting", IEEE Transactions on Dependable and Secure Computing, Vol. 5, No. 2, pp. 65-70, 2008.

[15] Sudharsanan S, "Shared Key Encryption of JPEG Color Images", IEEE Transactions On Consumer Electronics, Vol. 51, No. 4, November 2005

[16] Johnson M, Ishwar P, Prabhakaran V, Schonberg D, and Ramchandran K, "On Compressing Encrypted Data", IEEE Transactions On Signal Processing, Vol. 52, No. 10, October 2004

[17] Bharat B. Madan, K. Goseva-Popstojanova, K. Vaidyanathan and K.S. Trivedi, "A Method for Modeling and Quantifying the Security Attributes of Intrusion Tolerant Systems", Journal of Performance Evaluation, Elsevier Science Publishers, Vol. 56, No. 1, pp. 167-186, 2004.

[18] Parminder Kaur and Jagroop Singh. 2011. A Study Effect of Gaussian Noise on PSNR Value for Digital Images International Journal of Computer and Electrical E ngineering.Vol. 3, No.2, 1793-8163.

[19] Mrs. C. Mythili and Dr. V.Kavitha. Efficient Technique for Color Image Noise Reduction The Research Bulletinof Jordan ACM , Vol. II (III)

[20] Mr. Amit Agrawal and Ramesh Raskar. Optimal single image capture for motion deblurring. In Proc. IEEE Conference on Computer Vision and Pattern Recognition, pages 2560{2567, 2009.

[21] Mr. Pawan Patidar and et al. Image De-noising by Various Filters for Different Noise in International Journal of Computer Applications (0975 – 8887) Volume 9– No.4, November 2010

[22] Charles Boncelet (2005)."Image Noise Models". in Alan C.Bovik. Handbook of Image and Video Processing.

[23] Mr. Salem Saleh Al-amri and et al. Comparative Study of Removal Noise from Remote Sensing Image. IJCSI International Journal of Computer Science Issues, Vol. 7, Issue. 1, No. 1, January 2010 32 ISSN (Online): 1694-0784 ISSN (Print): 1694-0814

[24] C.P. Su, T.F. Lin, C.T. Huang and C.W. Wu, "A High-Throughput Low Cost AES Processor", IEEE Communications Magazine, Vol. 41, No. 12, pp. 86-91, 2003.