**Tribhuvan University**

**Institute of Science and Technology**

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**Central Department of Computer Science and Information Technology**

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**In the partial fulfilment of MSc.CSIT Second Semester**

**Seminar**

**“Analysis of Image Steganography with LSB and DCT”**

**Submitted by**

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611/077

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**Tribhuvan University**

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**Supervisor Recommendation**

This is to certify that Mr. Rishav Acharya (Roll no. 611/077) has submitted the seminar report on the topic **“Analysis of Image Steganography with LSB and DCT”** for the partial fulfilment of Master’s of Science in Computer Science and Information Technology, second semester. I hereby, declare that this seminar report has been approved.

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**Letter of Approval**

This is to certify that the seminar report prepared by Mr. Rishav Acharya entitled **“Analysis of Image Steganography with LSB and DCT”** in partial fulfilment of the requirements for the degree of Master’s of Science in Computer Science and Information Technology has been well studied. In our opinion, it is satisfactory in the scope and quality as a project for the required degree.

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**Rishav Acharya (611/077)**

# **Abstract**

Steganography is the science and art of concealing a message within another message or a physical object. In computing/electronic contexts, a computer file, message, image, or video is concealed within another file, message, image, or video. Image steganography is the method used in transmitting secret information by hiding it in plain sight inside a cover image. The secret information is hidden in a way that it not visible to the human eyes.

The main goal of this seminar report is to present how a message or information can be embedded into an image and how the embedded message or information can be extracted or decoded from that image. This report also presents the analysis of LSB based Steganography and DCT based Steganography in the form of MSE and PSNR. A histogram analysis is also done in between the cover image and steganographic images generated using LSB and DCT based Steganography. Since, MSE is the average of the squared errors of the image so, the low MSE value of image, the best image for the steganography. PSNR is used to calculate the quality of the image so, higher PSNR value is considered as the high-quality image.

**Keywords:** Steganography, Image steganography, Least Significant Bit, Discrete Cosine Transform, Mean Square Error, Point Signal to Noise Ratio

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# **List of Abbreviations**

BER - Bit Error Rate

dB - Decibel

DCT - Discrete Cosine Transform

DFT - Discrete Wavelet Transformation

LSB - Least Significant Bit

MSE - Mean Square Error

PSNR - Peak Signal to Noise Ratio

PVD - Pixel Value Differencing

# **Chapter 1: Introduction**

## **Overview**

Steganography is derived from two Greek words “Stegano” means sealed and “Graphy” refers to writing which means secret writing. Simply, these two words means “covered writing” or “sealed writing” [1]. Steganography is very old method of embedding information into other data by using some rules and techniques. In today’s modern digital world, everyone is sharing their data and information using different modern data sharing techniques so the data security issue has become very essential for everyone [2]. There are three types of steganography techniques; physical, digital, and printed steganography.

Physical Steganography has been widely used. In ancient time people wrote message on wood and then covered it with wax. Message was written on the back of postage stamps. Message was written on paper by secret inks. Digital Steganography is the art of invisibly hiding data within data. It conceals the fact that message exists by hiding the actual message. In this, secret data can be hidden inside the image, text, sound clip which can be represented in binary. Digital Steganography output can be in the form of printed documents. The letter size, spacing and other characteristics of a cover text can be manipulated to carry the hidden message. A recipient who knows the technique used can recover the message and then decrypt it. [3]

Image Steganography refers to the process of hiding message within an image file. The image selected for this purpose is called the cover image and the image obtained after steganography is called the steganographic image [4]. In image steganography, a message is embedded into an image by altering the values of some pixels, which are chosen by an embedding algorithm. The recipient of the image must be aware of the same algorithm in order to know which pixels he or she must select to extract the message. This seminar reports discuss an algorithm of image steganography based on LSB, and DCT. LSB insertion is a common and simple method to embed data in an image file. In this approach the LSB of a byte is restored with an M’s bit. This technique operates well for image steganography. The DCT transforms a signal or image from the spatial domain to the frequency domain. It separates the image into high, middle and low frequency components. Because these DCT modulus contain the low frequency information of image, as long as this information do not lose or lose little then the image can be renewed well. This enhances the robustness and concealment. An analysis is also performed on the image generated using LSB and DCT based steganography technique. For visual based analysis MSE and PSNR is used and for statistical analysis histogram analysis is done.

## **Problem Statement**

The purpose of this seminar report is to present how an information can be transferred from sender to receiver in the form of image. In some cases, data might be lost during the transmission process in the network or the data might be changed by the unauthorized person. This report presents the encryption and decryption technique which can be used to secure the data and information during transmission using just an image.

## **Objectives**

The main objective of this seminar is to study and analyze a technique that can be used as cryptographic scheme during data transmission.

# **Chapter 2: Background Study and Literature Review**

## **Background Study**

### **Image Steganography**

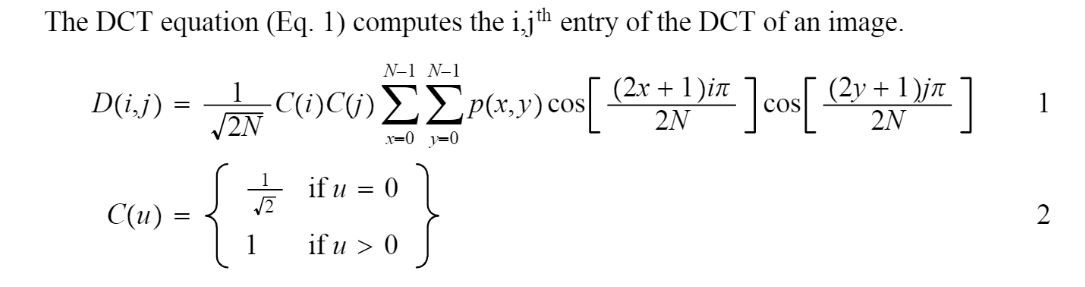
Image Steganography is the process of hiding information which can be text, image or video inside a cover image. In image steganography, the image contains the message or information that is being transferred. The term “cover image” is the image which is used to hide the message or information. The embedding algorithm is the procedure or algorithm that is used to hide message or information inside the cover image and then steganographic image is obtained. The steganographic image contains the message or information that is being shared within the image.

### **2.1.2 Discrete Cosine Transform**

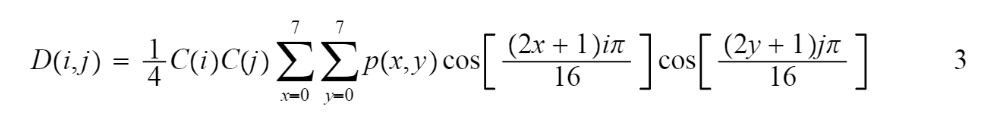
DCT coefficients are used for image compression. It separates the image into different parts of different importance. It transforms a signal or image from the spatial domain to the frequency domain. It separates the image into high, middle and low frequency components. In low frequency sub-band, much of the signal energy lies at low frequency which contains most important visual parts of the image, while in high frequency sub-band, high frequency components of the image are usually removed through compression and noise attacks. So, the secret message is embedded by modifying the coefficients of the middle frequency sub-band, so that the visibility of the image is not affected.

Discrete Cosine Transform is used in lossy image compression because it has very strong energy compaction, i.e., its large amount of information is stored in very low frequency component of a signal and rest other frequency having very small data which can be stored by using very a smaller number of bits (usually, at most 2 or 3 bit). To perform DCT Transformation on an image, first we have to fetch image file information (pixel value in term of integer having range 0 – 255) which we divide in block of 8 X 8 matrix and then we apply discrete cosine transform on that block of data. After applying discrete cosine transform, we will see that its more than 90% data will be in lower frequency component. For simplicity, we took a matrix of size 8 X 8 having all value as 255 (considering image to be completely white) and we are going to perform 2-D discrete cosine transform on that to observe the output.

The DCT Equation for 2D DCT has been given in the image below. P (x, y) denotes the pixels in the input image here.



However, when we are dealing with JPEG compression, we always take N = 8, which modifies the equation and gets us the equation below:



DCT is used in steganography as:

* Image is broken into 8×8 blocks of pixels.
* Working from left to right, top to bottom, the DCT is applied to each block.
* Each block is compressed through quantization table to scale the DCT coefficients and message is embedded in DCT coefficients.

### **2.1.3 Least Significant Bit**

Least significant bit (LSB) insertion is a common and simple method to embed data in an image file. In this approach the LSB of a byte is restored with an M’s bit. This technique operates well for image steganography. For hiding data within the images, the LSB approach is generally used. An image file is a file that shows multiple colors and intensities of light on different location of an image. Digital images are mainly of three types:

1. 8-bit images
2. 24-bit images
3. 32-bit images

The best type of image files to hide data inside is a 24-bit images. In 24-bit images we can embed three bits of information in each pixel, one in each LSB position of the three 8-bit values. Increasing or decreasing the value by changing the LSB does not change the appearance of the image; much so the resultant steganographic image looks almost same as the cover image. In 8-bit images, one bit of information can be hidden.

The LSB can be used to shift to a bit of the secret message. When it can use a 24-bit image, one can save 3 bits in every pixel by transforming a bit of each of the red, green and blue color element.

## **Literature Review**

There is various research done on the cryptographic scheme. Steganography is also one of the methods used by many people and researchers in order to transfer messages.

C, R Chowdary and co. on their paper [1], has discussed about the methods of Steganography using LSB and DCT based Steganography and performed an analysis using MSE and BER on embedded steganographic images obtained used both LSB and DCT based steganography. the LSB algorithm is used to embed the payload bits into the cover image to derive the steganographic image. The steganographic image is transformed from spatial domain to the frequency domain using DCT. Quantization and run-length coding algorithms are used for compressing the steganographic image to enhance its security. It is observed that secure images with low MSE and BER.

Ekta Walia, Payal Jain and Navdeep on their paper [2], has presented an analysis of LSB and DCT based Steganographic techniques using PSNR evaluation method. LSB based Steganography embed the message in least significant bits of digital picture whereas DCT based Steganography embed the message in least significant bits of the Discrete Cosine (DC) coefficient of digital picture. When information is hidden inside video, the program hiding the information usually performs the DCT. DCT works by slightly changing each of the images in the video, only to the extent that is not noticeable by the human eye.

Osama F. Abdel and co in their paper [3], has presented a comparison of two different techniques; LSB with no encryption and no compression and DCT where secret message is encrypted first then LSB technique is applied. Moreover, DCT is used to transform the image into the frequency domain. The LSB algorithm is implemented in spatial domain in which the payload bits are inserted into the least significant bits of cover image to develop the steganographic image while DCT algorithm is implemented in frequency domain in which the steganographic image is transformed from spatial domain to the frequency domain and the payload bits are inserted into the frequency components of the cover image.

Christian Bach and Ramadhan J. Mstafa on their paper [4], has discussed about information hiding in images using steganographic techniques. The authors have used the steganographic and digital watermarking methods to hide information and mix the information with other information that makes attackers difficult to recognize. The authors have reviewed some techniques of steganography and digital watermarking in both spatial and frequency domains and also explained types of host documents and focused on types of images.

Ritu Sindhu and co. in their paper [5], has discussed about data hiding using different steganographic technique such as, image steganography, video steganography, audio steganography, text steganography, and network steganography. The authors mainly focus to present steganography overview, its demand, advantages and the techniques used in it. DCT, DWT, DFT, PVD has also been discussed by the authors.

# **Chapter 3: Methodology**

In image steganography, the image contains the message or information that is being transferred. The term “cover image” is the image which is used to hide the message or information. The embedding algorithm is the procedure or algorithm that is used to hide message or information inside the cover image and then steganographic image is obtained. The steganographic image contains the message or information that is being shared within the image.

Read message to  
embed

Apply DCT in each block

Calculate and replace LSB

End

Start

Read Cover  
 Image

Figure 1: Flowchart of DCT based embedding algorithm

Read message to  
embed

Calculate LSB and replace with message

Steganographic Image

End

Start

Read Cover  
 Image

Figure 2: Flowchart of LSB based embedding algorithm

Steganographic  
 Image

Divide Steganographic Image

Apply DCT in each block

Calculate and replace LSB

End

Start

Read Steganographic  
 Image

Retrieve and convert to 8-bit character

Figure 3: Flowchart of DCT based extracting algorithm

Calculate LSB of each pixel

Retrieve and convert to 8-bit character

End

Start

Read Steganographic  
 Image

Figure 4: Flowchart of LSB based extracting algorithm

## **3.1 Algorithms of Steganography**

### **3.1.1 LSB Based Steganography**

* Algorithm to embed message

Step 1: Read the cover image and message which is to be hidden in the cover image.

Step 2: Convert text message in binary.

Step 3: Calculate LSB of each pixel of cover image.

Step 4: Replace LSB of cover image with each bit of secret message one by one.

Step 5: Write steganographic image

* Algorithm to extract message

Step 1: Read the steganographic image.

Step 2: Calculate LSB of each pixel of steganographic image.

Step 3: Retrieve bits and convert each 8-bit into character.

### **3.1.2 DCT Based Steganography**

* Algorithm to embed message

Step 1: Read cover image.

Step 2: Read secret message and convert it in binary.

Step 3: The cover image is broken into 8×8 block of pixels.

Step 4: Working from left to right, top to bottom subtract 128 in each block of pixels.

Step 5: DCT is applied to each block.

Step 6: Each block is compressed through quantization table.

Step 7: Calculate LSB of each DC coefficient and replace with each bit of secret message.

Step 8: Write steganographic image.

* Algorithm to extract message

Step 1: Read steganographic image.

Step 2: Steganographic image is broken into 8×8 block of pixels.

Step 3: Working from left to right, top to bottom subtract 128 in each block of pixels.

Step 4: DCT is applied to each block.

Step 5: Each block is compressed through quantization table.

Step 6: Calculate LSB of each DC coefficient.

Step 7: Retrieve and convert each 8-bit into character.

## **3.2 Evaluation of Steganography**

### **3.2.1 MSE Based Evaluation**

The square of error between cover image and the steganographic image is done in MSE based evaluation in steganography. Here, the distortion in between the two images is calculated. The MSE is computed by performing byte by byte comparisons of the two images, since a pixel is represented by 8 bits and hence 256 levels are available to represent the various gray levels. The MSE will result in a meaningful value only when each byte of an image is compared with the corresponding byte of another image.

MSE =

where,

Yi = observed values

= predicted values

n = number of data points

### **3.2.2 PSNR Based Evaluation**

PSNR is used to measure the quality of the image by comparing the cover image with the steganographic image. PSNR is used to calculate the quality of the steganographic image after embedding the secret message in the cover image. PSNR is often expressed on a logarithmic scale in dB. PSNR values falling below 30 dB suggest a fairly low quality, i.e., distortion because of embedding can be obvious; however, a high-quality steganographic image should struggle for 40 dB and above.

In this seminar report, we compare the MSE and PSNR value to the DCT and LSB embedded steganographic image.

PSNR = 10 log

PSNR = 10 log

# **Chapter 4: Implementation**

The implementation include in this seminar report is carried out in python programming. The python library used for implementation process is briefly described below:

1. **Pillow (PIL Fork)**

The Image module provides a class with the same name which is used to represent a PIL image. The module also provides a number of factory functions, including functions to load images from files, and to create new images.

* **image. open ():** This function identifies the file, but the file remains open and the actual image data is not read from the file until we try to process the data.
* **image. copy ():** This function copies the image as the original one.
* **image. size ():** This function gets the image size in pixels. The size is given as 2 -tuple width and height.
* **image. putpixel ():** This function modifies the pixels at given position.
* **image. save ():**  This is function is used to save the image.

In this seminar, this module is used to read, copy, modify pixel and to save image.

1. **OS**

The OS module in Python provides functions for interacting with the operating system. OS comes under Python’s standard utility modules. This module provides a portable way of using operating system-dependent functionality. The \*os\* and \*os.path\* modules include many functions to interact with the file system.

* **os. path. exist ():** This function checks weather the given path exists in current directory or not.
* **os. makedirs ():** This function makes new folder under the current directory.

In this seminar, this module is used to direct files to given directory in the system.

1. **Shutil**

The shutil module offers a number of high-level operations on files and collections of files. In particular, functions are provided which support file copying and removal.

* **shutil. imtree ():** This function deletes the entire directory tree.

Here, this module is used to delete entire directory from system in order to remove the conflict.

1. **CV2**

OpenCV is used for processing images and videos to identify objects, faces, and many more.

* **cv2. imread ():** This function is used to read image. It loads image from specified file.
* **cv2. imwrite ():** This function is used to save an image to specific location.
* **cv2. cvtColor ():** This function is used to convert an image from one color space to another.

This module is used to read, write and tilt the color space of image in this seminar report.

1. **Xlwt**

The xlwt module is used to generate spreadsheet compatible to Microsoft Excel 95 to 2003.

In this seminar report, this module is used to generate excel file of the error calculation between cover and steganographic images.

In LSB based Steganography and DCT based Steganography, the library pil fork is used to open the image that has been selected, cv2 library is used to read the image and os library is used to save the steganographic image after encoding and decoded text file after decoding the steganographic image.

In, DCT based Steganography, cv2 library is also used to split the cover image into RGB channels and numpy library is used to break the image into 8x8 blocks which is then run into DCT function and then through quantization table. The library cv2 is also used to merge the message into the image and then the image is saved using os library.

# **Chapter 5: Result and Analysis**

## **5.1 Result**

This seminar report demonstrates how message or information can be embedded into an image and extracted from the image using both LSB and DCT methods. This report also shows how changes occur in the original image and steganographic image during the phase of embedding using both the methods.

The message is hidden in the image using two methods: DCT and LSB. In DCT, the message is embedded into the image using blue channel of the image and compress the image as well as extract the message, which means hiding the message also by minimizing the size of image. And in LSB, the embedding is simple. In this approach, the LSB of a byte is restored with an M’s bit. The steganographic image is visually same as the cover image in LSB steganographic method. Here is the difference between the cover image and steganographic image using both LSB and DCT steganography methods.

Table 1: Cover vs Steganographic Images

|  |  |  |  |
| --- | --- | --- | --- |
| S. N | Cover Image | Steganographic Image | |
| LSB | DCT |
| 1 | Pepper.png |  |  |
| 2 | Lenna.png |  |  |
| 3 | Babylon.png |  |  |

There is no difference in visual pattern between cover image and steganographic image generated using LSB and DCT method of steganography. By looking just an image we cannot find the difference which one is original or cover image or steganographic images.

The figures below illustrate how the message is embedded into cover image and the extracted message from the steganographic image.

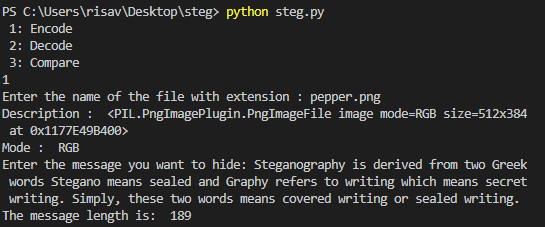


Figure 5: Embedding Procedure

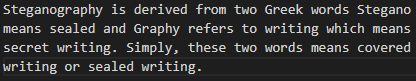


Figure 6: Decoded text from image

The comparison of steganographic images with cover image is done by finding the MSE and PSNR.

## **5.2 Analysis**

### **5.2.1 Visual Assessment Analysis**

Visual assessment analysis is done to measure the performance of the decoding procedure. Comparative analysis of LSB based and DCT based steganography has been done on basis of parameters like PSNR and MSE. The PSNR and MSE values for different set of images are measured and calculated.

Table 2: MSE and PSNR Measures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S. N | Image | Method | MSE (dB) | PSNR (dB) |
| 1 | Pepper.png | LSB  DCT | 0.0733  6853.5814 | 59.4789  9.7716 |
| 2 | Lenna.png | LSB  DCT | 0.1059  1888.259 | 57.8812  15.3709 |
| 3 | Babylon.png | LSB  DCT | 0.1492  6853.858 | 56.3907  9.7714 |

The MSE value for steganographic image generated using LSB method is low as compared to MSE value for steganographic image generated using DCT method for steganography, which means the image generated using LSB method is best compared to DCT one. The PSNR value for steganographic image generated using LSB method is higher as compared to PSNR value for steganographic image generated using DCT method for steganography, which means the steganographic image of LSB method is of high quality than the image of DCT steganography method.

### **5.2.2 Statistical Analysis**

Statistical analysis has been carried out with the help of histogram analysis. The histogram of an image normally refers to a histogram of the pixel intensity values. This histogram is a graph showing the number of pixels in an image at each different intensity value found in that image. Histogram of cover image and steganographic image is analyzed graphically.

Table 3: Histogram Analysis

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S. N | Cover Image | Cover Image Histogram | Method | Steganographic Image Histogram |
| 1 | Pepper.png |  | LSB  DCT |  |
| 2 | Lenna.png |  | LSB  DCT |  |
| 3 | Babylon.png |  | LSB  DCT |  |

It is seen that the histogram of cover image and steganographic image generated using LSB method is almost identical to each other whereas steganographic image generated using DCT has some distortion. The more distortion or difference in histogram compared to cover image the more security mechanism is imposed. This means the steganographic image of DCT is more secure than the image generated using LSB method of steganography.

# **Chapter 6: Conclusion**

This seminar report discusses in detail about the LSB and DCT algorithms on steganography application. LSB based steganography embed the message in LSB of cover image. DCT based steganography embed the message in LSB of DC coefficients. This report implements LSB based steganography, DCT based steganography and computes MSE and PSNR ratio as well as a histogram analysis is also done for the cover image and the both steganographic images generated using LSB and DCT based steganography. The LSB technique has been used to accommodate maximum payload. The entire payload is embedded into the cover image to obtain the steganographic image. The steganographic image in the spatial domain is transformed into frequency domain by applying DCT. The steganographic image is further compressed using quantization and run-length coding to derive a secure steganographic image. An exactly reverse procedure is followed to retrieve the message at the receiver. MSE is the average of the squared errors of the image so, the low MSE value of image, the best image for the steganography. PSNR is used to calculate the quality of the image so, higher PSNR value is considered as the high-quality image.

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