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Techniques of Image Mosaicing for Steganography

By

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A THESIS

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Abstract

Steganography is the science of hiding secret messages into cover media so that no one can realize the existence of the secret data. Image mosaicing is a technique which enables to combine together many small images into one large image, from which, more information can be collected easily. "Techniques of Image Mosaicing for Steganography" is a study basically focused on the use of different image mosaicing techniques for secured transfer of information containing images.

Among various techniques that have been implemented for mosaicing, secret-fragment-visible mosaic and cubism-like mosaic are implemented here. A number of experiments have been performed to analyze the performance of these image mosaicing techniques. The result obtained by embedding secret images into target images is then compared using rmse and psnr values. The result of the experiments conducted shows a trade-off between secure transfer of images and better recovery. The secret-fragment visible mosaic is better suited for applications which require secure transmission where the mosaiced images are more similar to the target images and cubism-like mosaic for those which require more accurate recovery of the original secret images. Since steganography focuses on more accurate recovery of the image being transferred with higher chances of secured transmission, this is better achieved using secret-fragment-visible mosaic.

Keywords:

Secret-fragment-visible mosaic, Cubism-like mosaic, Steganography

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List of Abbreviations

mse	mean square error
rmse	root mean square error
psnr	peak signal-to-noise ratio
wrt	with respect to

CHAPTER 1

INTRODUCTION

1. Introduction

1.1 Background

Information security is turning to be great challenge when sending information from one place to another with the aid of technology. Steganography is one of the techniques for the secured data transmission which involves hiding secret information generally inside other information in such a way that only the intended receiver will know the existence of secret information. This study is meant for combining small tiles of secret image to form a target in the sense of mosaic and comparing the mosaics obtained using different techniques. When this artwork is viewed at close, the observer can view smaller elements, yet when viewed at a distance the collection of tiles blend together to yield the overall picture. When the mosaic generating process starts, original image is divided into many tiles. Before splitting the image, compare the image for mosaic creation. Mosaic image is created automatically by composing small fragments of a given image into target image, achieving an effect of embedding the given source image secretly in the resulting mosaic image [1].

Steganography is the science of hiding secret messages into cover media so that no one can realize the existence of the secret data. Existing steganography techniques may be classified into three categories – image, video, and text steganographies, and image steganography aims to embed a secret image into a cover image with the yielded stego-image looking like the original cover image. Many image steganography techniques have been proposed, and some of these try to hide secret images behind other images. The main issue in these techniques is the difficulty to hide a huge amount of image data into the cover image without causing intolerable distortions in the stego-image. Lai and Tsai proposed a new type of computer art image, called secret-fragment-visible mosaic image, which is the result of random rearrangement of the fragments of a secret image in disguise of another image called target image, creating exactly an effect of image steganography. The above-mentioned difficulty of hiding a huge volume of image data behind a cover image is solved automatically by this type of mosaic image [2].

A new method of combining art image generation and hiding a secret image into this cubism like image to enhance the camouflage effect for various information-hiding applications is proposed in [3]. First, a new type of computer art, called line-based Cubism-like image, which keeps a characteristic of the Cubism art created by extract prominent lines and regions. Then the cubism like image is divided into target tiles and the secret is also divided into secret tiles of same size as target. A mapping sequence is created based on secret-target tile similarity and the secret image is embedded into the target using that mapping sequence. That mapping information is also embedded into the Cubism Image. Finally, a secret-embedded-mosaic-image is created as stego image and that is sent to the receiver. When the receiver gets the output image, he retrieves the mapping sequence and using that mapping sequence he will extract the secret image from the cubism image. Data hiding with the minimal distortion is carried out skillfully during the process of recoloring the regions and embedding is based on LSB replacement.

There are a number of techniques which can be adopted while mosaicing the images for steganography. Secret fragment visible mosaic, tile overlapping mosaic, cubism like image are some of them. Secret-fragment-visible mosaic image is created automatically by composing small fragments of a given image to become a target image in a mosaic form, achieving an effect of embedding the given image visibly but secretly in the resulting mosaic image [4]. Tile overlapping mosaic image is created by varying the overlapping degrees of the adjacent rectangular constructing units - tile images [5].

1.2 Problem Definition

Information security has been of great concern in today's world. Steganography means hiding some secret information into a cover file. Cover files may be audio, image, video etc. The main issue in steganography is to hide information in such a way that there is no significant change in quality and quantity of cover file. The secured transfer of information containing images via network is a must. Hence, there is a need of a technique which helps in transfer of images securely through the network and later recovery of the images at the receiving end.

A basic approach for this secure transfer is embedding the secret image containing information into another cover image in such a way that the image being transferred looks exactly like the cover image. There is lesser chance for the secret image being identified since the image is embedded into another, resulting in secured transfer of the image.

1.3 Objectives

The main objectives of this thesis study are:

i. To hide information containing secret image in cover image using image mosaics
ii. To compare steganography using different approaches of image mosaics

1.4 Scope of the Work

The scope of this thesis work is to support the purpose of secure transfer of images. Different techniques may be used for this purpose. One of them is hiding secret image into a target/cover image and transfering the cover image via the network in such a way that the presence of the secret image inside the target image may be realised only by the sender and receiver. Here, a target image is used to hide the secret image using image mosaicing and to compare the results using different mosaics. This work basically supports the need for secure transfer of some kind of images with the aid of image mosaics and more accurate recovery of the images being transfered.

1.5 Organization of Report

A brief description of steganography and mosaicing is presented here in Chapter 1 including the concept of combination of both for the purpose of secured transfer of images. Related works involving steganography and mosaics are presented in Chapter 2. The detailed algorithm and methodology used in this study are included in Chapter 3. The results and discussions after comparison of different kind of images are included in Chapter 4. The conclusion and recommendation are included in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2. Literature Review

2.1 Related Work

In traditional methods, secret text can be hidden into image which is called as Steganography. In some methods only text data can be encrypted but not image. Secret images can be hidden using water marking principles. Water marking is very simple process and it is weak that anyone can decrypt easily. Mosaic image technique is one of the efficient techniques to hide the secret images. This methodology needs another image which is said to be cover image. Creating mosaic image is also an art of computer. Many methods have been proposed to create different types of mosaic images by computer. An image is fragmented into small tiles. Then, these tiles are randomly embedded onto a cover image. For encryption embedding process should be performed in some order. Secret key is used for embedding the small tiles of secret image onto cover image. LSB (least significant bit) replacement scheme is a technique mainly used for embedding process. LSB technique reduces or avoids the blur effect of encrypted mosaic image. Almost all previous approaches filter out high frequencies in order to simplify mosaic generation. Most of the reversible watermarking approaches proposed so far incorporate a lossless data compression stage. The use of an elaborate data compression stage increases the mathematical complexity of the watermarking. There are some watermarking schemes that do not rely on additional data compression, as for instance, the circular histogram interpretation schemes, but they have the drawback of a low embedding capacity [1].

The original idea of the mosaic image steganography has been proposed by Secret-Fragment- Visible Mosaic Image-A New Computer Art and Its Application to Information Hiding by Lai and Tsai [2]. A new type of art image, called secret-fragment-visible mosaic image, which contains small fragments of a given source image is proposed in this study by Lai and Tsai. Observing such a type of mosaic image, one can see all the fragments of the source image, but the fragments are so tiny in size and so random in position that the observer cannot figure out what the source image looks like. Therefore, the source image may be said to be secretly embedded in the resulting mosaic image, though the fragment pieces are all visible to the observer. And this is the reason why the resulting mosaic image is named secret-fragment-visible.

In recent years, the topic of automatic art image creation via the use of computers arouses interests of many people and many methods have been proposed. The common goal of creating these image styles is to make the generated art images look like some other types of images. Mosaic image is also a type of computer art image is composed of many small identical tiles, such as squares, circles, triangles, and so on. Images may contain private or confidential information that should be protected from leakages during transmissions. Cubism artists transform a natural scene into geometric forms in paintings by breaking up, analyzing, and reassembling objects in the scene from multiple viewpoints. In addition, with the scene objects rearranged to intersect at random angles, each Cubism painting seems to be composed of intersecting lines and fragmented regions in an abstract style. The idea of the proposed art image creation technique as described in "An Enhanced Image Steganography Technique in Art Images" is inspired by these concepts of the Cubism art. [3]

A new type of image similarity method was proposed in "New Image Steganography by Secret Fragment Visible Mosaic Image for Secret Image Hiding", which created embedded image automatically by composing small fragments of given secret image in mosaic form in the target image. The mosaic image is yielded by dividing the secret image into fragments and transforming the color characteristics of secret image to that of target image. Skillful techniques are used in the color transformation process so that secret image may be recovered nearly lossless [4].

Data Hiding is a method that hides confidential data in a cover medium so that it can be kept as most secure. This secure data hiding method consists of two types of information, a set of secret information that is to be embedded and a set of the cover medium in which the information is kept. The main aim of data hiding is to keep the data as secure as possible and also to protect from the hackers. Data can be hided in various domains such as text, audio, video and on images. The significant importance in which the images are used for data hiding is that the human beings are very weak in analyzing the small color changes. Data can be kept secure in medical images, aerial images, texture images and also on art images. Aesthetic data hiding is a new form of data hiding by the use of art image generated by some art image generation algorithm. People are attracted by the art image and thus they are not noticed about the hidden data. Thus data can be kept more securely. Cubism images are a type of paintings in which they are formed by analyzing an image or objects from multiple viewpoints. Cubism paintings are composed of intersecting line segments and various regions from different viewpoints. Line-Based Cubism Art image is created based on the concepts of cubism art. Data Hiding and lossless recovery is carried out with security measures. [5]

CHAPTER 3

METHODOLOGY

3. Methodology

3.1 Working Principle

The basic working principle for cubism image creation is as shown in figure 3.1. The secret image is embedded into the target image or the cubism-like target image as shown in figure 3.2. The detailed algorithm is described in section 3.2.

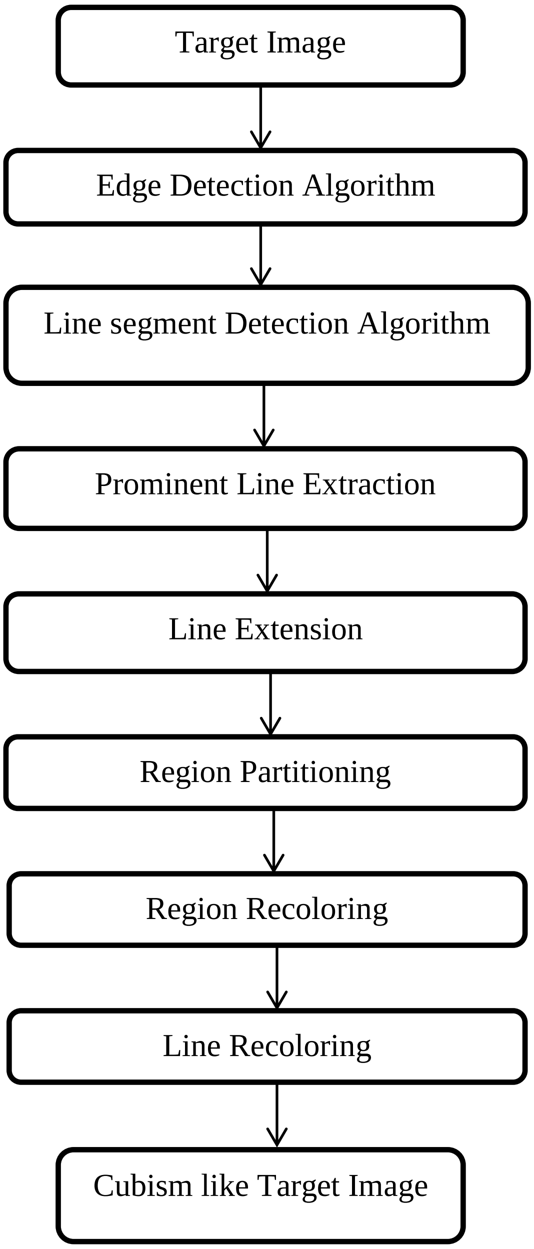


Figure 3.1 Process Flow for cubism-like target image creation

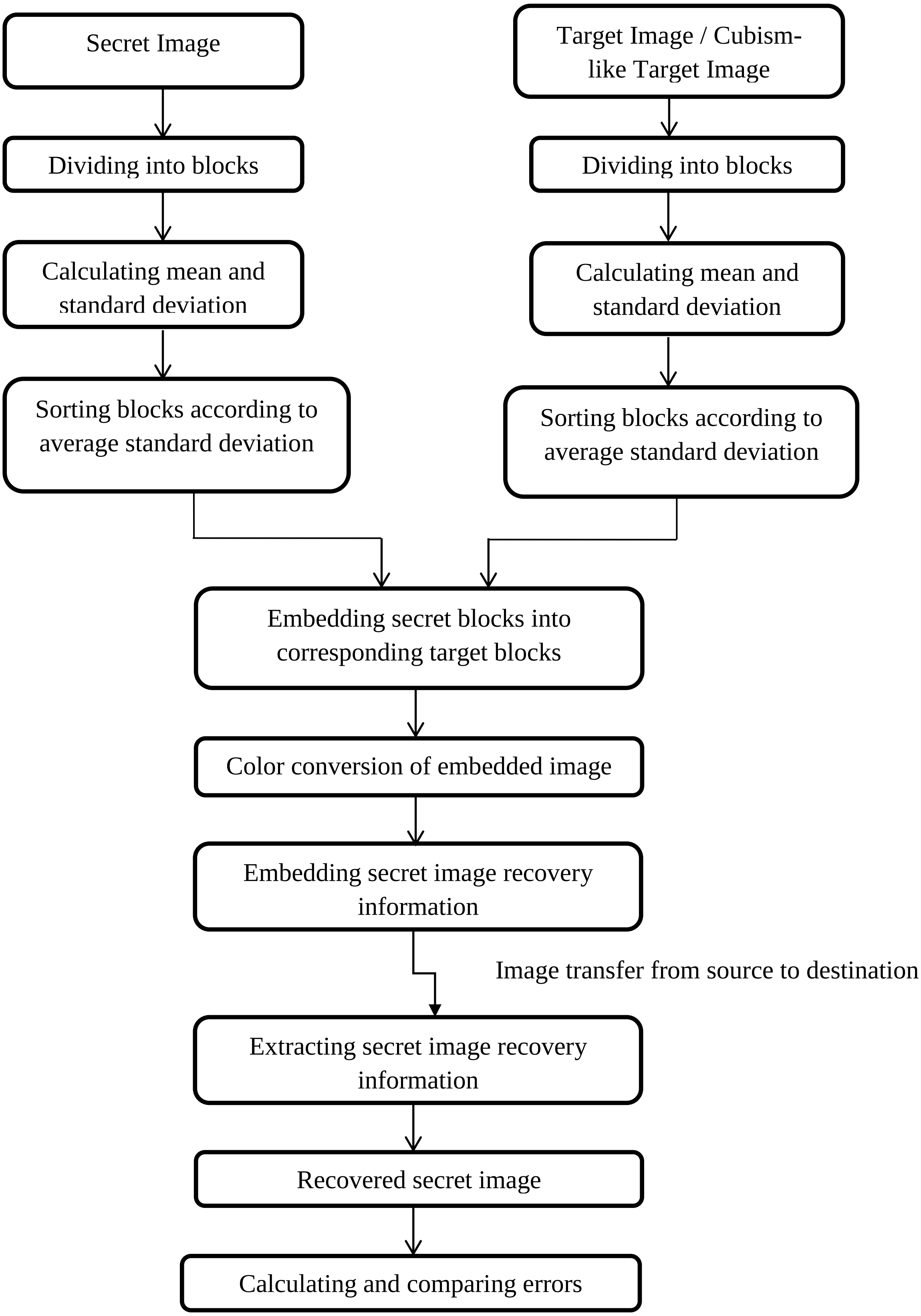


Figure 3.2 Process Flow for secret image embedding and recovery

The problems encountered in generating mosaic images by this method are discussed in this section, and the solutions to them are also presented.

3.1.1 Color Transformations between Blocks

Suppose that in the first phase of this method, a tile image T in a given secret image is to be fit into a target block B in a pre-selected target image. Since the color characteristics of T and B are different from each other, how to change their color distributions to make them look alike is the main issue here. More specifically, let T and B be described as two pixel sets {p1, p2, …, pn} and {p1′, p2′, …, pn′}, respectively, assuming that both blocks are of the same dimensions with size n. Let the color of pixel pi in the RGB color space be denoted by (ri, gi, bi) and that of pi′ by (ri′, gi′, bi′). First, we compute the means and standard deviations of T and B, respectively, in each of the three color channels R, G, and B by the following formulas:

$$\mu c = \frac{1}{n}\sum_{i=1}^{n} ci, \quad \mu c' = \frac{1}{n}\sum_{i=1}^{n} ci' \qquad \text{Eq. 3.1}$$

$$\sigma c = \sqrt{(1/n)\sum_{i=1}^{n}(ci - \mu c)^2}, \quad \sigma c' = \sqrt{(1/n)\sum_{i=1}^{n}(ci' - \mu c')^2} \qquad \text{Eq. 3.2}$$

where, ci and ci′ denote the C-channel values of pixels pi and pi′, respectively, with c denoting r, g, b.
Next, we compute new color values (ri″, gi″, bi″) for each pi in T by:

$$c_i'' = (\sigma_{c'}/\sigma_c)(c_i - \mu_c) + \mu_{c'} \text{ with } c = r, g, \text{ and } b. \qquad \text{Eq. 3.3}$$

This results in a new tile image T′ with a new color characteristic similar to that of target block B. Also, we use the following formula, which is the inverse of Eq. 3.3, to compute the original color values (ri, gi, bi) of pi from the new ones (ri″, gi″, bi″):

$$c_i = (\sigma_c/\sigma_{c'})(c_i'' - \mu_{c'}) + \mu_c \text{ with } c = r, g, \text{ and } b. \qquad \text{Eq. 3.4}$$

Furthermore, we have to embed into the created mosaic image sufficient information about the transformed tile image T′ for use in later recovery of the original secret image.

3.1.2 Choosing Appropriate Target Blocks to Fit Better

In transforming the color characteristic of a tile image T to be that of a corresponding target block B as described above, how to choose an appropriate B for each T (i.e., how to fit each T to a proper B) is an issue. If two blocks are more similar in color distributions originally, a better transformation effect will result. For this, we use the standard deviation of block colors as a measure to select the most similar target block B for each tile image T. First, we compute the standard deviations of every tile image and target block for each color channel. Then, we sort all the tile images to form a sequence, Stile, and all the target blocks to form another, Starget, according to the mean of the standard deviation values of the three colors. Finally, we fit the first tile image in Stile to the first target block in Starget; fit the second in Stile to the second in Starget and so on.

3.1.3 Embedding Secret Image Recovery Information

In order to recover the secret image from the mosaic image, we have to embed relevant recovery information into the mosaic image. The information required to recover a tile image T which is mapped to a target block B includes: (1) the sorted rows and columns of secret image; (2) the sorted rows and columns of target image; and (3) the means and the related standard deviation quotients of all color channels of mosaiced image.
After embedding the bit stream into the mosaic image, we can recover the secret image back. But some loss will be incurred in the recovered secret image (i.e., the recovered image is not identical to the original one).

3.1.4 Image Comparison

Similarity analysis is one of the important portions of this thesis. Following approaches have been implemented for image comparison.

3.1.4.1 Mean Square Error (MSE)

The mean square error (MSE) of an estimator measure of the average of the square of the errors, that is difference between estimator and what is estimated.
In this thesis, MSE is used to compare original images with recovered and with mosaiced image. MSE is calculated as:

$$MSE = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N}\left[Im(x,y)-Im'(x,y)\right]^2}{(M.N)} \quad \text{...Eq. 3.5}$$

Where, M, N stands for the size of the image in both horizontal and vertical axes, I_m is the original image and $I_{m'}$ is the reconstructed image that is to be examined.

3.1.4.2 Peak Signal to Noise Ratio (PSNR)

PNSR is defined as the ratio between the maximum possible power of signal and the power of corrupting noise that affects the fidelity of representation. Because many signal have wide dynamic range PNSR is usually expressed in term of logarithmic decibel scale.
PSNR is calculated using following formula:

$$PSNR = 20 * \log_{10}[\frac{255}{\sqrt{MSE}}] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq. 3.6}$$

3.2 Mosaic Image Creation and Secret Image Recovery Algorithms

Based on the above discussions, detailed algorithms for mosaic image creation and secret image recovery may now be described as:

Algorithm 1. Secret-fragment-visible Image Mosaic

Algorithm 1.1. Secret-fragment-visible mosaic image creation

Input: a secret image S with n tile images of size N_T; a pre-selected target image T of the same size of S;

Output: a secret-fragment-visible mosaic image F.

Steps:

Stage 1.1.1 — fitting tile images into target blocks.

1. Divide secret image S into a sequence of n tile images of size N_T, denoted as $S_{tile}=\{T_1, T_2, \ldots, T_n\}$; and divide target image T into another sequence of n target blocks also with size N_T, denoted as $S_{target} = \{B_1, B_2, \ldots, B_n\}$.

2. Compute the means (μ_r, μ_g, μ_b) and the standard deviations (σ_r, σ_g, σ_b) of each Ti in Stile for the three color channels according to Eqs. 3.1 and 3.2; and compute the average standard deviation $\sigma_{Ti} = (\sigma_r + \sigma_g + \sigma_b)/3$ for Ti where i = 1 through n.

3. Do similarly to the last step to compute the means ($\mu r'$, $\mu g'$, $\mu b'$), the standard deviations ($\sigma r'$, $\sigma g'$, $\sigma b'$), and the average standard deviation $\sigma_{Bj} = (\sigma r' + \sigma g' + \sigma b')/3$ for each Bj in Starget where j = 1 through n.

4. Sort the blocks in Stile and Starget according to the average standard deviation values of the blocks; map in order the blocks in the sorted Stile to those in the sorted Starget in a 1-to-1 manner.

5. Create a mosaic image F by fitting the tile images of secret image S to the corresponding target blocks of target image T.

Stage 1.1.2 — performing color conversion between the tile images and target blocks.

6. For each pair Ti → Bji, let the means μ_c and $\mu_{c'}$ of Ti and Bji respectively and the standard deviation be σ_c and $\sigma_{c'}$

7. For each pixel pi in each tile image Ti of mosaic image F with color value ci where c = r, g, b, transform ci into a new value ci″ by Eq. 3.3

Stage 1.1.3 — embedding the secret image recovery information.

8. For each tile image Ti in F, construct a bit stream Mi for recovering Ti as described in Section 3.1.3, including the bit-segments which encode the data items of: 1) the sorted rows and columns of secret image; (2) the sorted rows and columns of target image; and (3) the means and the related standard deviation of all color channels of mosaiced image.

Algorithm 1.2 Secret image recovery.
Input: a mosaic image F with n tile images used in Algorithm 1.1.
Output: the secret image S embedded in F using Algorithm 1.1.

Steps:
Stage 1.2.1 — extracting the secret image recovery information.

1. Extracting from mosaic image F, the bit stream Mt′ for secret image recovery by a reverse version of the LSB replacement scheme

2. Decomposing Mt into n bit streams Mi for the n to-be-constructed tile images Ti in S, respectively, where i = 1 through n.

3. Decoding the bit stream Mi of each tile image Ti to obtain the following data: 1) the sorted rows and columns of secret image; (2) the sorted rows and columns of target image; and (3) the means and the related standard deviation of all color channels of mosaiced image.

Stage 1.2.2 — recovering the secret image.

4. Recovering each block from the tile images Ti, i = 1 through n, of the desired secret image S by using the received information.

5. Composing all the final tile images to form the desired secret image S as output.

Algorithm 2. Cubism like Image Mosaic
Input: a secret image S with n tile images of size N_T; a pre-selected target image T of the same size of S;
Output: the secret image S embedded in cubism-like image.

Steps:
Stage 2.1: Prominent line extraction.

1. (Edge detection) Applying Canny edge detection to image S, resulting in a new image S' of edge points.

2. (Line segment detection)Applying the Hough transform to S' to find a list of line segments L1,L2,....Lm sorted according to their lengths, yielding a second new image S'' of the line type.

3. (Prominent line extraction) Finding prominent lines in S'' by the following steps.

3.1 Selecting those line segments in S'' with lengths larger than threshold Lmin and discard the others, resulting in a shorter list of line segments L1',L2',....Lm'.

3.2 For all i=0 through n and all j=0 through n with i≠j and both Li' and Lj ' not deleted yet, comparing Li' and Lj ' and and if the distance between Li' and Lj ' and is smaller than threshold, Dmin then deleting the shorter one of Li' and Lj '.

Stage 2.2 Region recoloring.

4. (Line extension) Extending each remaining line segment in S'' to the image boundaries of S''.

5. (Region partitioning) Partitioning S'' into regions R1,R2,...Rk by the extended lines.

6. (Region recoloring) Recoloring each region Ri in S'' by the following steps with i=1,2,....k.

6.1 Computing the area Ai (in unit of pixel) of Ri and the average color (Cir ,Cig ,Cib) of all the pixels in Ri.

6.2 Recoloring each pixel in Ri by (Cir, Cig, Cib).

7. (Line recoloring) Recoloring all region boundaries in S'' by the white color.

9. The final S'' is the desired line-based Cubism-like image SC.

Stage 2.3 Repeating all the steps from algorithm 1 using this line-based Cubism-like image SC as the target image.

Finally, calculating RMSE and PSNR values between the original secret image and the recovered secret image and between the mosaiced target image and original target image using both the algorithms and comparing them.

CHAPTER 4

RESULTS AND DISCUSSIONS

4. Results and Discussions

4.1 Overview

19 experiments are performed in total, 12 experiments comparing secret-fragment-visible mosaic and cubism-like mosaic and 7 experiments elaborating secret-fragment-visible mosaic. The results obtained using both the algorithms are then compared and analyzed. The images used are collected from various sources including reference papers, online databases and real life images captured using normal cameras.

4.2 Experiments

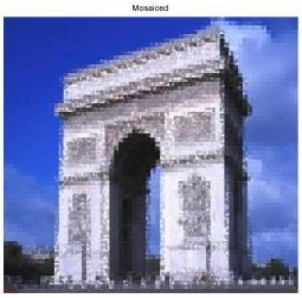
Experiment no. 1:

(a)

(b)

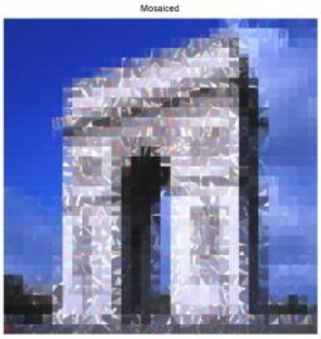
(c)

(d)



(e)

(f)



(g)

(h)

Figure 4.1.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 01

Table 4.1: Comparison of errors for images of Experiment no. 01

Blocksize	Error		Images
	rmse	psnr	
4x4	15.050491	24.579790	for mosaic image wrt target image
	3.957576	36.182218	for recovered secret image wrt original secret image
8x8	15.774188	24.171863	for mosaic image wrt target image
	5.670486	33.058398	for recovered secret image wrt original secret image
16x16	15.909995	24.097403	for mosaic image wrt target image
	6.922266	31.325838	for recovered secret image wrt original secret image

Figure 4.1.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.1 and Figure 4.1.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.1 shows the tabulation of rmse and psnr errors for different block sizes and images.

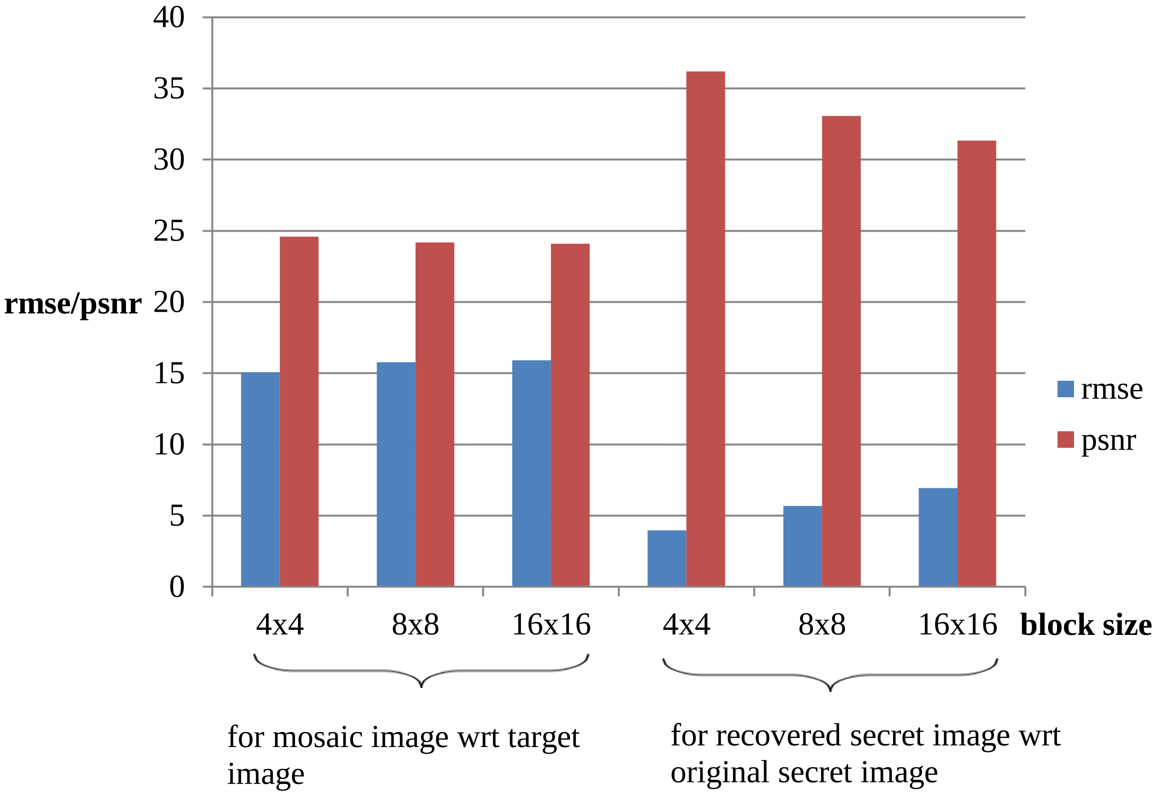
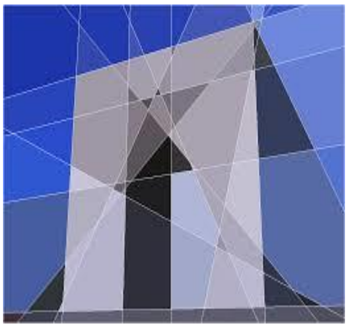


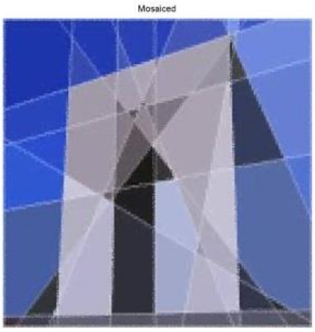
Figure 4.1.2: Plot of Table 4.1

Experiment no. 2:

(a)

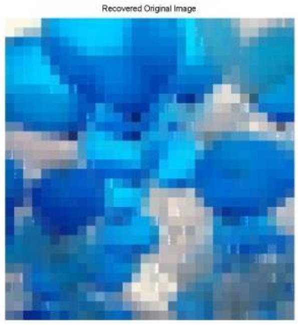


(b)



(c) (d)

(e) (f)



(g) (h)

Figure 4.2.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 02

Table 4.2: Comparison of errors for images of Experiment no. 02

Block size	Error		Images
	rmse	psnr	
4x4	15.175961	24.507680	for mosaic image wrt target image
	3.925698	36.252467	for recovered secret image wrt original secret image
8x8	15.813522	24.150232	for mosaic image wrt target image
	5.590372	33.181990	for recovered secret image wrt original secret image
16x16	15.924297	24.089598	for mosaic image wrt target image
	6.880601	31.378276	for recovered secret image wrt original secret image

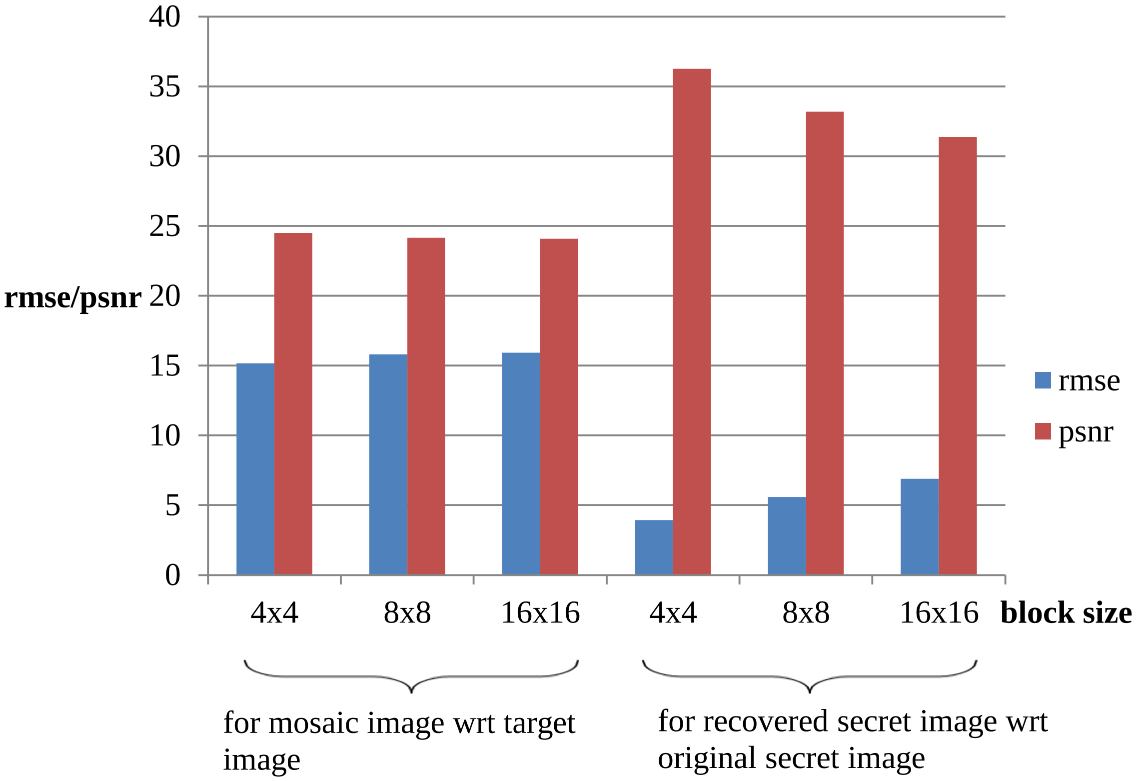


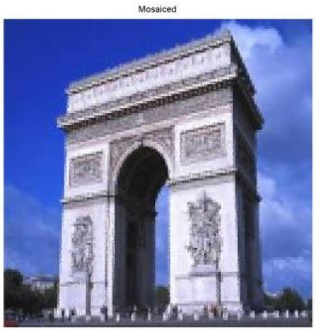
Figure 4.2.2: Plot of Table 4.2

Figure 4.2.1 shows the results obtained using secret image same as used in Experiment no. 01 and cubism form of the target image used in Experiment no. 01 for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.2 and Figure 4.2.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.2 shows the tabulation of rmse and psnr errors for different block sizes and images. On comparison of results obtained from Experiment no. 01 and Experiment no. 02, lower rmse and higher psnr of the mosaiced image with respect to the target image is obtained from Experiment no. 01 than Experiment no. 02 whereas lower rmse and higher psnr of the recovered secret image with respect to the original secret image is obtained from Experiment no. 02 than Experiment no. 01.

Experiment no. 03:

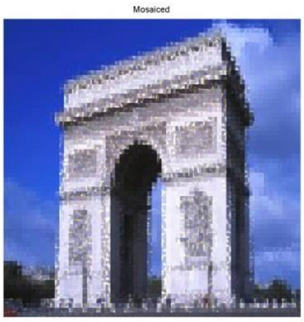
(a)

(b)



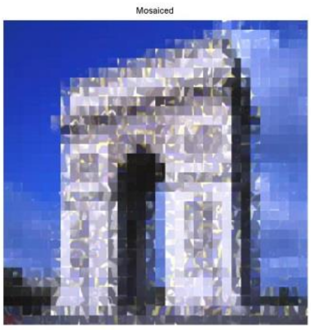
(c)

(d)

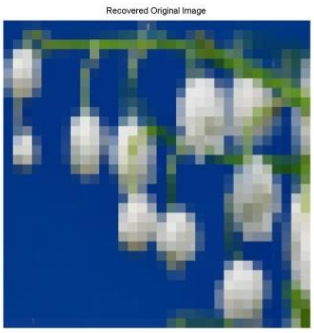


(e)

(f)



(g)



(h)

Figure 4.3.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 03

Table 4.3: Comparison of errors for images of Experiment no. 03

Block size	Error		Images
	rmse	psnr	
4x4	15.197099	24.495590	for mosaic image wrt target image
	4.049816	35.982097	for recovered secret image wrt original secret image
8x8	15.825360	24.143731	for mosaic image wrt target image
	5.589083	33.183993	for recovered secret image wrt original secret image
16x16	15.923364	24.090107	for mosaic image wrt target image
	6.814807	31.461733	for recovered secret image wrt original secret image

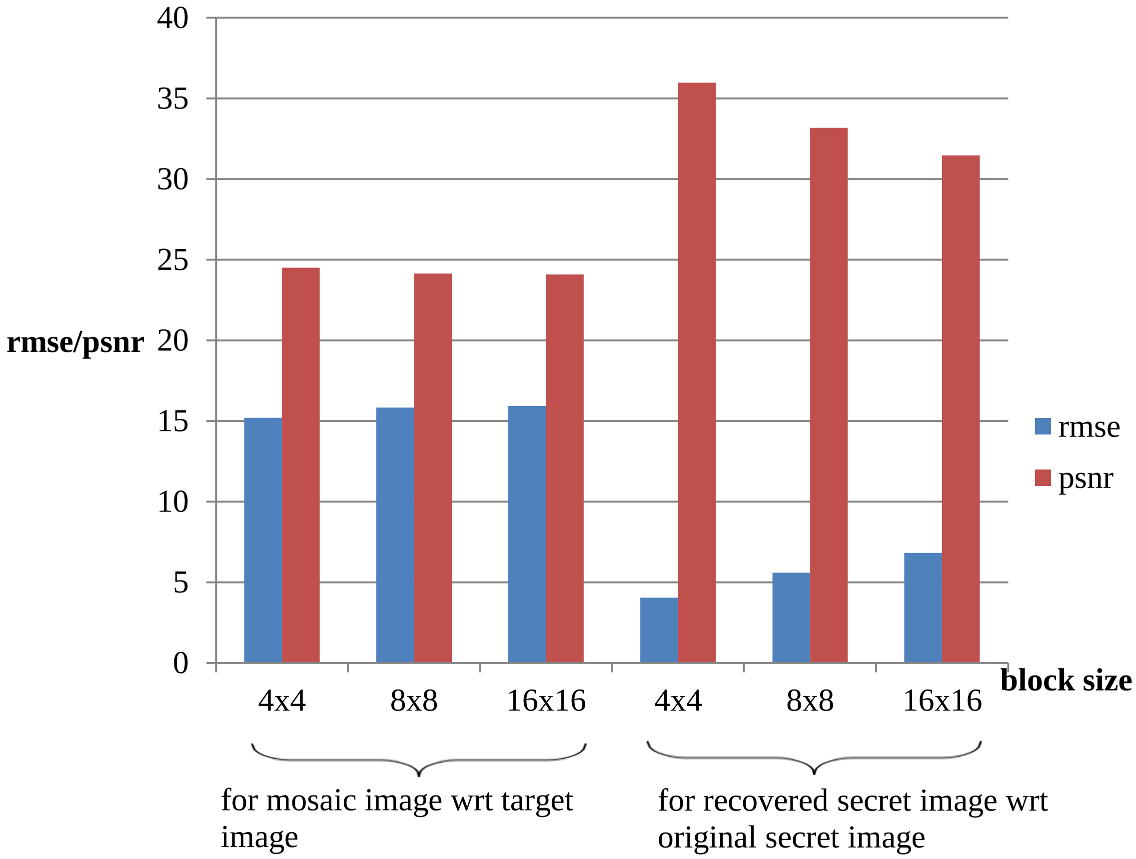
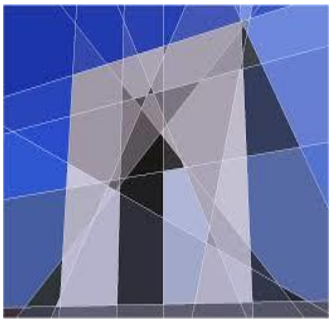


Figure 4.3.2: Plot of Table 4.3

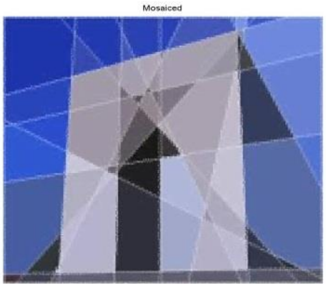
Figure 4.3.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.3 and Figure 4.3.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.3 shows the tabulation of rmse and psnr errors for different block sizes and images.

Experiment no. 04:

(a)

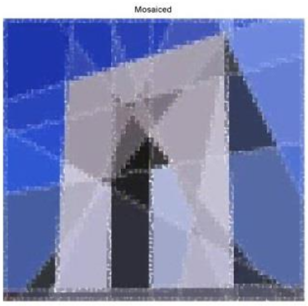


(b)



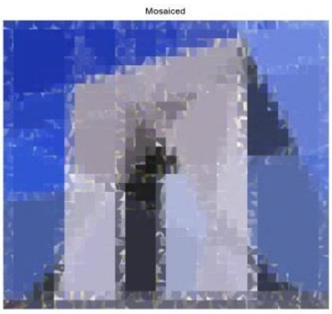
(c)

(d)



(e)

(f)



(g)

(h)

Figure 4.4.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 04

Table 4.4: Comparison of errors for images of Experiment no. 04

Block size	Error		Images
	rmse	psnr	
4x4	15.315925	24.427939	for mosaic image wrt target image
	4.008282	36.071639	for recovered secret image wrt original secret image
8x8	15.881952	24.112726	for mosaic image wrt target image
	5.503332	33.318289	for recovered secret image wrt original secret image
16x16	15.943569	24.079092	for mosaic image wrt target image
	6.767040	31.522829	for recovered secret image wrt original secret image

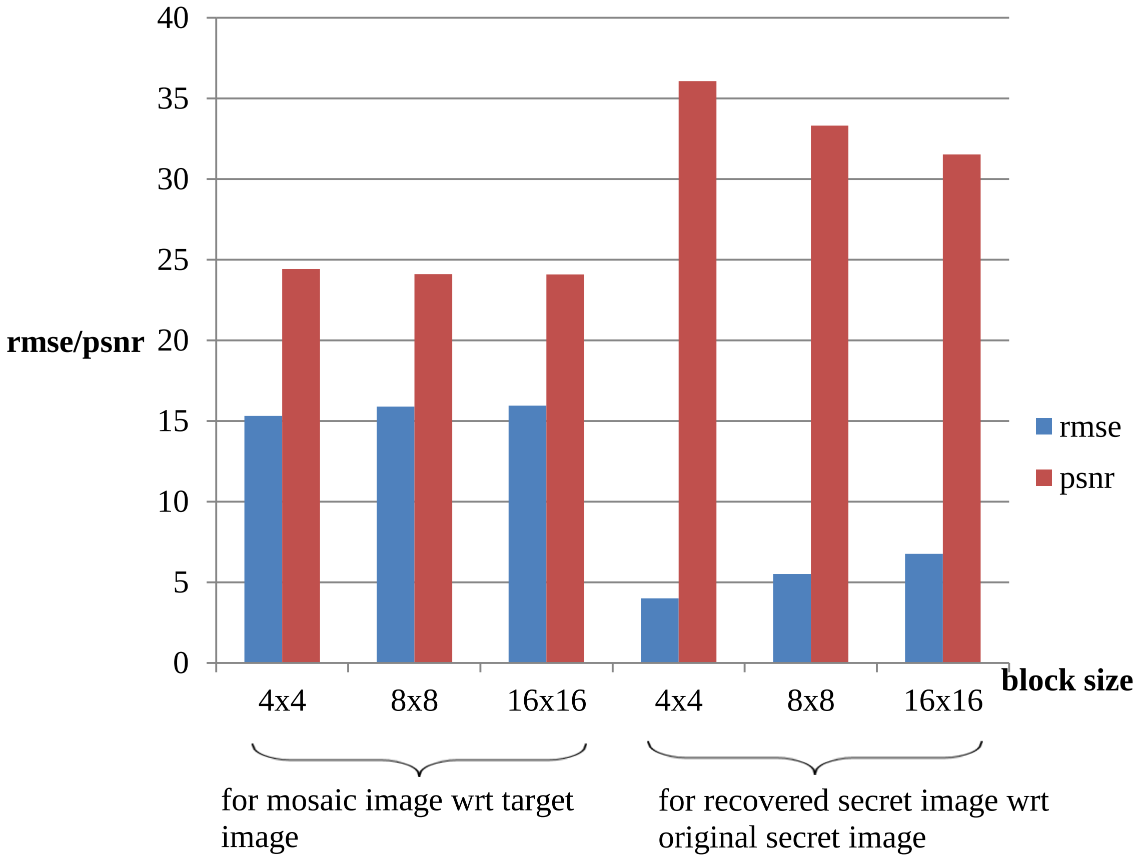


Figure 4.4.2: Plot of Table 4.4

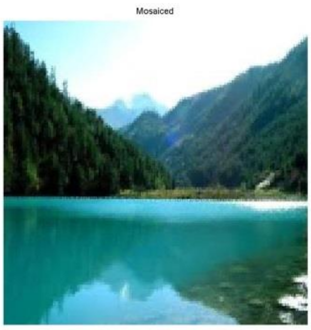
Figure 4.4.1 shows the results obtained using secret image same as used in Experiment no. 03 and cubism form of the target image used in Experiment no. 03 for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.4 and Figure 4.4.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.4 shows the tabulation of rmse and psnr errors for different block sizes and images. On comparison of results obtained from Experiment no. 03 and Experiment no. 04, lower rmse and higher psnr of the mosaiced image with respect to the target image is obtained from Experiment no. 03 than Experiment no.

04 whereas lower rmse and higher psnr of the recovered secret image with respect to the original secret image is obtained from Experiment no. 04 than Experiment no. 03.

Experiment no. 05:

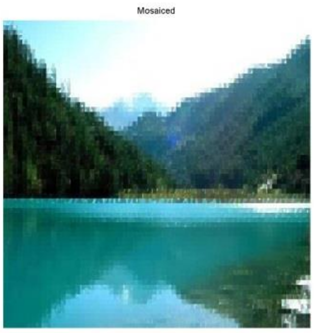
(a)

(b)



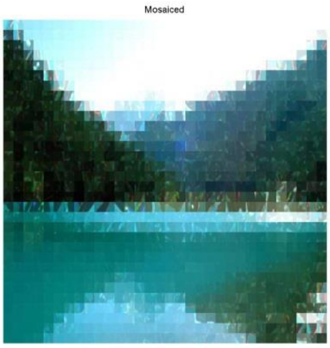
(c)

(d)



(e)

(f)



(g) (h)

Figure 4.5.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 05

Table 4.5: Comparison of errors for images of Experiment no. 05

Block size	Error		Images
	rmse	psnr	
4x4	14.518334	24.892468	for mosaic image wrt target image
	3.174454	38.097422	for recovered secret image wrt original secret image
8x8	15.137844	24.529523	for mosaic image wrt target image
	4.623788	34.830845	for recovered secret image wrt original secret image
16x16	15.326166	24.422133	for mosaic image wrt target image
	5.895024	32.721092	for recovered secret image wrt original secret image

Figure 4.5.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.5 and Figure 4.5.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.5 shows the tabulation of rmse and psnr errors for different block sizes and images.

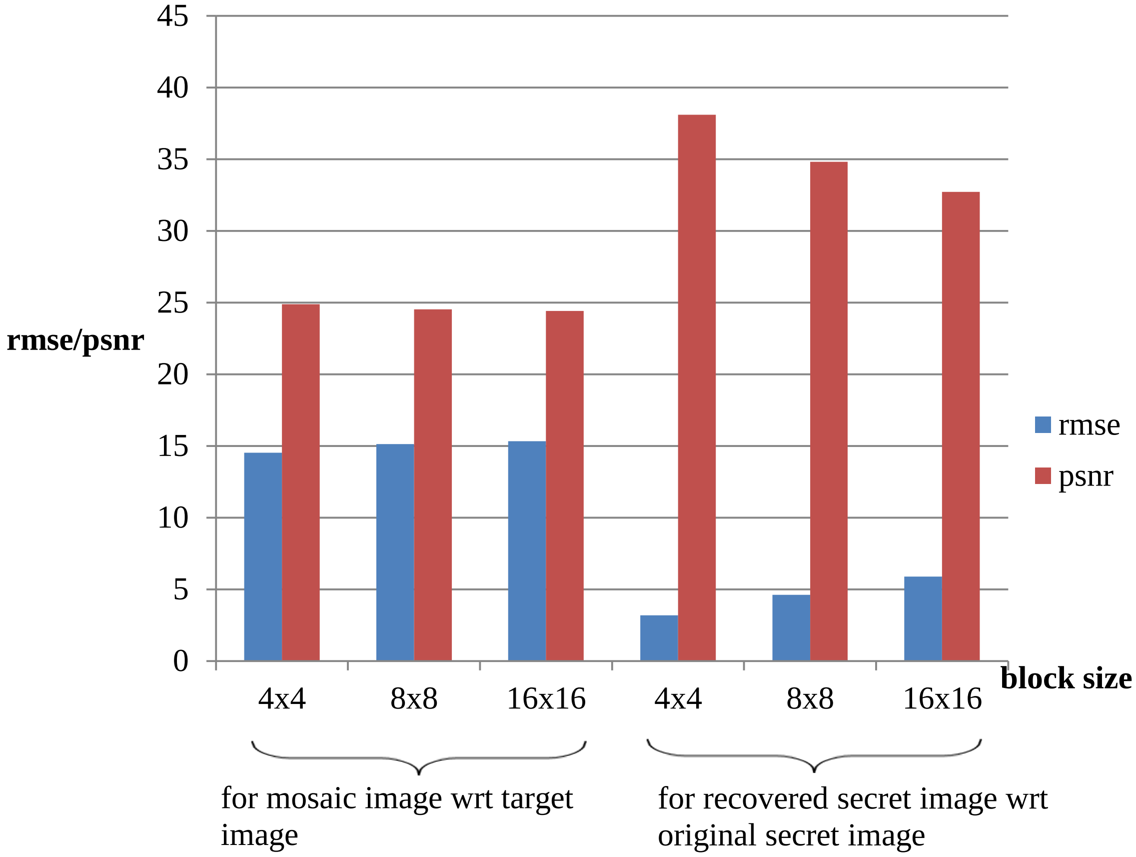
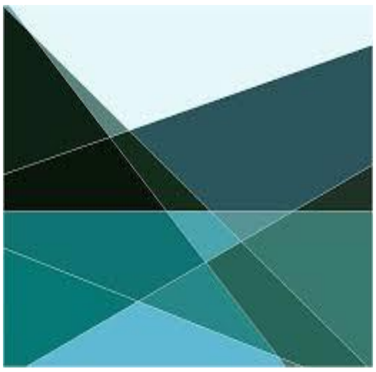


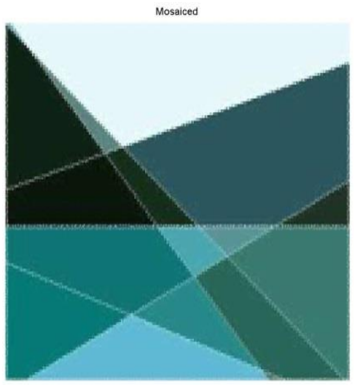
Figure 4.5.2: Plot of Table 4.5

Experiment no. 06:

(a)

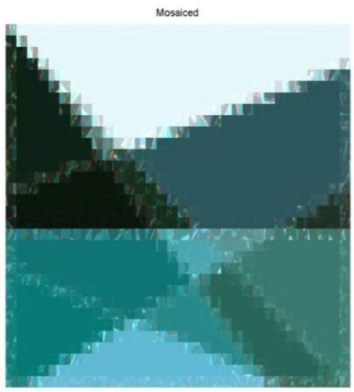


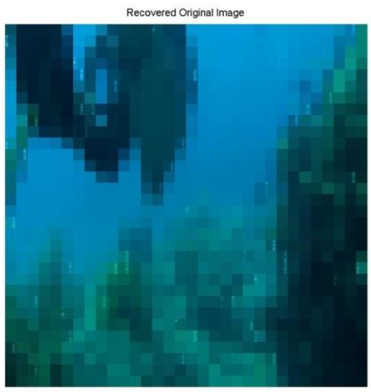
(b)



(c) (d)

(e) (f)





(g) (h)

Figure 4.6.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 06

Table 4.6: Comparison of errors for images of Experiment no. 06

Block size	Error		Images
	rmse	psnr	
4x4	14.614167	24.835322	for mosaic image wrt target image
	3.101430	38.299563	for recovered secret image wrt original secret image
8x8	15.334147	24.417611	for mosaic image wrt target image
	4.573480	34.925868	for recovered secret image wrt original secret image
16x16	15.608106	24.263800	for mosaic image wrt target image
	5.869083	32.759398	for recovered secret image wrt original secret image

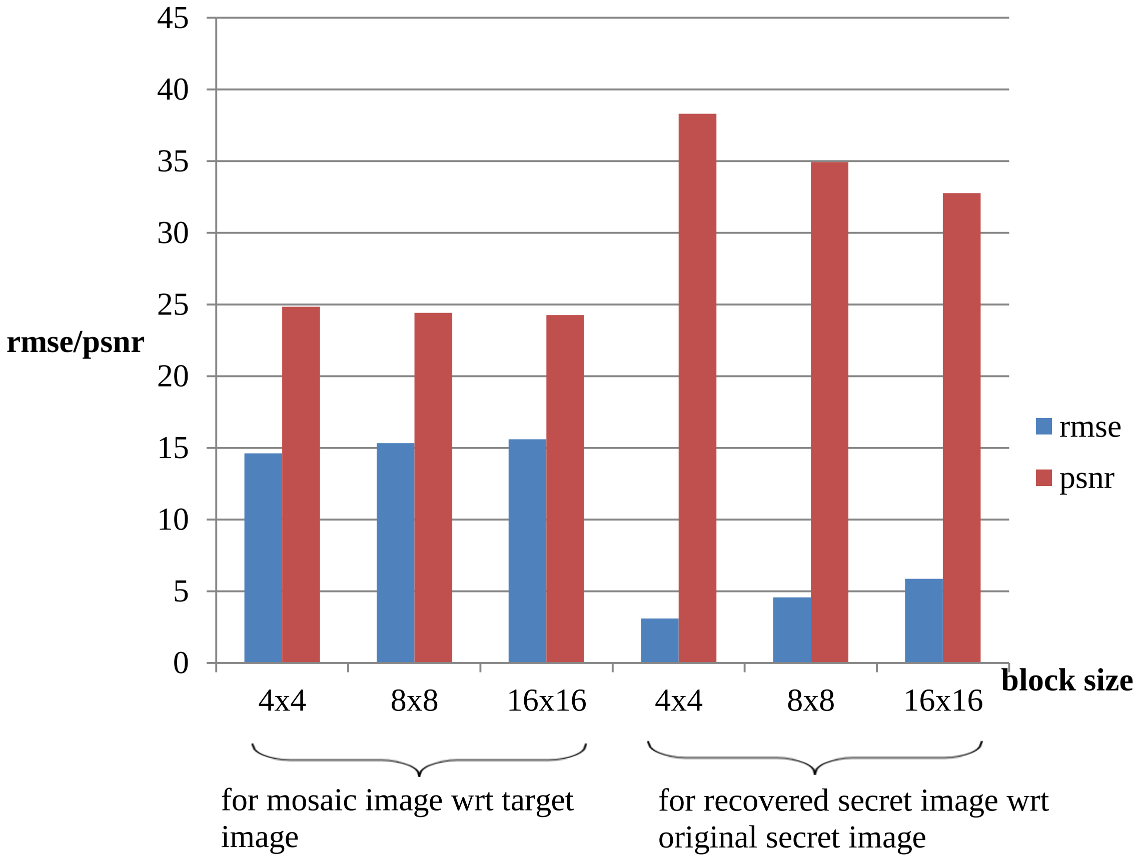


Figure 4.6.2: Plot of Table 4.6

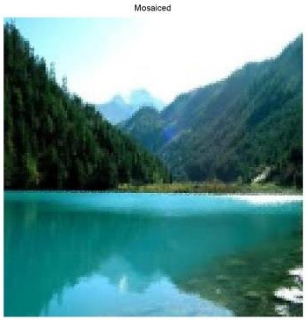
Figure 4.6.1 shows the results obtained using secret image same as used in Experiment no. 05 and cubism form of the target image used in Experiment no. 05 for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.6 and Figure 4.6.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.6 shows the tabulation of rmse and psnr errors for different block sizes and images. On comparison of results obtained from Experiment no. 05 and Experiment no. 06, lower rmse and higher psnr of the mosaiced image with respect to the target image is obtained from Experiment no. 05 than Experiment no.

06 whereas lower rmse and higher psnr of the recovered secret image with respect to the original secret image is obtained from Experiment no. 06 than Experiment no. 05.

Experiment no. 07:

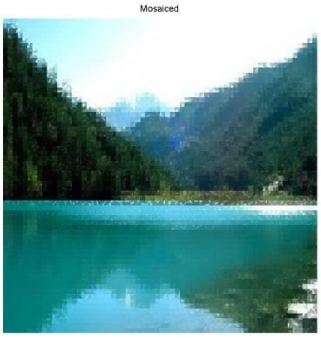
(a)

(b)



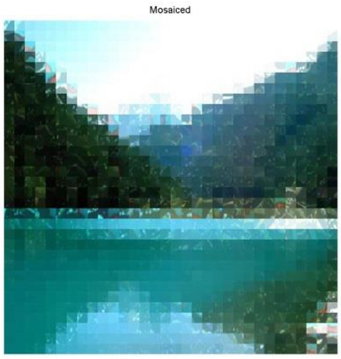
(c)

(d)

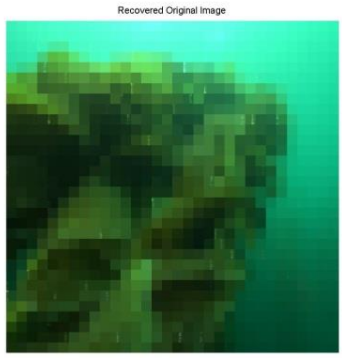


(e)

(f)



(g)



(h)

Figure 4.7.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 07

Table 4.7: Comparison of errors for images of Experiment no. 07

Block size	Error		Images
	rmse	psnr	
4x4	14.461943	24.926271	for mosaic image wrt target image
	3.357067	37.611602	for recovered secret image wrt original secret image
8x8	15.138017	24.529424	for mosaic image wrt target image
	4.394943	35.271738	for recovered secret image wrt original secret image
16x16	15.324866	24.422870	for mosaic image wrt target image
	5.163108	33.872579	for recovered secret image wrt original secret image

Figure 4.7.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.7 and Figure 4.7.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.7 shows the tabulation of rmse and psnr errors for different block sizes and images.

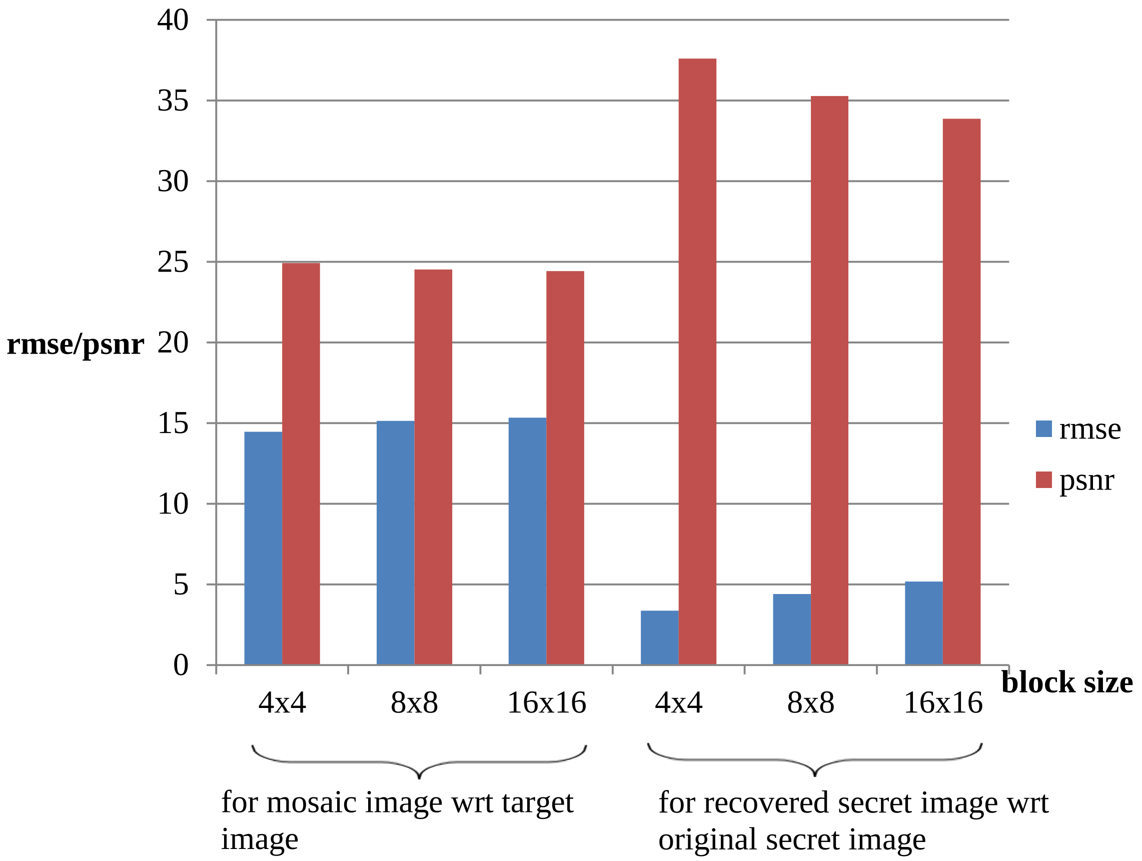
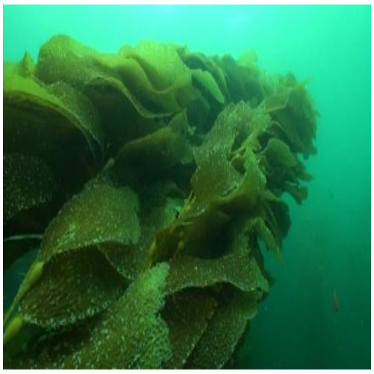
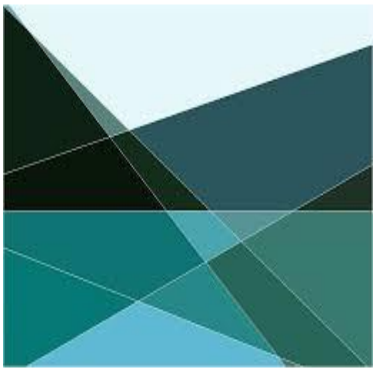


Figure 4.7.2: Plot of Table 4.7

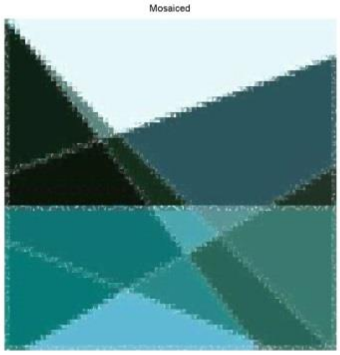
Experiment no. 08:



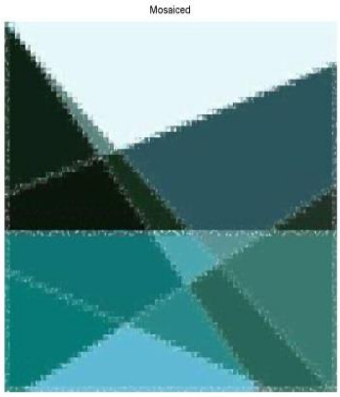
(a)



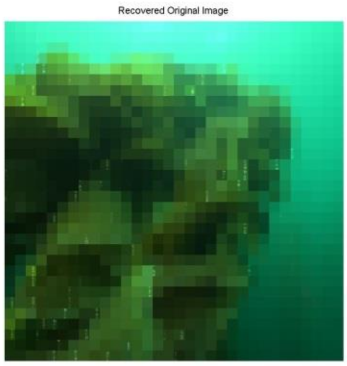
(b)



(c) (d)



(e) (f)



(g) (h)

Figure 4.8.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 08

Table 4.8: Comparison of errors for images of Experiment no. 08

Block size	Error		Images
	rmse	psnr	
4x4	14.606074	24.840134	for mosaic image wrt target image
	3.292013	37.781572	for recovered secret image wrt original secret image
8x8	15.304273	24.434550	for mosaic image wrt target image
	4.360040	35.340995	for recovered secret image wrt original secret image
16x16	15.596450	24.270289	for mosaic image wrt target image
	5.149713	33.895143	for recovered secret image wrt original secret image

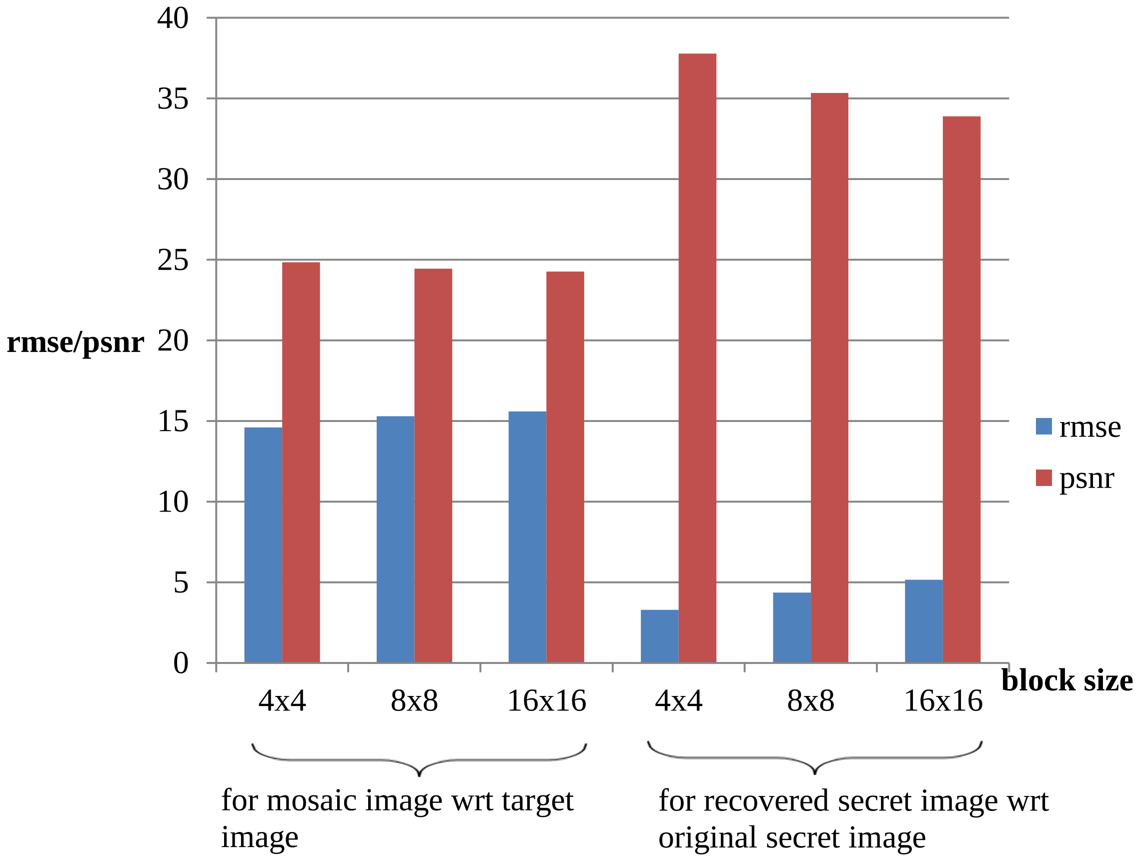


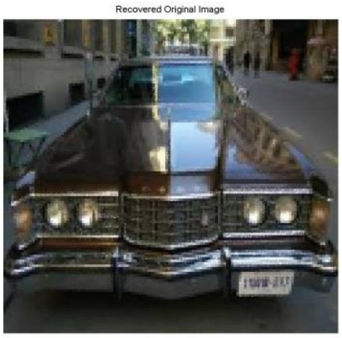
Figure 4.8.2: Plot of Table 4.8

Figure 4.8.1 shows the results obtained using secret image same as used in Experiment no. 07 and cubism form of the target image used in Experiment no. 07 for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.8 and Figure 4.8.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.6 shows the tabulation of rmse and psnr errors for different block sizes and images. On comparison of results obtained from Experiment no. 07 and Experiment no. 08, lower rmse and higher psnr of the mosaiced image with respect to the target image is obtained from Experiment no. 07 than Experiment no.

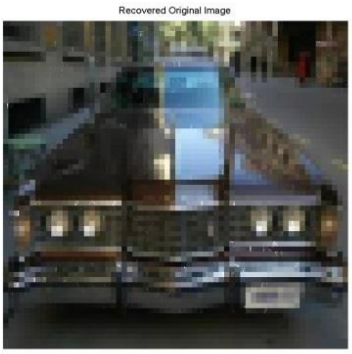
08 whereas lower rmse and higher psnr of the recovered secret image with respect to the original secret image is obtained from Experiment no. 08 than Experiment no. 07.

Experiment no. 09:

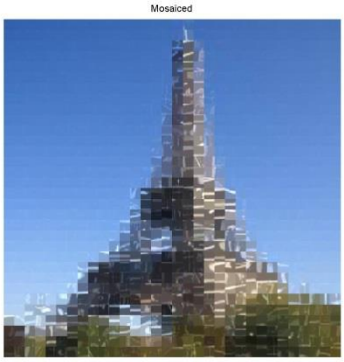
(a) (b)



(c) (d)



(e) (f)



(g) (h)

Figure 4.9.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 09

Table 4.9: Comparison of errors for images of Experiment no. 09

Block size	Error		Images
	rmse	psnr	
4x4	15.365416	24.399917	for mosaic image wrt target image
	5.464925	33.379119	for recovered secret image wrt original secret image
8x8	15.819093	24.147172	for mosaic image wrt target image
	6.977738	31.256511	for recovered secret image wrt original secret image
16x16	15.858607	24.125503	for mosaic image wrt target image
	7.723030	30.375049	for recovered secret image wrt original secret image

Figure 4.9.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.9 and Figure 4.9.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.9 shows the tabulation of rmse and psnr errors for different block sizes and images.

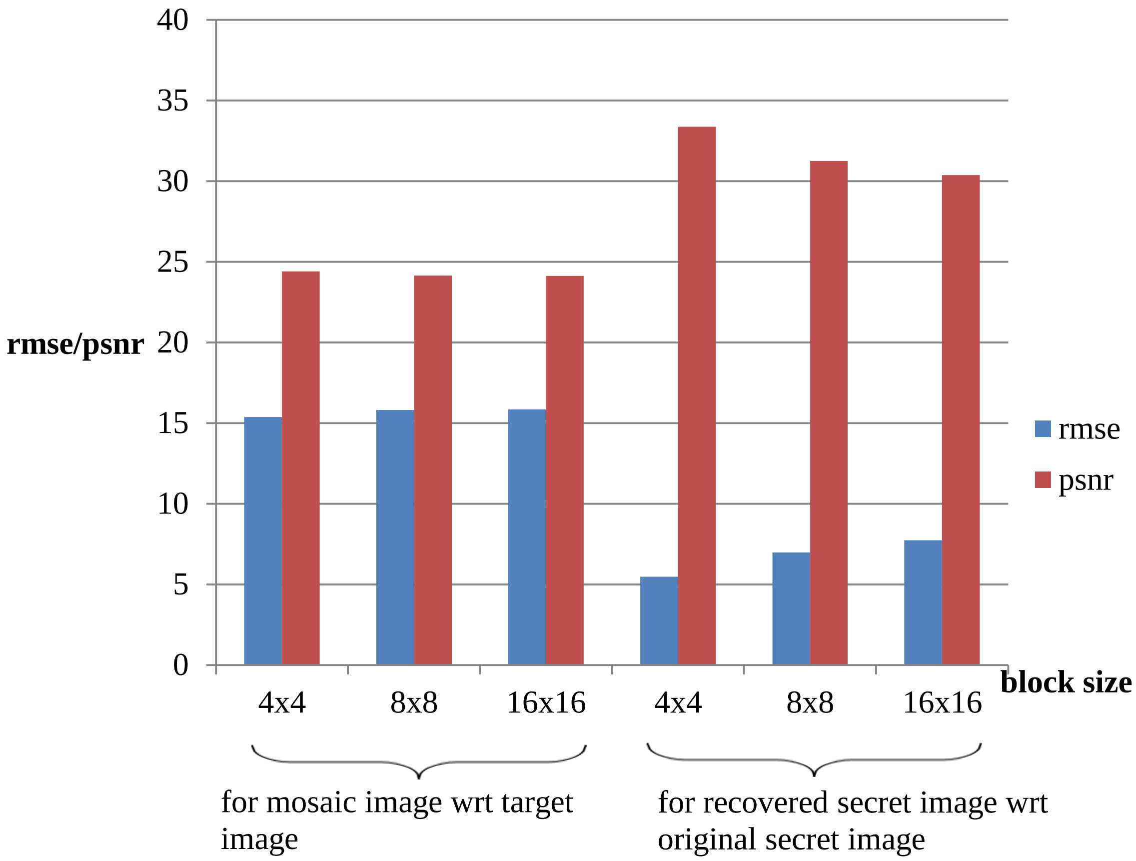
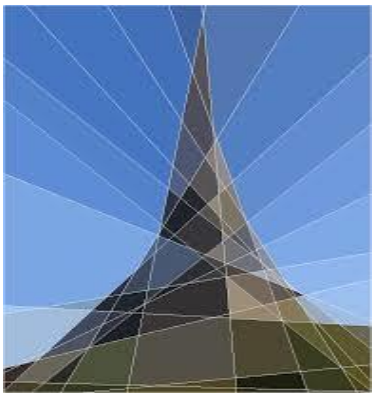


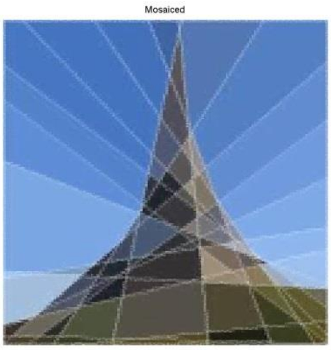
Figure 4.9.2: Plot of Table 4.9

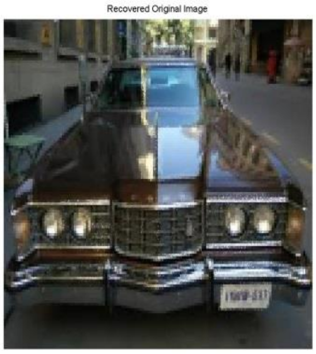
Experiment no. 10:

(a)

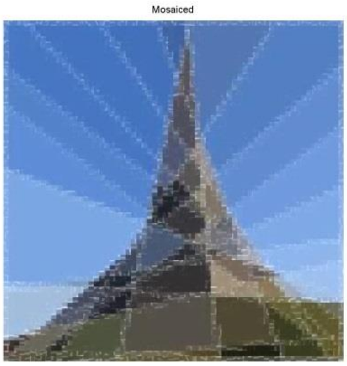


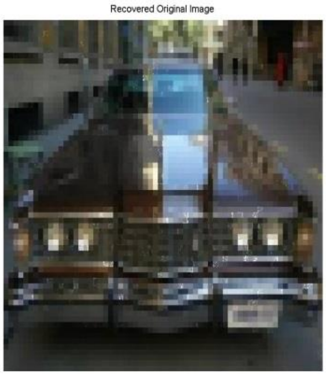
(b)





(c) (d)





(e) (f)

(g) (h)

Figure 4.10.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 10

Table 4.10: Comparison of errors for images of Experiment no. 10

Block size	Error		Images
	rmse	psnr	
4x4	15.551005	24.295634	for mosaic image wrt target image
	5.475120	33.362930	for recovered secret image wrt original secret image
8x8	15.917965	24.093053	for mosaic image wrt target image
	6.945049	31.297297	for recovered secret image wrt original secret image
16x16	15.944995	24.078316	for mosaic image wrt target image
	7.712486	30.386916	for recovered secret image wrt original secret image

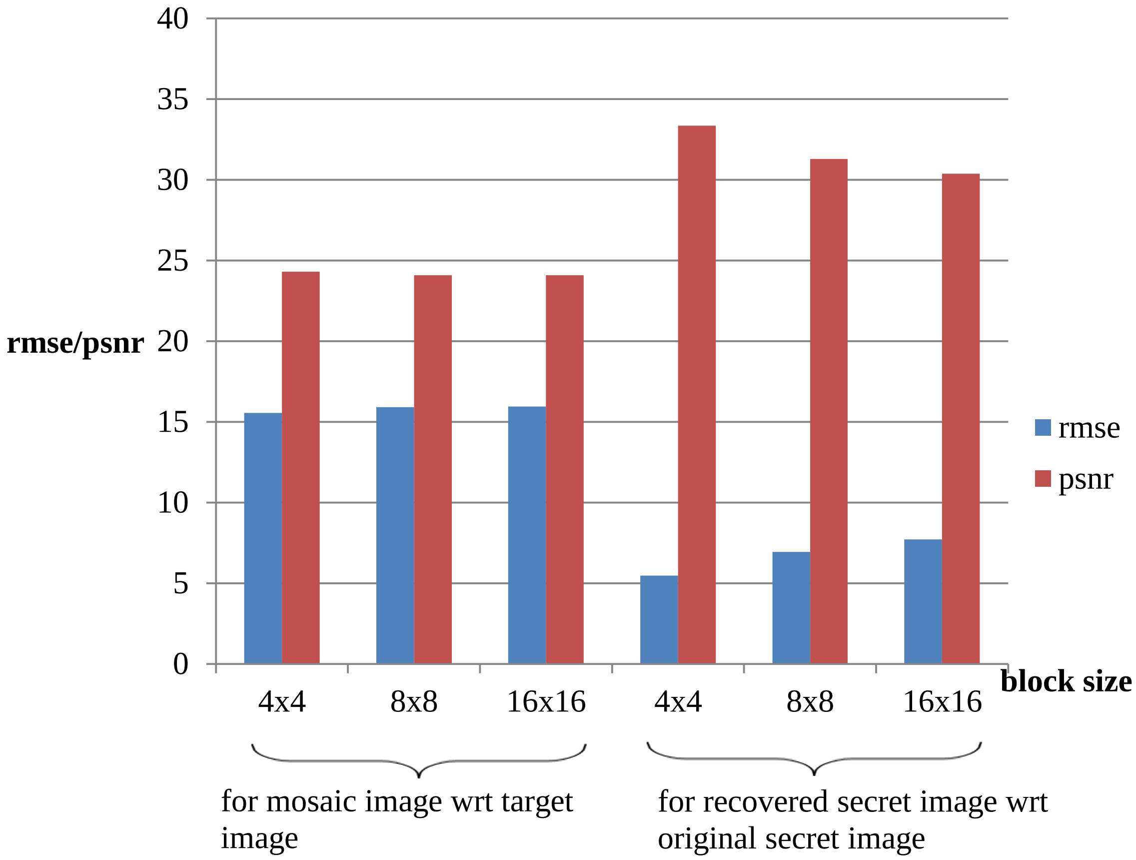


Figure 4.10.2: Plot of Table 4.10

Figure 4.10.1 shows the results obtained using secret image same as used in Experiment no. 09 and cubism form of the target image used in Experiment no. 09 for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.10 and Figure 4.10.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.10 shows the tabulation of rmse and psnr errors for different block sizes and images. On comparison of results obtained from

Experiment no. 09 and Experiment no. 10, lower rmse and higher psnr of the mosaiced image with respect to the target image is obtained from Experiment no. 09 than Experiment no. 10 whereas lower rmse and higher psnr of the recovered secret image with respect to the original secret image is obtained from Experiment no. 10 than Experiment no. 09.

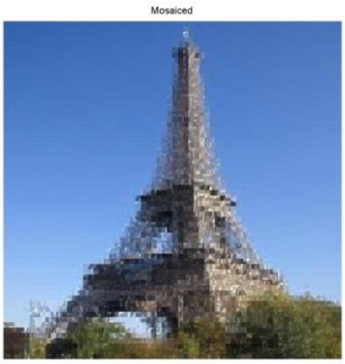
Experiment no. 11:

(a)

(b)

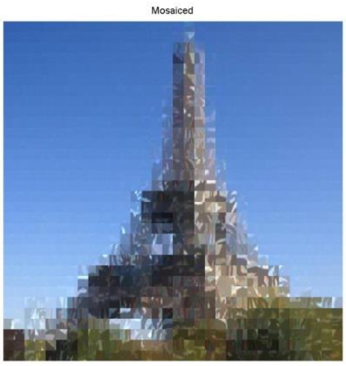
(c)

(d)

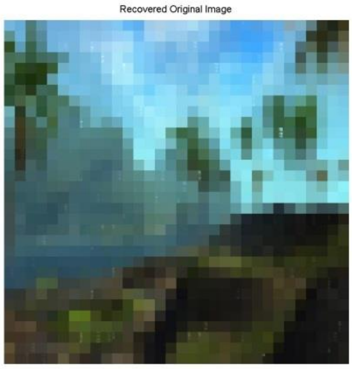


(e)

(f)



(g)



(h)

Figure 4.11.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 11

Table 4.11: Comparison of errors for images of Experiment no. 11

Block size	Error		Images
	rmse	psnr	
4x4	15.200185	24.493826	for mosaic image wrt target image
	4.221504	35.621460	for recovered secret image wrt original secret image
8x8	15.777943	24.169796	for mosaic image wrt target image
	5.798268	32.864838	for recovered secret image wrt original secret image
16x16	15.850698	24.129836	for mosaic image wrt target image
	6.954118	31.285963	for recovered secret image wrt original secret image

Figure 4.11.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.11 and Figure 4.11.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.11 shows the tabulation of rmse and psnr errors for different block sizes and images.

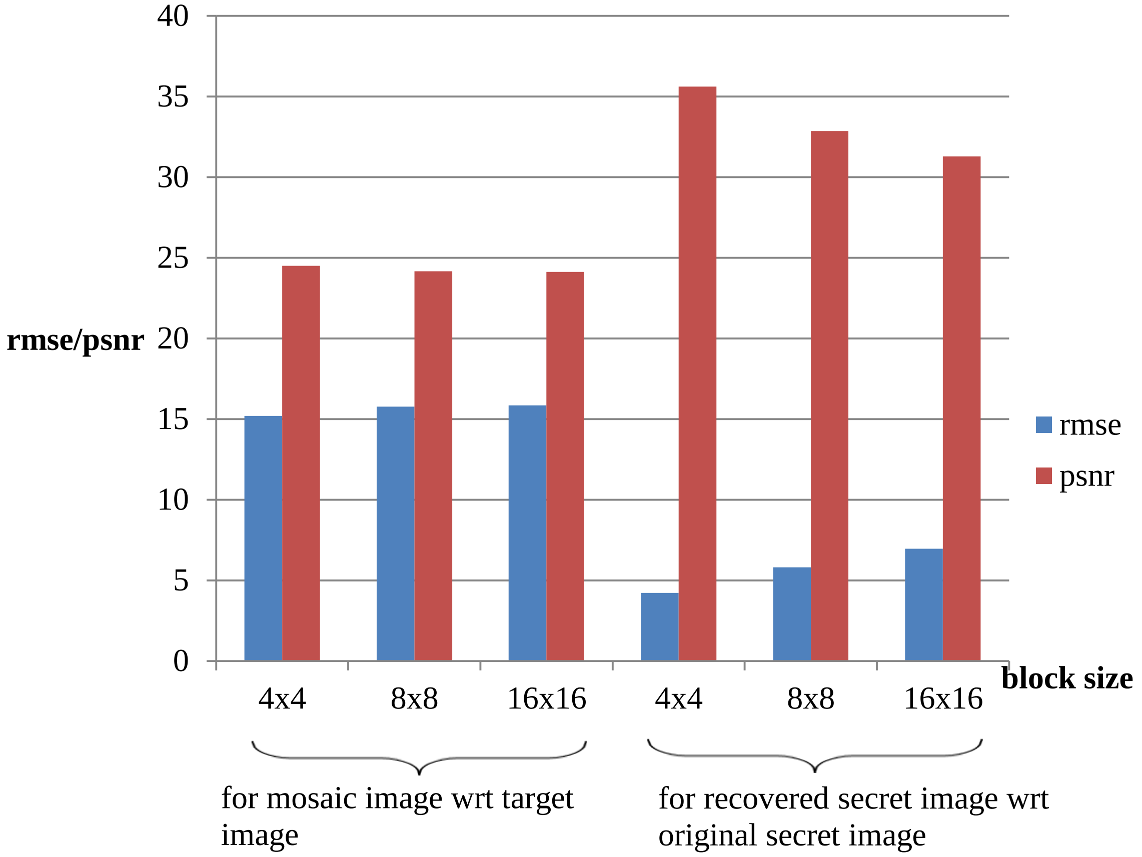
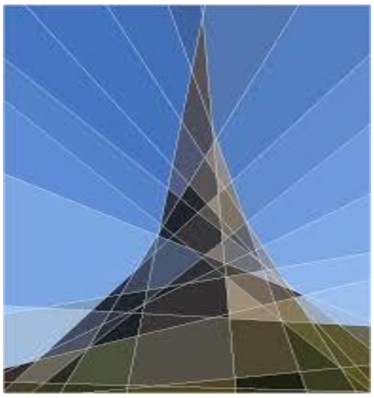


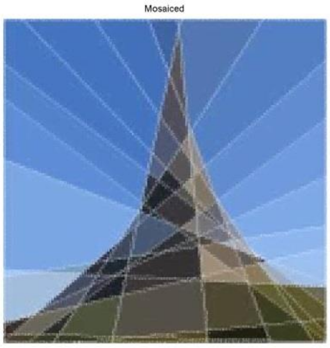
Figure 4.11.2: Plot of Table 4.11

Experiment no. 12:

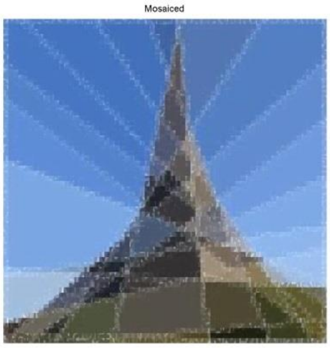
(a)



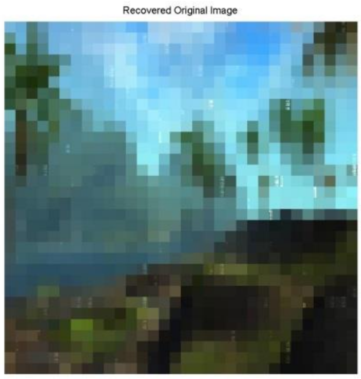
(b)



(c) (d)



(e) (f)



(g) (h)

Figure 4.12.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 12

Table 4.12: Comparison of errors for images of Experiment no. 12

Block size	Error		Images
	rmse	psnr	
4x4	15.355250	24.405666	for mosaic image wrt target image
	4.195103	35.675950	for recovered secret image wrt original secret image
8x8	15.872592	24.117846	for mosaic image wrt target image
	5.769323	32.908306	for recovered secret image wrt original secret image
16x16	15.934632	24.083963	for mosaic image wrt target image
	6.930438	31.315590	for recovered secret image wrt original secret image

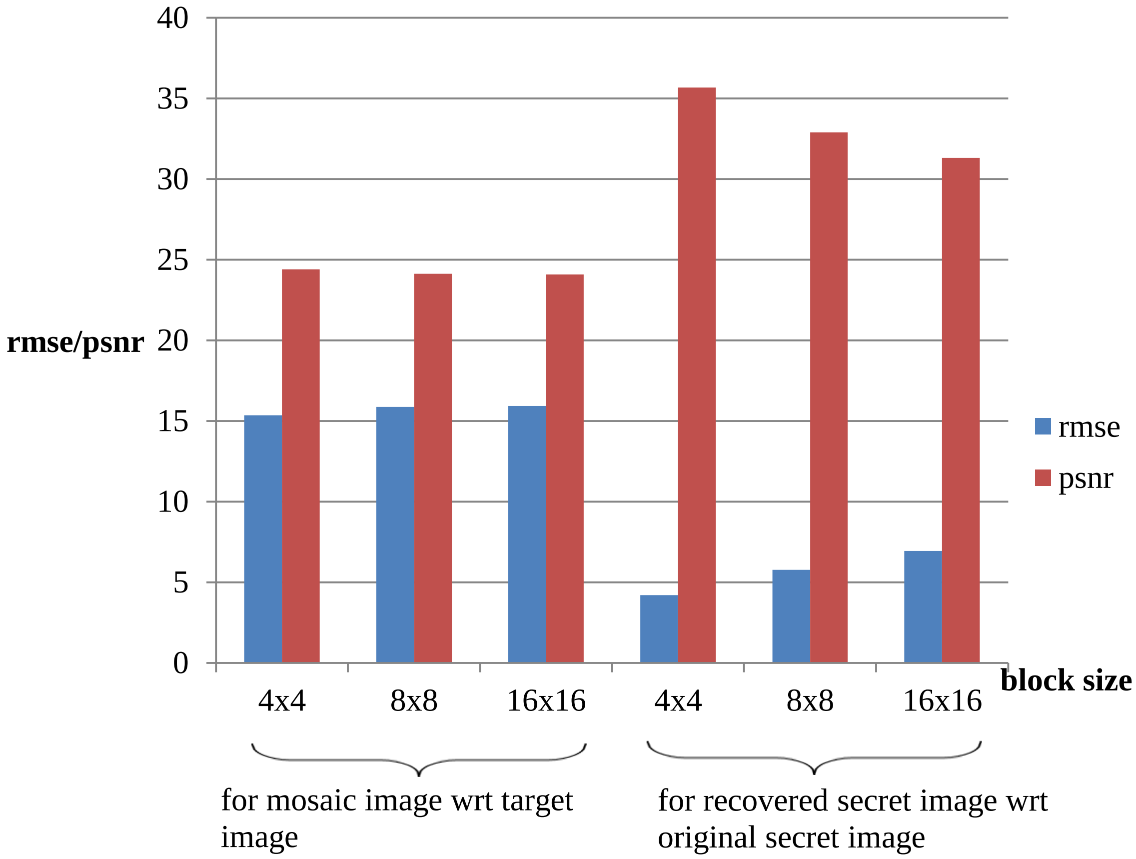


Figure 4.12.2: Plot of Table 4.12

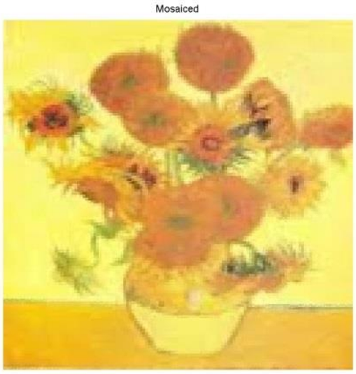
Figure 4.12.1 shows the results obtained using secret image same as used in Experiment no. 11 and cubism form of the target image used in Experiment no. 11 for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.12 and Figure 4.12.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.12 shows the tabulation of rmse and psnr errors for different block sizes and images. On comparison of results obtained from

Experiment no. 11 and Experiment no. 12, lower rmse and higher psnr of the mosaiced image with respect to the target image is obtained from Experiment no. 11 than Experiment no. 12 whereas lower rmse and higher psnr of the recovered secret image with respect to the original secret image is obtained from Experiment no. 12 than Experiment no. 11.

Experiment no. 13:

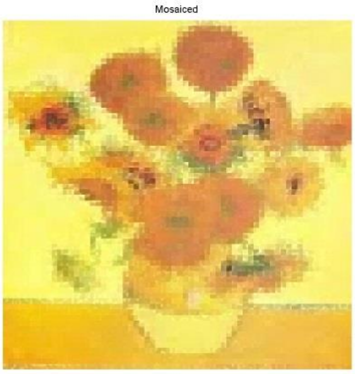
(a)

(b)



(c)

(d)



(e)

(f)

(g)

(h)

Figure 4.13.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 13

Table 4.13: Comparison of errors for images of Experiment no. 13

Block size	Error		Images
	rmse	psnr	
4x4	13.747725	25.366187	for mosaic image wrt target image
	4.173219	35.721379	for recovered secret image wrt original secret image
8x8	15.543497	24.299829	for mosaic image wrt target image
	6.485659	31.891722	for recovered secret image wrt original secret image
16x16	15.833678	24.139167	for mosaic image wrt target image
	8.054228	30.010325	for recovered secret image wrt original secret image

Figure 4.13.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.13 and Figure 4.13.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.13 shows the tabulation of rmse and psnr errors for different block sizes and images.

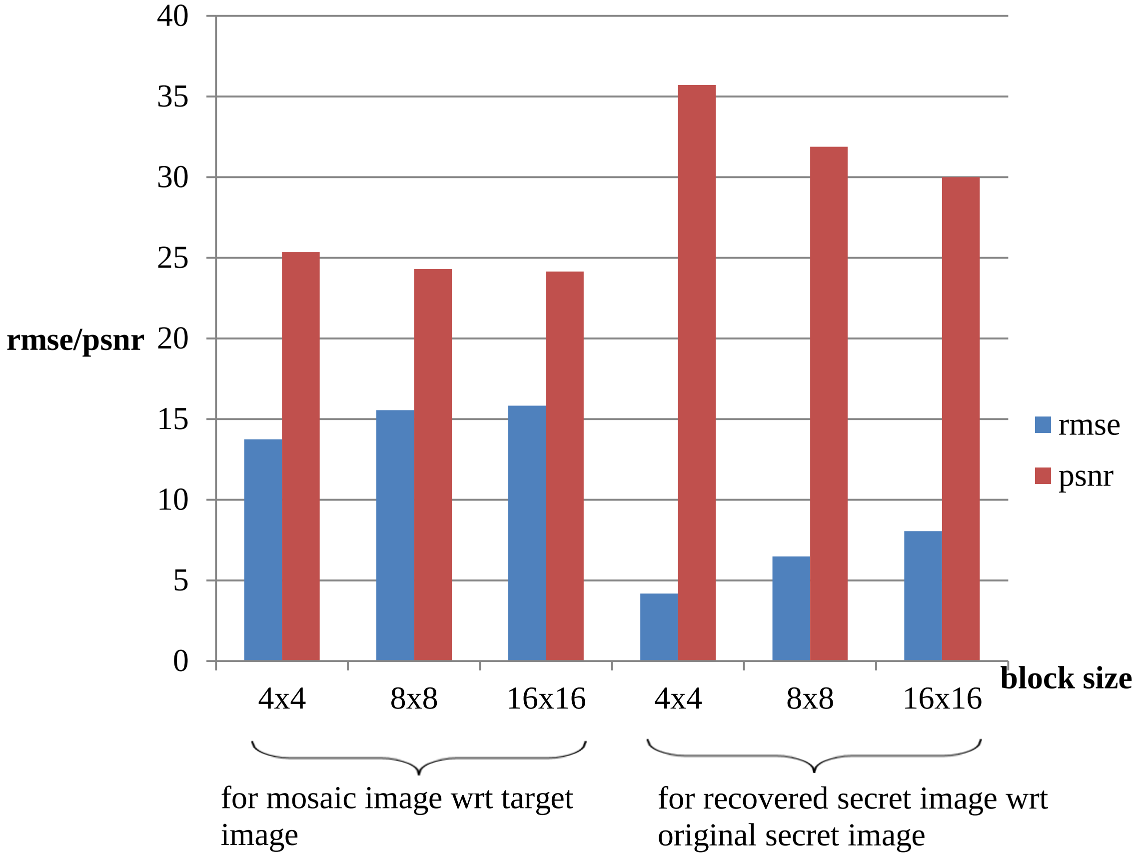
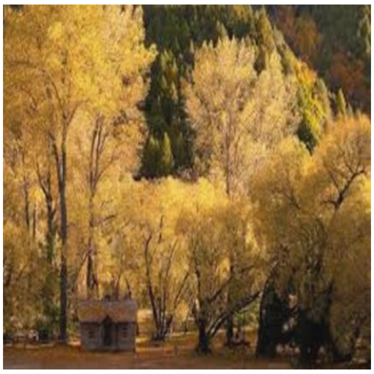


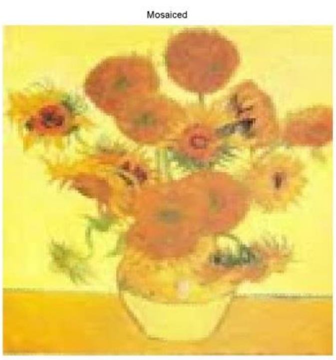
Figure 4.13.2: Plot of Table 4.13

Experiment no. 14:

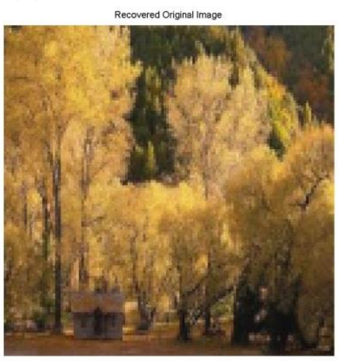


(a)

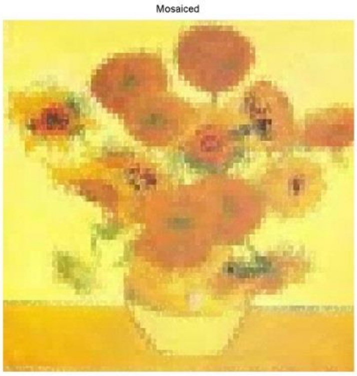
(b)



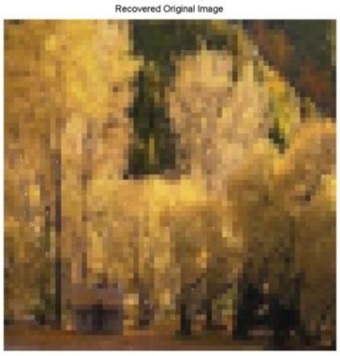
(c)



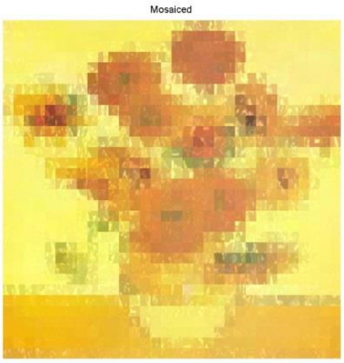
(d)



(e)



(f)



(g)

(h)

Figure 4.14.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 14

Table 4.14: Comparison of errors for images of Experiment no. 14

Block size	Error		Images
	rmse	psnr	
4x4	13.920433	25.257749	for mosaic image wrt target image
	5.694282	33.022024	for recovered secret image wrt original secret image
8x8	15.582983	24.277792	for mosaic image wrt target image
	7.271854	30.897900	for recovered secret image wrt original secret image
16x16	15.847845	24.131399	for mosaic image wrt target image
	7.861216	30.221009	for recovered secret image wrt original secret image

Figure 4.14.1 shows the results obtained using secret image and target image for three block sizes. The target image is the same as used for Experiment no. 13 being mosaiced with a different secret image. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.14 and Figure 4.14.2, the mosaiced images

are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.14 shows the tabulation of rmse and psnr errors for different block sizes and images.

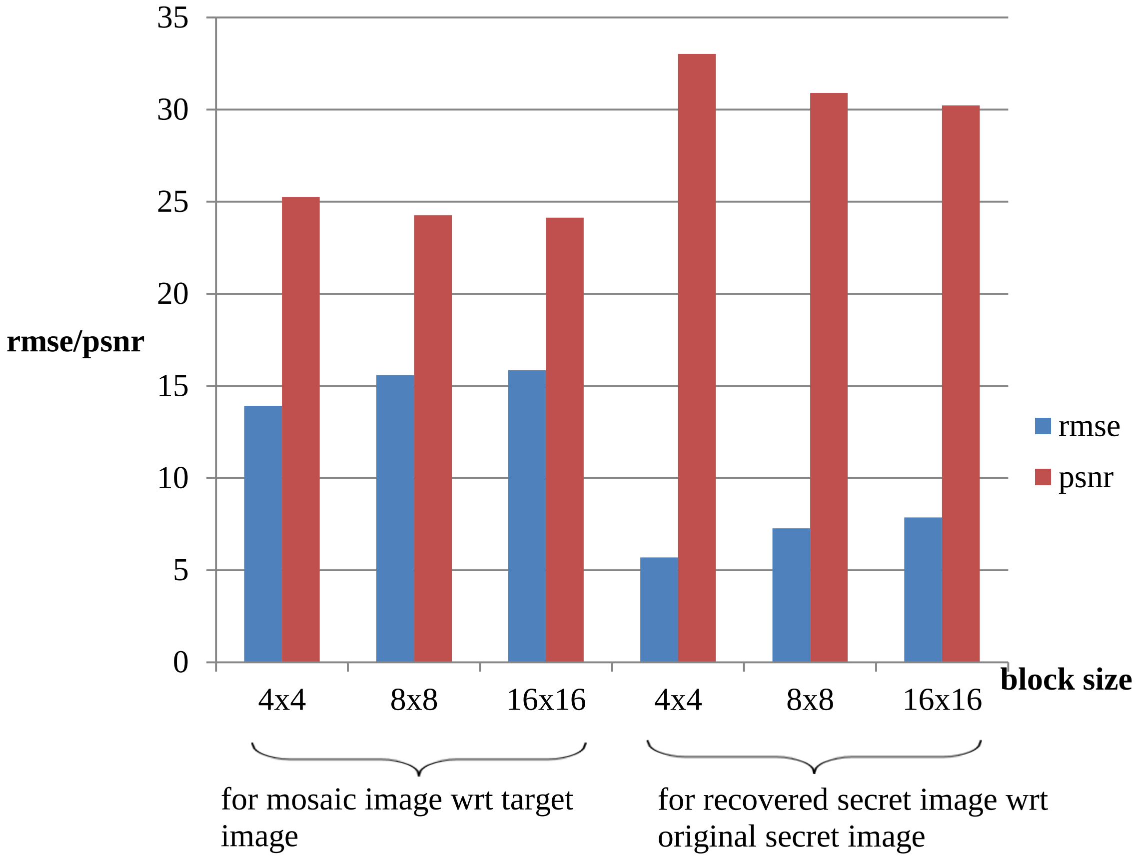
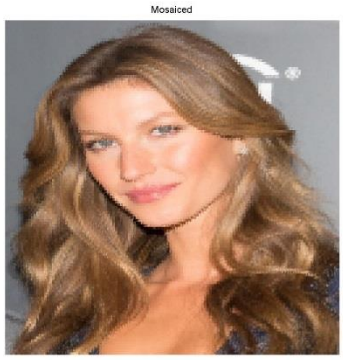


Figure 4.14.2: Plot of Table 4.14

Experiment no. 15:

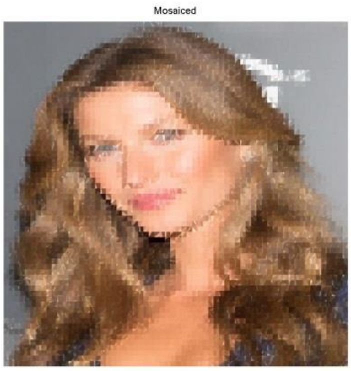
(a)

(b)



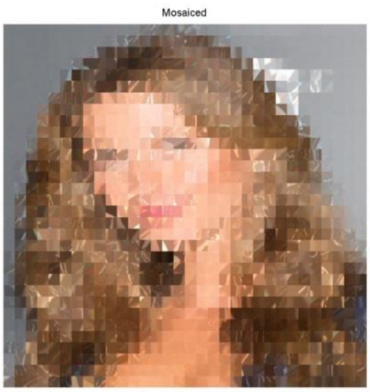
(c)

(d)



(e)

(f)



(g)

(h)

Figure 4.15.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 15

Table 4.15: Comparison of errors for images of Experiment no. 15

Block size	Error		Images
	rmse	psnr	
4x4	13.790232	25.339372	for mosaic image wrt target image
	4.862315	34.393941	for recovered secret image wrt original secret image
8x8	15.464201	24.344254	for mosaic image wrt target image
	6.005349	32.560038	for recovered secret image wrt original secret image
16x16	15.770990	24.173625	for mosaic image wrt target image
	6.932661	31.312804	for recovered secret image wrt original secret image

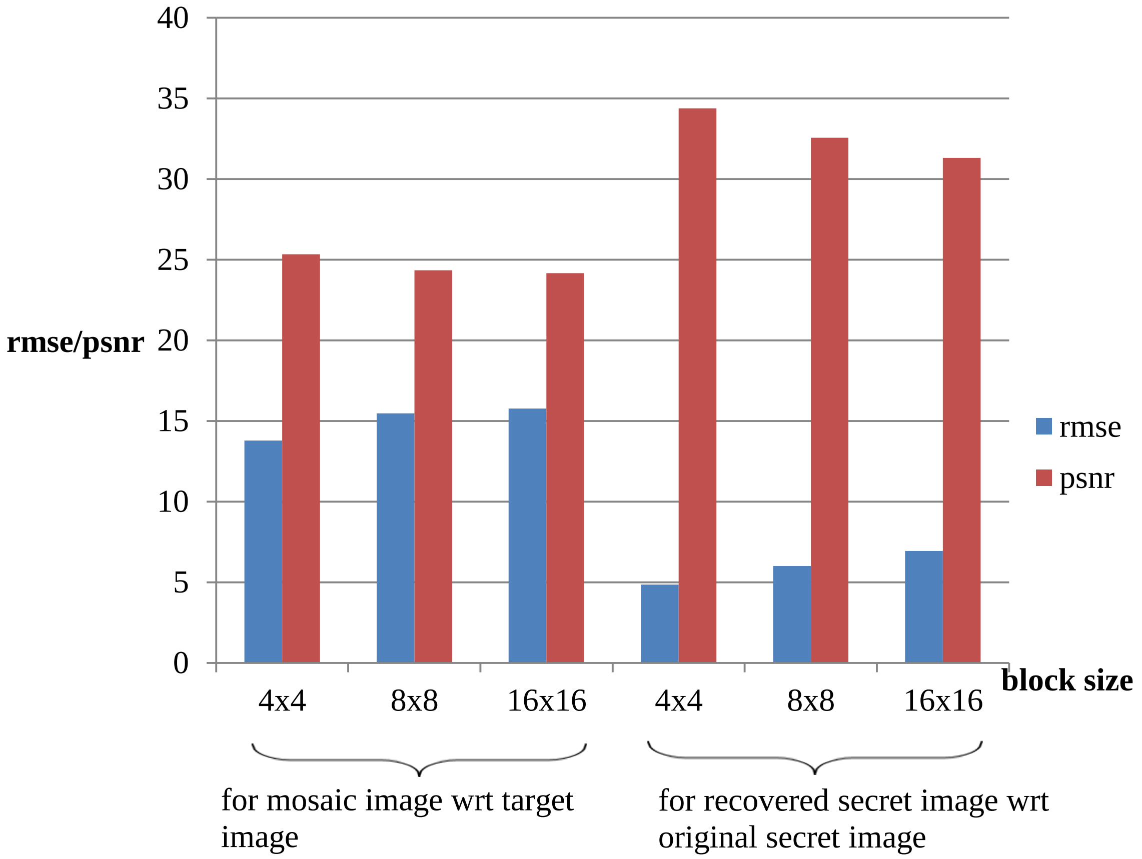
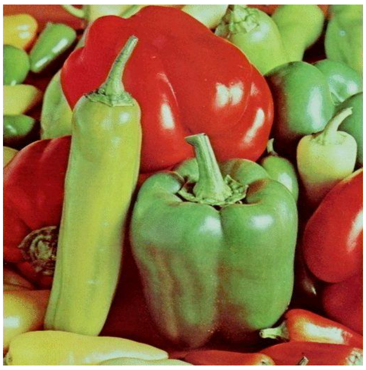


Figure 4.15.2: Plot of Table 4.15

Figure 4.15.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.15 and Figure 4.15.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.15 shows the tabulation of rmse and psnr errors for different block sizes and images.

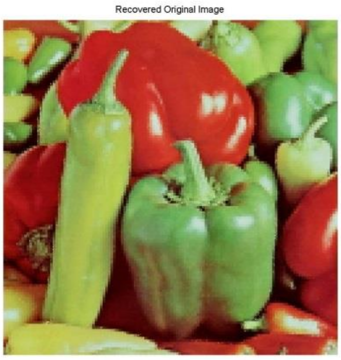
Experiment no. 16:



(a)

(b)

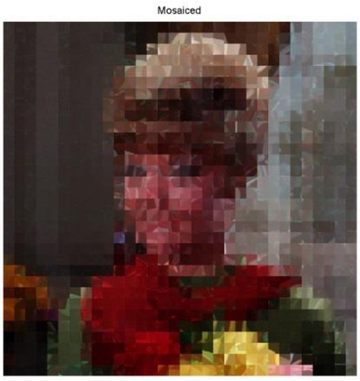
(c)



(d)

(e)

(f)



(g)

(h)

Figure 4.16.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 16

Table 4.16: Comparison of errors for images of Experiment no. 16

Block size	Error		Images
	rmse	psnr	
4x4	11.377331	27.009996	for mosaic image wrt target image
	4.601257	34.873275	for recovered secret image wrt original secret image
8x8	13.873150	25.287302	for mosaic image wrt target image
	6.163121	32.334790	for recovered secret image wrt original secret image
16x16	14.398690	24.964344	for mosaic image wrt target image
	7.256016	30.916839	for recovered secret image wrt original secret image

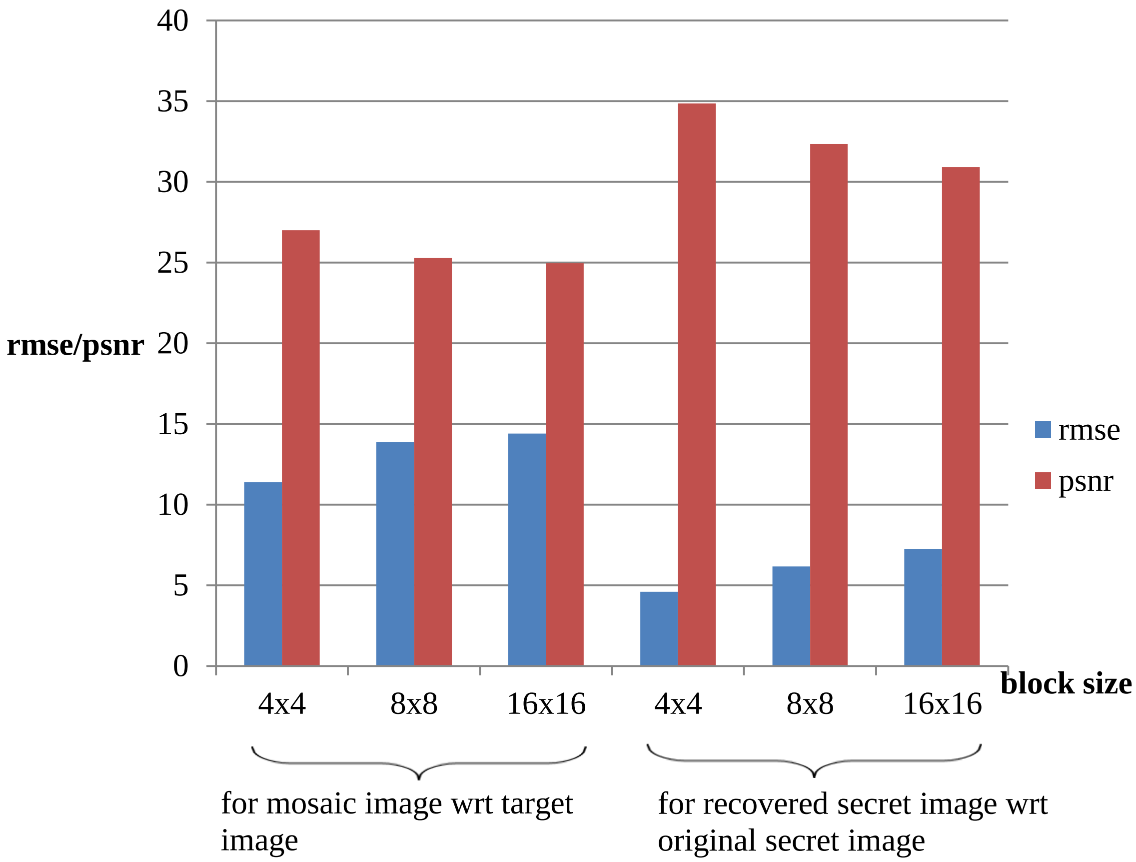


Figure 4.16.2: Plot of Table 4.16

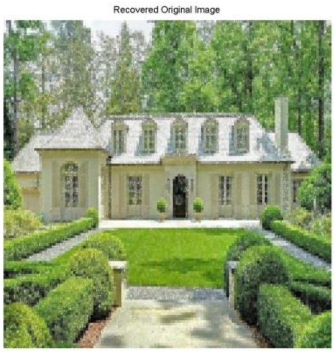
Figure 4.16.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.16 and Figure 4.16.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.16 shows the tabulation of rmse and psnr errors for different block sizes and images.

Experiment no. 17:

(a)

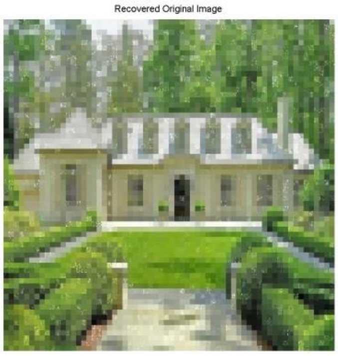
(b)

(c)



(d)

(e)



(f)

(g)

(h)

Figure 4.17.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 17

Table 4.17: Comparison of errors for images of Experiment no. 17

Block size	Error		Images
	rmse	psnr	
4x4	13.956698	25.235150	for mosaic image wrt target image
	8.442427	29.601457	for recovered secret image wrt original secret image
8x8	15.402768	24.378828	for mosaic image wrt target image
	9.429354	28.641164	for recovered secret image wrt original secret image
16x16	15.793583	24.161191	for mosaic image wrt target image
	9.858081	28.254956	for recovered secret image wrt original secret image

Figure 4.17.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.17 and Figure 4.17.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.17 shows the tabulation of rmse and psnr errors for different block sizes and images.

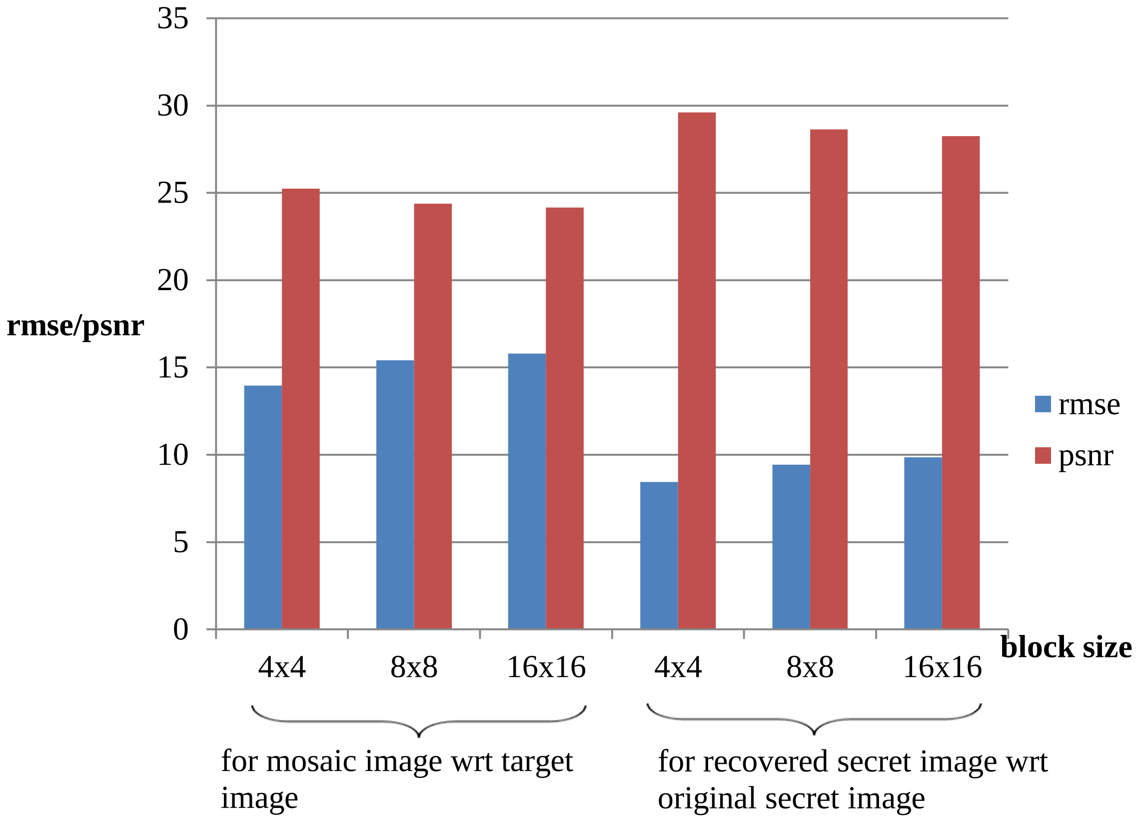


Figure 4.17.2: Plot of Table 4.17

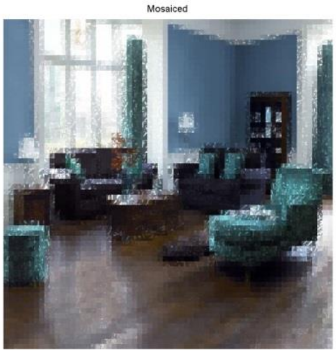
Experiment no. 18:

(a)

(b)

(c)

(d)



(e) (f)

(g) (h)

Figure 4.18.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 18

Table 4.18: Comparison of errors for images of Experiment no. 18

Block size	Error		Images
	rmse	psnr	
4x4	14.298727	25.024856	for mosaic image wrt target image
	5.948553	32.642576	for recovered secret image wrt original secret image
8x8	15.379337	24.392051	for mosaic image wrt target image
	6.831439	31.440560	for recovered secret image wrt original secret image
16x16	15.639752	24.246206	for mosaic image wrt target image
	7.187315	30.999471	for recovered secret image wrt original secret image

Figure 4.18.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.18 and Figure 4.18.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than

compared to higher ones. Table 4.18 shows the tabulation of rmse and psnr errors for different block sizes and images.

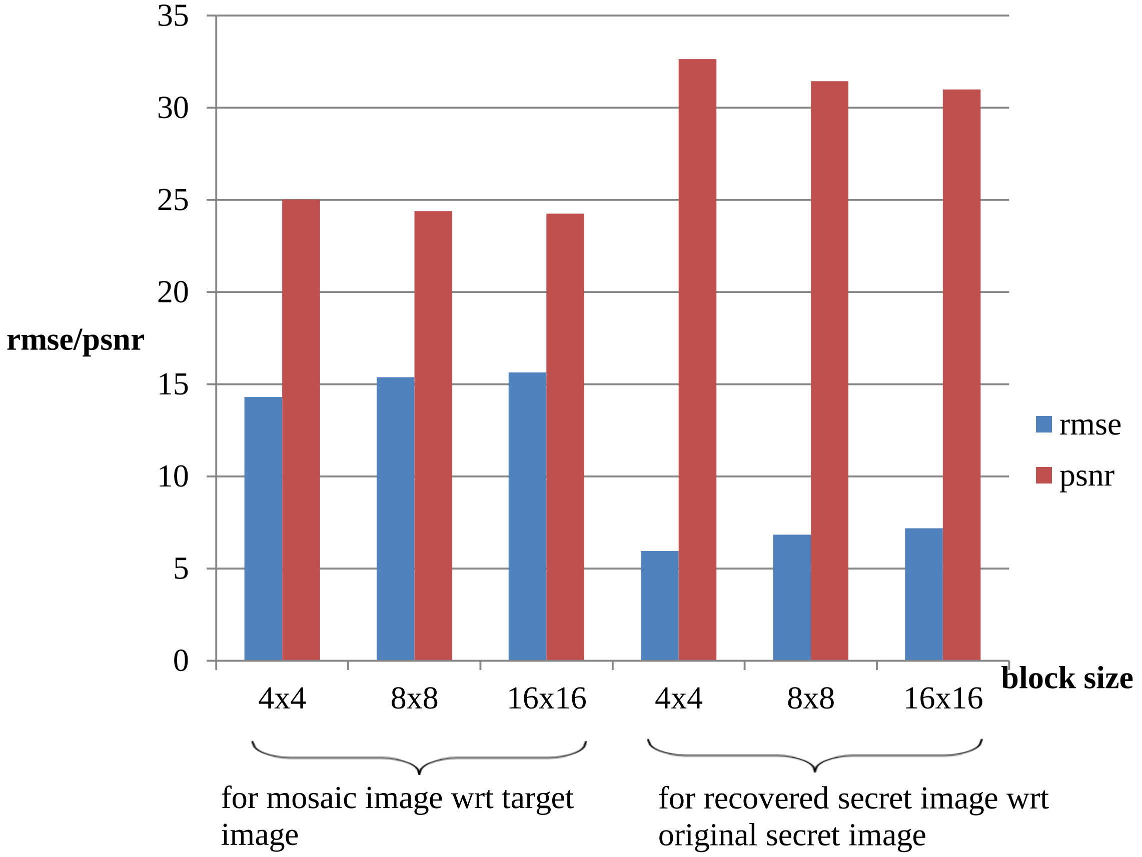
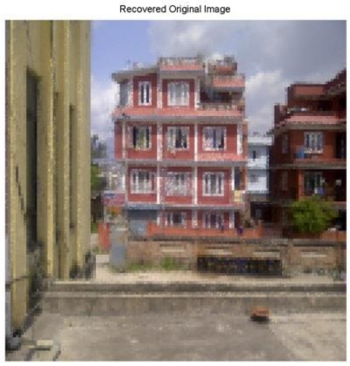


Figure 4.18.2: Plot of Table 4.18

Experiment no. 19:

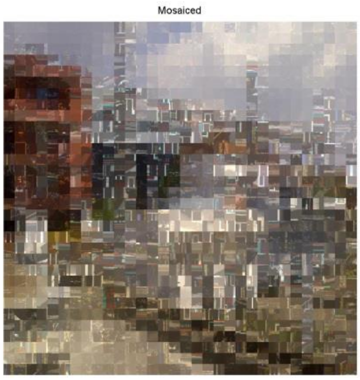
(a)

(b)



(c) (d)

(e) (f)



(g) (h)

Figure 4.19.1: (a)secret image (b)target image (c)mosaiced image for block size 4x4 (d)recovered secret image for block size 4x4 (e)mosaiced image for block size 8x8 (f)recovered secret image for block size 8x8 (g)mosaiced image for block size 16x16 (h)recovered secret image for block size 16x16 for Experiment no. 19

Table 4.19: Comparison of errors for images of Experiment no. 19

Block size	Error		Images
	rmse	psnr	
4x4	13.508455	25.518690	for mosaic image wrt target image
	5.904708	32.706835	for recovered secret image wrt original secret image
8x8	15.172831	24.509471	for mosaic image wrt target image
	7.102351	31.102761	for recovered secret image wrt original secret image
16x16	15.526713	24.309213	for mosaic image wrt target image
	7.946462	30.127328	for recovered secret image wrt original secret image

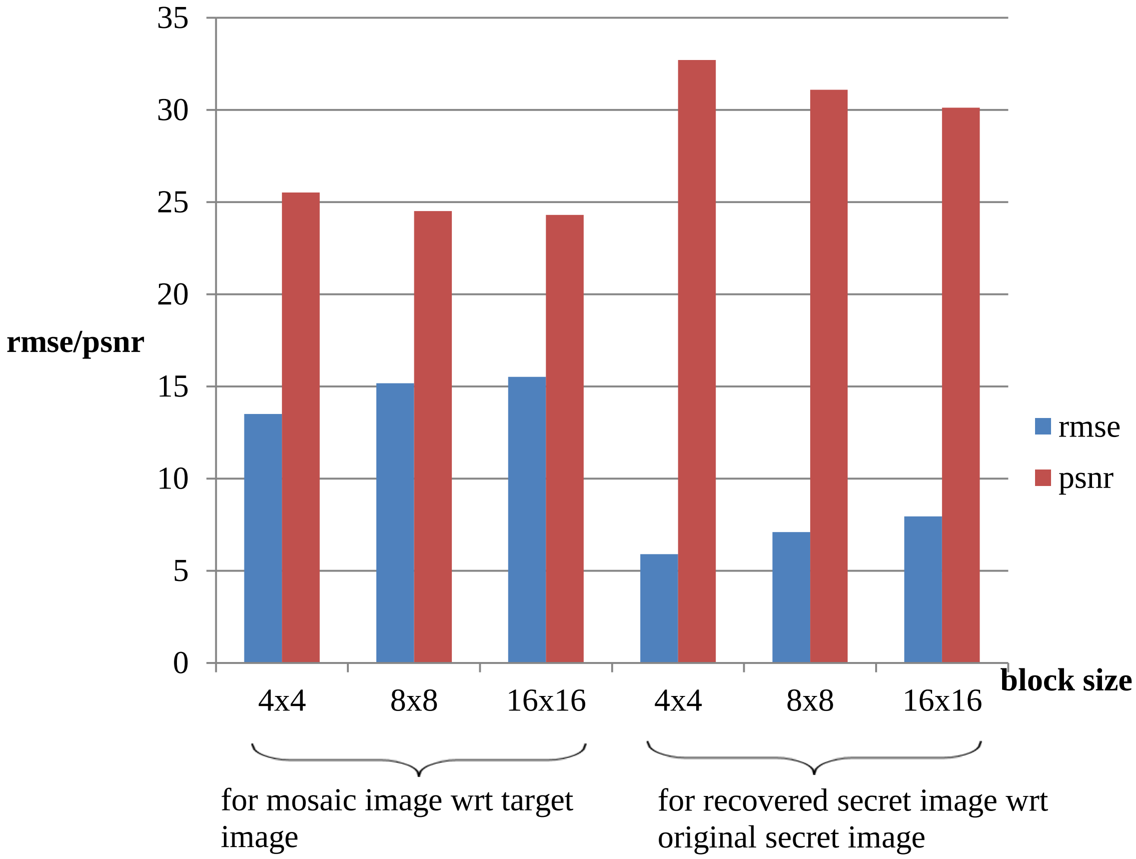


Figure 4.19.2: Plot of Table 4.19

Figure 4.19.1 shows the results obtained using secret image and target image for three block sizes. It shows that the mosaiced image obtained by combining secret image and target image is similar to that of the target image. As seen from the figure, also illustrated by Table 4.19 and Figure 4.19.2, the mosaiced images are more similar to the target images and recovered images to the secret images for lower block sizes than compared to higher ones. Table 4.19 shows the tabulation of rmse and psnr errors for different block sizes and images.

4.3 Discussion

This study is basically focused on examining the performance of two algorithms, namely secret-fragment-visible mosaic and cubism-like mosaic, for the purpose of secure transfer of images via network. As discovered from the experiments conducted, secret-fragment-visible mosaic algorithm has shown a better response when the primary concern is the secure transfer of images whereas cubism-like mosaic has shown smaller error values when the concern is primarily focused only to the accurate recovery of the images sent thereby, showing a trade-off between the two. But, the difference in error values between the two algorithms for accurate recovery is very less thereby leaving the choice of algorithm to the difference in error values for secure transfer, which is much lesser in case of secret-fragment-visible mosaic algorithm. For the purpose of examining the performance of these two algorithms, rmse and psnr values are calculated between the target image and the mosaiced image obtained by combining secret image and target image on the sender's side and between the secret image and the recovered secret image at the receiver's side.

A variety of images have been taken into consideration for conducting these experiments. Some images are directly taken from the reference papers making it easier for comparison of errors. Some standard test images have also been taken as secret images. Some are the real life images captured using normal cameras.

On comparison of results obtained from secret-fragment-visible mosaic and cubism-like mosaic, lower rmse and higher psnr of the mosaiced image with respect to the target image is obtained from secret-fragment-visible mosaic than cubism-like mosaic whereas lower rmse and higher psnr of the recovered secret image with respect to the original secret image is obtained from cubism-like mosaic than secret-fragment-visible mosaic. But, the difference in errors values between the two algorithms is very less in case of the recovered secret image with respect to the original secret image than that in case of the mosaiced image with respect to the target image thereby making secret-fragment-visible mosaic a better choice for steganography showing comparable errors for accurate recovery and much lesser errors for secure transfer of images.

Chapter 5

Conclusion and Recommendation

5. Conclusion and Recommendation

5.1 Conclusion

Mosaic image is created automatically by composing small fragments of a given image into target image, achieving an effect of embedding the given source image secretly in the resulting mosaic image. Steganography is the science of hiding secret messages into cover media so that no one can realize the existence of the secret data.

This study is meant for combining small tiles of secret image to form a target in the sense of mosaic and comparing the mosaics obtained using different techniques.

The experiments conducted conclude that the two algorithms have a trade-off for secure transfer of image or better recovery. For experiments without using secret-fragment-visible mosaic, there is a higher chance of secure transmission with lower rmse and higher psnr values for mosaiced images with reference to target images as compared to those using cubism-like images. Whereas in case of experiments using cubism-like image, there is a higher chance of better recovery of images with lower rmse and higher psnr values for recovered secret images with reference to original secret images as compared to those using secret-fragment-visible mosaic.

Since steganography requires more accurate recovery of the image being transferred with lesser chances of intrusion, secret-fragment-visible mosaic better serves for this purpose. The difference in errors values between the two algorithms is very less in case of the recovered secret image with respect to the original secret image than that in case of the mosaiced image with respect to the target image thereby making secret-fragment-visible mosaic a better choice for steganography showing comparable errors for accurate recovery and much lesser errors for secure transfer of images. A number of experiments have been explained above for the illustration. For better elaboration of the usability of secret-fragment-visible mosaic, some more experiments have been explained using different image block sizes and different test and real life images.

5.2 Limitation

i. **Image size:**
   The size of the target image and secret image needs to be same. If the sizes are different, the images need to be resized to make them equal-sized.
ii. **Image similarity:**
   The two images being combined need to be quite similar to each other. This makes the mosaiced image look more similar to the target image thereby making it useful for secured transfer.

5.3 Recommendation

In this study, the secret image and target image must be of same size and similar to each other. Here, the image similarity is observed manually and then the images are re-sized. Some algorithm can be initially applied which selects similar images of same size automatically from a given database. This would reduce the error as the computations would be more accurate than manual ones. Also, only two of the image mosaicing algorithms have been compared for steganography. This comparison can be further extended using other image mosaicing algorithms.

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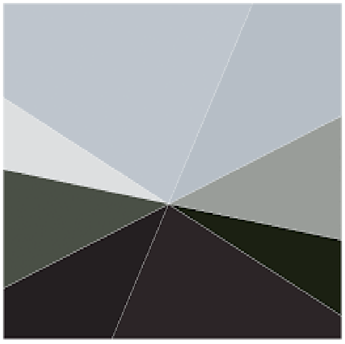
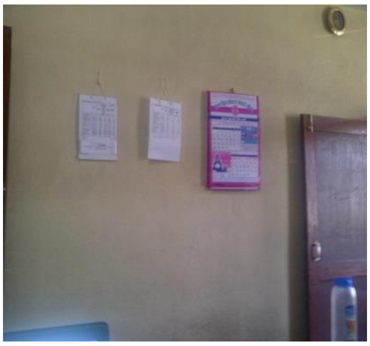
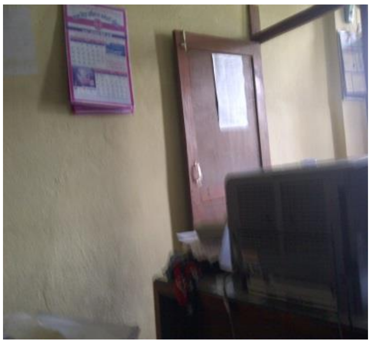
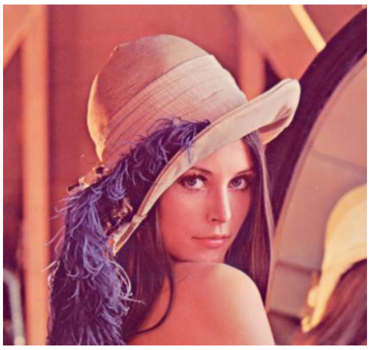
Appendix

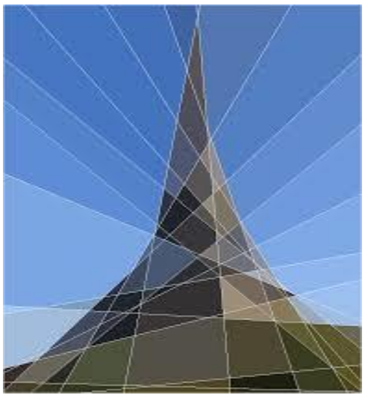
Collection of sample images:

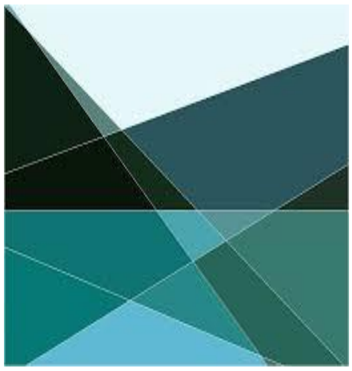


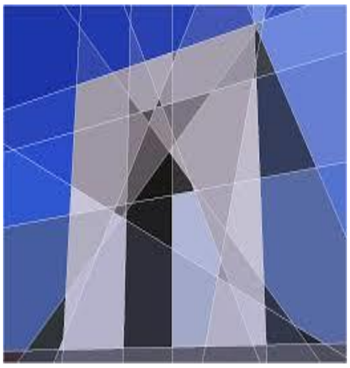













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