



Embedding Multiple Images in an Image Using Bit Plane Slicing

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Abstract --- In this paper, an image is sliced in their bit planes and up to seven different images in each step one by one are embedded in the actual image. The actual, stego and the extracted images are shown explicitly. The Mean Square Error (MSE) and Peak to Signal Noise Ratio (PSNR) indices have been determined in each case. Histograms for the computed values of MSE and PSNR indices are drawn.

Keywords--- Bit Planes, Stego image, MSE, PSNR.

I. Introduction

Steganography is the art of hiding information imperceptibly in a cover medium. The word *Steganography* is of Greek origin and means *covered* or *hidden writing*. The main aim in steganography is to hide the very existence of the message in the cover medium. Steganography and Cryptography are counter parts in digital security. The obvious advantage of steganography over cryptography is that messages do not attract attention to themselves, to messengers, or to recipients. During the last decade, an exponential growth in the use of multimedia data over the Internet is seen. These include Digital Images, Audio and Video files. This rise of digital content on the internet has further accelerated the research effort devoted to steganography. The various applications of steganography include secure military communications, multimedia watermarking and fingerprinting applications for authentication purposed to curb the problem of digital piracy. Although these are not perfect applications of steganography, many steganographic algorithms can be employed for these purposes as well.

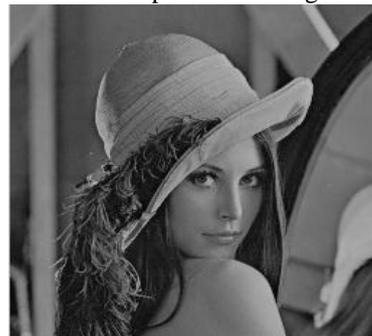
The grayscale images, also called intensity images, contain numbered values at these points, called pixels, between 0 for black and 255 for white, which can be represented as 8-bit binary strings ($2^8 = 256$). The numbers between 0 and 255 represent gradient gray values between black and white. Messages are hidden in the least significant bits of the 8-bit binary strings; hence the abbreviated name for this method is *LSB steganography*. Each character in a message has a binary representation under the ASCII (American Standard Code for Information Interchange) code, which assigns characters with integer values between 0 and 255. This system represents a way to express all necessary single character letters, digits, punctuations, symbols, etc. for general communication purposes. Grayscale images can be transformed into a sequence of binary images by breaking them up into their bit-planes. If we consider the grey value of each pixel of an 8-bit image as an 8-bit binary word, then the 0th bit plane consists of the last bit of each grey value. Since this bit has the least effect in terms of the magnitude of the value, it is called the least significant bit, and the plane consisting of those bits the least significant bit plane. Similarly the 7th bit plane consists of the first bit in each value. This bit has the greatest effect in terms of the magnitude of the value, so it is called the most significant bit, and the plane consisting of those bits the most significant bit plane.

II. Hiding a larger 512x512 image in a 256x256 image

Here, we hide a larger image *lena.tif* (512 x 512) image into a smaller cover image *cameraman.tif* (256 x 256). It is obvious that the bit planes 8, 7, 6, 5 contain vital information and bit planes 4, 3, 2, 1 contain very less information about the digital image. The bit planes 8, 7, 6, 5 of *lena.tif* are extracted and embedded into the bit planes 4, 3, 2, 1 of the digital image of *cameraman.tif*. The observations are presented in figure 1.



a



b

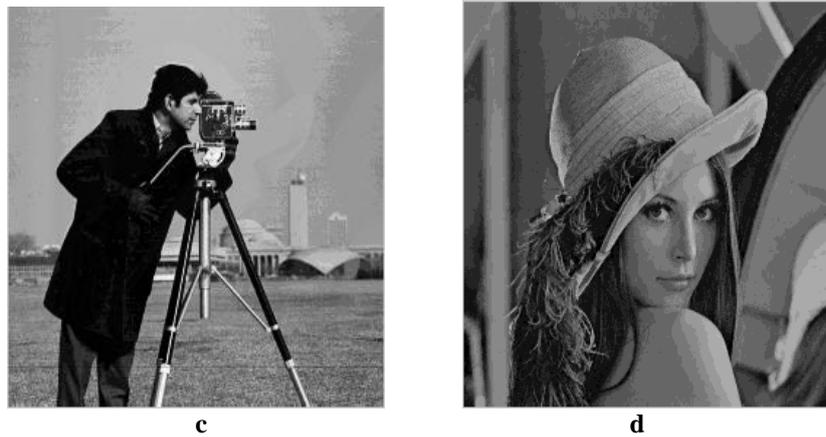


Fig 1. a. Original image cameraman.tif (256x256) b. Image to be hidden lena.tif (512x512) scaled to 1/2 c. Stego image and d. Extracted image

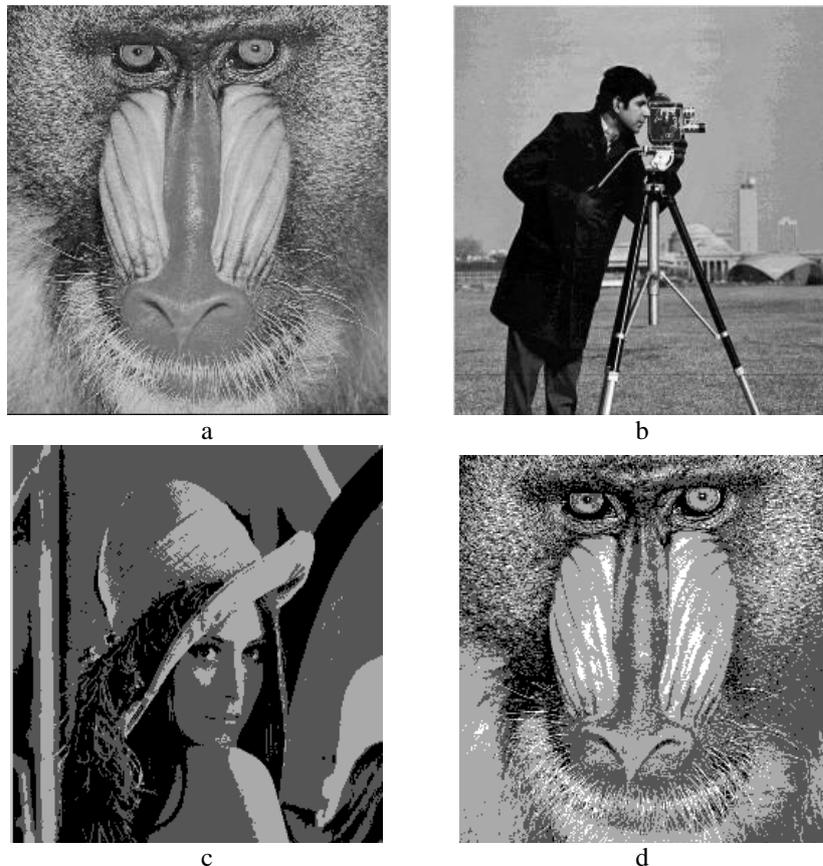


Fig 2. a. Image 2 to be hidden mandrill.tif (512x512) scaled to 1/2 b. Stego image (after embedding image 1 and image 2) c. Extracted image 1 (lena.tif) d. Extracted image 2 (mandrill.tif)

III. Hiding two larger 512x512 images in a 256x256 image

Here we take two 512x512 images lena.tif and mandrill.tif and hide it in cameraman.tif. We extract bit planes 8, 7 of lena.tif and hide in bit planes 1,2 of cameraman.tif and extract bit planes 8, 7 of mandrill.tif and hide in bit planes of 3, 4 in cameraman.tif. The actual, stego and extracted images are given in figure 2.

IV. Hiding three images in a 256x256 image

Here we take three images lena.tif, mandrill.tif and board.tif and hide these three images in cameraman.tif. We extract bit planes 8, 7 of lena.tif and hide in bit planes 1, 2 of cameraman.tif and extract bit planes 8, 7 of mandrill.tif and hide in bit planes of 3, 4 in cameraman.tif and extract bits 8, 7 of board.tif and hide in bits 5, 6 of cameraman.tif. The actual, stego and extracted images are given in figure 3.

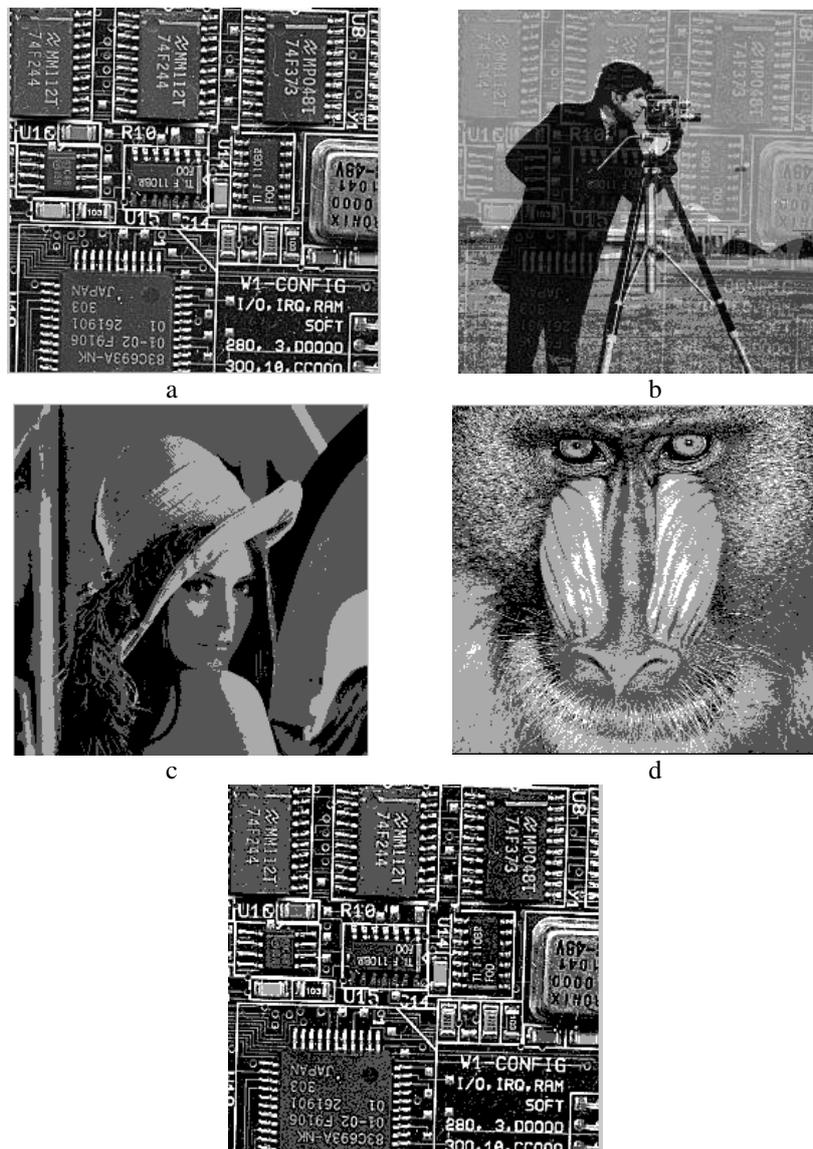


Fig 3. a. Image 3 to be hidden board.tif (256x256) b. Stego image (after embedding image1,image2 and image3) c. Extracted image1(lena.tif) d. Extracted image2(mandrill.tif) e. Extracted image 3(board.tif)

V. Hiding Four images in a 256x256 image:

Here we take four images lena.tif, mandrill.tif, board.tif and moon.tif and hide these four images in cameraman.tif. We extract bit planes 8 of lena.tif and hide in bit plane 1 of cameraman.tif, extract bit planes 8 of mandrill.tif and hide in bit plane of 2 of cameraman.tif and extract bit planes 8 of board.tif and hide in bit plane 3 of cameraman.tif, extract bit plane 8, 7 of moon.tif and hide in bit planes 4 and 5 of cameraman.tif. The actual, stego and extracted images are given in figure 4.



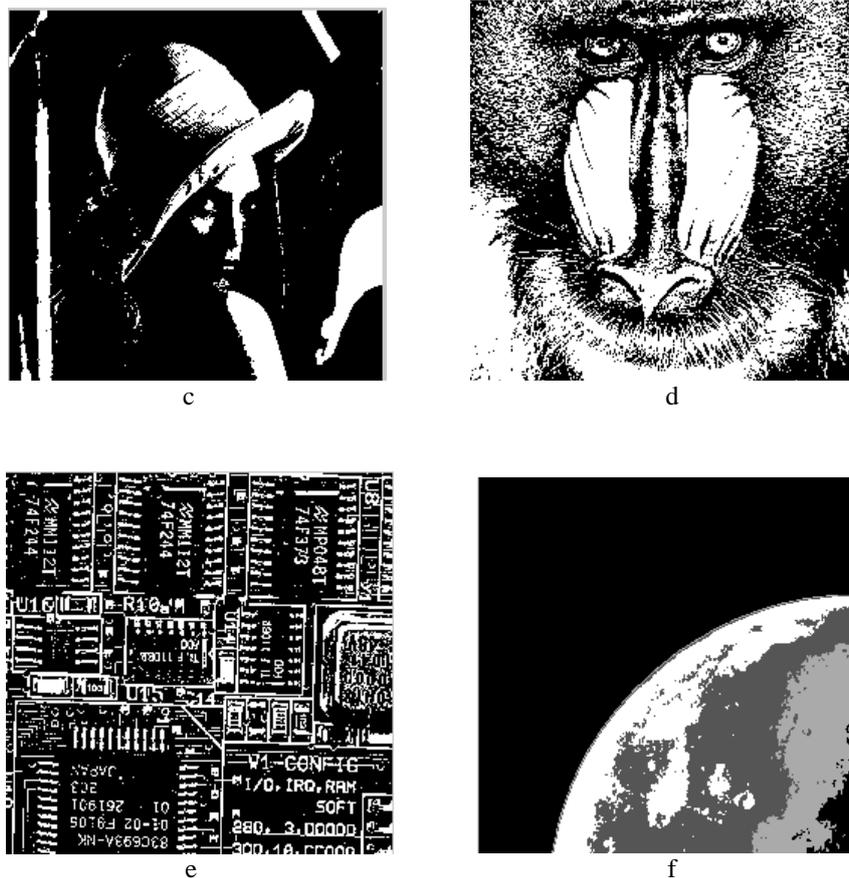


Fig 4. a. Image 4 to be hidden moon.tif (256x256) b. Stego image (after embedding image1,image2, image3 and image4) c. Extracted image 1 (lena.tif) d. Extracted image2 (mandrill.tif) e. Extracted image 3 (board.tif) f. Extracted image 4 (moon.tif)

VI. Hiding Five images in a 256x256 image

Here we take five images lena.tif, mandrill.tif, board.tif, moon.tif and trees.tif and hide these five images in cameraman.tif. We extract bit planes 8 of lena.tif and hide in bit plane 1 of cameraman.tif, extract bit planes 8 of mandrill.tif and hide in bit plane of 2 in cameraman.tif and extract bits 8 of board.tif and hide in bit plane 3 of cameraman.tif, extract bit plane 8 of moon.tif and hide in bit planes 4, extract bit plane 8, 7 of trees.tif and hide in bit planes 6 and 5 of cameraman.tif. The actual, stego and extracted images are given in figure 5.



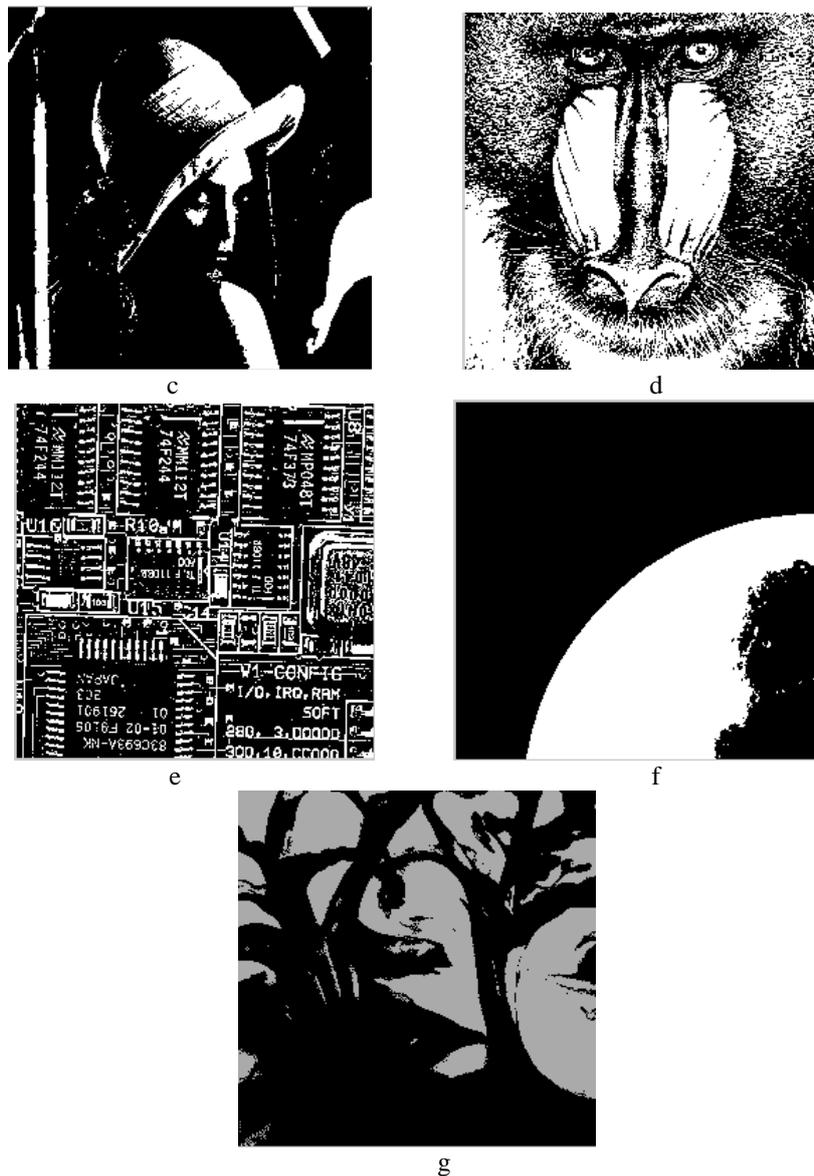


Figure 5: a. Image5 to be hidden trees.tif (256x256) b. Stego image (after embedding mage1, image2, image3, image 4 and image 5) c. Extracted image 1 (lena.tif) d. Extracted image 2 (mandrill.tif) e. Extracted image 3 (board.tif) f. Extracted image 4 (moon.tif) g. Extracted image 5 (trees.tif)

VII. Hiding Six images in a 256x256 image

Here we take six images lena.tif, mandrill.tif, board.tif, moon.tif, earth.tif and drill.tif and hide these six images in cameraman.tif. We extract bit planes 8 of lena.tif and hide in bit planes 1 of cameraman.tif, extract bit planes 8 of mandrill.tif and hide in bit planes of 2 in cameraman.tif, extract bit planes 8 of board.tif and hide in bit planes 3 of cameraman.tif, extract bit plane 8 of moon.tif and hide in bit planes 4, extract bits 8 of earth.tif and hide in bit planes 5, extract bits 8,7 of drill.tif and hide in bit planes 7, 6. The actual, stego and extracted images are given in figure 6.

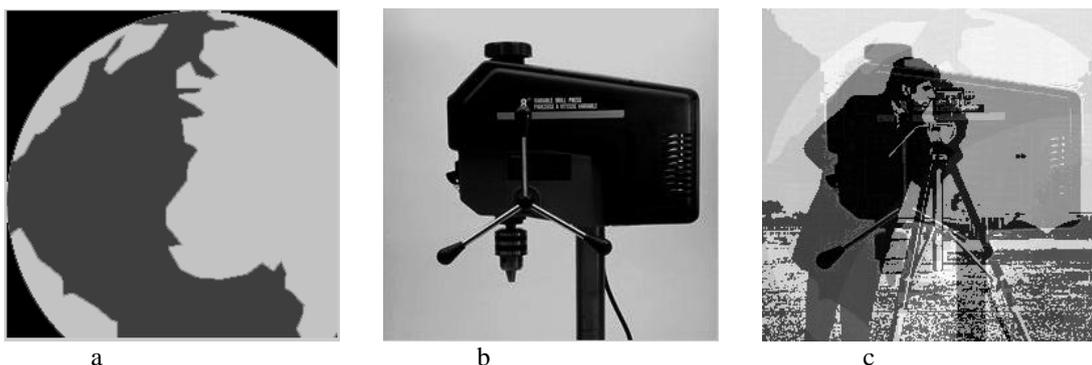
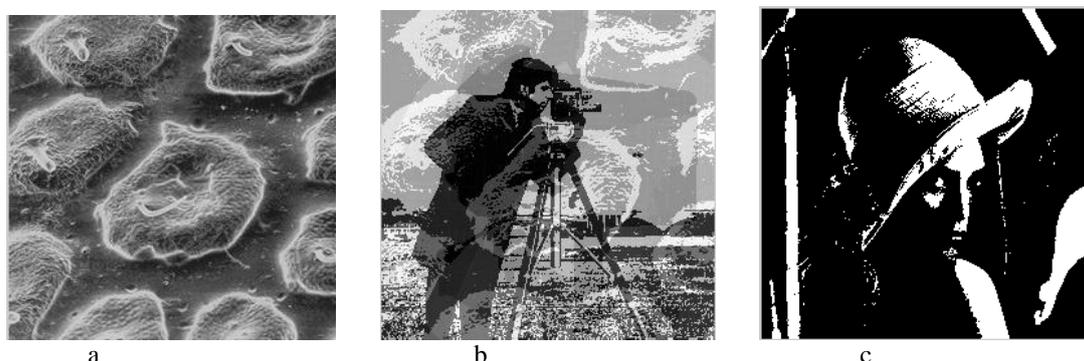




Figure 6: a. Image 5 to be hidden earth.tif (256x256) b. Image 6 to be hidden drill.tif (256x256) c. Stego image (after embedding image1, image2, image3, image4, image 5 and image 6) d. Extracted image1 (lena.tif) e. Extracted image 2 (mandrill.tif) f. Extracted image 3 (board.tif) g. Extracted image 4 (moon.tif) h. Extracted image 5 (earth.tif) i. Extracted image 5 (drill.tif)

VIII. Hiding Seven images in a 256x256 image

Here we take seven images lena.tif, mandrill.tif, board.tif, moon.tif, earth.tif, drill.tif and micro.tif and hide these seven images in cameraman.tif. We extract bit planes 8 of lena.tif and hide in bit plane 1 of cameraman.tif, extract bit planes 8 of mandrill.tif and hide in bit plane 2 of cameraman.tif, extract bit planes 8 of board.tif and hide in bit plane 3 of cameraman.tif, extract bit plane 8 of moon.tif and hide in bit plane 4 of cameraman.tif, extract bit planes 8 of earth.tif and hide in bit plane 5 of cameraman.tif, extract bit planes 8 of drill.tif and hide in bit planes 6 of cameraman.tif, extract bit planes 8 of micro.tif and hide in bit planes 7 of cameraman.tif. The actual, stego and extracted images are given in Figure 7.



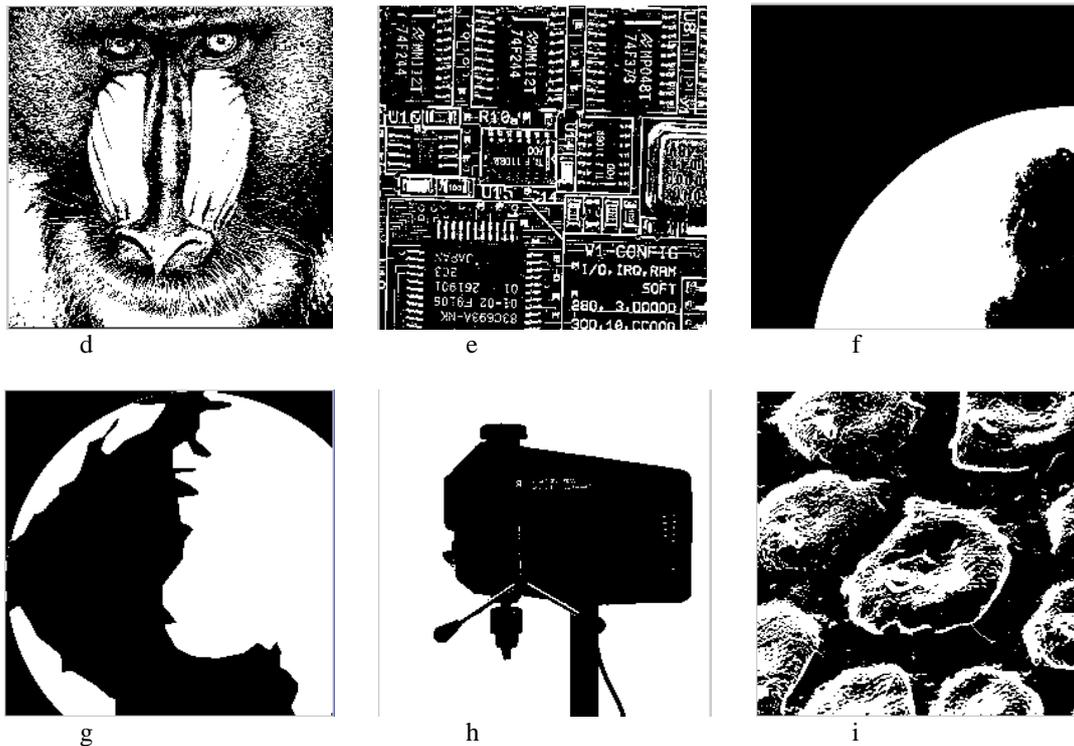


Fig 7 a. Image 7 to be hidden `micro.tif` (256x256) b.Stego image (after embedding image 1, image 2, image 3, image 4, image 5 , image 6 and image 7) c. Extracted image 1 (`lena.tif`) d. Extracted image 2 (`mandrill.tif`) e. Extracted image 3 (`board.tif`) f. Extracted image 4 (`moon.tif`) g. Extracted image 5 (`earth.tif`) h. Extracted image 6 (`drill.tif`), i. Extracted image 7 (`micro.tif`)

The Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) are performance parameters to measure the quality of image.

- ❖ MSE: It is defined as square of error between cover stego-image. The error indicates the distortion in an image.MSE can be calculated by using two dimensional mathematical equation described as follows:

$$MSE = \left(\frac{1}{N}\right)^2 \sum_{i=1}^M \sum_{j=1}^N (X_{ij} - \bar{X}_{ij})^2$$

where X_{ij} = the value of pixel in cover image and \bar{X}_{ij} =the value of pixel in stego-image and N is the size of image.

- ❖ PSNR: It is a measure of quality of image. PSNR can be calculated by using the mathematical formula given below:

$$PSNR = 10 \times \log \frac{255^2}{MSE} \text{ db}$$

Table 1. The computed values of PSNR and MSE

S.No.	Number of Images Hidden	PSNR	MSE
1.	One image	40.50749	5.78537
2.	Two images	37.42493	11.76488
3.	Three images	30.99868	51.66692
4.	Four images	33.73477	27.51714
5.	Five images	33.44778	29.39694
6.	Six images	26.87397	133.56215
7.	Seven images	27.48554	116.01839

The histograms of the computed values of PSNR and MSE indices for each of the number of images embedded are presented in figures 8 and 9.

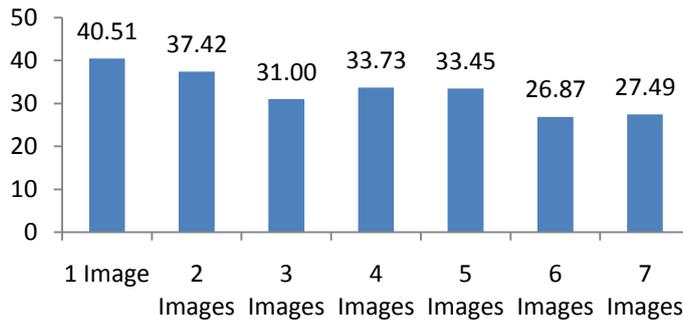


Figure 8: Histogram of PSNR Values

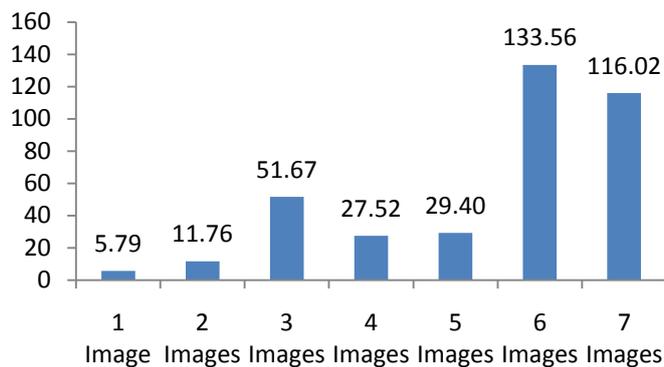


Figure 9: Histogram of MSE Values

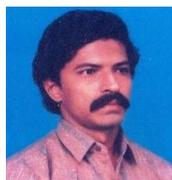
IX. Conclusion

This paper has given a brief outline how images can also be embedded as text steganography. Adding one image in each bit plane up to seven images have been dealt with actual example. We notice that embedding more than one image in an image, loses its resolution. However where image quality is not needed and number of images are of more important, than we can go for this proposed techniques.

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Author Biography



H. Faheem Ahmed earned his M.Tech. degree in Information Technology from Punjabi University and M.Phil. degree in Computer Science from Manonmaniam Sundaranar University. He is pursuing Ph.D. in Computer Science. He has guided 50 M.Phil. research scholars in Computer Science. He is currently the Head of the Department of Computer Science and Applications, Islamiah College, Vaniyambadi and is serving the institution for the past 28 years. His research interest includes Steganography and Image processing. He has published 8 research articles and authored one book.



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