Image Steganography by Variable Embedding and Multiple Edge Detection using Canny Operator

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ABSTRACT
This paper proposes a method for image steganography. According to Human Visual System, any variation in the edges shown in the images has a low probability of being perceived by the human eyes, thus data can be hidden in the pixel of the cover image. These edges can be detected by using sophisticated operators like Canny edge detection operator. The gradient of the pixel of the image is determined and the image edges are detected by taking a threshold value of the gradient image. Here we go for multiple edge detection so that more number of pixels around the edge area is detected using the above method. Thus resulting in embedding of more information bits in the LSB of the image pixels further again we go for variable embedding so the combination of multiple edge detection and variable embedding improves the data hiding capacity. The multiple edge detection is limited to three times so as to reduce the distortions. To further increase the data hiding capacity and at the same time maintain a respectable PSNR variable embedding method is employed. For extraction of data the stego image is compared with the cover image, and the variation in the pixel values are detected, thus the embedded data is efficiently extracted.

General Terms
Security.

Keywords
Steganography, Multiple Edge Detection, Variable Embedding, Canny Operator.

1. INTRODUCTION
Due to the enormous growth in the field of communication, the security of information is a must need. Many techniques like Cryptography have evolved. Different methods to encrypt and decrypt data in ordered to keep the information secrete are developed over the year. Unfortunately it is sometimes not enough to keep the contents of a message secrete, it may also be necessary to keep the existence of the message secrete. The method hence developed is 'Steganography'.

Steganography is the technique used to hide the information in some other information so that the existence of the secrete message cannot be detected easily. In Image steganography image is used as the cover information. The Cover image is the one in which the secrete data is embedded. The image thus obtained by embedding secrete data into the cover image is called Stego-image.

All digital images are made up of pixels. Each pixel is represented by a value that corresponds to the color level of that pixel. In Gray-scale images each pixel is represented by 8-bits, hence there are 256 distinct levels of shades. Hence all pixels are represented with a value corresponding to their color level. For the image of size 512×512 pixels will have approximately 2.09715×10^6 bits and if we hide the information in LSB of each pixel we can hide about 262.144×10^3 bits of data in an image. This makes steganography to hide large data in the images. And this method of hiding data in LSB of the each pixel is proposed by Marghny Mohamed, Fadwa Al-Afari, and Mohammed Bamatraf [1]. But the extraction of the data was easy as extracting every LSB gives the message and the security was less. Moazzam Hossain, Sadia Al Haque, Farhana Sharmin [2] proposed steganography method using neighborhood pixel information. But the PSNR is obtained was about 43.144dB and the visual quality was poor. Subsequently Chen [3] [4] proposed a method using DWT and DFT to get phase of image and achieve hiding a secrete image into a cover image. The algorithm has advantage in capacity, but vision effect is unsatisfactory.PSNR was less than 40dB. LiLi, Bin Luo, Qiang Xiaojun Fang [5] proposed a method using edge detection using sobel operator. The sobel operator is not enough accurate in finding the edges of image .the capacity for gray scale image is 2 bits per pixel, hence the capacity is less.

To overcome these disadvantages multiple edge detection and variable embedding methods are proposed in this paper. Multiple edge detection is the method in which the edge of the image is detected multiple times. Further instead of sobel operator 'canny operator' is used which has a more efficient algorithm in finding the edge of the image. This increases the data hiding capacity in the image. But if we only focus on increasing the data hiding capacity the PSNR decreases and the image appears distorted which hampers the main aim of image steganography i.e. stealth hiding. Hence, we propose a method called variable embedding. In variable embedding method the number of data bits hidden in each pixel is varied according to the pixel's gradient value (i.e. whether it is an edge or not). So using the method in this paper we can hide more data with a good visual clarity and PSNR.

2. METHODS USED IN THIS PAPER

2.1 Multiple Edge Detection
Edge detection is the technique in which firstly, the gradient of the image is determined using some operators like Sobel operator or Canny operator. The disadvantage of Sobel operator is that the gradient value calculated in this method is raw and the detection of image edges are not so accurate. This is mainly because of presence of noise in the image. Hence this paper proposes canny operator, this operator is nothing but a filter. 2-dimensional convolution of this filter with the smoothened image gives the gradient image. A Gaussian filter is used to smoothen the image. This reduces the noise margins in the image and accurate gradient value can be obtained.Gradint calculation is done horizontally and vertically. The vector resultant of these two components yields the gradient image.

Gaussian filter,

$$A = 1/159 \begin{pmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{pmatrix} * \text{Image}$$

$$G_x = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} * A \qquad \ldots (1)$$

$$G_y = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix} * A \qquad \ldots (2)$$

$$G = G_x + G_y \qquad \ldots (3)$$

'A' is the smoothened image.

'*' is 2-dimensional convolution.

This creates a gradient image. Then a threshold value is taken as the reference and gradient of image pixels are compared with this threshold value. Only those pixels in which the gradient value is more than threshold are considered as edge pixels. Thus the image obtained is edge detected image. If this method is repeated for multiple times, then the number of pixels that are in the vicinity of the edge of the image also increases. It can be seen that the number of pixels nearly doubled using multiple edge detection and hence the data hiding capacity is increased largely.

2.2 Variable Embedding

Variable embedding is the method in which the message to be hidden is converted into bit streams and it is embedded to the image. Optimal number of bits that can be hidden in each pixel is determined and the message is broken accordingly this is known as Variable Embedding Ratio [VER].We know that as per human visual system variation in edge pixel is less detected by human eyes so using this phenomenon we can embed more data bits in edge pixels and less in other pixels. This paper uses 4:2 variable embedding that is 4 bits are embedded in edge detected pixels and 2 bits in other pixels. Thus the visual quality of the stego image is not compromised and more number of data bits can be hided with an allowable PSNR. The variable embedding ratio can be suitably choosed by the user depending on the number of data bits that are to be hidden and quality of stego image that can be allowed.

The VER forms a secret key without which extraction is not possible. This serves the purpose of hiding data into the image in such a way that only an authorized user can retrieve the data that are hidden.

3. EMBEDDING ALGORITHM

3.1 Embedding Of Secret Data

The algorithm to embed secret data into the cover image as proposed by this paper using the above methods is as follows,

1. The cover image is taken and the areas of the image containing the edges are identified by determining the gradient of the image using canny operator as per (1), (2) and (3).

2. The edge detected image is again subjected to step 1 to further determine extra number of edges and it's done till the requirement is met (optimal to use 2 – 3 times for a 512 * 512 gray scale image) so that quality of the stego image formed after embedding is not compromised.

3. Now the pixel containing the edge detected areas of the image, variation of which is insensitive to human vision is identified. These are the selected pixels to hide the secret data. Let the number of edge detected pixels after multiple times edge detection be x.

4. The secret data or the message which has to be embedded into the image is converted into a stream of bits. Let the number of bits in the streams be y.

5. The chosen Variable Embedding Ratio [VER] is 4:2 that is 4 bits are embedded in edge pixels and 2 bits in other pixels. The VER so chosen is a compromise between the visual quality and embedding capacity required. If a higher VER is chosen then the number of bits that can be embedded increases but the visual quality and PSNR decreases.

6. The maximum number of bits that can be embedded for the given Variable Embedding Ratio [VER] is limited to z = 4*x +2*(512*512 – x), as 512*512 gives the total number of pixels for cover image taken. So the total bits to be embedded(y) should be less than or equal to z otherwise the extra number of data bits are lost.
   That is, y <= z.

7. Once the edge pixel is detected 4 bits from the y bits are embedded into the image pixel by LSB substitution process in all other pixels only 2 bits are embedded using LSB substitution process.

8. This process is carried on till all the y bits are embedded.

3.2 Extraction of Data bits

For extracting data, in our proposed paper, the cover image is correlated with the stego image, for the extraction process the user should know the VER ratio which is used in embedding procedure.

On knowing the VER ratio the inverse process of that done in the embedding procedure is carried on by correlating the cover image with the stego image.

Using this procedure all the y bits that are embedded are retrieved successfully.

4. EXPERIMENTAL ANALYSIS

A gray scale image of size 512*512, Lena, is used as a test image. As per the paper the edge of the figure is determined using both Sobel and Canny operator using Matlab7.12 tool and it is found that the number of pixel determined by sobel operator is much less than the Canny, and there is also some discontinuity on the image formed by the sobel operator. Thus more number of pixels at the edges is identified by Canny operator which is omitted by sobel operator. Hence more number of bits can be embedded keeping the visual quality high. This forms the main reason for proposing canny operator instead of sobel operator.

Figure 4 shows Lena image after subjecting to multiple edge detection up to 3 times as proposed by the paper, here we can see that the number of pixels identified is more thus data embedding is also more.

Table 1.comparision between different VER

VER	Maximum bits that can be hidden	PSNR in db
4:0	126616	38.21
4:1	525612	37.11
4:2	600256	36.47

The Table1 shows that the number of bits that can be embedded is increased at the cost of visual quality and PSNR, of the stego image thus formed.

It can be seen from Table 1 that as VER increases the data hiding capacity also increases at the cost of PSNR which reduces and the maximum hiding capacity is also the function of VER.

There is a sudden increase in the data hiding capacity for 4:1 compared to 4:0 this is because in the later case only the edge detected pixel is considered for embedding not the other pixels compared to the former where data is embedded in all pixels variably. But the visual quality obtained in case of 4:0 is much greater than that obtained in other considered VER.

Table 2. PSNR at different loads for VER of 4:2

VER	Bits hidden	PSNR in db
4:2	524288	37.66
	262144	40.48
	131072	44.95

The table2 gives the experimental results using VER of 4:2 as the number of bits that are hidden increases and the PSNR reduces.
For a VER of 4:0 the data bits are embedded only in the edge pixels but not in other pixels. Here data embedding is a measure of only the edge pixels detected. Hence for this VER the visual quality of the obtained image is very good but it is at the cost of poor embedding capacity of only 126616 bits which is just slightly more than 0.5bpp, whereas for higher VER the embedding capacity is more than 2bpp(bits per pixel).
The maximum hiding capacity acquired in the Four Neighbor and Diagonal Neighbor Method is 392208 bits and 395680 bits respectively. In our method we acquired a maximum hiding capacity of 600256, hence in our method the hiding capacity has increased greatly with only a little compromise in the

PSNR.

Table 3 Methods proposed by Moazzom Hosain, Sadia Al Haque and Farhana Sharmin

Method	Maximum Hiding Capacity(In Bits)	PSNR(In dB)
Four Neighbors	392208	41.1468
Diagonal Neighbors	395680	40.6505

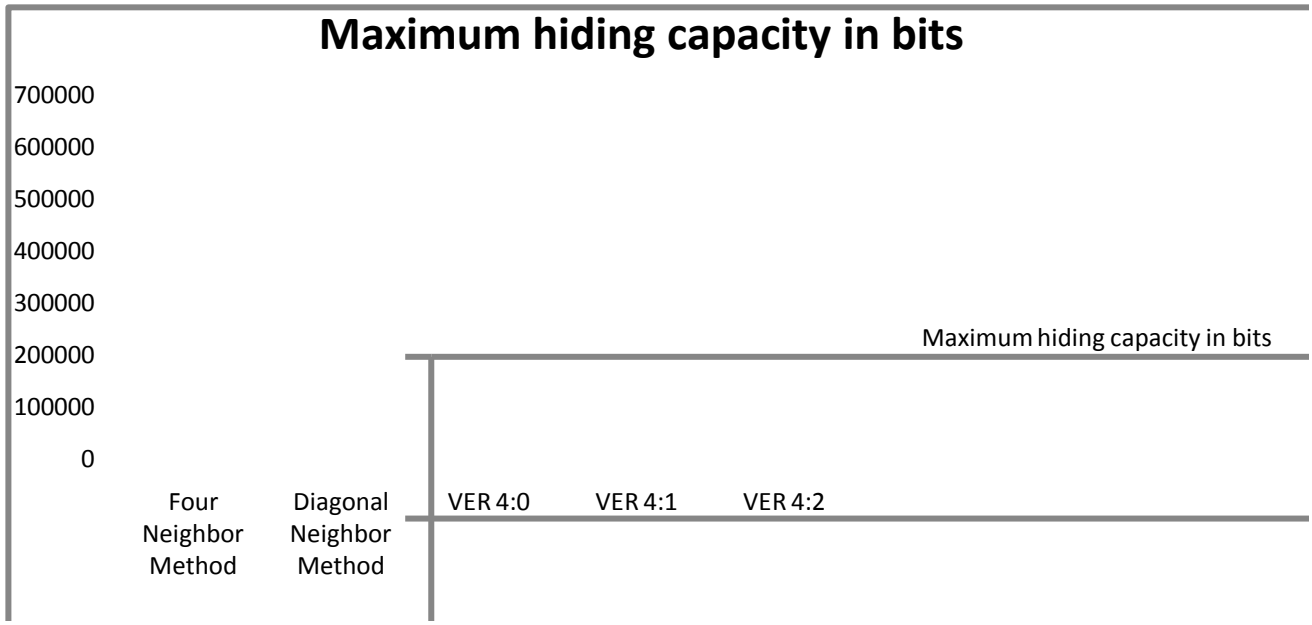

Figure 1.Cover Image

Figure 2. Edge detected image using canny operator

Figure 3.Edge detected image using sobel operator

Figure 4.Multiple edge detected image Using canny operator

Figure 5. Stego image formed formed for 600256 bits hiding with VER of 4:2

Figure 6. Stego image for 525612 bits hiding with VER of 4:1

Figures 5 and 6 are the images formed by hiding data of variable loads at different VER.

Figures 7 and 8 are the enlarged versions of the stego and cover images which show the variation in pixel values of the stego image formed due to embedding of message bits into the cover image. It is by this comparison the original data bits is retrieved from the stego image provided the user knows the VER used in embedding process.

5. CONCLUSIONS

In this paper an image steganographic method by multiple edges detection using Canny operator and Variable Embedding method is proposed. By using this method the data hiding capacity is improved and secrecy of the embedded data bits can be provided. It is also seen that the stego image formed is of good quality. Further work is to enhance the visual quality of the stego image by further improving the PSNR value.

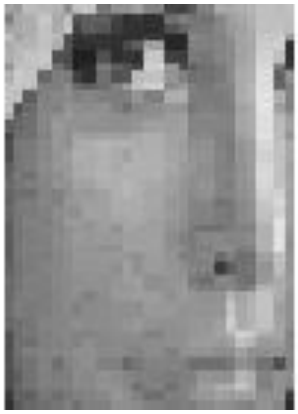

Figure7. Enlarged portion Figure 8. Enlarged portion of Stego image of Cover image

6. REFERENCES

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