Steganography Technique for Embedding Secure Data into the Image Regions with Abrupt Changes

Osama Hosam[1, 2], Zohair Malki[1]

[1.] Computer Science Department, Computer Science and Engineering College in Yanbu, Taibah University, Yanbu, Saudi Arabia.
[2.] Computer Graphics Dept. IRI, The City for Scientific Research, Alexandria, Egypt
mohandesosama@yahoo.com, zmalki22@gmail.com

Abstract: In digital communications, Steganography is defined as the science of embedding secure data into digital media when transferring the digital media through insecure channel. Human Visual System (HVS) and statistical methods must not be able to detect the embedded data. We have developed new technique based on feature extraction. A Gaussian pyramid is created with multi-resolution images, for each image the features are extracted and then the multi-resolution images are combined to create a complexity measure for each feature. We have selected the region with the highest complexity to embed the secure data. Results show high quality of the stego-images when compared with the similar methods.
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1. Introduction

With the increase of the computer processing power, internet and the increasing need of data communication, steganography is needed to make secure communication. Steganography is the art of hiding secret data in digital media and creating secret channel for communication between a sender and receiver. Embedding and extraction are the main methods needed in steganography procedures. Embedding is done on the sender side and extraction is done on the receiver side. The first approach to digital steganography was discussed in [1]. The authors proposed a method known as LSB or Least Significant Bit. They embedded secret message in the 4 LSB of each pixel in the image. The authors in [2] evaluated the distortion of LSB embedding for all bits of image pixel. The LSB embedding for the first bit was evaluated achieving high imperceptibility and less noise. The more bits are used for LSB embedding, the more noise appears in the image. When LSB embedding is done for the whole pixel bits, the resulting image is completely distorted. Other approaches to steganography can be found in [3, 4]. In this paper, an adaptive LSB approach is proposed. Instead of directly embed bits in LSB, image features with high intensity variations are selected for embedding. The technique extracts the features of the image as region segments. Region segments are the areas which has comparatively similar pixel intensity. These region segments are assigned a complexity 0 or CPX0. A multi-resolution analysis is used to extract the regions with abrupt change in color intensity. The multi-resolution analysis will result in three levels of region segments. Each level is assigned different complexity measure, namely CPX1 and CPX2. LSB embedding algorithm is used to embed secret data into the CPX2 regions. The noisy blocks in the image are used to carry the secret data. Results shows increased imperceptibility compared to previous methods. In section 2 we will introduce the proposed technique. In section 3 some experiments will be done, and discussion about the experiments and their results will be introduced.

2. The Proposed Algorithm

The technique extracts the features of the image as region segments. Region segments are the areas which has comparatively similar pixel intensity. These region segments are assigned a complexity 0 or CPX0. A multi-resolution analysis is used to extract the regions with abrupt change in color intensity. The multi-resolution analysis will result in three levels of region segments. Each level is assigned different complexity measure, namely CPX1 and CPX2. LSB embedding algorithm is used to embed secret data into the CPX2 regions. The noisy blocks in the image are used to carry the secret data. We will introduce the embedding algorithm then the extracting algorithm.

2.1 Message embedding

The features of the image will be extracted. Then a multi-resolution analysis is applied to the image to create different levels of complexity. Finally LSB embedding is used to embed the secret data.

1. Extracting image features: The features are extracted using the Histogram segmentation. The features extracted from the image are region segments; it will be extracted as follow:

- Histogram segmentation [5] can be viewed as an operation that involves tests against a function *T* of the form

$$T = T[x, y, p(x, y), f(x, y)] \quad (1)$$

where f(x,y) is the gray level of the point (x,y) and p(x,y) denotes some local property of this point, The Histogram of the image is obtained then two threshold values are selected in the Histogram that will divide the image into three groups g1,g2, and g3 each group contains different gray level region segments [6]. The proposed histogram segmentation can be defined as,

$$Pixl(x, y) \in \begin{cases} g1 & if\ 0 < f(x, y) \le T1 \\ g2 & if\ T1 < f(x, y) \le T2 \\ g3 & if\ T2 < f(x, y) \le 255 \end{cases} \quad (2)$$

- For each group a series of (low, medium and high) resolution images are created, which is the multi-resolution images for each group. It is created by reduction in size by a factor of two using Gaussian convolution filter *h(x)* ,

$$h(x) = \sqrt{2\pi}\sigma A e^{-2\pi^2\sigma^2 x^2} \quad (3)$$

where σ is the standard deviation of the Gaussian curve.

- A binary map for each of multi-resolution images will indicate, for each pixel, whether it belongs to the group or not, as shown by equation (4).

$$g(x, y) = \begin{cases} 1 & if\ f(x, y) > T \\ 0 & if\ f(x, y) \le T. \end{cases} \quad (4)$$

Thus the pixels labeled 1 correspond to the region segment, whereas pixels labeled 0 correspond to the background.

- Finally the open operator of the morphology filter is applied on the low resolution images for each group to remove the small region segments which is not considered as a background features.

2. Creating the levels of complexity for the image regions: For each group, three resolution images have been created. Now, we have a collection of 9 images, 3 for each group. The levels of complexity for each region can by creating by using the following procedure

- The multi-resolution images are resized to the original image size.
- For each group, the corresponding multi-resolution images are combined together to get 4 levels of complexity. As shown in Figure. 1, the low resolution images contain the regions with smooth areas. The small regions will be removed from the image since it reflects abrupt change in the intensity of the region. The region must be big enough to be considered as smooth areas. When combining the three resolution images, the internal part of the region is assigned complexity 0, because it is mainly background or inside-object part. The complexity is increased as we get near the border of the region. It reflects abrupt change in the image intensity, such as the line segments. Complexity 3 is assigned to the parts of the image which is not extracted by the segmentation procedure. It means these parts are noisy parts and have no fixed shape or intensity.

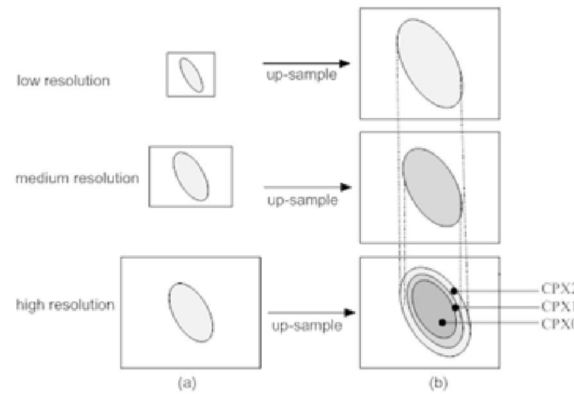

Figure. 1. The multi-resolution images are used to assign a level of complexity for each extracted region. The parts near the border of the region will be assigned higher complexity than the parts inside the region (smooth areas).

3. Watermark embedding by using LSB: LSB embedding algorithm will be used, in which the secret data are spread out among the regions with different complexity measure. This can be achieved if both the sender and receiver having the same secret key or share a secure key. This key can be used to generate pseudorandom numbers, which will help extracting the secret image by defining the regions and the order in which the secret data is laid out.

Embedding starts from regions with CPX2. If the size of the embedded message is large, CPX1 and CPX0 regions will be used for embedding.

The advantage of that method is that it incorporates some cryptography concepts that diffuse the secured data. However, it goes beyond just making it difficult for an attacker knows that there is a secret message. It also makes it harder to determine that there was a secret message in the first place. The reason is because the randomness makes the embedded message seem more like noise statistically than in the straight forward embedding method.

2.2 Message extraction

The secret message is extracted by creating the multi-resolution images, and then the complexity is assigned to each region segments. We start be extracting the data in CPX2 then move to CPX1 if the message size is still smaller than expected.

3. Results and Discussions

The proposed technique is evaluated for different types of images. We have selected the standard images which are used frequently in image steganography experiments. The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are two standard measurements used to compare different steganography techniques. The PSNR means how much signal are remaining after adding noise. So higher PSNR means high quality stego-image, and vice versa. The MSE is cumulative squared error between the original image and the stego-image. Before giving mathematical formula for computing PSNR, MSE formula must be stated first. MSE is calculated by using the following mathematical equation

$$MSE = \frac{\sum_{M,N}[I_{1(m,n)} - I_2(m,n)]^2}{M*N} \quad (5)$$

Where M and N are the number of rows and columns in the input image respectively. *I1(m,n)* is the original image, *I2(m,n)* is the stego-image. Now, PSNR can be calculated by using the following equation

$$PSNR = 10\, log_{10}\left[\frac{R^2}{MSE}\right] \quad (6)$$

Where R represents the maximum intensity value in the image, its value is 255 for 8-bits/pixel image. Our proposed method is evaluated by two types of measurements, HVS (Human Visual Systems) and PSNR.

3.1 HVS (Human Visual System)

Since the human vision can't detect change in the regions with sudden change, we concentrated our watermarking areas on those areas with comparatively random change. In Figure. 2, four different images are used to evaluate our algorithm. The test data include images for Lena, Girl, F16 and Baboon. All have the same size (512x512) represented in gray scale format by 8 bits/pixel. The experiments are executed on the above images by using the straight forward LSB embedding algorithm. The results reflected previous work done in [2]. The experiment is done by embedding 31.99 Kbytes of data into each image. The 4 LSB's are used for embedding. For example, a 512x512 image, the total embedding capacity = 512x512x4 Bits (128 Kbytes). Embedding process starts from the upper-left corner of the image increasing into the bottom direction and moving horizontally column by column. The image contains 512 columns, each column has 4x512 Bits

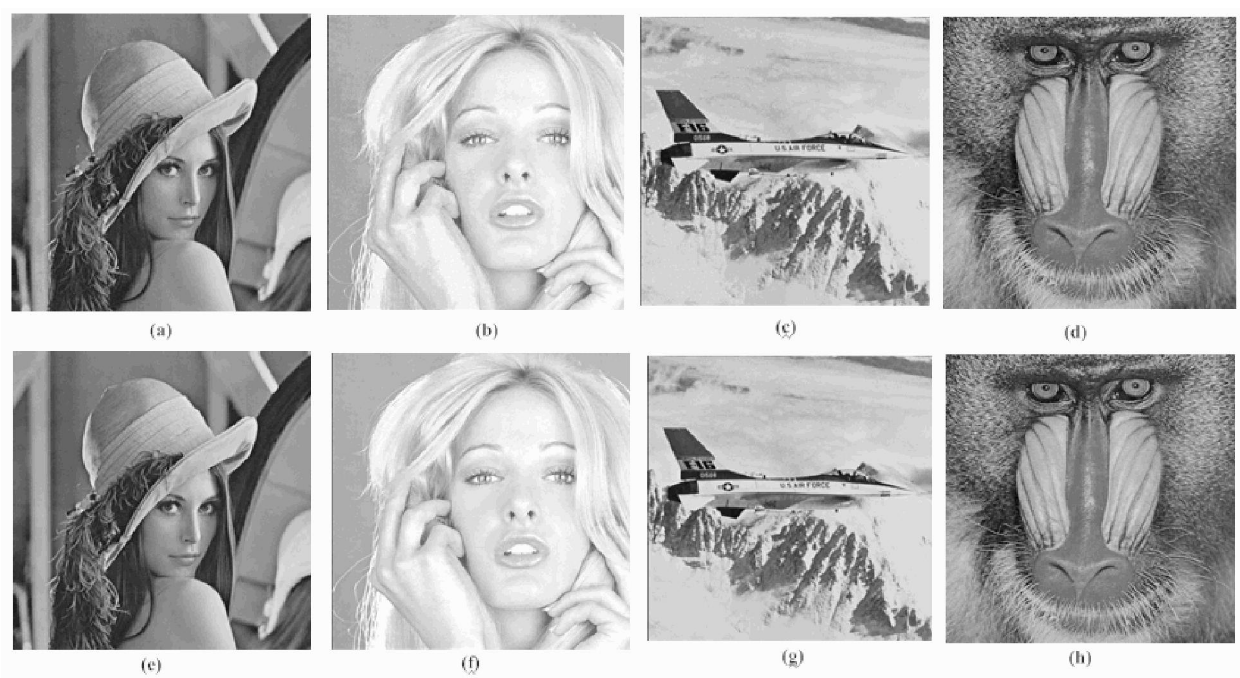

Figure. 2. Comparing the proposed steganography algorithm with the algorithm introduced in [2] after embedding 31.99 Kbytes of data. Images (a) to (d) show the results introduced in [2] after embedding 31.99 Kbytes in the 4 LSB's. Images (e) to (h) show the proposed algorithm results after embedding in the 4 LSB's and 2 LSB's. The distorted parts of the images (a) to (d) can be noticed in the left side of each image.

(0.25 Kbytes) as a carrier bits. To embed 31.99 Kbytes (~ 32 Kbytes) we need 128 columns out of 512 columns which is around a quarter the total number of the image columns. The straight forward LSB will affect only the left part (quarter) of the image, the experiment results for the above scenario is shown in Figure. 2 (a)-(d). and Table I

For the proposed algorithm, we committed an experiment by using the same data set used above. A total of 31.99 Kbytes are embedded into the images. Instead of embedding directly into the 4 LSB's of the image, we used a collection of 4 LSB's and 2 LSB's. as shown in Table II First the images are processed to extract the features, then a complexity is assigned to each extracted feature (regions in our algorithm are the extracted feature). The embedding is done by embedding into the regions with CPX2, if CPX2 pixels are not sufficient, the CPX1 pixels are used in addition to CPX2. 4 LSB's are used for embedding into CPX2 regions, while 2 LSB's are used for embedding into CPX1 regions.

In the experiment we extracted the regions with CPX2=35 Kbytes, CPX2= 40 Kbytes, CPX2= 18 Kbytes and CPX2=42 Kbytes for Lena, Girl, F16 and Baboon images respectively.

We also extracted the regions with complexity CPX1=12 Kbytes, CPX1=35 Kbytes, CPX1=42 Kbytes and CPX1=23 Kbytes for Lena, Girl, F16 and Baboon images respectively. To embed 31.99 Kbytes of data into Lena image, we found that CPX2=35 Kbytes, i.e. CPX2 region pixels will be sufficient for the embedding process. However, for the F16 image, CPX2=18 Kbytes is not sufficient for the embedding process, so CPX1=42 region pixels are used in addition to CPX1.

Comparing the images in Figure. 2(a)-(d) (which show the results of the algorithm in [2]) with Figure. 2(e)-(f) (which shows the results of our algorithm) we find that the visual quality of our algorithm is higher than the visual quality of the straight forward LSB algorithm.

Table I. The results of the straight forward LSB algorithm introduced in [2] for different number of LSB's

Number of LSB's used	Image name	Message Size (Kbytes)	MSE	PSNR (dB)
1 Bit	Lena	31.99	0.50	51.13
	Baboon	31.99	0.50	51.11
	F16	31.99	0.49	51.15
	Girl	31.99	0.50	51.13
2 Bits	Lena	63.98	2.40	44.32
	Baboon	63.98	2.40	44.32
	F16	63.98	2.39	44.34
	Girl	63.98	2.38	44.35
4 Bits	Lena	63.98	19.90	35.14
	Baboon	63.98	19.91	35.14
	F16	63.98	19.53	35.22
	Girl	63.98	20.55	35.00
8 bits	Lena	63.98	891.32	18.63
	Baboon	63.98	1183.75	17.39
	F16	63.98	3019.34	13.33
	Girl	63.98	3495.29	12.69

3.2 PSNR(Peak Signal to Noise Ratio)

The quality of the stego-images can be measured by using PSNR, higher PSNR means higher quality and lower PSNR means lower quality. Lena, Baboon, F16 and Girl images are used for embedding different number of LSB's as shown in Table I. Increasing the number of LSB's will distort the image. For Lena image, when using one LSB, PSNR is 51.13 dB, using 8 LSB's will degrade the image making its PSNR equal to 18.63 dB which means high distortion to the image or complete distortion of the image. To compare our algorithm with the straight forward LSB introduced in [2] we have fixed the embedding size to 31.99 Kbytes. The above images are used as a message carrier for the 31.99 Kbytes message. The algorithm in [2] gives results for PSNR, about 51 dB. While our algorithm gives results for PSNR, about 54 dB which is higher compared to the straight forward LSB embedding method. The results of the proposed algorithm are shown in Table II.

Table II. The results of embedding 1 LSB with the algorithm in [2] compared to the results of the proposed algorithm after embedding in 2 LSB's and 4 LSB's in CPX2 and CPX1 respectively.

LSB's used	**Image Name**	**Message Size (Kbytes)**	**MSE**	**PSNR (dB)**	**LSB's Used**	**MSE**	**PSNR (dB)**
1 Bit	Previous Method				**2 Bits & 4 Bits**	Proposed Method	
	Lena	31.99	0.50	51.13		0.22	54.44
	Baboon	31.99	0.50	51.11		0.21	54.43
	F16	31.99	0.49	51.15		0.23	54.46
	Girl	31.99	0.50	51.13		0.23	54.45

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Corresponding Author:
Osama Hosam
Computer Science Department
Taibah University, Saudi Arabia
E-mail: mohandesosama@yahoo.com

References

1. C. Kurak and J. McHugh, A cautionary note on image downgrading, in: Proceedings of the IEEE 8th Annual Computer Security Applications Conference, 30 Nov-4 Dec, 1992, pp. 153-159.
2. Puneet Kr Sharma, Rajni: Analysis Of Image Watermarking Using Least Significant Bit Algorithm, International Journal of Information Sciences and Techniques (IJIST) Vol.2, No.4, July 2012.
3. Sakakura, T.; Hayashi, A.;" A simple detection scheme of LSB steganographybased on statistics of image difference signal" Information Theory and its Applications (ISITA), 2010 International Symposium, DOI: 10.1109/ISITA.2010.5649311 , Page(s): 320 – 325, Year: 2010
4. Ming Chen, Ru Zhang, Xinxin Niu, Yixian Yang, "Analysis of Current Steganography Tools: Classifications & Features," iih-msp, pp.384-387, 2006 International Conference on Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP'06), 2006
5. Osama Hosam, Xingming Sun: Three-Dimensional Reconstruction Using Enhanced Shape from Stereo Technique. ACIS-ICIS 2009: 627-632
6. Han-Suh Koo and Chang-Sung Jeong, "An Area-Based Stereo Matching Using Adaptive Search Range and Window Size", Department of Electronics Engineering, Korea University, Korea, 2001.

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