Dynamic Pattern Based Image Steganography

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Abstract—Steganography is the art of hiding secret information in media such as image, audio and video. The purpose of steganography is to conceal the existence of the secret information in any given medium. This work aims at strengthening the security in steganography algorithm by generating dynamic pattern in selection of indicator sequence. In addition to this dynamicity is also encompassed in number of bits embedded in data channel. This technique has been implemented and the results have been compared and evaluated with existing similar techniques.

Index Terms—Indicator, Intensity, Steganography, Steganalysis

1 INTRODUCTION

Information is the wealth of any organization. This makes security a major concern in today's world. Cryptography is a technique for securing the secrecy of communication and many methods have been developed to encrypt and decrypt the messages. Unfortunately it is sometime not enough to keep the contents of message secret it may be also necessary to keep the existence of message secret which is done by steganography. Steganography involves hiding information inside any cover media (image or audio or video file[5]) such that it appears no message is hidden[9]. Several methods have been proposed for image based steganography such as LSB [4], RGB single and multi channel embedding.

In this paper we propose a Dynamic Pattern based Image Steganography (DPIS) technique for RGB based image steganography. DPIS technique ensures minimum capacity for storing secret message than existing techniques and it also ensures that channels containing relatively lower colour values can store more bits of data. Experimental results show that our technique performs much better than the existing techniques. The paper is organized as follows Section 2 deals with brief description of existing techniques, Section 3 explains the proposed technique Section 4 depicts the evaluation criteria and experimental results and Section 5 concludes the paper.

2 RELATED WORK

There are many methods exists for image steganography [8] such as Fibonacci data hiding technique, DCT Algorithm, Data hiding using Prime numbers, etc. This section focuses on the algorithms which uses RGB channel for Steganography.

Adnan Gutub et.al [1] uses any one of the channels as Indicator channel. Indicator channel indicates the data channel among the other two channels. The Indicator channel is chosen in sequence with ‘R’ being the first.

- If the last two bits of the indicator are ‘00’ then no data is embedded in the channel 1 and channel 2.
- If the last two bits of the indicator are ‘01’ the no data is embedded in channel 1 and 2 bits of data is embedded in channel 2.
- If the last two bits of the indicator are ‘10’ then two bits of data is embedded in channel 1 and no data is embedded in channel 2.
- If the last two bits of the indicator are ‘11’ then two bits of data is embedded in channel 1 and channel 2.

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Mohammad Tanvir Parevez et al. [7] uses the concept that the lower color value of a channel has less effect on the color of a pixel than the higher value, therefore more data bits can be embedded in the lower color channel. The number of bits embedded in each channel depends on the partition schema which is static throughout the embedding process. Among the R, G, and B channels, any channel can be chosen as the indicator channel and it can be made random. Indicator channel sequence rotates in a circular way through the embedding process.

The above-listed techniques suffer from the following limitations:

- Data are embedded sequentially in all pixels.
- Data are embedded using static partition schema or same number of bits in the channel.
- Fails to detect whether the stego image has been modified by the intruder.

DPIS technique overcomes these limitations and it has been proven by experimental results.

3 DYNAMIC PATTERN BASED IMAGE STEGANOGRAPHY (DPIS) TECHNIQUE

In this section, Dynamic Pattern-based Image Steganography technique (DPIS) was discussed in detail. The idea behind our technique is that the dominant color or significant color in a pixel should not suffer from data embedding while the insignificant color channel can be used for data embedding. Figure 1 and Figure 2 depict the embedding and extracting process of DPIS.

Major steps in the DPIS technique:

- Generate the random string of length say ‘N’ in terms of R, G, and B.
- From the generated indicator sequence, choose the indicator channel and check whether the indicator channel is the lowest among the other channels. If Indicator is lowest, then skip the pixel from embedding else embed the data.
- Choose the data channel from the remaining two channels.
- The number of bits to be embedded in data channel is determined at runtime and it is not predetermined.

At the extraction part, channel in which data is embedded is communicated in the LSB of the indicator channel.

- The indicator sequence should be obtained from the embedding part.
- If the LSB of Indicator channel is ‘0’, the channel follows immediately after the indicator is the data channel.
- If the LSB of Indicator channel is ‘1’, the channel precedes the indicator is the data channel.

To extract the exact number of bits embedded in data channel, we need to know:

- If the LSB of third channel is ‘0’, then three bits of data are embedded in data channel.
- If the LSB of third channel is ‘1’, the four bits of data are embedded in data channel.

DPIS technique has been tested on different image categories such as portrait, flower, nature, toys etc. Figure 3 to Figure 5 shows the Cover and Stego images generated through DPIS technique.
Fig. 1. Flow chart for embedding

Fig. 2. Flow chart for extracting
Fig. 3 (a). Cover Image, Image Size: 300 x 266

Fig. 3 (b). Stego Image, Pixel used for embedding: 3486, Secret Message Size: 15358

Fig. 4 (a). Cover Image, Image Size: 323 x 429

Fig. 4 (b). Stego Image Pixel used for embedding: 4714, Secret Message size: 21133

Fig. 5 (a). Cover Image, Image Size: 274 x 255

Fig. 5 (b). Stego Image Pixel used for embedding: 6298, Secret Message Size: 27755
4 Evaluation Criteria and Experimental Results for Proposed Technique

DPIS technique is implemented in MATLAB and evaluated against the existing [1][5][7] and proposed parameters.

- a) Robustness
- b) Capacity
- c) Invisibility
- d) Behaviour of proposed technique on common steganalysis methods
- e) Detection of tampered stego images

4.1 Robustness

Robustness is measured by the difficulty level of the intruder to break the key for any technique. Given any RGB image intruder may try for brute force attack for locating the Indicator. If the indicator is identified then data channel can be easily traced out and secret message can be extracted or cramped.

The number of distinct pattern of indicator sequence shown in Table 1 is obtained by the formulae \(3^{(n-2)} \times 2\) where n is the length of the indicator sequence.

For all our experiments the indicator length of 20 have been chosen that generates 7,74,840,978 distinct indicator sequences, which is very difficult to break by brute force attack.

### TABLE 1
LENGTH OF INDICATOR SEQUENCE AND NUMBER OF DISTINCT PATTERNS

| Length of the Indicator | Number of distinct pattern |
|-------------------------|---------------------------|
| 3                       | 6                         |
| 10                      | 13,122                    |
| 15                      | 3,13,8846                 |
| 20                      | 7,748,40,978              |

4.2 Capacity

Capacity is key important evaluating parameter in steganography technique. Capacity is defined as number of pixels used in the cover image to embed the secret message of any length. Our DPIS technique uses very minimum number of pixels compared to the existing technique and this has been proved by experimental results in Table 2. Graphical representation of the table 2 is shown in the figure 6.

![Graph showing pixel utilisation by existing and proposed technique](image-url)
4.3 Visibility

Once the message has been embedded in cover image changes in the pixel value should not be noticed in the stego image. It is very hard to find the small color change in the cover and stego image by human eye. For this histogram comparison is used by steganalyst to identify the stego image by comparing the histogram of cover image and stego image.

Based on this experiments have been conducted and separate histograms are drawn for cover and stego image. It is observed that there is no major difference visible while comparing Red, Green and Blue histogram of both cover and Stego Images. Figure 7-8 shows the histogram of RGB channels.

Fig. 7 (a). Original Image Red Histogram
Fig. 7 (b). Original Image Green Histogram
Fig. 7 (c). Original Image Blue Histogram
Fig. 8 (a). Stego Image Red Histogram
Fig. 8 (b). Stego Image Green Histogram
4.4 Behavior of proposed technique on common steganalysis methods

Steganalysis is the art and science of detecting messages hidden using steganography [10]. The most common steganalysis methods used for RGB based steganography are

- Brute force attack on Indicator sequence
- Extracting data from all pixels
- Extracting same number of bits from data channels

Brute force attack on Indicator sequence:

Brute force attacks for steganography [3] involves in trying all possible keys until valid key is found. In dynamic pattern based image steganography technique, indicator channel contains the information where the data are stored. Intruder may try the brute force attack on indicator sequence until meaningful message is traced. In all our experiments length of indicator sequence is greater or equal to 20 so number of distinct pattern generated is very high and it cannot be broken by brute force attack.

Extracting data from all the pixels sequentially:

In DPIS method data are not embedded in all the pixels sequentially. Some pixels in the sequence are missed inorder to strengthen the technique. The Table 4 shows the result of extracting data from all the pixels from stegoimage shown in Figure 10.

The above experiment depicts that even if one value in the indicator sequence is not correct, embedded secret message cannot be extracted.
4.5 Detection of tampered stego images

In DPIS technique, provision has been given to check whether the stego image has been modified by any intruder [2]. Before decrypting the embedded message the stegoimage is checked for any change done by intruder. If stegoimage is not tampered then the extraction part will be executed.

This has been achieved in the DPIS technique by communicating the information about unmodified pixels and their values to the counter part. Table 6 shows the comparative study of some important features between DPIS and existing techniques.

| Features                         | RGB Intensity based variable bits | Pixel Indicator | DPIS technique          |
|----------------------------------|----------------------------------|-----------------|-------------------------|
| Indicator sequence               | Vary in length of 3              | Static          | Varying with different length |
| Brute force attack               | Breakable                        | Breakable       | Not Breakable           |
| Number of bits embedded in data channel | Static and depends on partition schema | Static | Dynamic and its decided at run time |
| Sequential data embedding in all pixels | Yes                            | No              | No                      |
| Tampered stego image detection at decryption part | Not possible | Not possible | Possible |

TABLE 6
EXPERIMENT RESULT: COMPARATIVE STUDY OF SOME IMPORTANT FEATURES BETWEEN PROPOSED AND EXISTING TECHNIQUES

Fig 11: Stegoimage generated by DPIS algorithm

TABLE 5
EXPERIMENT RESULT: EMBEDDED MESSAGE AND MESSAGE EXTRACTED WITH UNIFORM NUMBER OF BITS FROM PIXELS IN THE STEGO IMAGE

| Embedded Secret Message in cover medium | Secret message from stegoimage obtained by extracting 2 bits from all data channels |
|----------------------------------------|----------------------------------------------------------------------------------|
| Pondicherry University Computer Science Dept | Sj Lx5@Oq4ht=Y w6BGw0 4 H | -xy |
4 Conclusion

In this paper, dynamic pattern based image steganography technique has been introduced. This technique addresses key important issues like dynamicity in data embedding and indicator sequence and thus making it difficult to hack by steganalyst. Moreover it also detects whether the stego image has been modified by intruder during transmission. DPIS technique results in very high capacity with low visual distortions and all this have been proved by experimental results. DPIS technique has also been compared with important feature of other steganography algorithms.

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