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An Analysis on LSB Image Steganography with Colour Image as Cover

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ABSTRACT
LSB-based steganographic methods embed secret messages into the cover image by directly manipulating the least-significant-bit (LSB) plane. Although it is not the best steganographic method, LSB replacement is worth studying because of its large embedding capacity and simplicity. In LSB replacement, the LSB plane is simply replaced with the secret message so that the LSB values carry the hidden message directly. As more and more techniques of hiding information (Steganography) are developed, the methods of detecting the use of steganography (Steganalysis), also advance. Most steganography techniques change the properties of the cover source which increases the probability of detecting the changes. The DCT-M3 algorithm reduces significantly the number of changes in the cover image; the embedding capacity has been improved by 16.7% approximately while maintaining minimum detectability against blind steganalysis schemes. The effectiveness of steganography is measured using three parameters. First, the steganographic technique must provide the maximum information. Second, the embedded data must not be traceable to the viewer. Third, the hidden information should be successfully retrieved at the receiver. It is difficult to recognize the existence of a hidden data in the cover image using the existing methods. This is because embedding is randomly performed in the frequency domain.

General Terms
Steganography, LSB (Least Significant Bit) image.

Keywords
LSB image, steganography, secret message, image cover, LSB plane, hidden information.

1. INTRODUCTION
Staeanography is closely related to cryptography. Unlike cryptography where communication is overt, but the content is secret, steganography is the science of secretly communication by means of concealing information within some data medium. It encompasses a large variety of techniques and protocols. Steganography can range from a simple modification of English text by modulating active and passive voices to utilizing the least significant bits in digital image pixels to unobtrusively embed addition information. Any steganographic technique will necessarily cause some distortion or modification of the original data. The key to successful steganography is to ensure the distortion caused by the hidden data is undetectable visually by either a human observer who knows the data is there or one who does not.

Steganography is one of the most powerful techniques to conceal the existence of hidden secret data inside a cover object. Images are the most popular cover objects for Steganography. Embedding secret information inside images requires intensive computations, and therefore, designing Steganography in hardware speeds up Steganography.

2. LSB IMAGE STEGANOGRAPHY
LSB-based steganographic methods embed secret messages into the cover image by directly manipulating the least-significant-bit (LSB) plane. Although it is not the best steganographic method, LSB replacement is worth studying because of its large embedding capacity and simplicity. In LSB replacement, the LSB plane is simply replaced with the secret message so that the LSB values carry the hidden message directly. The method either increments/decrements even pixel values or leaves them unmodified, while odd values are left unchanged or incremented/decremented. As a result, the replacement scheme makes the distribution of the odd/even pixel values almost equal. In other words, a pair of odd/even pixels keeps a balanced distribution of numbers. Such a phenomenon happens as long as the hidden message is random and the embedding capacity is 1 bit-per-pixel or so. Many statistical steganalysis methods including pair of value analysis and RS analysis can easily detect the existence of hidden messages by exploiting the histogram of the pixel values. Simple solutions against steganalysis include either reducing the embedding capacity or improving the statistical distribution of pixel values.

LSB matching does not simply replace the LSB plane of the cover image in the same manner as LSB replacement. Instead, if the message bit does not match the LSB value of the cover image, then there is a random increment/decrement of the value of the cover pixel. To ensure the invertibility of the process, pixel values are never modified to fall outside of the allowable range. Due to this sophisticated hiding scheme, detection is much harder than LSB replacement [2].

3. RELATED WORK
This paper presents a least significant bit (LSB) matching steganography detection method based on statistical modeling of pixel difference distributions. Previous research indicates that natural images are highly correlated in a local neighborhood and that the value zero appears most frequently in intensity differences between adjacent pixels. The statistical model of the distribution of pixel difference can be established using the Laplace distribution. LSB matching steganography randomly increases or decreases the pixel value by 1 when the message is embedded; thus, the frequency of occurrence of the value zero in pixel differences changes most dramatically during message embedding. Based on the Laplacian model of pixel difference distributions, this paper proposes a method to estimate the number of the zero difference value using the number of non-zero difference values from stego-images and uses the relative estimation error between the estimated and actual values of the number of the zero difference value as the classification feature. Experimental results indicate that the proposed algorithm is effective in detecting LSB matching steganography and can achieve better detection performance than the local extreme method under most circumstances [1].

In this paper, a novel steganographic method is proposed employing an immune programming strategy to find a near-optimal solution for the pair-wise least-significant-bit (LSB) matching scheme. The LSB matching method proposed by Mielikaien utilizes a binary function to reduce the number of changed pixel values. However, his method still has room for improvement. A tier-score system is proposed in this paper to assess the performance of ifferent orders for LSB matching. An immune programming approach is adopted to search for a near-optimal solution among all the permutation orders. The proposed method can reduce the distortion of the stego image, improve the visual quality, and decrease the probability of detection. The experimental results show that the proposed method achieves better performance than Mielikainen's pair-wise LSB matching method in terms of distortion and survival probability against steganalysis [2].

Quantum computation has the ability to solve some problems that are considered inefficient in classical computer. Research on Quantum image processing has been extensively exploited in recent decades. Quantum image information hiding can be divided into quantum image digital watermarking, quantum image steganography, anonymity and other branches. Least significant bit (LSB) information hiding plays an important role in classical world because many information hiding algorithms are designed based on it. In this paper, based on novel enhanced quantum representation (NEQR), the concrete least significant qubit (LSQb) information hiding algorithm for quantum image is given firstly. Because information hiding located on the frequency domain of an image can increase the security, we further discuss the frequency domain LSQb information hiding algorithm for quantum image based on quantum Fourier transform. In our algorithms, the corresponding unitary transformations are designed to realize the aim of embedding the secret information to the least significant qubit representing color of the quantum cover image. Finally, we illustrate the procedure of extracting the secret information. Quantum image LSQb information hiding algorithm can be applied in many fields according to different needs [3].

In this paper, we present a scheme based on feature mining and pattern classification to detect LSB matching steganography in grayscale images, which is a very challenging problem in steganalysis. Five types of features are proposed. In comparison with other well-known feature sets, the set of proposed features performs the best. We compare different learning classifiers and deal with the issue of feature selection that is rarely mentioned in steganalysis. In our experiments, the combination of a dynamic evolving neural fuzzy inference system (DENFIS) with a feature selection of support vector machine recursive feature elimination (SVMRFE) achieves the best detection performance. Results also show that image complexity is an important reference to evaluation of steganalysis performance [4].

This paper presents a novel method for detection of LSB matching steganography in grayscale images. This method is based on the analysis of the differences between neighboring pixels before and after random data embedding. In natural images, there is a strong correlation between adjacent pixels. This correlation is disturbed by LSB matching generating new types of correlations. The presented method generates patterns from these correlations and analyzes their variation when random data are hidden. The experiments performed for two different image databases show that the method yields better classification accuracy compared to prior art for both LSB matching and HUGO steganography. In addition, although the method is designed for the spatial domain, some experiments show its applicability also for detecting JPEG steganography [5].

This paper proposes a new robust chaotic algorithm for digital image steganography based on a 3-dimensional chaotic cat map and lifted discrete wavelet transforms. The irregular outputs of the cat map are used to embed a secret message in a digital cover image. Discrete wavelet transforms are used to provide robustness. Sweldens' lifting scheme is applied to ensure integer-to-integer transforms, thus improving the robustness of the algorithm. The suggested scheme is fast, efficient and flexible. Empirical results are presented to showcase the satisfactory performance of our proposed steganographic scheme in terms of its effectiveness (imperceptibility and security) and feasibility. Comparison with some existing transform domain steganographic schemes is also presented [6].

Steganalysis can be used to classify an object whether or not it contains hidden information. In this article, is presented, a novel approach to detect the presence of least significant bit (LSB) steganographic messages in the voice secure communication system. A distance measure, which has proven to be sensitive to LSB steganography by analysis of variance (ANOVA), is denoted to estimate the difference between the host signal and the stego signal. Then an maximum likelihood (ML) decision is combined to form the classifier. Statistical experiments show that the proposed approach has a highly accurate rate and low computational complexity [7].

In this research, on the basis of the differential phase-shift keying (DPSK) technique which is widely used in digital communication systems to develop a steganography scheme, we aim to hide a ''secret image'' into a cover image of the same size so that the resultant image has no noticeable degradation. In our approach, three strategies are used to achieve this goal: (1) Compress the secret image to reduce the number of secret bits. The set partitioning in hierarchical trees (SPIHT) codec were used to obtain a high reconstructed image quality and low bit rate image compression. (2) A neighbor block signal phase comparison (NBSPC) mechanism is used to offer the location for secret data embedding. (3) A fold phase distribution differential phase-shift keying FPDPSK mechanism is used to improve the quality of the cover image. With our contribution, we have developed the fold phase distribution DPSK concept to obtain more than 1.5 dB quality improvement and twice the noise margin than the standard DPSK technique on the same test condition [8].

In this research of color image hidden scheme, we aim to conceal a secret image into the cover image of the same size without noticeable degradation. In our approach, discrete wavelet transform (DWT) and set partitioning in hierarchical trees (SPIHT) codec are used to obtain a low bit rate and high reconstructed quality image compression. In the embedding process, an adaptive phase modulation (APM) mechanism and discrete Fourier transform (DFT) were adopted for secret data embedding. Simultaneously, nearest phase modulations (NPM) was used to improve the imperceptibility and decrease degradation of cover image. Both the chaotic mechanism (CM) and frequency hopping (FH) structure were hired to enhance the security of the scheme. Comparing with other data-hiding techniques, our proposed method has three advantages. (A) The extracted secret image has high quality reconstruction by using SPIHT coder. (B) The stego-image possesses excellent imperceptibility without noticeable degradation because secret data was concealed in the phase by using APM and NPM. (C) Have very large embedding capacity, it allows the size of secret image to be the same as the cover image [9].

This paper deals with a method to protect the color information of images by providing free access to the corresponding gray level images. Only with a secret key and the gray level images, it is then possible to view the images in color. The approach is based on a color reordering algorithm after a quantization step. Based on a layer scanning algorithm, the color reordering generates gray level images and makes it possible to embed the color palette into the gray level images using a data hiding algorithm. This work was carried out in the framework of a project aimed at providing limited access to the private digital painting database of the Louvre Museum in Paris, France [10].

Steganography is the only answer for secure and secret communication. Existing methods in image steganography focus on increasing embedding capacity of secret data. According to existing methods, the experimental results indicate that two pixels are required for one secret digit embedding. In direction of improve the embedding size of secret data, a novel method of Pixel Value Modification (PVM) by modulus function is proposed. The proposed PVM method can embed one secret digit on one pixel of cover image. Thus, the proposed PVM method gives good quality of stego image. The experimental outputs validate that good visual perception of stego image with more secret data embedding capacity of stego image can be achieved by the proposed method [11].

Steganography is the science of hiding data into innocuous objects such that the existence of the hidden data remains imperceptible to an adversary. Steganography in images have varied techniques of implementation developed over time. Protection of the hidden information from an adversary is the most important goal of steganography and hence it is obvious that the security of a steganography system will increase if the payload remains illegible to an attacker even if he holds knowledge about the embedding method. It is also evident that certain areas in an image are more efficient for hiding data than the other parts of the image. These are called Regions of Interest or ROIs. Edge areas in an image are one of the ROIs that can be used for steganography. This paper proposes an edge adaptive image steganography mechanism which combines the benefits of matrix encoding and LSBM to embed data and also uses a chaotic mapping scheme to provide enhanced security to the payload. Efforts have been given to ensure that the proposed mechanism conforms to high Imperceptibility and Fidelity which are the essential quality requirements for any image steganography system [12].

In this paper a Genetic Algorithm based steganographic technique in frequency domain using discrete cosine transform has been proposed. A 2×2 sub mask of the source image is taken in row major order and Discrete Cosine Transformation is applied on it to generate four frequency components. Two bits of the authenticating image are embedded into each transformed coefficients except the first one. In each coefficient second and third positions from LSB are chosen for embedding in the transform domain. Stego sub intermediate image is generated through reverse transform. Sub mask from this intermediate image is taken as initial population. New Generation followed by Crossover is applied on initial population to enhance a layer of security. New Generation is applied to initial population. Rightmost three bits of each byte are taken, a consecutive bitwise XOR is applied on it in three steps which generates a triangular form. The first bit of each intermediate step is taken as the output and Crossover is performed on two consecutive pixels where two LSB bits of two consecutive bytes are swapped. The dimension of the hidden image is embedded followed by the content. Reverse process is followed during decoding. The proposed scheme obtains high image fidelity, PSNR and high capacity of embedding in stego images compared Chang Chin et al [13].

In this paper, a new secure communication protocol that combines steganography and cryptography techniques organically is proposed. It is based on the LSB matching method and the well-developed Boolean functions in stream ciphers. The cover media employed focuses on grayscale images, and the Boolean function is used for encryption and controlling the pseudo-random increment or decrement of LSB. Unlike the existing methods of doing encrypting and hiding separately, this protocol is one-stop, accomplishing them all at once. Therefore, it needs less computation than the existing methods do while maintaining high secure quality. To our knowledge, this is the first secure protocol of this kind. And this method not only is easy to be implemented, but also has almost optimal embedding ratio, what's more, it is highly robust to resist regular steganalysis, such as RS analysis, GPC analysis, $\chi 2$ –analysis [14].

This paper is based on image steganography that is Least Significant Bits (LSB) techniques on images to enhance the security of the communication. The LSB-based technique is the most challenging one because it is difficult to differentiate between the cover-object and stego-object, if few LSB bits of the cover object are replaced. The LSB approach combined with F5 algorithm and matrix embedding which is applied on both spatial and frequency domain of an image. The Mean squared error (MSE) and Peak signal to noise ratio (PSNR) was used as the performance measure to compare the different LSB techniques. This paper shows that MSE and PSNR of LSB techniques with Matrix embedding yields better results [15].

In the field of security different steganography techniques hides data within the cover media in such a way so that human perception cannot follow it. All of these also try to follow three challenges of steganography i.e. robustness, imperceptibility and capacity. This proposed technique meets these three challenges very efficiently. Here the secret data are not directly embedded within the cover file but the intensity of cover pixel are adjusted in such a way so that at the receiver side the actual target bits are extracted from stego image by performing binary addition. The embedding also performs binary addition among desired number of bits selected from LSB and the two LSBs of the result of binary addition are considered as the interpretation of two target data bits. The maximum change in the intensity value is nominal and is not depends on the number of LSB layer chosen for binary addition. Since the actual data are not hidden thus intruders cannot get it by just using the concept of standard LSB extraction technique. Even though they are able to know the binary addition technique used here then also don't get the actual target bits without knowing the number of LSB layers involved for binary addition. Two data bits are embedded in each pixel so from capacity point of view this technique is two times better than standard LSB technique for steganography [16].

In the recent past some steganography techniques by combining least significant bit (LSB) substitution and pixel value differencing (PVD) have been proposed to improve upon the hiding capacity and peak signal-to-noise ratio (PSNR). This paper proposes a steganographic technique by using both LSB substitution and PVD with in a block. The image is partitioned into 2×2 pixel blocks in a non-overlapping fashion. For every 2×2 pixel block the upper-left pixel is embedded with k-bits of data using LSB substitution. Then the new value of this pixel is used to calculate three pixel value differences with the upper-right, bottom-left, and bottom-right pixels of the block. Then data bits are hidden using these three difference values in three directions. Both horizontal and vertical edges are considered. There are two variants proposed by using two different range tables. In the first variant (Type 1) the PSNR is improved and in the second variant (Type 2) both PSNR and hiding capacity are improved [17].

Verifiable Secret Image Sharing has become an important field of study in modern cryptography. As the era demands the need of security and verifiability to resist cheating scenario, a new secret image sharing scheme identifying the existence of cheater is introduced and analyzed in this paper. A method to ensure integrity of secret image prior to its recovery is proposed. An n x n secret image and n x n verification image are used to generate shares which are embedded into a cover image for transmission. Structural similarity and mean square error measure of reconstructed verification image with original verification image verifies the coherence of the secret. Computational cost of this method is low which makes it suitable for covert message communication and sharing of scanned documents [18].

Steganography is a data hiding technique that is widely used in various information securing applications. Steganography transmits data by hiding the existence of the message so that a viewer cannot identify the transmission of message and hence not able to decrypt it. This work proposes a data securing technique that is used for hiding multiple color images into a single color image using the Discrete Wavelet Transform. The cover image is split up into R, G and B planes. Secret images are embedded into these planes. An N-level decomposition of the cover image and the secret images are done and some frequency components of the same are combined. Secret images are then extracted from the stego image. Here, the stego image obtained has a less perceptible changes compared to the original image with high overall security [19].

A new secured image/video transmission technique is proposed in this paper. Here video is considered as a sequence of frames. The secret image is automatically transformed into a secret-fragment visible mosaic image. This image looks similar to a randomly selected target image. The target image is used to cover or hide the secret image. Also relevant information for reconstructing the secret image is embedded on the mosaic image by a loss less data hiding scheme using a key. The secret image is divided into cells and the color characteristics of each cell are transformed to that of the divided target blocks. In order to reconstruct the secret image losslessly, skilful techniques are designed to conduct the color transformation process. Performance evaluations of the proposed method shows improved peak signal to noise ratio compared with the existing method [20].

Information security relies mainly upon encryption, and in some cases, steganography for an extra layer of security. Steganography is the science and art of secret communication between two sides that attempts to conceal the existence of the message. Many steganographic techniques have been proposed, all of them make statistically noticeable changes in the properties of the cover carrier particularly when the message payload is high. In this paper, we propose a new methodology of transform domain JPEG image steganography technique that provides high embedding performance while introducing minimal changes in the cover carrier image. The algorithm, named DCT-M3, uses modulus 3 of the difference between two DCT coefficients to embed two bits of the compressed form of the secret message. The proposed algorithm reduces significantly the number of changes in the cover image; the embedding capacity has been improved by 16.7% approximately while maintaining minimum detectability against blind steganalysis schemes [21].

4. OUTCOMES OF THE STUDY

As more and more techniques of hiding information (Steganography) are developed, the methods of detecting the use of steganography (Steganalysis), also advance. Most steganography techniques change the properties of the cover source which increases the probability of detecting the changes. The DCT-M3 technique introduces a new algorithm for embedding the secret message by trying to minimize the changes in the cover image properties. The DCT-M3 algorithm reduces significantly the number of changes in the cover image; the embedding capacity has been improved by 16.7% approximately while maintaining minimum detectability against blind steganalysis schemes.

Another idea is to transmit and receive secret image/video by hiding it on a target mosaic image/video. Here the system considers the secret image and secret video separately and a graphical user interface is provided to select whether a secret image or video is to be transmitted.

The effectiveness of steganography is measured using three parameters. First, the steganographic technique must provide the maximum information. Second, the embedded data must not be perceptible to the viewer. Third, the hidden information should be successfully retrieved at the receiver. It is difficult to recognize the existence of a hidden data in the cover image using the existing methods. This is because embedding is randomly performed in the frequency domain. Another idea proposed by D. Baby, J. Thomas, G. Augustine, E. George, and N. R. Michael for Image securing method using steganoraphy. They proposed a data securing technique that is used for hiding multiple color images into a single color image using the Discrete Wavelet Transform. The color image is split up into R, G, and B planes. Secret images are embedded into these planes. An N-level decomposition of the cover image ad the secret images are done and some frequency components of the esame are combined. Secret images are then extracted from the stego image. Here the stego image obtained has a less perceptible changes compared to the original image with high overall security. Proposed approach provides a good PSNR and SSIM value which establish the robustness of this work. The SSIM value of the secret images shows that the data is successively retrieved at the receiver. DWT is thus found to be a comparatively better approach as it increases payload of the steganographic process by data compression.

Another secure verifiable scheme for secret image sharing was introduced by A. Rose, and S.M. Thampi. They proposed a method to ensure integrity of secret image prior to its recovery is proposed. An n x n secret image and nxn verification image are used to generate shares which are embedded into a cover image for transmission. Structural similarity and mean square error measure of reconstructed verification image with original verification image verifies the coherence of the secret. Computational cost of this method is low which makes it suitable for covert message communication and sharing of scanned documents.

5. CONCLUSION

As listed in the related work, so many researchers have worked on LSB-based steganographic and proposed various methods of hiding message either into the cover image or in the target image like pair-wise LSB matching scheme. Many steganography detection methods are also proposed may be based on statistical method of pixel difference distribution, pair-wise least significant bit (LSB) matching scheme, quantum image steganography, mining and pattern classification, differences between neighboring pixels before and after random data embedding, etc. During our study, I found that more research work is done on the LSB based detection methods rather than improving the hiding strategies. So, we suggests that innovations are also required in the message hiding with the LSB based steganography using colour images as the cover.

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