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Original Article

A Critical and Comparative Study of Data Immersing in Video Steganography

Alaknanda S. Patil [1], G. Sundari [2]

[1]*Research Scholar, Department of ECE, Sathyabama Institute of science and technology, Chennai, India*
[2]*Professor, Department of ECE, Sathyabama Institute of science and technology, Chennai, India*

[1]patilalaknanda@yahoo.com

Abstract — *Because of the rapid expansion of video data on the Internet, video steganography has grown in-demand options. Messages are increasingly being communicated on information superhighway platforms such as YouTube and Facebook, placing a greater real-time impact on the steganography of video. There are various methods for concealing data in video, each with its own set of advantages and disadvantages. Spatial domain methods, transform domain methods, and other methods are some of the several categorizations of current techniques depending on the embedding domain. Because pixel intensity determines how much data is preserved in the Spatial Domain approach, a significant quantity of data may be stored without being seen. However, the grade of video files may degrade after embedding particular sections. It is determined by the authentic multimedia files' colour depth, and the bit's amount injected. The little deterioration is due to the high quality of the pixels and the use of fewer bits. This article's goal is to provide an updated exhaustive review of the multiples of multimedia steganographic methods. When developing a decent steganographic algorithm, security, resilience, embedding payload, embedding efficiency and robustness against attackers are critical considerations. The concept of video steganography can be implemented with Matlab, Java and Python software.*

Keywords — *DNA, Data security, Data embedding, Imperceptibility, Steganography.*

I. INTRODUCTION

The unrevealed information transmission in the video is becoming a crucial practice day by day. The use of wireless communication as well the tremendous usage of the Internet, is insisting on thinking over secret data transmission. The transmission of digital data in an open transmission media can be easily tinkered by prohibited users. By maintaining privacy and security, confidential information can be embedded in the video by cryptography and steganography mechanism. Any video steganographic scheme's video quality and imperceptibility are thought to be crucial characteristics for determining its effectiveness during communication and storage. The authentic information is usually not kept in its real format when data is hidden. The format is transformed into an analogous multimedia file format [1].

Steganography method using video can take place in various forms as – spatial domain, transform domain, spread spectrum technique, statistical technique as well masking and filtering technique [2]. Various cryptography research approaches have been tested, such as Rivest Cipher 4, Data Encryption Standard, Advanced Encryption Standard and Rivest-Shamir-Adleman encryption, where data are embedded in terms of cipher-text with the help of a secret key [3].

A secret key is used to embed encrypted information for later usage in order to strengthen the system's security. The hidden image or video can only be decoded by receivers who have the correct key. The embedder and detector are the two methods that makeup video steganography. There are two data sources in the embedder: the first is the payload, which refers to the number of confidential messages embedded inside of a shield. The second is the cover video, which serves as a shield for the message [4, 5]. Encrypting the secret message before putting it on the cover gives an extra degree of protection to the communication. If the steganography fails and the presence of the message is discovered, the attacker must still crack the Encryption to discover the concealed message [6].

The following factors are critical in the steganography process: imperceptibility, robustness, transmission security, and embedding capacity. Imperceptibility or transparency denotes the invisibility of concealed information contained in the cover parameter without affecting visceral quality through information embedding. The amount of data that may be buried in the cover media without causing apparent distortion is referred to as capacity.

II. LITERARY MONOGRAPH

The video steganography using Least Significant Bit is implemented by many researchers with different combinations in the spatial domain and transform domain. Few of them are elaborated on here.

In work done by A. Swati et al., a data concealing method will be constructed utilizing LSB substitution and a polynomial equation to insert information in specified video frames and specific frame locations. The placement of the message binary bit insertion in the video file is determined using polynomial equations. Key is expressed as a set of polynomial equations with varying coefficients [1].

B. Gupta has given the statistical technique of LSB, which is implemented to hide confidential data by changing various properties of cover media. The message is converted to encrypted text using the Modified Advanced Encryption Standard (MAES) algorithm, which is subsequently hidden in video using the Discrete Wavelet Transformation technique. The frequency-domain analysis is experimented with using 2nd level DWT, and the encoded text is stored in the frame. The masking and filtering technique is utilized to hide information by marking 24-bit and greyscale images. The decoder compares the original cover sequence of alterations to the modified cover sequence and thereby recovers the secret message [2].

T. Idbeaa et al. have explained the data embedding into a compressed movie using the embedding-based byte differencing technique, which seeks to insert data in both inter and intra frames. EBBD covers two types of security: data encryption and data concealment. As a result, confidential data is encrypted using the (S-DES) technique with the PN sequence during the embedding phase. It is a frequency domain analysis. In 64 DCT coefficients, the 2-D DCT is operated on each non-overlapped 8x8 block. The quality metrics evaluated are SSIM and PSNR, which gives a very good perceptual quality [3].

The confidential message is encoded using a mathematical formula, explained by Z. S. Younus et al. The formula makes use of a group of random numbers as the key. These key numbers fluctuate in each execution to maintain the security of the inserted data and to increase the safety of the confidential data. To solve the drawback of the conventional LSB approach, which used a selection of serial pixels. The algorithm of the knight tour is used to pick out the pixels randomly inside the frame of the video used for embedding the unrevealed message. This increases the resilience and the recommended method's security. After that, using the LSB technique in bits, the encrypted unrevealed message is put into the specified pixels (7 and 8). According to the observational data, the put-forward method performs the previous steganography method in terms of quality, higher PSNR and lower MSE [4].

G. S. Issac et al. has worked on the unrevealed image, which is instantly become a visible mosaic picture with secret fragments. This parameter as image resembles a randomly chosen target image. The secret image is covered or hidden by the target image. A lossless data hiding approach employing a key also embeds crucial data for reassembling the concealed image on the mosaic image. Cells are used to split the hidden image, and each cell's colour attributes are changed to match the divided target blocks. Skilful approaches are developed to undertake the colour transformation procedure in order to recreate the hidden image losslessly. The LSB replacement has a lower likelihood of image deterioration and has a higher embedding capacity [5].

Y. Wang et al. have used two different stenographic technologies (LSB and Hamming Code) to improve information security. (3,1) Hamming codes and LSB are used to encode secret messages in the respective channels R, G, and B. Because the image's sharp sections can withstand extra alterations than the smoothened areas. The image's edge regions contain more unrevealed messages, while the smooth regions contain only a small amount of information. Payload capacity, peak signal-to-noise ratio, mean square error, and histogram analysis are used to assess the proposed HLAH method's performance. The results of the experiments reveal that the suggested HLAH approach has a higher inserting capacity than other methods, as well as provides better quality of image [7].

M. Hashemzadeh has given the main proposal of this work as to recognize and use highly dynamic sections in video sequences to hide data. Then the appropriate quantity of data is inserted in the chosen regions. The dynamics of the scenes are studied using motion hints from feature points, and then the interests' regions are chosen accordingly. Some statistical indications acquired from the behaviours of the feature points are used to determine the capacity of inserting for each pixel. The experimental findings on a large database reveal that the suggested strategy outperforms existing methods by a significant margin [8].

P. Dixit et al. have merged two approaches, cryptography and steganography, which is known as metamorphic cryptography. Plaintext messages containing sensitive information are translated to their ASCII equivalents and then converted to binary values. It uses the compression of binary index method to data reduction up to 50%, which results in increasing capacity of payload. The output of the preceding processes is transformed into DNA nucleotide sequences. With the aid of the LSB algorithm, the concept of steganography is implemented [9].

For video steganography, a 3-3-2 LSB-based system was utilized as the foundation by K. Dasgupta et al. The base technique is improved by applying a Genetic Algorithm (GA), which strives for optimal inserted data imperceptibility. An anti-steganalysis investigation is performed to determine the frame's innocence in comparison to the original frame. The suggested system performance is implemented as a VStego Engine, with IDE as Visual C++ 2012 [10].

The goal of this research is decided by A. Fatnassi et al. to provide a multilayered safe channel for transferring sensitive data across an unstable network. The NOLSB technique is utilized to encrypt the unrevealed video first. The generated cypher video is buried in a larger multimedia file. To improve resource usage and optimize bandwidth, this video file is encrypted using the (m,k) firm approach. Then, in order to ensure security, video shares are delivered in the network via many channels. This technology makes sure that multimedia files may be redeemed at the recipient end even if certain parts are lost throughout the network, eliminating the requirement for the sender to send the multimedia file [11] again.

A hash-based least significant bit (LSB) approach is proposed by K. Dasgupta et al. The secret information is contained in the LSB of the cover frames in this spatial domain approach. The secret information is split into eight bits, which are then encoded in the RGB pixel values of the cover frames. The insertion point in LSB bits is chosen using a hash function. The suggested approach is evaluated in the form of PSNR (Peak Signal to Noise Ratio) in comparison to the actual cover video, as well MSE (Mean Square Error) averaged across all video frames between the original and steganographic files. The image fidelity (IF) of the steganographic video file is also assessed, and the findings reveal negligible deterioration [12].

In this approach, the DCT & LSB Modification technique is used for embedding a text file inside a video file while maintaining the video's functionality. V. Bodhak et al. have worked on each block, which is subjected to DCT and compressed using a quantization table. The LSB of each DC coefficient is calculated and replaced with a hidden message bit. This technique employs undetectable change. This suggested solution aims for excellent security due to the impossibility of an eavesdropper to discern buried information [13].

D. Gaikwad et al. have used a steganographic technique for concealing variable-sized hidden messages within video files. Encryption and compression methods are employed here. When the secrete file is huge, compression is utilized before hiding it with the LSB steganography technique. The password serves as a secret for Encryption and decoding. Text and graphic files both can be concealed of various sizes within a movie cover file. The authentication key is used to enter and exit the setup. It makes the setup more robust and safe. Only the authorized user has the ability to hide and reveal the message. To test the system, text and graphic files of various sizes are employed [14].

P. Bhautmage et al. propose a new technique for data embedding and extraction from high-resolution AVI films. Rather than changing the cover file's LSB, the LSB and LSB+3 bits are changed in alternating bytes of the cover file. Prior to the start of the embedding procedure, the confidential message is encrypted with a simple mechanism as bit exchange. An index for hidden information can also be constructed and inserted into a video's frame. One can quickly extract the secret message with the use of this index, which can shorten the extraction time [15].

H. Gupta et al. proposed a method for substituting one, two, or three LSBs of each pixel in a video frame, as well as the use of the Advance encryption standard (AES). Individual frames in a video are extremely difficult to analyze, making an intruder's job tough to assume that a picture is concealed in the movie. The peak to signal noise ratio (PSNR) for 1 bit LSB substations is higher than for 3 bit LSB substations, indicating that as the LSB substation bits' number grows, so does the security level. PSNR is reduced in this article when the number of LSB substation bits is increased while security is also raised [16].

R. Banupriya et al. transformed a video file into sequences of the frame first, and then the movie is encrypted with the Chaos Encryption method. And single frame from the sequence will be chosen to hide the confidential data for safe data transmission. To prevent data hacking, the suggested approach additionally employs RC7 Encryption to encrypt secret text data into cypher text. After encrypting the data, the data hider will use the adaptive LSB embedding method to hide the confidential, encrypted data in the specified frame. The unrevealed data will be retrieved using the necessary key for picking the coefficients of the pixel, and it will be recovered by decrypting the original information using the key of Encryption in the data extraction module. Finally, based on picture and data recovery, the execution of this concept in Encryption and concealment of data will be evaluated [17].

V. Kapoor et al. have suggested a method based on the RGB model's Pixel Value Extraction, which use the LSB insertion technique to hide the text into the video file. After passing various checks on its imperceptibility and capacity, the confidential data is put into frames of video. We did some Quantitative Analysis on several forms of data in this study as well. Peak Signal to Noise Ratio and Mean Square Error is used to analyze the outcome [18].

R. J. Mstafa et al. suggested the approach which is divided into four stages: a) use of Hamming codes (15, 11) to pre-process the confidential message, resulting in an encrypted message; b) detection of face and tracing are used on the shield videos to determine the ROI - a region of interest, which is defined as facial regions; and c) Using an adaptive LSB replacement approach, the encrypted unrevealed message is inserted in the ROIs of multimedia frames. In every face pixel, 1, 2, 3 and 4 LSBs are utilized to insert 3, 6, 9, and 12 bits of the respective confidential information, and d) the secret message is extracted by the RGB colour components of the stego video's facial regions. The suggested approach improves the visual quality of stego movies while also increasing their embedding capability. Furthermore, when compared to state-of-the-art approaches, the two pre-processing stages improve the proposed algorithm's security and resilience [19].

The secret message (English text) is buried by the LSB method in the edges of the frames. AVI movie without affecting the frame details. This technique is implemented in MATLAB R2013a. The secret message was encoded in frames 38,39,40,41 and 42, which were chosen because they contain adequate edge point data. A. M. Aaref has been successful in achieving high embedding and higher quality of encoded secret messages [20].

S. e. Abed et al. present a revolutionary automated system for attaining two layers of video security, which includes encryption and steganography techniques. The approach improves the protection of sensitive data while maintaining the capacity and accuracy of the films. Firstly, the confidential data is encoded using the Java language and the AES - Advanced Encryption Standard algorithm, rendering the unreadable data. Secondly, encoded data is hidden in video pictures utilizing the implementation of FPGA hardware, which converts the data unseeable. The least significant bit (LSB) approach is employed in this study; a 1–1–0 LSB system is used to preserve the extreme imperceptibility of the frame. The video frames are randomly chosen by the randomization algorithm. The randomization approach spreads the data among the frames of video, making it difficult to data retrieval in its original arrangement without a correct key [21].

By marginally perturbing the motion estimation procedures, hidden message bits are inserted into motion vector values. To improve steganographic security (statistical undetectability), two approaches are implemented. First, the motion estimation perturbations are tuned to ensure that the modified motion vectors remain locally optimal, rendering targeted detectors ineffective. Second, a two-tyred coding structure is employed to manage the ME perturbations to minimize the total embedding impact under a particular relative payload. The suggested technique by Y. Cao et al. delivers a substantially greater level of security than other existing motion vector-based approaches, according to experimental data. In the meanwhile, the rebuilt visual quality and coding efficiency are both slightly harmed [22].

Initially, the video file is transformed to picture frames. The Least Significant Bit replacement approach is then used to conceal data in random frames at random locations. N. Kar et al. suggested architecture to evaluate in terms of mean squared error, and peak signal-to-noise ratio assessed of the steganographic and original files and averaged over all frames of video. DNA-based steganography is extremely important in the field of privacy and secure communication. In this paper, DNA properties-based mechanism for sending data disguised within a video file is implemented [23].

TABLE 1. ADVANTAGES AND DISADVANTAGES OF STUDIED TECHNIQUES

Technique	Domain	Reference	Advantages	Disadvantages
LSB & polynomial equation	Spacial domain	[1]	The usage of the key in the term of equations of a polynomial with varying coefficients improves the key's complexity and strength.	Because of the variable coefficients in polynomial equations, it becomes complicated.
Modified Advanced Encryption Standard (MAES) algorithm, DWT & LSB	Frequency domain	[2]	Converting the secret message in cipher text and then hiding this cipher text in video using Discrete Wavelet Transformation technique, which is robust to the common attacks.	It can be easily attacked, such as compression, transformations, etc.
Embedding-based byte differencing (EBBD), DCT & LSB	Frequency domain	[3]	The suggested EBBD has good performance with a superior trade-off in the forms of imperceptibility and payload while ensuring low bitrate rise and little reduction of values of PSNR.	It deals with security concepts: data concealing and data encryption. But PSNR & SSIM results are not so approachable.
Knight Tour Algorithm and LSB	Spacial domain	[4]	To strengthen security, the algorithm of knight tour is used to improve the technique of LSB to insert data in the video frame by random selection of the pixels which were used for inserting instead of serially selected in standard LSB.	Implemented on only. AVI video
Reversible Color Transformation & LSB	Frequency domain	[5]	1. Skilful approaches are developed to undertake the colour transformation procedure in order to recreate the hidden image losslessly. 2. Performance measurements of the suggested approach reveal that it outperforms the existing method in the form of PSNR.	Rarely preferred for grey images
LSB & Hamming code (HLAH)	Spacial domain	[7]	Improves the capacity to hide confidential information and gives hidden image quality with imperceptibility.	Compression resistance is lacking.
motion clues of feature points & LSB	Spacial domain	[8]	0.52 bpp and 50.66 dB are the typical capacity for embedding and perceptual invisibility rate, respectively.	Cover movies with no moving objects or areas cannot be utilized with this strategy.
DNA Sequence, Index Compression & LSB	Spacial domain	[9]	The secret message is converted to ASCII, binary values, and then compressed (50%). This	In this Video steganography, text data insertion is possible, but

			information is contained in the cover using LSB.	audio data insertion is challenging.
Genetic Algorithm (GA) & LSB	Spacial domain	[10]	The two most important factors are believed to be imperceptibility and video quality.	Despite the fact that GA has been highly effective as an optimizer, additional optimizing techniques are in the works.
Near-Optimal Least Significant Bit (NOLSB)	Spacial domain	[11]	Cover video's capacity and robustness are also enhanced, making it more resistant to Steganalysis and statistical assaults.	The NOLSB is the least significant bit in a video pixel's byte value.
A hash-based least significant bit	Spacial domain	[12]	The approach may be used without modification with Flash Video FLV files.	For compressed video formats such as MPEG, the footage must first be decompressed before the approach can be applied to uncompressed video.
DCT & LSB	Frequency domain	[13]	Capability to embed and expose the correct concealed information from a video system without interfering with the new or running application.	Text data insertion is feasible with this Video steganography, but audio data insertion is difficult.
LZW algorithm & LSB	Spacial domain	[14]	Because the compressed clandestine file is hidden using the LSB approach, large amounts of data can be inserted.	This Video steganography allows for the insertion of text and image data, but audio data insertion is challenging.
LSB & LSB+3 bits changing in cover file's alternate bytes	Spacial domain	[15]	The Bit Exchange Method speeds up the extraction process.	Not resistant to compression and not tamper-proof.
Three bit LSB & Advanced encryption standard (AES).	Spacial domain	[16]	For each frame, the autocorrelation between the real image and the encrypted image is computed (Images). As a result of the AES algorithm, Hackers cannot readily hack crucial information with key lengths of 128, 192, and 256 bits.	Text and picture data may be inserted with this Video steganography; however, audio data embedding is difficult.
Chaos Encryption method, RC7 Encryption & LSB	Spacial domain	[17]	The same confidential message is hidden in all frames picked randomly. If a hacker attempts to dump certain steganographed frames, the secret information can still be retrieved from other remaining stegano frames. As a result, it aids in resisting assaults on video clips.	It is not resistant to compression. There is a lot of data insertion going on, and it's a lot of repeatable data insertion going on.
RGB model's Pixel Value Extraction & LSB	Spacial domain	[18]	It can work with MPEG format, AVI & 3GP video file format.	It is less secure at the receiver end.
1, 2, 3 & 4-LSBs	Spacial domain	[19]	The technique proposed increases the stego videos' visual quality while simultaneously boosting their embeddability, robustness & security.	Due to the usage of more LSBs for concealment, there is increased visual distortion. As well, it is not tamper-proof
LSB embedding in the edge of the frames of the. AVI video without	Spacial domain	[20]	Obtaining greater embedding and better encoded secret message quality.	It is not resistant to compression & data is hidden in individual frames.

changing the details of frames				
AES & LSB with FPGA	Spacial domain	[21]	With randomness in frame selection, it provides great frame imperceptibility.	The system is hardware dependent.
A motion vector, motion estimation & DCT	Frequency domain	[22]	Modifying Motion Vectors without compromising their local optimality considerably reduces the likelihood of being found.	Because of the process of motion estimation perturbation, this technique is quite computationally demanding.
DNA based steganography & LSB	Spacial domain	[23]	It causes the steganographic multimedia file to degrade as little as possible.	The complexity of the system is increased by analyzing PSNR, MSE, histogram differences, and pixel correlation.
PVD & LSB	Spacial domain	[24]	CNN algorithm is used to identify authorized users, with 97.47 percent validation accuracy.	Only.AVI video files are supported by this system.

III.FUTURE SCOPE

With respect to the studied analysis of the existing approaches of video steganography, some of the future outlooks are mentioned for further research.

Image communication was made secure by conducting reversible colour modification, which is suggested to implement on video & audio as embedding parameters [5]. The HLSB technique's future potential is a software-based Steganographic Engine for video steganography. It can be worked with audio signal insertion in multimedia [1, 12]. At the moment, data concealment is implemented in compressed video format. Uncompressed video formats may be conceivable for future implementation. Therefore, the MPEG4 format can be supported. Instead of concealing a single frame at a time, concealing multiple frames will be feasible in the future [14]. A key that indicates erratic values collection for picking frames and inserted audio or image files inside a movie may be utilized in conjunction with other ways for selecting pixels, such as the PMM and GLV methods [4]. The FPGA implementation may be expanded to accommodate several LSB techniques (one-bit LSB, two-bit LSB and mix-bit LSB) [21].

IV. CONCLUSION

This study provides an in-depth examination of video steganography techniques. An introduction of steganography employing various cover types was provided, with a focus on the steganography of video and its utilizations. Various codifications of current approaches are shown in combination with LSB technology.

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