A Survey on Medical Images for Reversible Data Hiding Techniques

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Abstract: In the recent trends, technology has advanced so much that most of the individuals are using internet for communication purpose. It became very easy, accurate and fast to send data with the help of internet from one end to another across the world. The major issue while sending data over the internet is the security of the data whether it is personal or confidential. Many of the techniques are there for protecting the data, but data hiding is the most protective technique in data security. Basically, Data hiding is a technique in which secret data is embedded into the cover image and at the receiver side, the host will extract the secret data. Another technique is reversible data hiding (RDH) in which the host can extract the secret data as well as the original image without any loss of data. In this paper, we represent an overview of the recent research in the field of the reversible data hiding techniques, related methods and procedures.

Keywords: data hiding, steganography, embedding capacity, PSNR

I. INTRODUCTION

Technology has always been doing a wonderful job of bringing prominent changes in the life of people. Human beings have been constantly working on newer innovations to facilitate their life on the earth. There has been a revolution in communication with the invention of the computer and mobiles. With these technologies we are becoming fully dependent on them. All these technologies are meant to be discovered for a particular reason like search engines are there in order to manage the huge form of data. Information technology is known as the application for the computers which helps in store, retrieve, transmit, and manipulate data and moreover it helps in control the information frequently related to business or any other enterprise. Now a day's IT (information technology) is used in many fields and one of the popular fields is Medicinal Science, which is further known as Health Information Technology (HIT). HIT is used for making data which helps in both health and health care. More and more health care institutes are using information technology for storing information related to patient's health care which helps in the improvement of their health. But HIT is basically not a health provider only, it also helps the patients to interact with their doctor's in order to learn and share information related to their health issue. It works just like a team that helps in keeping you healthy.

With the ascent of the PCs in 1950's, overall utilization of the computer technology started in the field of the medicines. The main expert association for health informatics was established in Germany by Gustav Wagner in 1949. Health informatics otherwise called HIS (Health Information System) is a discipline at the convergence of information science, software engineering, and medicinal services. Health informatics tools incorporate different benefits like by using electronic health care record we can reduce the use of paper, also its helps in provide accurate information to the doctors, if in case we are consulting more than one doctor. It helps in provide direct access to the patient's health record, so it reduces the unnecessary tests and the procedures from the different doctors. HIT is interlinked with different medical fields like nursing, dentistry, drug store, general health check-up, bio medical research etc. Everywhere throughout the world, numerous progressions have been happened in the field of therapeutic instruction with the advancement of Information technology. It is exceptionally useful to the healthcare sector. The most important and popular advantage that IT has given to health care is electronic health record (EHR) also known as electronic medical records. Personal health records and E-prescribing are also a part of the health information technology. With the assistance of this technology medicinal information can be changed over into a single database. This won't just lessen the utilization of paper yet it likewise enables the medicinal information suppliers to gain the main data of the patients like therapeutic information, drugs, etc. in just a second with a single click of a mouse.

Steganography is a combination of greek words "stegos" which means "cover" and "grafia" which means "writing" and further it is defined as "covered writing". Steganography is basically an art of secret communication by hiding information or message into another image, text, audio or video without anyone knowing about the message is hidden inside. Now a days it is becoming more popular, sending information through the internet is not safe, so it the safest method to send secret information as no one can judge that message is hidden inside the image. Due to its advantages like it provide integrity, confidentiality, authenticity of the data it is much used in the

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medical field, military, corporates, banking sector where communication is hidden.

Information security can be done by using different methods like cryptography, steganography and watermarking. Figure.1 shows some of the information hiding methods. Cryptography basically scrabble the message and on the other hand, steganography hides the message in such a way that there is no knowledge of the existence message inside the information. Steganography is the safest method for sending information on the unsecure zone as compared to cryptography. Watermarking is a technique in which the information which verifies the owner is used to embed into the digital image.

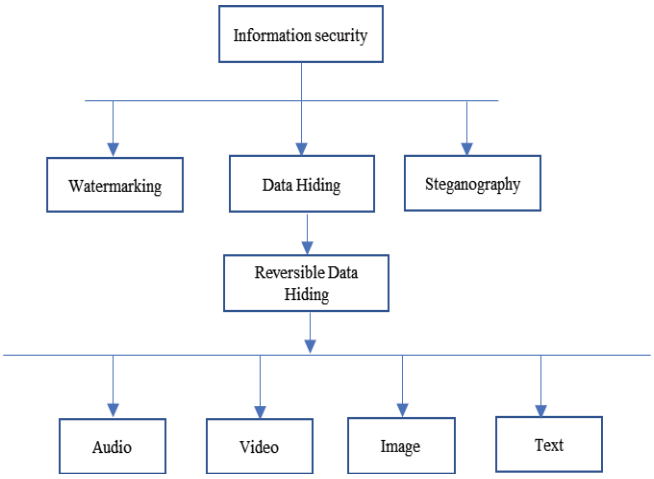

Fig. 1. Types of Information Security

The data embedding process usually result in the loss of the cover image. However, in applications like medical, military forensics and banking loss of the information is not allowed, so in order to get the data lossless, reversible data hiding is introduced. Reversible data hiding is a technique with the help of which data is recovered in its original form after the extrication of the embedded data. In figure 2, it shows the different types of domain comes under reversible data hiding technique.

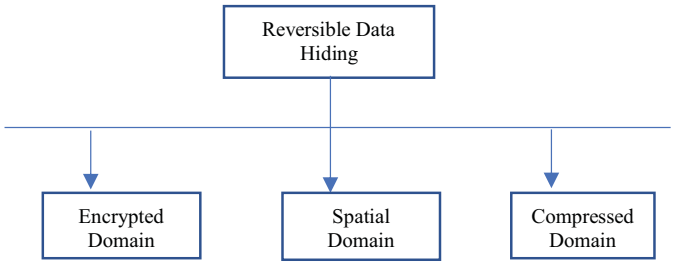

Fig. 2. Reversible Data Hiding

II. RELATED WORK

Different existing techniques that are used for data hiding and extraction of the embedded data are discussed here. Further the related work is divided into three different domains that is spatial domain, encrypted domain and compressed domain.

A. Spatial Domain

First, confirm that you have the correct template for your paper size. This template has been tailored for output on the A4 paper size. If you are using US letter-sized paper, please close this file and download the Microsoft Word, Letter file. Tian [1] proposed a method which embeds secret data bits by modifying pixel pairs by their differences. The embedding capacity is determined using a threshold value. During embedding phase, underflow and overflow issues might occur. Alattar [2] presented an algorithm for embedding reversible by using difference expansion of quads with low level of image distortion. This algorithm hides triplets of bits in the difference expansion of quads of adjacent pixels. The results show that, it is superior to Tian's [1] algorithm in terms of embedding capacity. Lou *et al.* [3] worked on an algorithm based on multiple-layer data hiding technique using reduced difference expansion in spatial domain. Also, they defined the transformation function method in order to decrease the value of the difference expansion. With this, the value of the transformed difference expansion could be close to the cover image. Further, their method provides more embedding capacity as compared to Tian's difference expansion method, at same level of image quality. Fallahpur *et al.* [4] worked on shifting histogram-based algorithm. In this method, first of all, the author divides the whole image into different tiles and then their histogram is being shifted between maximum and minimum range of the frequency. And then the author inserted the data at the pixel level having the maximum frequency. By using this method, the author increased the data hiding capacity as well as the images quality.

Also, this method not only improves the data hiding capacity but also marked images quality. Qershi *et al.* [5] proposed method divides the method into two schemes, in the first scheme both Tian's and Chiang's method were compared, on the other hand they combined both Tian's and Alattar's scheme together. It is observed that the first scheme has lower PSNR and not suitable for X-ray images. Another method provides higher hiding capacity but is visual quality is less as compared to another scheme. Kumar *et al.* [6] presented a method which is lossless and based on histogram shifting technique. The author, increased data hiding capacity with the help of hierarchical block division method, that's why, it becomes more compatible with the medical images. In order to increase the performance for data hiding capacity and PSNR they used optimal recursive method. Huang *et al.* [7] presented a method histogram shifting method for image reversible data hiding by using difference bit-embedding strategy in high bit depth of volume structure medical images. Also, they solve the underflow and overflow problem by applying utilization rate and histogram shifting technique. Yang *et al.* [10] presented a method which helps in the improvement of the image quality

and high data embedding capacity. They adopt a new method known as adaptive threshold detector (ATD) which automatically divides the region of interest (ROI) and non-region of interest (NROI) into two different parts. Further, it approximates (ROI) and (NROI) and then the data is embedded into them. The above method avoids the overflow and underflow information but need to embed the side information as an additional information. Parah *et al*. [11] presented a scheme in which the image is divided into blocks and further that blocks are divided into two types known as seed and non-seed pixels. In this method, they hide the patient's information in the non-seed pixels. They embed checksum bits along with the electronic patient record for tamper detection if it occurs during transmitting the data. In order to prevent from least significant bit removal, embedding is carried on the intermediate significant bit substitution. Gao *et al*. [12] proposed algorithm achieves tamper localization against the attacks on region of interest. Also, this method provides contrast enhancement of the region of interest without any distortion. By using Ostu's automatic optimal thresholding method, they segment the region of interest and the background into two parts. The author expands the peak pairs of the region of interest's histogram so that embedding data as well as contrast enhancement of region of interest, achieved without any distortion. Kanso *et al*. [13] presented scheme divided into two different phases known as shuffling phase and masking phase. Both of the different phases are block based and further they used the chaotic cat map in order to shuffling and masking input image. This type of mixing of the blocks further results in strong chaining of the image blocks, in order to defeat differential attacks. Huang and Lin [15] presented a method in which three neighboring pixels are used to predict the current pixel. They used two histograms for the prediction errors. The author embeds the secret message by using these two histograms in the original image rather than the histogram of the original image. Also, the results show that this method gives purer payload as compared to Ni's [32] algorithm.

Yang *et al* [16] proposed method adopts a new technique called adaptive threshold detector. The above technique is used to separate the region of interest and non-region of interest in to two parts. Contrast enhancement is done on the region of interest by stretching the grayscale and after that data is embedded in the peak bins of the stretched histogram instead of extending the histogram bins. Liu *et al* [17] presented an algorithm in which cover image is partitioned into region of interest and non-region of interest and then image is encrypted using an encryption key. LSB substitution algorithm is used to embed the data. Dmour *et al* [18] worked on private symmetric encryption algorithm for converting the secret data into ciphertext. Edge detection method is used to embed and identify the edge pixels. Hamming code and syndrome trellis code both the methods are used in the enhancement of the mechanism. The secret data is embedded into non-region of interest. Pai *et al* [20] presented an approach related to adaptive threshold detector, further which helps in the segmentation of ROI and NROI. The author used two different methods that is simple least significant bit (SLSB) for hiding secret data in NROI and the remaining data in ROI by using high payload frequency-based reversible image hiding (HPFRIH). Brar and Kaur [22] proposed a method called class dependent coding scheme (CDCS) in order to embed EPR and this will result in the increased of the embedding capacity. Huang *et al* [23] presented a histogram shifting method particularly for reversible data hiding testing on high bit depth medical images. Utilization rate and histogram shifting methods are used in order to avoid underflow/overflow problem. Kim *et al* [24] presented a method which is a combination of three different techniques that is hamming code, least significant bit and optimal pixel adjustment process, which is called as hybrid data hiding. They introduce these methods basically for the security purpose as mismanagement in the data of the patients can cause serious issue. Huang and Fang [25] proposed a method in which they compared two schemes known as histogram and difference expansion scheme and found that histogram-based scheme performs better than another scheme. Also, the above method is more helpful in X-ray or CT medical images. Lee e*t al* [26] proposed an algorithm based on histogram shifting. This method gave higher PSNR value as compared to the Ni's [32] algorithm. Also, this algorithm is quite simple with low execution time. Parah *et al*. [27] proposed a pixel to block conversion technique to ensure the reversibility of the medical images. The patient's information, watermark data and the checksum data, all are embedding by using a method called intermediate significant bit substitution in order to avoid the least significant bit removal or the replacement attack.

The above technique is more efficient than the traditional interpolation methods. Parah *et al* [28] proposed scheme is combination of pixel repetition method and modular arithmetic. The author compares both MOD 4 and MOD 8 techniques with each other. The scheme is mainly tested on the common medical images, test images and some of the images from UCID repository. Dmour and Ani [29] proposed method is a combination of both steganography and cryptography inorder to protect the secret data. Hamming code and syndrome trells code, two message coding methods have been used in order to increase the efficiency. Edge detection method is used to distinguish and embed in the edge pixels and further which results in the improved stego image quality. The confidential data is embedded into the NROI, whereas ROI is preserved for more modifications. Liu *at el* [30] proposed method is a combination of prediction error expansion with sorting technique that embeds EPR in to the ROI and by using the histogram shifting method recovery data is used to embed in the NROI. Mantos and Maglogiannis [31] proposed method divides the region of interest and non-region of interest into two different parts. Data relayed to patient diagnose is embedded into the region of interest and on the other hand location map needed for the recovery of data is kept into non-region of interest. Cryptography is used for the security of the

patient's data. Ni *et al.* [32] presented a method in which the highest, first zero and peak points are obtained then histogram is shifted to right such that peak points are now empty locations and data is embedded in peak points reversibly but according to this method, it is not useful for images having horizontal histogram. Tai *et al*. [33] presented a technique, in which reversibility is obtained by hiding data into the peak value of histogram that is generated by taking pixel difference with its neighbor. First histogram of image is created for error difference among visited and neighbor pixel. For data embedding those pixels are considered whose difference value lies on the peak value of the histogram. Zhang *et al.* [35] proposed a technique in this paper through which performance is improved by making a space before encryption with the help of histogram shifting techniques on estimation errors of some pixels and this emptied room is used for data embedding. First some pixels are selected let say r% denoted by G using encryption key and calculate their estimating error from the surrounding 1-r% pixels, denoted by H using some threshold number. Content owner replace gray values in G with estimated errors and vacate room by modifying histogram of new G, after this G is encrypted differently using a random integer and H is encrypted using AES encryption technique. Zhang [36] proposed a methodology where message can be embedded in encrypted domain jointly and can be regenerated at the receiver side after decryption.

For this first image encryption is done using stream cipher and sends to data hider where he divides the encrypted pixels of image into blocks of same size and embeds a bit in every block. The first blocks are divided into two sets F1 and F2 pseudo-randomly for embedding purpose and then embeds message in it by flipping three LSBs. At the receiver, message can be extracted after decrypting the image. Data bits are extracted by exploiting fluctuation value of block of decrypted image. During calculation of fluctuation value of a block, all block pixels are not included means boundary pixels are excluded from calculation. Wu and Sun [37] proposed a method where pixels in block are to form two sets. Selection is made in such a way that selected pixel's neighbour pixels always remain not selected and thus not contribute in data embedding hence increased PSNR is achieved, because not all pixels in a set is changed and also improved bit error rate is achieved. Data extraction is done using adaptive interpolation technique. Hong *et al*. [38] proposed an enhanced variant of Zhang's [35] reversible data hiding strategy in embedding of the images. There results show that the above method gave good performance than the Zhang's work. Liao and Changwen [39] presented the extended work of Zhang and Hong. Like previous methodology, first image encryption is done using stream cipher then image blocks are separated into overlapping blocks. For embedding, each and every block is pseudo-randomly partitioned into two sub-partitions, M0 and M1 and according to embedded bit three LSB of the sub partition are modified. In this technique, fluctuation function is modified by calculating different fluctuation values for three categories of pixels in a block that is pixel with two neighbors, pixels with three neighbors and pixels with four neighbors. Puech *et al.* [40] proposed data embedding in encrypted domain reversibly. They use AES encryption algorithm for hiding the image content. An image is separated into different blocks of equal size and then they are encrypted by using AES encryption algorithm. For data hiding, bit-substitution function is used to hide bit in each encrypted block.

B. Encrypted Domain

Liu *et al*. [8] presented a method which is a combination of PEE (prediction error expansion) and sorting technique. They embed the patient's information into the ROI by combining the prediction expansion error and the sorting technique. For the recovery purpose they embed another information in the non-region of interest (RONI) by using histogram shifting technique. Parah *et al*. [9] presented a scheme which is known as pixel to block conversion. They used chaotic encryption technique for the security of the data to be embedded. Checksum bits are generated to overcome the problem of tamper detection and localization. They used intermediate significant bit substitution (ISBS) for embedding EPR, checksum and watermark data. Qian *et al*. [34] presented a different method that is feasible for block-enciphered images. By using the encryption key and block cipher algorithm the sender encrypts the original image, before information is uploaded to a remote server. Kumar *et al*. [41] proposed a strategy which utilizes histogram shifting and difference expansion with the end goal to extricate the original image and bio-medical information. Every pixel is encoded by open key of paillier cryptosystem algorithm. The homomorphic multiplication is utilized to grow the histogram of the image in encrypted domain. The histogram shifting is done in the encrypted domain based on homomorphic addition and adjacent pixel difference. The message is embedded into the host picture pixel difference. On the receiver side, the encrypted image with additional data is decrypted by the receiver using his private key. Wang *et al.* [43] presented a scheme which specifically uses four least significant bits of the original image in order to hide the confidential data and a mapping technique called logistic mapping is employed to scramble cover image before embedding operation. Aydogan and Bayilms [44] proposed a block based matching technique which is used to embed information related to patient's diagnosis. Author introduced eight different scanning orders in which six are newly developed scanning orders and further it will help in the improvement of the image quality.

C. Compressed Domain

Wu *et al*. [14] presented an algorithm based on spatial additive watermarking, which is further combined with the modulo addition method. The above method provides authenticity and protection of the image. They only considered one square ROI in the above method. Rani and Lakshmanan [19] proposed a run length encoding compression technique in this paper. The

algorithm is divided into three different phase that is phase one where data is to be hidden. The image is being compressed in the second phase and in third phase the image is decompressed to get the secret data. Chao *et al* [21] presented a scheme based on bipolar multiple-base conversion. It allows different types of electronic patient record (EPR) information to be hide in the identical mark. Basically, above method provide integration, safeness, privacy, validation, processing time complexity and frequency to change a key. Rani and Lakshmanan [42] proposed a run length encoding method in order to compress the medical image. This method is divided into three different phases, in the first phase text data is hidden in the medical image. In the second phase compression is performed on the stego images and decompression is performed in the third phase so that hidden data is retrieved Chang *et al*. [45] presented a scheme for encryption of JPEG bit streams. He constructed a method by using reserving-room-before-encryption manner, in which cover JPEG bitstream is meant to be reconstructed with tiny distortion, so that the reserve space is enough for further embedding of data after that the modified JPEG is meant to be encrypted.

III. CONCLUSION

This paper provides a brief description of the various methods or techniques used in the reversible data hiding. Also, it is categories in three different domains i.e spatial, encrypted and compressed domain. It focuses mainly on hiding the data and then comparing the results. Some of the method shows large embedding capacity and some shows low embedding capacity. In some cases, distortion has a huge effect on both the data and image but in some cases it is negligible. For the security point of view, it is necessary to develop an effective system which provides embedding capacity and recovery with any loss of data.

TABLE I: Comparison of Different Methodsbased on PSNR and Embedding Rate

Author's name	Domain	Method	PSNR (dB)	Embedding rate (bpp)
Chao *et al.* [21]	Compressed	Bipolar TER multiple-base algorithm	42.6	Not mentioned
Tian [1]	Spatial	Difference expansion	44	0. 15
Alattar [2]	Spatial	Difference expansion	43.58	3
Tai *et al.* [33]	Spatial	Pixel value difference	48.35	0.08
Puech *et al*. [40]	Spatial	Advanced encryption standard algorithm	66.13	0.06
Wu *et al*. [14]	Compressed	Modulo 256	49.6	Not mentioned
Luo *et al*. [3]	Spatial	Difference expansion	42.91	0.5
Qershi. [11]	Spatial	Difference expansion	40.12	0.74
Rani *et al* [19]	Compressed	Run-length encoding	48.32	0.5
Liao and Changwen. [39]	Spatial	Absolute mean difference	37.85	1
Kumar *et al*. [41	Encrypted	Paillier cryptosystem algorithm	53.9	0.27

TABLE II: Comparison of Different Methodsbased on PSNR and Embedding Rate

Author's name	Domain	Method	PSNR (dB)	Embedding rate (bpp)
Dmour *et al.* [29]	Spatial	Hamming code and Syndrome Trellis code	68.28	1
Liu *et al.* [8]	Encrypted	LSB substitution	102.25	0.5
Parah *et al*. [9]	Encrypted	Pixel to block	46.36	0.75
Rani *et al.* [42]	Compressed	Run-length encoding	44.22	0.5
Yang *et al*. [10]	Spatial	Contrast stretching	16.52	3
Aydogan *et al*. [44]	Encrypted	Scanning order selection	56.6	0.5
Parah *et al*. [11]	Spatial	ISBN	46.84	0.75
Kim *et al*. [24]	Spatial	Hamming code, LSB, OPAP	50	1.99
Wang *et al* [43]	Encrypted	LSB substitution	54.47	0.99
Parah *et al*. [28]	Spatial	Pixel repetition method	39.25	2.25

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