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Hybrid transform based reversible watermarking technique for medical images in telemedicine applications

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Abstract

In telemedicine, medical images are broadcast in a secured manner and received correctly without any loss. This paper proposes a novel reversible watermarking technique in transform domain for medical images without any additional key information. In traditional transform based watermarking method, the embedding capacity is less also requires additional key information for lossless recovery of the original image at the extraction side. This paper overcomes that difficulty in transform domain by using a novel hybrid reversible watermarking algorithm to increase the embedding capacity. Integer wavelet transform (IWT) and Discrete Gould transform (DGT) are used to develop a secure and reversible medical image watermarking. At the sender side, watermark information is embedded within a wavelet sub band using DGT and at the receiver side, the embedded watermark is extracted and the exact original medical image is reconstructed without any additional information. Experimental results for medical images and ordinary images show that the

proposed method meets out the requirements of the image watermarking system such as imperceptibility, capacity, reversibility and robustness. The output of the proposed method is superior to the existing methods

Introduction

In a digital world, with the fast development of information and communication technology, the information is transmitted from one location to another location. During transmission over the digital media, the information may get forged by the unauthorized people. So information protection is needed during transmission through an unsecured medium. Information hiding is the art of protecting the information in a secured manner. Steganography and watermarking techniques are two main categories of information hiding. Both will hide the secret information within a cover media (text, image, audio, and video). But steganography obscure the existence of secret information and can be used for one-to-one communication. In watermarking, the existence of information is known or unknown and is used for one-to-many communication. Steganography system fails when the secret information is known. The watermarking system fails when the secret information is removed or manipulated.

With the fast growth of telemedicine, medical images are mainly used for diagnosis. Medical information is highly valuable and sensitive due to the importance in diagnosis, treatment and research [1], [2], [3]. Transmitting medical information through a public network leads security issues like modify, remove, unauthorized access, etc. Therefore, it is essential to protect the medical information. Digital image watermarking provides a high security and privacy for medical images. In medical image watermarking, electronic patient record (EPR) is embedded in a medical image without any noticeable changes in the medical image [2], [4], [5]. In telemedicine, for diagnosis, the medical images are transmitted to the remote specialists with patient information. At the remote side, there is a need to recover the medical image without loss, because small distortion/changes lead to wrong diagnosis. Lossless information hiding called reversible image watermarking technique is must for secure transmission of medical images. Reversible watermarking provides imperceptible, robustness, high payload capacity with the lossless recovery of medical images [1], [2], [3], [4], [5], [6], [7], [8], [9], [19]. Now, many researchers introduce a reversible medical image watermarking in telemedicine.

Reversible image watermarking is mainly performed by Difference Expansion (DE) [10], [11], [12], Histogram shifting (HS) [13], [14], compression [15], [16] and different transform techniques [17], [18], [19], [20].

In [10], Tian proposed a DE based reversible watermarking method. The adjacent pixel difference value is shifted in order to embed secret information within a cover image. A Location map is considered as additional data for lossless recovery of the original image. It is also transmitted along with the original image to the receiver.

A region based reversible watermarking scheme [11] was proposed based on interpolation error expansion. With the help of interpolation technique, non-sampled pixel interpolation error values are identified. Using histogram, this error values are expanded to embed secret information and preserve the high image quality. In [12], prediction error expansion based reversible information hiding scheme is proposed. Three neighboring pixels are used to calculate the prediction error of the current pixel. By expanding the calculated prediction error, the secret data is embedded with high embedding capacity. At the receiver side, the secret data extracted and the original image is reconstructed without any loss.

In [13], HS based reversible data hiding was developed using a pair of points. The histogram is shifted towards left side or right side depends on the pair of points and space was encountered to embed secret data. At the receiver side, using the same pair of points, secret data are extracted. Reversible data hiding [14], an extended version of [13], which stored pair of point within its neighboring pixels to avoid peak point transmission and also recover the original image with the help of additional information without any loss.

For the lossless recovery of the original image, in data hiding technique, some auxiliary information is needed and it is embedded along with secret information within a cover image. It reduces the embedding capacity and affects the image quality. To avoid this situation, compression technique is needed. Companding based reversible watermarking technique using integer wavelet transform (IWT) is proposed [15]. Depending on the threshold value, the wavelet coefficients are compressed, which are having the values more than the threshold and they carry the secret information. In [16], a novel adaptive thresholding based companding reversible watermarking technique is developed. With block based reversible watermarking, the secret information is embedded, extracted and also the original image is recovered without any loss. It avoids histogram pre and post processing and improves the image quality.

In [17] using discrete wavelet transform (DWT), the cover image is divided into 4 sub bands. Two sub bands are considered for watermarking. Two parts of watermark are embedded within a singular value DWT sub bands of the cover image. In [25], Lifting wavelet transform (LWT) is applied to original image. Then, LH3 sub band coefficients are shuffled randomly and grouped into blocks. Again, all the grouped blocks are shuffled. From shuffled block, significant region blocks are identified to embed a shuffled watermark bit. All the

modified blocks and coefficients again reshuffled and inverse LWT is applied to form a watermarked image. At the extraction side, the same embedding procedure is performed. The watermark is extracted using the embedding index values. In [18], [19] a new transform based reversible watermarking is developed using slantlet transform (SLT). The original image is divided into blocks and the SLT is applied to each block. Then maximum absolute mean value is calculated. Using histogram modification, the secret message bits are embedded. To extract secret message and recover the original image correctly, the embedding positions are considered as side information and transmitted to the receiver along with the watermarked image. Robust and secure watermarking technique is developed using IWT and singular value decomposition (SVD) [20]. Image watermark and its generated digital signature are embedded within singular values of the wavelet coefficients. So the ownership is authenticated first at the extraction side, in order to verify the authentication, before watermark extraction.

Section snippets

Related work

In telemedicine application, the robust, reversible and blind medical image watermarking technique is required for secure medical data transmission. In [21] blind, fragile watermarking method is proposed for medical images based on Region of Interest (ROI). Manually the ROI region is selected first, and then hashes value of selected is generated using SHA-256. To increase the security level, one-to-one mapping function is used. Patient information is encrypted using advanced encryption standard

Integer wavelet transform

Normally in recent transform based research work, DWT is used. But it is not suitable for lossless data hiding. Because the integer pixel value is converted to floating point using conventional wavelet transform. During embedding, the values are changed. At the receiver side, there is no guarantee of extracting the original integer values of the floating point

values. Some values are truncated. It affects the entire recovery process, diagnosis process and also leads to wrong results. So to

Experimental results and discussion

To evaluate the proposed reversible watermarking technique, several types of ordinary images from the website [40], [41] and original medical images from Anbu hospital, Kumbakonam, Tamilnadu, are used. All the images are converted to grayscale and resized to 512×512. The proposed method is evaluated based on four important characteristics of the image watermarking technique such as imperceptibility, reversibility, capacity and robustness. Imperceptible referred as, embedded watermark in the

Conclusion

In this paper, a novel blind reversible medical image watermarking technique is proposed using a hybrid technique in the transform domain for secure transmission of medical data. By applying IWT to cover medical image, the proposed method obtains the high frequency subbands. In these subbands, non-overlapping blocks are identified and DGT is applied for embedding the EPR. At the receiver side, the original medical image and the watermark information are extracted as it is on the sender side.

Conflicts of interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Recommended articles

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>
> ...Although the scheme extracts both the watermark with zero error and recover original image perfectly but at the cost of perceptual quality of the watermarked images, the embedding capacity is also very low (0.08 bpp). In Selvam, Balachandran, Iyer, and Jayabal (2017) proposed a transform domain based reversible watermarking technique for medical images using Integer Wavelet Transform (IWT) for the decomposition of cover image into the frequency sub-bands and applying Discrete Gould transform (DGT) to the non-overlapping blocks of high frequency sub-bands. Depending upon the embedded watermark bit in a block, a DGT coefficient of that block is modified....

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