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A Reversible Data Hiding Scheme for Efficient Management of Tele-Ophthalmological Data

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ABSTRACT

Advancements in medical sciences and induction of advanced technologies have led to increased role of medical images in tele-diagnosis. This paper proposes a technique for easy, efficient and accurate management of distributed medical databases and alleviates the risk of any distortion in images during transmission. It also provides remedy of issues like tampering, accidentally or intentionally, authentication and reliability without affecting the perceptual properties of the image. The technique is blind and completely reversible. Values of PSNR and BER imply that the changes made to original images are imperceptible to the Human Visual System. Performance of the technique has been evaluated for fundus images and the results are extremely encouraging. The technique is lossless and conforms to the firm necessities of medical data management by maintaining perceptual quality and diagnostic significance of the images, therefore is very practical to be used in health care centers.

KEYWORDS

Blind, Data Hiding, Fundus Images, Lossless, Medical Image Watermarking, Reversible, Tele-Ophthalmology, Watermarking

INTRODUCTION

Advancements in medical domain have led to the growth of a range of electronic medical appliances for the purpose of diagnosis and cure of diseases. Improvements in communication techniques through internet allow for remote access of this medical diagnostic information for manifold purposes like tele-diagnosis and tele-consultation.

In majority of hospitals and health care centers, the patient related information and associated medical images are stored independently in large databases as different files. Storage and distribution of these images require a key, patient's name or unique ID, for identification of images. The images, if detached from records, can lose their identity (Goldbaum et al., 1990, Singh et al., 2016). Therefore, patient details and medical images should be properly structured, so as to avoid mistreatment and loss of data. Also, this data is not protected from any illegal access and may be manipulated easily. So, there is an urgent necessity to protect and handle this data unfailingly. For authentication purposes, it is essential that some watermark with identity of patient must be embedded in the original image itself (Meher et al., 2006). This can be achieved by watermarking or data hiding. However, the embedding procedure will deform the images. These changes due to the insertion process are not acceptable to medical practitioners because deformation may make the modified medical images unfit for advance diagnosis. Therefore, it is important to strike the best possible balance between

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embedding capacity and the image quality as the requirements in medical images are different from those of general functions of data hiding.

The reversible data hiding schemes may be the solution for this difficulty. Reversible data hiding gives the capability to recover the exact cover image after the extraction of watermark. The lossless insertion may increase the size of the original image but after extraction of data, original image is recovered in its original size (Rocek et al., 2016; Celik et al., 2006). Lossy insertion process cannot be applied in medical applications. Reversibility can be assured if adequate free space can be found or formed to hide the data within the host image while maintaining the features of the cover uncontaminated. In medical applications, the deformations after removing the watermark should be zero (Fridrich et al., 2002).

Studies on medical image watermarking have identified three possible classes of algorithms (Coatrieux et al., 2006). The first-class techniques are those which embed the data in Region of Non-Interest (RONI) while leaving the Region of Interest (ROI) to medical practitioner (Anisha Joseph et al., 2015; Coatrieux et al., 2013; Eswaraiah et al., 2015). The second-class methods are based on reversible watermarking (Irany et al., 2011; Gouenou Coatrieux et al., 2013, Singh et al., 2016). As soon as hidden information is extracted, original image can be retrieved. Third category is based on non-reversible traditional watermarking techniques which bring in minimal alteration up to acceptable limits (Dutta et al, 2014, Dutta et al., 2015).

Watermarking process can be carried out in two major domains namely, spatial and frequency. The spatial domain based techniques started with LSB (Least Significant Bit) substitution (Shanmugam et al., 2008; Eswaraiah et al., 2012; Velumanil et al., 2010, Sharma et al., 2015). In frequency domain, watermark is hidden in transform domain coefficients. For the reason that the watermark is spread across the image, this practice is not vulnerable to numerous attacks (Chen et al., 2012; Karasad et al., 2016; Dey et al., 2012; Kumar et. al., 2013, Poonkuntran et. al. 2014). Literature review reveals that the techniques mentioned have several disadvantages like some of them are irreversible, some have tedious task of deciding and separating ROI from RONI and many are not perfectly reversible. Therefore, a need was felt to develop a technique which would have zero distortion effect on the image after extraction of hidden data.

The main contribution of this paper is a data hiding scheme for fundus images which may assist tele-ophthalmological applications. The proposed scheme is fragile which means that if the image is manipulated by any means, either legal or ethical, the image will be declared unfit for advance diagnosis. Watermark contains patient information as name, id, and date of image acquisition, thus making the image self-identifiable. This proposed scheme completely satisfies the primary requirement of watermarking in medical images that the distortion in recovered image at receiver's side should be zero so that accurate diagnosis of image can be done.

Other challenge in this context is to devise a lossless as well as blind data hiding scheme. This approach satisfies both the design requirements. At the receiver side, only modified image is required for extraction of hidden data, thus categorizing this scheme as blind. The proposed method is lossless which declares it to be appropriate for medical images as no information is tampered in the recovered image at receiver's side. This scheme has been validated on publicly available DRIVE database which indicates that it has potential applications in the areas where images contain very sensitive data and conforms to the firm necessities of medical data management by maintaining their perceptual quality and diagnostic significance.

Rest of the paper is organized as follows. The need for watermarking of medical data is given in Section 2; the choice of data hiding technique is presented in Section 3. Section 4 presents the proposed data hiding algorithm. Section 5 shows the experimental results and comparison with