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Unique identification code for medical fundus images using blood vessel pattern for tele-ophthalmology applications

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ABSTRACT

Background and objective: Identification of fundus images during transmission and storage in database for tele-ophthalmology applications is an important issue in modern era. The proposed work presents a novel accurate method for generation of unique identification code for identification of fundus images for tele-ophthalmology applications and storage in databases. Unlike existing methods of steganography and watermarking, this method does not tamper the medical image as nothing is embedded in this approach and there is no loss of medical information.

Methods: Strategic combination of unique blood vessel pattern and patient ID is considered for generation of unique identification code for the digital fundus images. Segmented blood vessel pattern near the optic disc is strategically combined with patient ID for generation of a unique identification code for the image.

Results: The proposed method of medical image identification is tested on the publically available DRIVE and MESSIDOR database of fundus image and results are encouraging.

Conclusions: Experimental results indicate the uniqueness of identification code and lossless recovery of patient identity from unique identification code for integrity verification of fundus images.

1. Introduction

Sharing of medical images has wide variety of applications like tele-diagnosis, tele-surgery, tele-medicine, tele-opthalmology, etc. It has been found that security and identification of medical images have been a critical issue for the patients [1,2] in these applications. Patient identification and distinct identification are important requirements in clinical practices to prevent medical errors. Accurate identification of medical image is a serious issue as any error in such cases can cause threat to proper diagnosis. In addition to transmission of medical images, the issue of correct identification is required for medical images when stored in databases. Hence there is a need to develop efficient and secure algorithms for correct identification of medical images during transmission and storage for such applications.

The existing work to solve the issue of medical image identification is based on steganography and medical image watermarking methods. In the existing literature, different watermarking methods have been proposed to verify medical image integrity. The methods of medical image watermarking can be broadly classified in three different categories [3]. The first category is based on the segmentation of medical image into medically informative (ROI) and noninformative

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regions (RONI), and then medically noninformative regions are considered for hiding the patent identity. Qershi et al. [4] developed a hybrid ROI-based watermarking method in which the medical image is divided into three regions: ROI, RONI, and border pixels, and then the patient's ID and hash value of ROI are embedded inside ROI using modified DE technique. Wu et al. [5] developed region based watermarking methods for medical image identification by embedding patient information into medically noninformative region. Kim et al. [6] proposed a region-based tampering detection and restoring scheme based on image homogeneity analysis for medical image identification and integrity verification.

The second category in medical image watermarking is the reversible watermarking method that ensures that original image is completely recovered without losing any information of the image. Gouenou Coatrieux et al. [7,8] developed algorithms for reversible Watermarking to solve the issue of medical image identification. Hirak Kumar Maitya et al. [9], Feng Bao et al. [10], Muhammad Arsalan et al. [11] reported reversible image watermarking methods for medical image identification and integrity verification.

In the third category of watermarking methods, the patient ID is embedded in the host images without degrading the quality of image to an extent where the medical information in the image is not lost. Vleeschouwer et al. [12], Malay Kishore Dutta et al. [13,14] developed image watermarking algorithms for correct identification of medical images during transmission and storage in such applications.

Robust and imperceptible image watermarking method can be an option to solve the issue of image identification but it may tamper the image and there may be loss of medical information in the image. In the case of medical image identification where any compromise with information loss is not acceptable, watermarking method is not a right choice as any error in such cases can cause threat to proper diagnosis. Hence, there is a need to develop algorithms for accurate identification of medical images without causing any loss of medical information. This paper presents an algorithm for unique identification code generation for medical image identification for tele-medicine applications. This work proposes an algorithm for generation of unique identification code for accurate identification of medical images in such applications and also may be useful for identification of medical images in databases.

The main contribution of this paper is an algorithm to generate unique identification code for fundus images to provide a possible solution in the direction of medical image identification for tele-ophthalmology applications. Local features from the blood vessels of the image are used to generate a unique pattern which ensures that it will comply for accurate identification. This unique pattern is strategically combined with a patient ID resulting into a unique identification code (UIC) making the method a full proof framework for distinct identification of medical images. At the diagnosis center the patient ID is accurately recovered from the unique identification code for that particular image to solve the issue of integrity verification.

Another significant contribution of the proposed method is unlike existing methods of steganography and watermarking, here there is no tampering or embedding in the medical image and hence there is no degradation in the quality of the image. The encryption method used is lossless ensuring that the unique identification code retains all the information. This may be considered as a significant development to ensure distinct identification of medical images accurately without loss of information.

The proposed algorithm seems to be an appropriate solution to solve the issue of threat of loss of identity of medical images during transmission and data storage. The proposed method may be of great help in tele-ophthalmology applications where perfect and uncompromised identification is required for medical images as this has direct relevance to proper diagnosis.

The rest of the paper is organized as follows. Section 2 tells the design challenges associated with generation of identification code for medical images. Section 3 describes the unique features of the fundus image which are used for generation of identification code. The next section discusses the proposed methodology, including the generation of unique identification code for fundus image and recovery of patient ID for integrity verification of image. Section 5 presents the experimental results, and the next section includes the final discussion and remarks on experimental results. Section 7 draws a conclusion to the paper and discusses some future works which may be possible in this area of work.

2. The design challenges in identification code generation for medical images

There are design challenges associated in identification code generation for medical images to address the issue of medical image identification during transmission and storage of medical images in tele-ophthalmology applications. Some of the design challenges are mentioned below:

1. The identification code used for medical image security should be unique so that the particular image is uniquely identified in medical image database. The generated identification code should be visibly noninformative to maintain the security of medical information and patient ID.
2. The identification code should be generated without any loss of medical information. In the case of medical images, loss of medical information is not acceptable as it may cause threat to proper diagnosis.
3. For integrity verification of medical images, there should be lossless recovery of patient identity from that generated unique identification code for medical images.

Considering these design requirements in generation of identification code, there is a need to find unique features in fundus image to generate unique identification code.

3. Fundus image—unique features

Fundus image is the photograph of the interior surface of the eye, which includes the retinal blood vessels, optic disk and macula. Optic disc is a bright spot where retinal blood vessels converge. Fig. 1 represents digital fundus image of left and right eye. Optic disc, macula, fovea and bold vessels are marked in the fundus image shown below: