Carrying Digital Watermarking for Medical Images using Mobile Devices

K. Ravali[1], P. Ashok Kumar[2], Srinivasulu Asadi[1]

[1]Dept of IT,S.V.E.C, Tirupati J.N.T.Univeristy, Anantapur,A.P - 517102, India
[2]Dept of MCA,S.V.I.M, Tirupati,S.V University, Tirupati,A.P - 517102, India

Abstract-In medical facilities, mobile devices provide the medium for remote diagnosis and information retrieval. Mobile devices aid medical personnel by allowing them to access information ubiquitously. The medical doctor or radiologist may use his mobile device to view patient's medical images. But security and privacy is the major issue for such type of remote diagnosis. The existing system does not support remote diagnosis over mobile communication network. Therefore, in the proposed system remote diagnosis is supported, where a doctor can verify the medical images in his mobile device, though he is far away from the patient. This Telemedicine application requires authentication for safe transmission. The Region of Interest (ROI) is the crucial part for accurate diagnosis and should not be disturbed. To overcome this problem, image segmentation is applied to select only the required portion of medical image and Digital Watermarking using Discrete Cosine Transform is applied to the medical images in the portions of Region of Non Interest (RONI). The mobile devices cannot store large image files and transmission requires more bandwidth. So compression is applied on the image that is to be transmitted.

General Terms-Telemedicine, Medicinal Imaging, Segmentation, Digital Watermarking,.

Keywords-Watermarking, Digital Watermarking, Telemedicine, Medical imaging, discrete cosine transform (DCT).

1. INTRODUCTION

Telemedicine facilitates the provision of medical aid from a distance. It is an effective solution for providing specialty healthcare in the form of improved access and reduced cost to the patients and the reduced professional isolation of the doctors. Telemedicine [1] can enable ordinary doctors to perform extra-ordinary tasks.

1.1 Telemedicine:

The delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities.

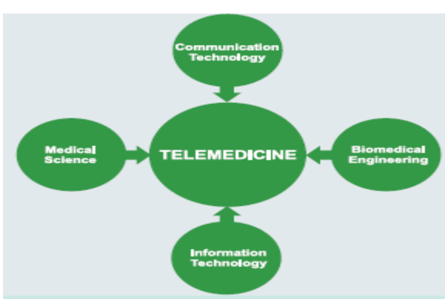

Fig 1.1: Telemedicine and its ingredients

1.2 Technology of Telemedicine:

Telemedicine is a confluence of Communication Technology, Information Technology, Biomedical Engineering [2] and Medical Science. The Telemedicine system consists of customized hardware and software at both the Patient and Specialist doctor ends with some of the Diagnostic Equipments like ECG, X-ray and pathology Microscope/Camera provided at the patient end.

Through a Telemedicine system consisting of simple computer with communication systems, the medical images and other information pertaining to the patients can be sent to the specialist doctors, either in advance or on a real time basis through the satellite link in the form of Digital Data Packets [3]. These packets are received at the specialist centre, the images and other information is reconstructed so that the specialist doctor can study the data, perform diagnosis, interact with the patient and suggest the appropriate treatment during a Video Conference with the patient end. Telemedicine facility thus enables the specialist doctor and the patient separated by thousands of kilometers to see visually and talk to each other.

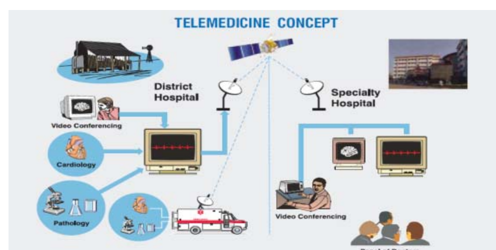

Fig 1.2: Concept of Telemedicine

1.3 Mobile Telemedicine System:

A mobile telemedicine system [4] provides a platform for data acquisition from numerous instruments and its harmonious transmission and delivery to healthcare providers through 3G-based wireless networks. Because this system can be used in any geographical area in which 3G networks provide coverage, it offers significant hope in reducing mortality and morbidity as well as presenting monetary savings. Below are a number of scenarios that benefit from the use of 3G-based wireless networks. A teletrauma system can provide continuous real-time voice, video, and medical data input between an ambulance and a level I trauma center. This system benefits pre-hospital trauma care, especially in situations where long transport time or multiple transfers are involved. Such a solution can improve the quality of trauma care, expediting the evaluation and management of injured victims, thereby increasing the chances of timely and appropriate actions. The only constraint imposed on the patient's location is that it needs to be covered by a 3G wireless network.

Mobile devices are widely available to both consumers and businesses at affordable prices. These devices have the computational power to achieve tasks that were infeasible a few years ago. In medical facilities, mobile devices provide the medium for remote diagnosis and information retrieval. However, there are strict privacy issues that must be met.

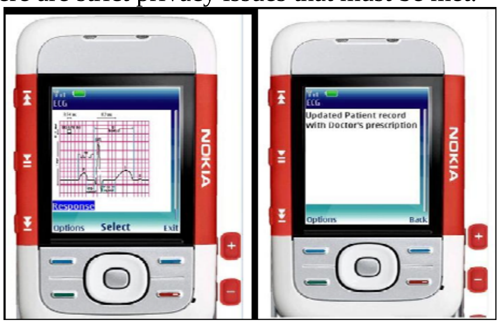

Fig 1.3 Telemedicine over Mobile Devices

1.4 Security in Telemedicine:

For any effective Telemedicine application, security plays a vital role. This is because even a small tamper done on medical image, results in misdiagnosis. So, in this regards various watermarking systems have been introduced in the field of telemedicine.

Watermarking [6] is embedding data directly into a file data like audio, video and images, usually by making minor variations to pixel brightness. Watermarks are not text that is included in the file description "Comments" field. The variations in the data bits are subtle and cannot be detected by the human eye. The patterns are repeated many times, allowing the information contained in the watermark to be recovered even if the image is cropped.

2. RELATED WORK:

Various digital watermarking techniques like Medical imaging, Segmentation, Wavelet Transform, Cryptography, and Stenography are studied.

Digital audio, video, and pictures are increasingly furnished with distinguishing but imperceptible marks, which may contain a hidden copyright notice or serial number or even help to prevent unauthorized copying directly. Military communications systems make increasing use of traffic security techniques which, rather than merely concealing the content of a message using encryption, seek to conceal its sender, its receiver or its very existence. Similar techniques are used in some mobile phone systems and schemes proposed for digital elections. A common use of information hiding is to hide the physical storage layout for data so that if it is changed, the change is restricted to a small subset of the total program.

3. DISCRETE COSINE TRANSFORM:

A discrete cosine transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio and images (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient (as explained below, fewer are needed to approximate a typical signal), whereas for differential equations the cosines express a particular choice of boundary conditions.

In particular, a DCT [12] is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common.

The main advantages of DCT are, Efficiency, Basic vectors are comprised of entirely real valued components; It is purely real and easy.

The main advantage with DCT is that only performs spatial correlation of the pixels inside the single 2d block is considered and the correlation from the pixels of neighboring blocks is neglected.

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$$X_k = \sum_{n=0}^{N-1} x_n \cos\left[\frac{\pi}{N}\left(n+\frac{1}{2}\right)\left(k+\frac{1}{2}\right)\right] \qquad k = 0, \dots, N-1.$$

3.1 Discrete wavelet transform

A discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency and location information (location in time).

The discrete wavelet transform has a huge number of applications in science, engineering, and mathematics and computer science. Most notably, it is used for signal coding, to represent a discrete signal in a more redundant form, often as a preconditioning for data compression

3.2 Digital Watermarking:

The advent of the Internet has resulted in many new opportunities for the creation and delivery of content in digital form. Applications include electronic advertising, real time video and audio delivery, digital repositories and libraries, and Web publishing. An important issue that arises in these applications is the protection of the rights of all participants. It has been recognized for quite some time that current copyright laws are inadequate for dealing with digital data. This has led to an interest towards developing new copy deterrence and protection mechanisms. One such effort that has been attracting increasing interest is based on digital watermarking techniques. Digital watermarking is the process of embedding information into digital multimedia content such that the information (which we call the watermark) can later be extracted or detected for a variety of purposes including copy prevention and control. Digital watermarking has become an active and important area of research, and development and commercialization of watermarking techniques is being deemed essential to help address some of the challenges faced by the rapid proliferation of digital content.

Digital watermarks are potentially useful in many applications like, ownership assertion, finger printing, copy prevention or control, fraud and tempering detection, id card security.

3.3 Watermarking Issues:

The important issues that arise in the study of digital watermarking techniques are, Capacity, robustness, transparency, security.

Digital watermarking is recent research field; therefore its intrinsic limitations are not understood yet. The blind watermarking algorithm which is really robust is not in existence today. Another disadvantage is that owner can erase the watermark.

To hide information inside an image, there are several available domains like spatial domains or DCT domains.

4. RESULTS

4.1 Image Segmentation:

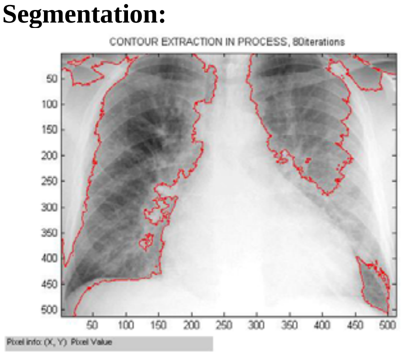


Fig. 4.1: Segmenting a medical image

The medical image is subjected to undergo segmentation and interested contours are extracted. Based on the contours the Doctor or radiologist determines the interested areas in the medical image.

4.2 Segmentation Results of various medical images:

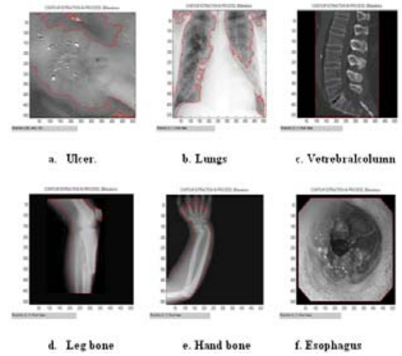


Fig. 42: Segmentation of various medical images

Various medical images are subjected to undergo segmentation and interested contours are extracted. Based on the contours the Doctor or radiologist determines the interested areas in the medical image.

4.3 ROI Masking:

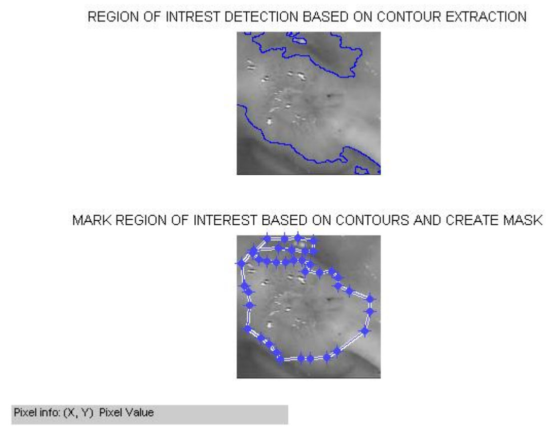


Fig. 4.3: Masking the ROI

Based on the contours extracted from the segmentation process, the Region of Interest (ROI) is to be masked.

4.4 Watermark Embedding:

Fig. 4.4: Watermark embedding and Image Restoring

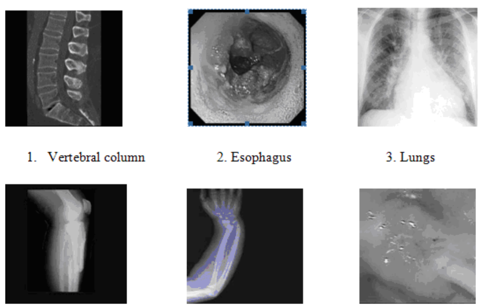
After masking, the watermark is embedded in the RONI. Then the image is reconstructed by adding ROI to watermarked image.

4.5 Watermark Extraction:

Fig. 4.5.: Watermark extraction

Watermark is extracted from transmitted image and is authenticated based on its recognition.

4.6 Various input medical images:



1. Vertebral column 2. Esophagus 3. Lungs

4. Leg 5. Hand 6. Ulcer

4.6: various input medical images

Table 4.1: Various Medical images and their experimental results

S.No	Medical Image Input	PSNR	Normalized Cross Correlation
1	Vertebral column	49.4154	0.6654
2	Esophagus	54.7413	0.7532
3	Lungs	60.8781	0.9213
4	Leg	42.8119	0.5428
5	Hand	38.3485	0.5012
6	Ulcer	59.9099	0.8612

5. CONCLUSIONS

The proposed system made the possibility of implementing the telemedicine provision over a mobile communication network. The proposed system has adopted the secured transmission by provisioning the digital watermarking technique. The proposed system has following advantages:

Best suitable for mobile communication network, Carries less resolution images which save the bandwidth of transmission medium, Is completely ubiquitous, Makes the doctor more geographically flexible, Security provisions are high as it includes Digital watermarking techniques, Provision of accurate diagnosis as crucial Region of Interest remains unaltered.

The proposed system has following limitations:

When the Region of Non interest is less, there is difficulty in extraction of watermark, Not suitable for images like ECG (Electrocardiography), EEG (Electroencephalography), etc., The Elapsed time is more when high resolution image is given as input.

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