A Literature Survey on Digital Watermarking on Medical Image

Kavitha K. J., Dr. B. Priestly Shan

***Abstract*— Medical imaging is becoming very popular as it offers the ease of access of medical information over the remote places. This field has become a very challenging area to provide security and protection of medical images. This article presents the various hiding techniques, a suitable hiding technique for medical images (MI), various types of medical imaging, effect of watermarking on MI, work done by others on MI, limitations of current existing water marking techniques and the possible solution to overcome its limitations.**

***Index Terms*— Hiding techniques, security, watermarking**

I. INTRODUCTION

From the past decade there is a drastic development in the field of Internet, communication technology which leads to the transfer of data over the remote places within no time. It also enables the healthcare professionals to transfer the MI and information of the patient over the internet for further consultation. And there is a chance of corrupting the MI or changing the medical information. Hence to avoid, hiding techniques are employed.

There are numerous hiding techniques are available. The data hiding is broadly classified as follows depending on the nature of hiding the information.

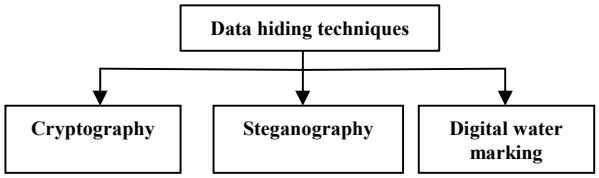

Figure 1: Data hiding techniques

Cryptography: It protects the information by encoding it in unreadable format [23].

Steganography: It is the method of hiding the message within another message which is invisible to the common eye.

Digital watermarking (DWM): In this technology, a cover image is embedded within another image without much distortion.

For MI, DWM is more suitable as it can hide the medical information or digital signature or hospital logo (cover/watermark) into the MI. Later the hidden information can be extracted. Tampering detection or privacy and integrity of patient's information can be provided by DWM technique.

The block diagram for embedding watermark is as shown below:

There are various methods of medical imaging are available such as:

1. X-Ray imaging
2. Computed tomography imaging(CT):
3. Molecular Imaging/Nuclear medicine imaging including positron-emission tomography (PET)
4. Magnetic resonance imaging (MRI)
5. Ultrasound imaging

X-ray imaging uses X-rays to take the images of bones, some tumors and other dense matter. Even though the X-ray image is very fast and help to diagnose various diseases and injuries like conked out bones, cancers and some infections , it is very dangerous as it is very much ionized which leads to the cancer in future specially for children.

CT imaging uses numerous X-rays in order to produce the cross- sectional layer which shows detailed images inside the body that includes bones, limbs, tissues and cancers. CT imaging is capable of detecting the presence of very severe problems and also can be used to check whether a previously treated disease has recurred. In this method also there is a risk of getting cancer due to exposure to ionizing radiation (X-rays). This method uses higher doses than other imaging techniques and also the injecting dye may lead to the kidney problems and some procedures needs anesthesia.

Molecular imaging is a comparatively new discipline that allows the biological processes taking place in the body to be viewed at a cellular and molecular level. The main advantage of this imaging technique is, it is painless, it can show the working of different parts of a body , detect problems much earlier and shows the depth of cancer spread and tell about whether the treatment given is working or not. But it also involves exposure to ionizing radiation, radioactive material may cause allergic or injection-site reactions in some people, PET scanners cause some people to feel claustrophobic, which may mean sedation is required.

Magnetic resonance imaging (MRI) Uses magnetic fields and radio waves to show detailed images of organs, soft tissues, bones, ligaments and cartilage. MRI can provide comparable information to CT imaging in some type of analysis. More over it does not uses ionizing radiation and painless. But MRI is a lengthy and noisy procedure, a slight movement can damage the image which may requires retesting, anesthesia may required in the case of children, injection of a contrast medium/dye can cause kidney problems or it may result in allergic.

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Ultra sound (US) imaging uses high frequency sound waves to produce moving images onto a screen of the inside of the body, that may include organs, soft tissues, bones, and an unborn baby. US imaging is a safe and comparatively painless, does not uses ionizing radiation and also does not require a injection of contrast medium/dye and hence there is no risk of kidney problems or allergy. It can help to diagnose a range of conditions in different parts of the body, such as the abdomen, pelvis, blood vessels, breast, kidneys, muscles, bones, joints and used to check the health of a baby during pregnancy. But the disadvantage with US imaging is the quality and interpretation of the image mainly depends on the skill of the person doing the scan.

From the above we can see that US imaging is safe MI technique and image quality entirely depends on the skill of a person doing the scan.

Nowadays, color MI is widely used for scanning purpose.

The security and integrity can be provided to the reports and scanning reports of a patient with the help of digital water marking technique and can be transmitted to the distance places if higher diagnosis is required. The digital water marking should be applied in such a way that it should not affect the information of a scanning or medical report since a small mistake in the diagnosis may cause severe problems. And also it should be capable of detecting any tampering that has been done to the MI so that we can avoid the wrong diagnosis.

In any medical images, we have two regions: Region of interest (ROI) and Region of non interest (RONI). Usually the watermark is embedded in RONI to avoid the destruction of the MI.

II. Literature Survey

Many researchers have worked on DWM for MI to provide the security and integrity. Malay Kishore Dutta et.al worked on retinal MI, to hide a digital watermark having patient identity in the medical image without modifying the size, without corrupting the medical image and preserving the perceptual similarity of image [1] for telemedicine applications. In this they have employed SVD based algorithm to implement. They have implemented DWM only on retinal images and other performing parameters are to be still evaluated.

A.Umamageswari et.al worked on ultrasound images for secure transmission of medical images over the Internet. They have employed Additive hash function (AHF) and Advanced Classical Cipher (ACC) [2] algorithms to embed the information in medical images in JPEG format. Kerberos algorithm is been employed to authenticate the MI in web server. But the achieved PSNR can be still improved and other metric parameters can be still evaluated.

Meryem Benyoussef et.al implemented watermarking for medical images based on Dual Tree Complex Wavelet Transform (DT-CWT) and Visual Cryptography concept (VC) [3]. This work is been implemented for mammograms images from MIAS database and have shown that this proposed method can withstand various geometric attacks.

Muhammad Tahir Naseem et.al implemented the invertible watermarking method using chaotic key to authenticate the medical images [4]. Here they have employed Run length encoding for compression and Arnold transform to transform the image.

Arijit Kumar Pal et.al implemented a reversible watermarking technique for biomedical images. In this work they have employed odd-even methodology [5] to embed the data in the medical images. The PSNR was achieved to 55db for any hiding capacity which could be improved.

Syifak Izhar Hisham et.al employed spiral numbering methodology to hide the watermark in LSB of each pixel the medical images [6] and showed that this method could help to repair the attacked/tampered area and recover a legal image. In this proposed method they have calculated MSE and PSNR for various attacks like unsharp mask filter, cloning, JPEG compression etc.

O´scar J Rubio et.al worked on DICOM echocardiograms medical images to implement the watermarking technique. Distortion free watermarking algorithm [7] is been used to embed the data and CDF 9/7 wavelet transform is used. The implemented work is specially designed only for DICOM medical images.

Adiwijaya et.al implemented medical image watermarking using modified LSB and Huffman coding for compression [8]. They have implemented this work for bitmap ultrasound images of 8-bit color depth. The quality of the 10 medical images is been evaluated and achieved a PSNR up to 48.6db and error rate was varying up to 46.3%.

Nilanjan Dey et.al has implemented watermarking for intravascular ultra sound medical video images (IVUS) [9] using DCT, DWT and SVD. MATLAB 7.0.1 is been used for the implementation. The metric parameters for evaluating the video is been calculated. The PSNR was achieved up to 50.8122db, correlation coefficient was 0.9990.

Nisreen I. Yassin et.al implemented blind watermarking for medical images and medical video frames using Principle Component Analysis (PCA) and Digital Wavelet Transform (DWT) [10]. They have used Quantization Index Modulation as the method for implementing blind watermarking system. This method is applied on different type of medical images such as MRI, CT, ultrasound and X-rays. The PSNR was achieved as 53.9717db, Normalized Correlation (NC) as 0.9844. They have also shown that at 60% compression, the NC values of medical frames do not go under 0.7.

Baiying Lei et.al implemented robust watermarking integer wavelet transform (IWT) and Singular value Decomposition (SVD). For controlling the quantization steps [11] to withstand the watermarking strength, differential evolution is employed. The maximum PSNR achieved is 48.35 db and MSSIM as 0.9934.the best quantization step achieved is 104.3 and NC is 0.96648. The result obtained is compared with GA algorithm and shown that the proposed DE method is more appropriate than GA algorithm.

Soumyo Bose et.al implemented DWT based watermarking using threading method. Using multiple threading methods [12], more than one image frames were watermarked and also measured the computation time to compare the time gain in

parallel processing with respect to serial processing. They have shown that by reducing the number of frames keeping threading constant, the computation time can be reduced.

Sonika C. Rathi et.al [13] has implemented watermarking technique for medical images for providing protection and authentication. They have used GUI based segmentation approach to separate ROI from RONI.

In the above mentioned, almost all the works are done with grey images. But as already mentioned nowadays color MI is been employed to get more accurate data. Some of the authors have also worked on color medical image watermarking and medical videos.

Mohamed M. Abd-Eldayem implemented a security technique for medical images including gray and color images [12], using digital watermarking and encryption technique. They have applied the technique on eight gray scale DICOM medical images and the have got the minimum SNR 49 dB with average of 56.63 dB and standard deviation 11.29; and also the maximum value of MSE obtained is 0.156 with average equal about 0.124 and standard deviation 0.0.02; The minimum PSNR obtained is 56.2 dB while the maximum value equals58.13 dB with the average equals 57.25 dB, and standard deviation equals 0.7. For color images the results are;
the BER is zero for all six color images. The minimum SNR is 45.37 dB with an average about 51.33 dB and standard deviation 4.72. The average MSE is about 0.117 with 0.034 standard deviation. The PSNR with minimum value equals 56.89 dB while the maximum value equals 59.56 dB with the average equals 57.62 dB, and standard deviation equals 1.31.

Nisreen I. Yassin, National Research Center, Cairo, Egypt et.al implemented a blind watermarking algorithm in order to transfer medical data over the public network. In this work, text is embedded as a watermark into (YCBCR) color channels of each medical video frame using Discrete Wavelet Transform and Principle Component Analysis. In this work the PSNR obtained is 46.68db, the maximum character embedded is 146 and the size of the frame selected was 512X512.

III. TYPES OF WATERMARKING TECHNIQUES

The watermarking techniques can be categorized as shown below:
These techniques are more advantageous than DWT.
Visible WM: In this technique the embedded watermark is visible to the human eye. It is used for copyright protection.

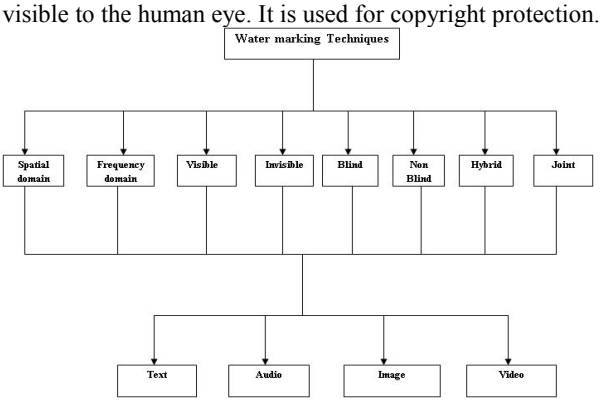

Figure 1: Classification of Water marking Techniques
Spatial domain: In this technique the watermark is directly embedded in the cover image without transforming the image. The most commonly used spatial techniques are LSB and SSM modulation techniques [14].

Frequency domain: In this technique the image is transformed into frequency domain to get more information [15]. The most commonly used transform domain techniques are DFT, DCT, and DWT. Nowadays the new approaches like LWT, IWT with lifting scheme is used for watermarking.
Invisible WM: In this type of watermarking technique, the watermark embedded in the cover image is not visible to the human eye. This type can be used for the authentication purpose.
Blind WM: In this type of watermarking technique, original image and watermark/key is not required to extract the watermark [18].
Non-Blind WM: In this type of watermarking technique, original image and watermark/key is required to extract the watermark [18].
Semi-Blind WM: In this type of watermarking technique, some of the features of the original image is required at the time of extraction [18].
Hybrid WM: In this technique, more than one method can be combined to get a robust WM technique. For example, DWT, DCT and SVD method can be combined get more effective results [15].
Joint WM: In this technique encryption technique can be combined with watermarking techniques to get good results [19].

IV. SECURITY REQUIREMENTS FOR MI

Even a small distortion or minor modification in the medical images may result in the wrong diagnosis.
To avoid this, care should be taken before diagnosing a medical image.
Imperceptibility: the water mark which is embedded in the original image should not be visible to the human eye [20]

V. ESTIMATION OF THE QUALITY METRICS FOR MI

To evaluate the performance of the medical image/video watermarking, the WMed image has to be estimated in terms of various parameters.
The Quality metrics used for MI can be categorized under two types:

1. Image quality estimate: The quality of the image can be measured using the following parameters:
   - PSNR
   - MSE
   - SSIM
   - NC(NORMALISED CORRELATION COEFFICIENT)
   - BER(Bit Error Rate)

2. Integrity and Tamper Estimate: the integrity of the image can be evaluated by the following parameters.
- Mean
- Median
- Rotation
- Noise
- Crop

CONCLUSION

From the above study, we can see that WM is the possible solution to protect the MI. Still efficient results can be obtained by combining the positives of many WM techniques with encryption technique.

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