Determination and Statistical Analysis of Effective Watermarking Application among Varied Medical Images

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Abstract

As security is very crucial in almost every sector of services nowadays, watermarking is more or less an important mechanism in securing vital information such as medical images. Water marking aimed at providing secure medical images through integrity verification, such that unauthorized person cannot be able to modify it. In a bid to find a secured watermarking technique which prevents a medical image from degradation, this research explores a mechanism known as Hybrid Transformed Watermarking. Two mechanisms are employed that include Discreet Cosine Transform (DCT) and Discreet Wavelet Transform (DWT). The two techniques were combined to transform a medical image with the intent of providing authenticity and integrity verification, the final result was an efficient watermarked imaged.

Keywords: Discrete Wavelet Transform, *Angiogram, Discrete Cosine Transform, SSIM, Watermarking*

Introduction

Transfer of digital medical images within and outside network makes authenticity and integrity verification requirement a necessity. The authenticity and integrity verification can be achieved using watermarking technique as stated in Ayuba (2013). Watermarking is a technique aimed at proffering security to medical image through integrity verification that ensured unauthorized persons have not modified the image while Authentication determines whether the image certainly belongs to the right patient (Ayuba, 2013). The Digital Imaging and Communication in Medicine (DICOM) is an advancement of a system known as Picture Archiving and Communication System (PACS) which was designed to cater for network security issues. However, DICOM cannot proffer security to images outside the network because it stores security information on header of the data on transit (Ayuba, 2013). As stated in a medical image watermarking review that data encryption using digital signature is

not sufficient in providing the required protection, this is because digital signature stores information on the header file thereby separating it from the original image and it cannot withstand file conversion (Ayuba, 2013). Medical image watermarking has more advantages when compared to Virtual Private Network (VPN) and Data Encryption through confidentiality and integrity verification. (Planitz & Maeder (2005) stated that medical image watermarks are used to authenticate the image by tracing the origin of such image and investigate the integrity by assuring that no changes have been made on the images. Variation of image source (i.e. Angiography, CT, MRI etc) plays an important role in the performance of a watermarking application due to differences in image features. The level of degradation that may possibly exist between original and watermarked images can be investigated by adopting some quality metric. This quality metric are Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Structural Similarity Index Measure (SSIM) (Pal, Ghosh, & Bhattacharya, 2012). The research evaluates the best image for medical watermarking using SSIM quality metric. The widely adopted watermarking techniques are basically spatial and frequency domain types. However, the frequency domain watermarking has proved to be more robust in comparison with its counterpart strategy (Ayuba, 2013). In 2007, Navas demonstrated that spatial domain watermarking technique can be prone to image degradation and should not be employed in medical imaging. The watermarking technique suitable for medical imaging must be lossless in order to comply with the stringent requirement for quality (Navas, 2007). This research focus and adopt a mechanism known as Hybrid Transformed Watermarking where two frequency transforms which include Discreet Cosine and Discreet Wavelet Transform respectively are employed.

Mathematical Background

The Hybrid method (i.e. Hybrid Transformed Watermarking) transforms signal into an elementary independent manner while containing the algorithm that can decorrelates the

input signal. Its formula converts sequence of real number into complex number (Ezhilarasan, Thambidurai, Harish, Muthuraman, Arulsezhian, Arun, Anand, Kumar, Krishnan, 2008).

$$f_j = \sum_{k=0}^{n-1} x_k \cos\left[\frac{\pi}{n} j\left(k+\frac{1}{2}\right)\right]$$ .....Equation (1)

The fundamental idea of the wavelet transform is to denote any arbitrary function as a superposition of a set of such wavelets or basis functions. The wavelets are acquired from a single mother wavelet through multiplicative scaling and shifting (Mohanty, 1999).

$$h_0 = \frac{1+\sqrt{3}}{4\sqrt{2}}, h_1 = \frac{3+\sqrt{3}}{4\sqrt{2}}, h_2 = \frac{3-\sqrt{3}}{4\sqrt{2}}, h_3 = \frac{1-\sqrt{3}}{4\sqrt{2}}$$ ..... Equation (2)

A comparative analysis of DCT and DWT transform watermarking techniques as discussed by DWT shows better result. The concept of combining the two transform is meant to remedy the side effect of one transform over the other (Ezhilarasan, Thambidurai, Harish, Muthuraman, Arulsezhian, Arun, Anand, Kumar, Krishnan, 2008).

Methodology

This watermarking application was employed on medical images for the purpose of authenticity and integrity verification. The application inserts watermark into a given medical image and extract the same watermark so as to obtain the originality of the image. The application can also be used to extract the result of the Structural Similarity Index Measure (SSIM) on the three (03) categories of images (Angiogram, CT Scan and Ordinary images). The application uses a hybrid transformation where the original image undergoes a Discreet Cosine Transform (DCT) which further transforms into Discreet Wavelet Transform (DWT) and the watermark image or text will be inserted into the combined transformed image to obtain watermarked image. The Figure below indicates the embedding process.

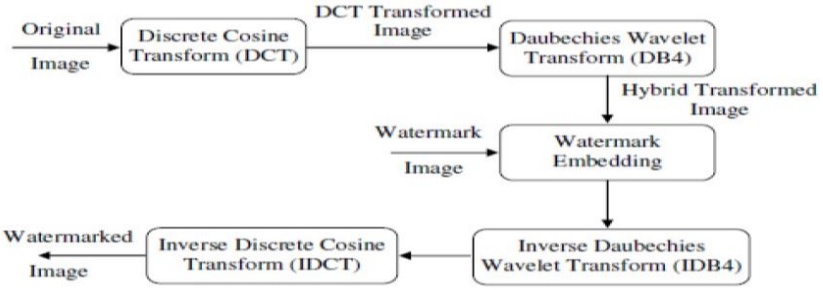

Figure 1: Flowchart (Umaamaheshvari, 2012)

Quality Metrics

The research uses a mathematical model for comparing the original and the watermarked images and presents their structural analysis. The model is given below as:

$$SSIM(x,y) = \frac{(2\mu x\,\mu y + c1)(2\sigma xy + c2)}{(\mu x^2 + \mu y^2 + c1)(\sigma x^2 + \sigma y^2 + c2)}$$

……Equation (3)

Equation 3: SSIM Equation (Rouse & Hemami, 2008)

The use of the Structural Similarity Index Measure (SSIM) indicates correlation between the watermarked image and the original image. Correlation will always fall between -1.0 and +1.0. If the correlation is positive, we have a positive relationship which means the Watermarking Application is highly effective (Pal et al., 2012). However, if correlation is negative, the relationship is negative, that is there is no relationship between the original Image and the Watermarked Image which thus, signify that the Watermarking Application is not effective (Rouse & Hemami, 2008).

Data Presentation, Analysis & Interpretation of Result

The data was obtained from the Watermarking application using SSIM quality metric which gives the correlation between the original and watermarked image. The table 1 indicates the values obtained using the three (3) sets of images:

Table 1: Representing data for evaluating the performance of images in Watermarking Application

S/N	Angiogram Images		CT Scan Images		Ordinary Test Images	
	DESCRIPTION	SSIM	DESCRIPTION	SSIM	DESCRIPTION	SSIM

1	IM5.bmp	0.9764	CT Coronary Sinus Colour	0.8276	Baboon Color.jpg	0.5483
2	IM6.bmp	0.9587	CT Chest	0.7672	BaboonGray.jpg	0.7553
3	IM9.bmp	0.9760	CT Heart Angio.bmp	0.8793	BurgaerGirl.jpg	0.8358
4	IM10.bmp	0.9586	CT Heart Image2.bmp	0.8127	Cameraman.jpg	0.9287
5	IM11.bmp	0.9775	CT Lungs.bmp	0.7517	CrossProcess.jpg	0.7551
6	IM12.bmp	0.9626	CT Lungs2.bmp	0.8864	Girl.jpg	0.8550
7	IM13.bmp	0.9987	CT Lungs2.bmp	0.8902	LightHouse.jpg	0.4900
8	IM14.bmp	0.9995	CT Pulmonary.bmp	0.6924	BarbaraGray.bmp	0.8069
9	IM17.bmp	0.9880	CT Thoracic.bmp	0.7357	PepperColor.jpg	0.9516
10	IM18.bmp	0.9278	CT Heart VR.bmp	0.6374	PepperGray.jpg	0.7789

Statistical Analysis:

Hypothesis:

Ho: There is no significant difference among the mean performance of the images used for evaluating the performance of the watermarking application (U1=U2=U3)

HA: There is significant difference among the mean performance of the images used for evaluating the performance of the watermarking application (U1≠U2≠U3).

Table 2: SPSS Result:

ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.250	2	.125	12.489	.000
Within Groups	.270	27	.010		
Total	.520	29			

Level of Significant = 0.05

Decision:

We now reject Ho since F calculated is greater than F tabulated i.e. 12.489 > 3.35 at 2, 27 degrees of freedom. It was further confirmed using pair wise comparison test or multiple comparison tests which shows that Angiogram images are much more significant when compared with Test Images followed by CT Images. Test Image is the least significant among the set of image.

Table3: Comparative result

(I) IMAGE	(J) IMAGE	Mean Difference (I-J)	Std. Error	Sig.
ANGIOGRAM IMAGE	CT IMAGE	.1843200*	.0447445	.000
	TEST IMAGE	.2018200*	.0447445	.000
CT IMAGE	ANGIOGRAM IMAGE	-.1843200*	.0447445	.000
	TEST IMAGE	.0175000	.0447445	.699
TEST IMAGE	ANGIOGRAM IMAGE	-.2018200*	.0447445	.000
	CT IMAGE	-.0175000	.0447445	.699

Conclusion:

In conclusion, the result shows Ho is rejected and HA is accepted, this shows that there is significant difference in the mean performance of the images used for evaluating the performance of the watermarking application. In addition to the significant difference, multiple comparisons show how the Angiogram images were found to be the best then followed by CT and Test Images. The Angiogram images are more similar then followed by the CT Scan Images then the Test Images when employed in the watermarking application. This conclusively shows that the Angiogram images are more suitable for use with the application when compared with CT and Test Images.

Recommendation:

Considering the high demand need to secure medical imaging, and base on the result obtained in this research, it can therefore be recommended that angiography should be used in acquiring medical images for watermarking application.

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