Performance Evaluation of Different Medical Image Watermarking Techniques using EBCDIC coding

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ABSTRACT
In today's multimedia world, everything has got digital around us. Even in medical application the traditional diagnosis is replaced by e-diagnosis. Nowadays, transmission of digitized medical information has become very easy due to the availability and generality of internet. However the digital form of these images can easily be manipulated and degraded. The problem of copyright protection and medical security poses a big challenge to privacy protection using watermarking techniques. This paper presents a framework on digital watermarking as an effective technology to protect property rights and limit the distribution of multimedia data. In this paper a CT scan of head is taken as cover image in which the patient's detail and doctor's detail together taken as a watermark and encoded by coding technique called EBCDIC coding technique to enhance the robustness of proposed method. The scheme is blind so that the EPR(Electronic patient record) can be extracted from the medical image without the need of original image. Therefore proposed method is useful for telemedicine applications. The performance of different techniques is evaluated by considering the correlation factor for exact recovery of watermark and PSNR for perfect reconstruction of watermarked image. High value of PSNR indicates better reconstruction of medical image.

Keywords
Watermarking, DCT, FFT, DWT.

1. INTRODUCTION
Recently, telemedicine applications in teleconsulting, telediagnoisis, telesurgery and remote medical education play a vital rule in the evolution of the healthcare industry. Hospitals and medical centers have huge databases including medical images, text and patient records. The exchange of these databases through the networks requires content management to index medical record information and a high degree of security and authenticity to preserve the privacy of the patients' information. To achieve these objectives, different techniques of digital watermarking have been employed. We can use the watermarking in order to hide the patient information in the form of a watermark. This is called as an Electronic Patient record (EPR).Combination of Image Watermarking with the Electronic Patient record(EPR) as anonymous authentication code offers a new image authentication code offers a new image management layer to control image authenticity, Such a process can be introduced in image management software and participate to improve maintainability of the system while preserving maintainability of the system while preserving patient privacy. Electronic Patient record can also help to gather various medical images and documents of a single person with ease. The confidentiality of patient data is improved by hiding the EPR data as a watermark. In addition to that, both the storage and transmission bandwidth requirements for medical images are reduced. For biomedical images, modifications are not allowed during data transfer over networks for obvious legal reasons. Digital watermarking can embed messages without changing the image size and without violating the DICOM format maintaining the following necessary conditions:

(1) There should be minimal perceptible changes in the watermarked image. The watermarked image should visually be the same as the original image [1].
(2) The watermarking technique should be reversible. This means that the watermarked image should revert back to its original form on removal of the water mark [2].
(3) There should be no impact on the stored images in the PACS server due to introduction of the watermark [3].

Digital watermarking is one of the safest and popular methods to enhance medical data security [5]. It is the process of embedding information into a digital image with an imperceptible form for the human visual system such that the hidden information or the watermark can be extracted or recovered afterwards [6-8]. However, medical image watermarking requires extreme care when embedding additional information because the additional information should not degrade the medical image quality[2].
In this paper, a new blind watermarking method is suggested. The medical image is taken as the cover image to embed the patient's information as watermark. The watermark is the EPR which can include doctor's information, patient information, diagnosis and some data related to the medical case. All the information is coded by EBCDIC code to enhance robustness. This paper is organized as follows; The proposed algorithm is described in Section 2. In section 3, the experimental results are introduced and discussed. Finally section 4 concludes the paper.

2. PROPOSED APPROACH

The medical image watermark embedding and detecting process is well explained by the figure 1(a) and 1(b). The watermarking embedding process consists of two phases. In phase one, the medical image is taken and is processed by applying DWT/DCT and DFT.In second phase, the data of patient is taken from the hospital like patient ID and doctor ID which will be unique for every patient, which is concatenated together and then encoded by using EBCDIC coding and read into an grayscale image. After applying IDWT/IDCT and IDFT, the watermarked image is obtained. The watermark detecting process is just reverse of the embedding process which is explained above. At the detecting process the patient information is extracted from the image which claims that the received watermarked image is the image of the patient which has to be diagnosed and is not tampered at all.

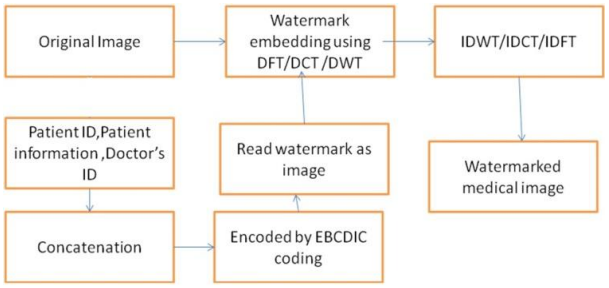


Figure 1(a). Watermark Embedding

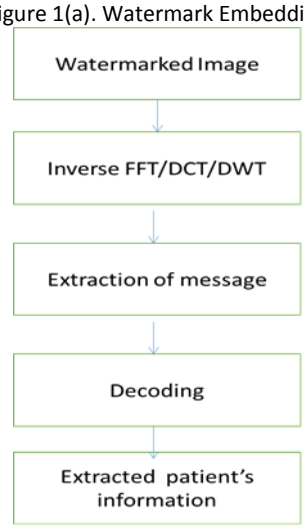


Figure 1(b).Watermark extraction

3. PERFORMANCE PARAMETERS

3.1 Peak Signal to Noise Ratio

The term peak signal-to-noise ratio (PSNR) is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale. The mathematical representation of the **PSNR** is

$$PSNR = 20\log\left(\frac{MAXf}{\sqrt{MSE}}\right)$$

where the **MSE** (*Mean Squared Error*) is

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2$$

'f' represents the matrix data of our original image 'g'represents the matrix data of our degraded image in question, 'm' represents the numbers of rows of pixels of the images and 'i' represents the index of that row **n** represents the number of columns of pixels of the image and j represents the index of that column $\mathbf{MAX_f}$ is the maximum signal value that exists in our original "known to be good" image

3.2 Correlation Coefficient

Correlation Coefficient defines the similarity between the original watermark and the extracted watermark. Mathematically it can be defined as

$$\frac{\sum(x_i - x_m)(y_i - y_m)}{\sqrt{\sum(x_i - x_m)^2}\sqrt{\sum(y_i - y_m)^2}}$$

4. RESULTS & CONCLUSION

Figure 2 shows a CT scan of image is taken for watermarking with three different techniques FFT, DCT and DWT.The watermark contains the patient's and doctor's information like patient's ID, doctor's ID, patient's age and gender etc.The patient's information is encoded by EBCDIC coding in which one single character is encoded by 8 binary bits which makes the length of watermark long enough to provide the robustness against watermark. Further the encoded watermark is converted into an image.

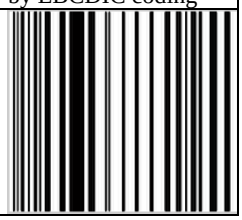
Original Image	Patient's Data	Watermark Encoded by EBCDIC coding
	**MR/10/5933/ 29/F/D0142**	

Figure 2. Original image and encoded watermark

Figure 3 shows the results obtained after watermarking only for a single image. It clearly shows that watermarking done with DWT gives the best result in terms of PSNR and correlation coefficient.PSNR obtained by DWT gives the value as 98.9728 which is highest among the three techniques which indicates the better reconstruction. The correlation coefficient factor from DWT is coming out to be 0.9998 which is nearby close to 1 which indicates the exact recovery and similarity of extracted watermark with the original watermark. As we can see by FFT we get the distorted extracted watermark in which the watermark is not at all similar to the original watermark hence giving the correlation factor as 0.3008 also PSNR value obtained by FFT is 59.0862 which does not give good reconstructions whereas DCT and DWT gives comparatively good results in terms of correlating factors.Hence we can conclude that among all three techniques which we have used for watermarking medical images, DWT gives the best result in terms of PSNR and Correlation coefficient.

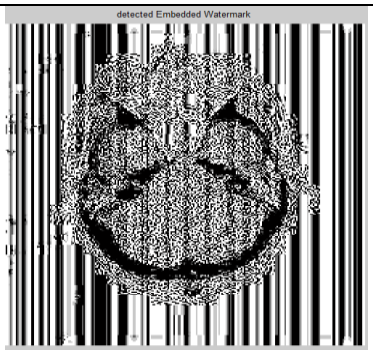
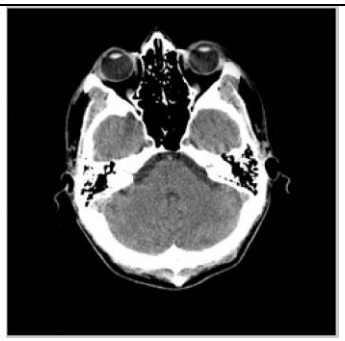
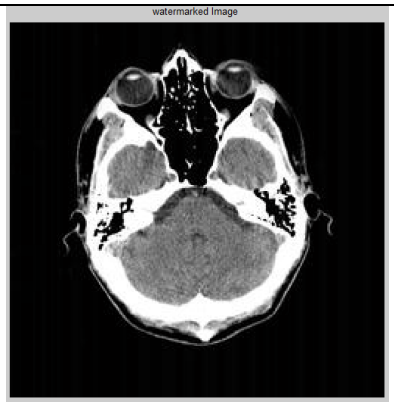
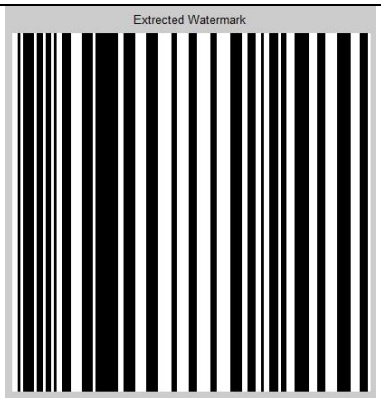
Technique used	Watermarked Image	Extracted watermark	PSNR(dB)	Correlation coefficient
FFT			**59.0862**	**0.3008**
DCT			**85.2776**	**0.9853**
DWT(Haar)			**98.9728**	**0.9998**

Figure 3.Results showing comparison of different Watermarking techniques for medical CT scan image

Table 1: EBCDIC Code Table

		Low Order Bits															
		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
High Order Bits	0100	space										¢	.	<	(	+	|
	0101	&										!	$	*	)	;	¬
	0110	-	/									¦	,	%	_	>	?
	0111										`	:	#	@	'	=	"
	1000		a	b	c	d	e	f	g	h	i						
	1001		j	k	l	m	n	o	p	q	r						
	1010		~	s	t	u	v	w	x	y	z						
	1011																
	1100	{	A	B	C	D	E	F	G	H	I						
	1101	}	J	K	L	M	N	O	P	Q	R						
	1110	\		S	T	U	V	W	X	Y	Z						
	1111	0	1	2	3	4	5	6	7	8	9						

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