Evaluation of Image Watermarking by DCvT for Telemedicine and Healthcare Field

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Abstract: Image watermarking deals with content authentication and proof of ownership. It has been used in our research as a part of application in telemedicine of health care field. Implementation has been carried out to authorize any medical image report being supervised by particular medical supervisor as a sign of a valid treatment and therapy. In case of image watermarking, two images are overlapped in such a way that one act as a cover imagse and the other one as a watermark itself. A number of transformations are utilized for implementation of image watermarking like wavelet transform, curvelet transform, Contourlet transform, Ridgelet transform etc. The method is chosen as per its own characteristics and advantages. Here, in this paper, we have implemented the watermarking of the medical images using Curvelet Transform and the results are compared with those obtained by Wavelet Transformation implementation on to the same images. Also, the results of software implementation carried out on MATLAB computation platforms are discussed.

***Index Terms*–Image watermarking, DCvT, Telimedicine and Healthcare, PSNR and Robustness**

I. INTRODUCTION

Images are 2 Dimensional pictorial representations of the objects. Fundamentally, they are 2D signal processed by the HVS. These 2 dimensional arrays of pixels i.e. images do play a vital role in a number of real time applications nowadays such like GIS, Remote Sensing, Telemedicine, Biomedical etc. This paper focuses particularly on telemedicine application development. In case of certain severe dieses and physical disorders, the patients need to take opinion from more than one medical consultant. In case, each newer doctor is required to go through the previous consultancy and details of the patients in form of previous records. To make this process easier for particularly those branches of medical which are concerning images like X-Ray, MRI, CT etc., an image processing application of image watermarking has been proposed here for doctors' evidence as a secrete message. This incorporates to the proof of ownership of the medical image document that it has been examined and suggested by the particular doctor only. Hence the patients do not need to carry all the credentials wherever they move but only a soft copy of watermarked medical image. Even this copy is not compulsorily needed to be carried with them (patients) in case of availability of the dispensaries having facility to store such patients' histories in form of data base. In this article, first the implementation of the image watermarking is described and its results are shown. For watermark formation, the utilized transformation is the Discrete Curvelet Transform.

II. IMAGE WATERMARKING AND CURVELET TRANSFORM

The term, watermarking means an act of having evidence of authentication and proof of ownership. There are various types of watermarking i.e. text watermarking, image watermarking, audio watermarking, video watermarking etc. from which we are focusing on image watermarking. The ways by which we can watermark any image do contain mainly two categories: Spatial Domain and Transform Domain watermarking techniques. From the previous research work, it is seen that watermark formed using spatial domain techniques tend to poor robustness and immunity to tempering [16] [17]. Hence, as per the application requirements, transform domain techniques are required to be implemented. The different transformations used are LSB method, DCT, DWT, DCvT etc. Wavelet transform is best suitable for point singularity and not well suited for line or edge and surface singularities. For representing them a novel approach is DCvT – discrete curvelet transformation [1]. For image watermarking of medical images the reconstruction of the original image having curved surfaces and boundaries must be reconstructed very carefully and without any loss. The comparative study of various transformations used for image watermarking formation is carried out and then the most optimum transform method is employed for this research work. For the comparative analysis of the results obtained by the scholars, consider [19].

Thus for watermarking of the medical images, DCvT has been adopted as a transformation platform for non-blind image watermarking. In the following sections, the proposed algorithm of DCvT based image watermarking and the corresponding results are discussed.

III. ALGORITHM PROPOSED

In this research work the watermark embedding and watermark extraction processes are carried out by using Curvelet Transform. The input images are fed to the algorithm and as an output we are obtaining the watermarked image. The target is to build a robust and non-blind watermarked image. The whole strategy of the work involves 5 steps- *Watermark Embedding*, *Watermark Extraction* and *testing of Robustness* of the extracted watermark. Consider the following system block diagram that specifies the work approach in detail:

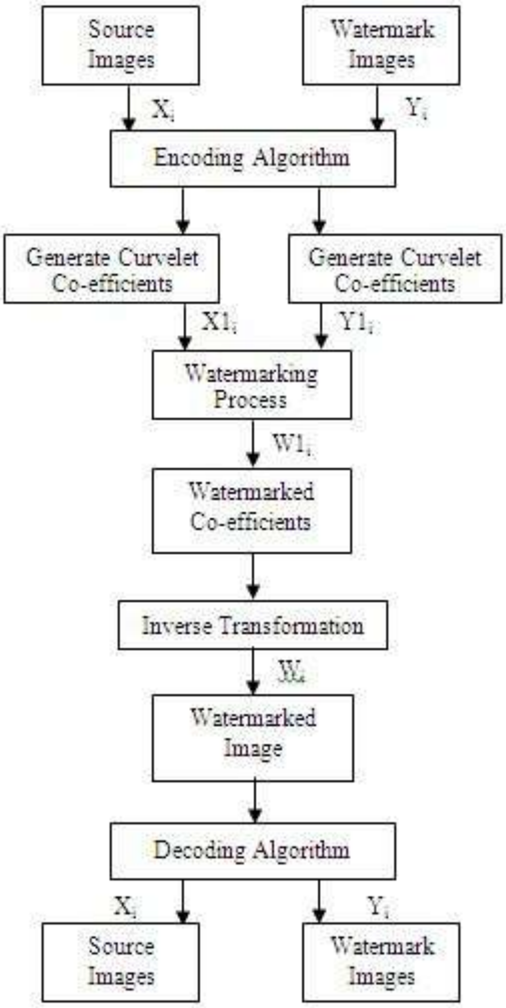

Fig. 1. Proposed Block Diagram

The diagram indicates the basic steps of the proposed scheme. The reverse flow is implemented for the extraction procedure of watermarking. The resultant curvelet co-efficients do correspond to the watermarked data. Here, watermark implemented is of the following form:

$$X_i + (S^* Y_i) = W1_i \quad (1)$$

Where,
X_i = Cover image components; i = no. of image data sets
Y_i = Watermark image components
W_i = Watermarked image component
S = scale parameter

By choosing different values of scales we can vary the robustness of the system. Here in this experimental results, we have utilized scale parameter, S = 0.0001. By applying the Inverse Transformation, we are able to obtain the Watermarked Image. Now, in case of receiving end, as decoding process, so obtained co-efficient are received and onto them Forward Transformation is applied and with the help of cover image co-efficient watermark is differentiated. At the end of this process watermarked image separates the embedded watermark.

IV. SOFTWARE IMPLEMENTATION

In implementation, the whole implementation strategy has been mentioned. Here, the Ridgelet based curvelet transformation is implemented. We can have following three distinct ways to perform the curvelet transformation:

i) Ridgelet based CvT to analyze the objects with discontinuities along the straight line

ii) Band pass filtering, a method of separating an object out into a series of disjoint scales

iii) Multi scale Ridgelet with pyramid of multiple windows

The Ridgelet corresponding to the each direction is taken for a particular angle ‘θ’, scale ‘a’ and position ‘b’ to generate curvelet co-efficient, theoretically. In this way, co-efficient are formed and all the co-efficient are obtained.

Consider the following diagram as our implementation onto MATLAB software:

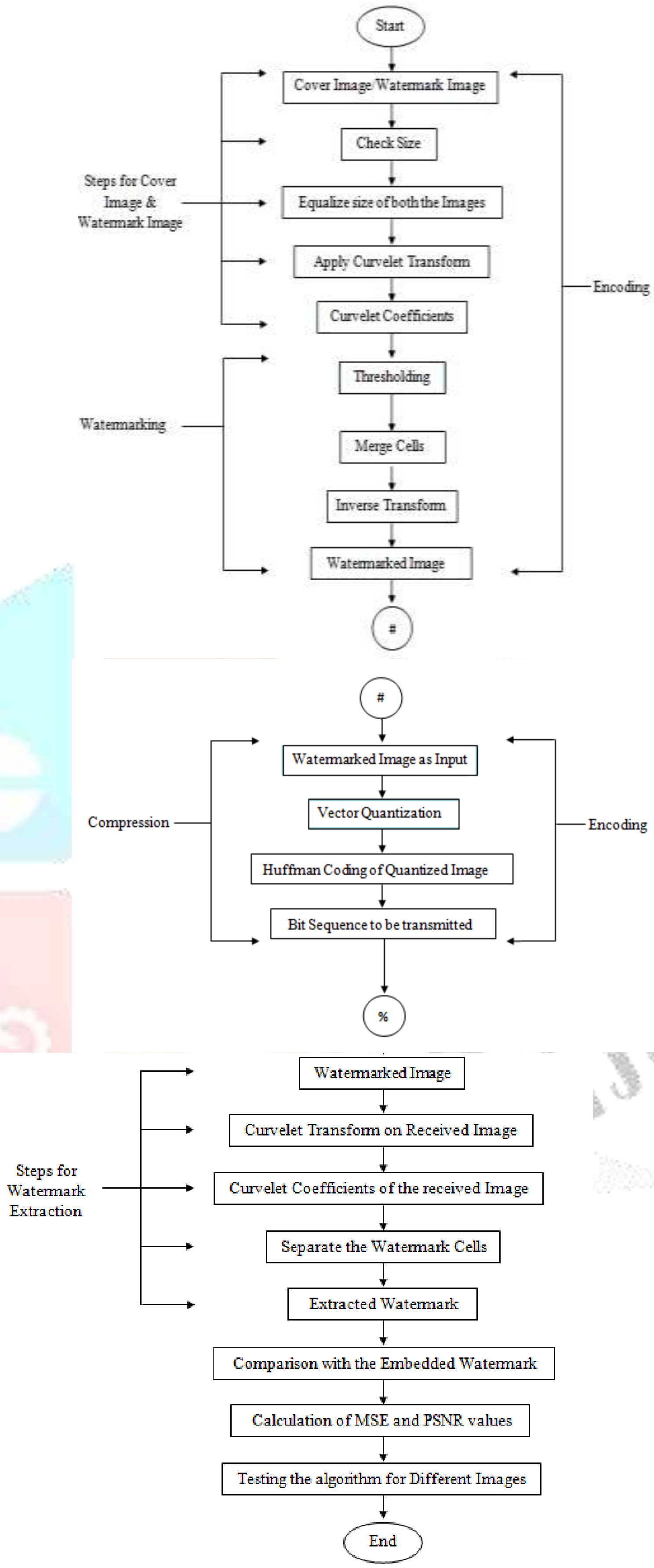

Fig. 2. Proposed Implementation of Watermarking on MATLAB

In the next section, the results of image watermarking carried out by DCvT are discussed.

V. RESULT ANALYSIS

Here, in this section, we have shown the results for Image Watermarking using DCvT and the same obtained by DWT methods. By performing the experiments on MATLAB, for the same cover images and watermark images, but with different transforms i.e. DCvT and DWT, we are getting the following values. Results measured are in terms of MSE, PSNR and time taken for the whole process by applying the inputs to DCvT based image watermarking algorithm and the same to the DWT based image watermarking algorithm. For this experiment, all the taken signature image sets are Internet Images taken just for the experiment purpose (and not for any other purpose) from the web. Consider the following obtained results of extracted watermark using both the systems and their HVS quality as well:

Fig. 3Extracted Watermark Set-1-DCvT [simulated image]

Fig. 4Extracted Watermark Set-2-DCvT [simulated image]

Fig. 5Extracted Watermark Set-3-DCvT [simulated image]

Fig. 6 Extracted Watermark Set-1-DWT [simulated image]

Fig. 7Extracted Watermark Set-2-DWT [simulated image]

Fig. 8 Extracted Watermark Set-3-DWT [simulated image]

Fig. 9 Extracted Watermark Set-4-DCvT [simulated image]

Fig. 10 Extracted Watermark Set-5-DCvT [simulated image]

Fig. 11Extracted Watermark Set-6-DCvT [simulated image]

Fig. 12Extracted Watermark Set-4-DWT [simulated image]

Fig. 13Extracted Watermark Set-5-DWT [simulated image]

Fig. 14Extracted Watermark Set-6-DWT [simulated image]

TABLE I. COMPARATIVE ANALYSIS OF RESULTS OBTAINED FOR IMAGE WATERMARKING USING DCVT AND DWT

Sr. no.	Cover image set	Watermark Image Set	MSE	PSNR	Time	MSE	PSNR	Time
			DCvT			DWT		
1	img3.jpg	Watermark1 = sign2.jpg	-6.2017e+08	42.0683	10.37	0.7467	3.3526	4.98
2	mri01.tif		-6.2017e+08	42.0683	10.42	0.6202	6.6929	4.96
3	x-ray.bmp		-6.2017e+08	42.0683	10.37	0.6861	2.9172	5.06
4	x-ray01.bmp		-6.2017e+08	42.0683	10.48	0.6588	5.1317	4.97
5	AnkleFracture.bmp		-6.2017e+08	42.0683	10.94	0.4890	8.4510	5.09
6	hand-xray.bmp		-6.2017e+08	42.0683	10.50	0.4741	8.0121	5.12
7	images (1).bmp		-6.2017e+08	42.0683	10.34	0.4919	7.2667	5.51
8	images.bmp		-6.2017e+08	42.0683	10.43	0.6540	2.5711	5.09
9	LUNG3B		-6.2017e+08	42.0683	10.57	0.4922	7.7036	5.61
10	Chest X-ray Image.bmp	[internet image]	-6.2017e+08	42.0683	10.53	0.3417	11.1760	5.54
11	img3.jpg	Watermark2 = Signature.jpg	-6.2948e+08	42.1295	15.50	6.2680e+04	-110.0261	3.92
12	mri01.tif		-6.2948e+08	42.1295	15.54	6.2641e+04	-108.5353	4.57
13	x-ray.bmp		-6.2948e+08	42.1295	15.72	6.2661e+04	-111.3047	3.92
14	x-ray01.bmp		-6.2948e+08	42.1295	15.07	6.2652e+04	-109.4952	3.95
15	AnkleFracture.bmp		-6.2948e+08	42.1295	15.32	6.2595e+04	-109.1471	4.16
16	hand-xray.bmp		-6.2948e+08	42.1295	15.02	6.2571e+04	-109.8929	4.31
17	images (1).bmp		-6.2948e+08	42.1295	14.71	6.2579e+04	-110.2692	3.94
18	images.bmp		-6.2948e+08	42.1295	10.99	6.2646e+04	-112.1280	4.90
19	LUNG3B		-6.2948e+08	42.1295	11.05	6.2572e+04	-109.8263	4.67
20	Chest X-ray Image.bmp	[internet image]	-6.2948e+08	42.1295	16.49	6.2510e+04	-109.9938	3.93

So calculated PSNR and MSE values are achieved by using the following standard equations for the process:

$$PSNR = 10 * \log\left[\frac{\left(2^n - 1\right)^2}{MSE}\right] \quad ; n \in N \qquad (2)$$

Where, the value of Mean Square Error is calculated by the equation given below:

$$MSE = \sum_{i=0}^{K-1}\sum_{j=0}^{M-1}\left[\frac{\left(f(i,j) - g(i,j)\right)^2}{M * K}\right] \quad ; i, j \in N \qquad (3)$$

This value of PSNR is in dB.The corresponding comparison PSNRs obtained by DCvT and DWT implementation has been given below:

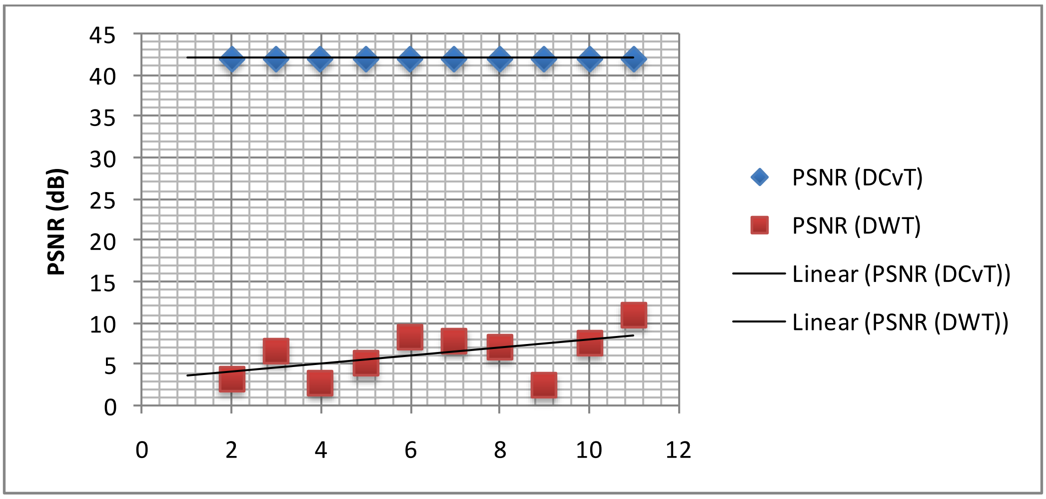

Fig. 15 PSNRs using DCvT and using DWTof different cover images for a fixed watermark

Here, PSNRs are obtained for a fixed watermark with variable cover images. Similar results can be obtained for all data points of different cover images keeping a watermark fixed.

As for a fixed watermark, DWT gives different PSNRs compared to DCvT. In that case, considering averages to these varying values (DWT) and values of PSNRs by DCvT are shown below:

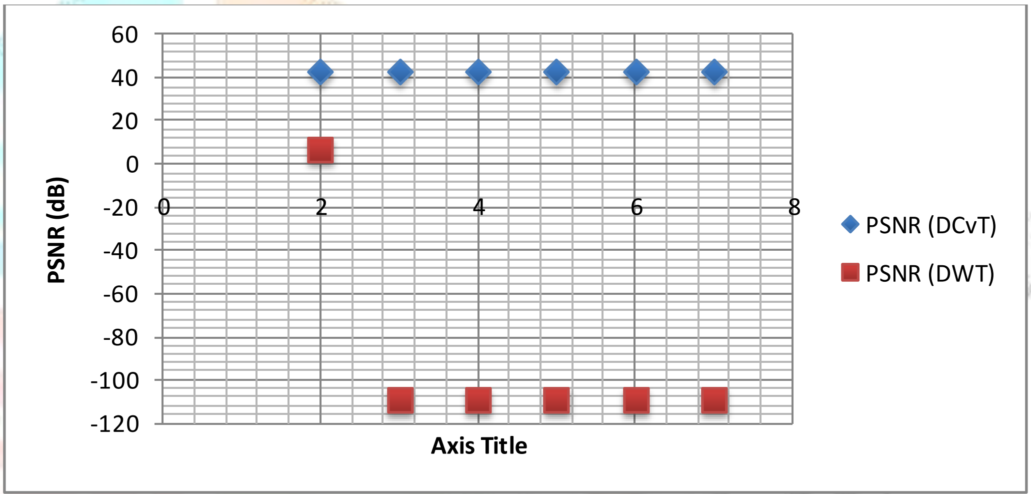

Fig. 16 PSNRs using DCvT and using DWTof different cover images and watermark images

This indicates that higher PSNR using DCvT as compared to the same using DWT.

VI. Outcomes

The research work carried out so far and obtained corresponding results lead to following key findings:

Image watermarking carried out by DCvT of medical images which is our approach to use for these types of image data sets for watermarking to developing telemedicine application. The utilized transform method gives better results particularly for medical type images to perform watermarking operation. The corresponding statically analyzed data in terms of PSNR and MSE has been calculated where negative PSNR values are obtained in DWT based watermarking process while reverse watermarking process i.e. extracting the watermark from a watermarked image. Such negative PSNR can be improved in case of very large image size which is not practical for health care sector. The problem for the medical image data is overcome with the help of applying DCvT during the process of watermarking particularly for the medical images.

The result analysis indicates the image quality of the extracted watermark remained preserved with different combinations of cover images implemented via DCvT (Fig. 27).

We could conclude that the PSNR depends on cover image in case of DWT but using DCvT, it is not depending on the cover image. In contrast, using DWT, for a particular cover image and watermark image, it shows a range of fluctuations in performance parameters measurements. The same issue is faced in case of combination of fixed cover image and varied watermark images. The PSNR and the MSE parameters for DCvT are better compared to that of DWT for medical images (Fig. 28).

It leads to a tradeoff between both these parameters and the total time of processing. For our research, the quality and details of the recovered image is of priority rather than a highly time efficient system.

From all these findings, we come to the conclusion that for the case for image watermarking of medical images, we find DCvT is better suitable technique and should be used to develop a commercial application for medical/ health care field.

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