Volume 6, Issue 12, December 2016 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Blind Water Marking of 3-D Images Using DWT-SVD Technique

Rikky Rastogi
Computer Science, Sharda University, India

Dr. Rakesh Kumar
Computer Science, NITTR Chandigarh, India

Abstract: ***It has been known that blind watermarking scheme are more robust and secure against distortion-less attacks like vertex reordering and similarity transformation. Thus, it is required to develop watermarking scheme which is secure against both distortion and distortion-less attacks as well as maintaining the perceivable visual quality of processed 3-D image. To protect the digital multimedia content over the internet becomes a major issue for the owner of the content and various service providers. Here we propose blind watermarking algorithm for 3-D images by applying the hybrid DWT-SVD technique. We have combined the advantages of DWT and SVD to increase the effectiveness of the algorithm. Apply DWT to get the four sub bands of the original image then only on the single band apply SVD to get approximate cofficients and embed watermark on the singular value decomposed approximate cofficients. To gain the more robustness multiple SVD is applied on the watermarked image. We will use MATLAB to simulate our proposed work. We will test the results of both algorithms on the basis of subjective and objective measurement of visual quality of watermarked image. We will also demonstrate that proposed work is also robust against various attacks.***

Keywords: Blind Watermarking, DCT, DWT, SVD, Watermarking Technique

I. INTRODUCTION

In the present scenario, Watermarking is one of the most recent techniques which is used for the exclusive rights defense of digital communication. Digital watermarking is known as the art of hiding the information associated to digital information (i.e. an image, song, video etc.) within the information itself. In the process of digital watermarking, a portion of digital signal known as watermark is inserted into actual host digital data so that there are some updations in the features of the host digital signal. The embedded digital watermark generates the digital data about the author of the digital data and can be used to establish the possession in legal argument that is based on the watermark embedded which is used to protect the copyright of the owner. Various applications of the watermarks instead of the copyright protection are also possible such as tracking content distribution, fingerprinting, authentication, covert communications, labeling for data retrieval, error recovery in multimedia transmission, linking real objects to the digital world, annotation and copy control [1] [2].

To provide the security of the digital media, server has to be secure. One of the methods to maintain the security, user can confidentially give the details of user id and password on the secure server by using the predefined cryptographic algorithm such as SSL (secure socket layer) and he is able to gain access of the digital media. However, this can not guarantee that the subject will not be illegally used when the digital media is accessed by the user's computer because the user can modify the piracy otherwise his/her computer can be incompatible to handle the further problems. In this situation, we can see that putting the records on a secure computer does not always give assurance for the security. Therefore, the user needs more enhance mechanisms which contribute an extra security layer to protect the contents on digital media.

Various methods have been proposed to protect the contents on the digital media whose main wit focus on images, text, video and audio. Different watermarking techniques have been already applied on the digital media, but these techniques are not exactly providing the security and the robustness. On the basis of these reasons such as security and dimension, we can create new developing techniques for digital image more promising and challenging. Our approach consists in evaluating perceived geometric distortions directly by applying the DWT (Discrete wavelet transform) and SVD (Singular Value Decomposition) jointly. To achieve this, in a first stage, a series of adequate subjective experiments should be carried out to assess and to quantify the characteristics of perceptible distortions which are generated by watermarking operations. Then, mathematical operators capable of quantifying the most important characteristics must be designed. Finally, additional subjective tests will be needed in order to validate the degree of accuracy of the objective metric when compared to a subjective assessment.

This paper is organized as follows: Section 2 discusses the existing methods. In Section 3, we propose hybrid DWT-SVD technique for watermarking. In Section 4, we analyze and compare the existing and proposed schemes in terms of various attacks. Section 5 concludes this paper.

II. EXISTING WORK

Kejariwal Arun [1] identified those data embedding and data hiding techniques which are used to attempt to patent the digital data that is generously available on the World Wide Web to defend the owner's privileges. Ohbuchi R., Aono M., Masuda H., [2] discussed 3D model of polygon geometry based on embedding data. The author has presented various essential methods and algorithm for inserting data into the three dimensional polygon models. Koller, David and Levoy Marc [3] considered several techniques for defending 3D graphics content. The author describes a rendering the remote system have developed intended for involving archives of three dimensional models whereas defending the 3D geometry from unconstitutional extraction. Additionally, author demonstrates how digitized three dimensional models can be used to generate accurate physical replicas of art works such as Michelangelo's David. Levoy, M.et al. [4] discussed the challenges which they have faced in constructing this structure, the solutions author engaged, and the lessons author educated. The author developed for managing very huge scanned models. The author determined in scrupulous on the extraordinary design of laser triangulation scanner and software and on the algorithms. Arun K A, Jeno poul P [6] identified that a new imperceptible multiple digital watermarking proposal is to handle with the contented defendion problem of DIB and R three dimensional images. Author observed that the proper insertion order plays an even additional important role in data embedding the DIBR three dimensional images in addition the standard requirement of orthogonally of mutual among orientation patterns for numerous watermark embedding. Oliver Benedens [7] introduced a data embedding algorithm that is appropriate for embedding secure data embedding into 3 D polygon based models. Oliver Benedens [8] identified a digital watermarking algorithm which is used to embed private watermarks. This technique showed promising prospective with respect to toughness against mesh simplifications. Robustness achieved at the uppermost rate was fighting to a simplification which reduced the model to 36 percent of its actual number of faces. Limitation of this algorithm is that the huge amount of a priori data needed before watermark recovery. Oliver Benedens [9] introduced two methods, one method is vertex flood and another is triangle flood comprising fully of triangles which embeds logical digital watermark in 3-dimensional system. These two methods modify only geometry of the model and do not require being two manifold. Oliver Benedens [10] presented a mechanism which is used to embed private or public readable watermark into 3-dimensional models. This mechanism uses the polygonal models or the algorithm known as NURBS surfaces. Benedens Oliver and Busch Christoph [11] described an embedding watermark into 3D polygonal models which are dedicated for Digital Watermarking system. The structure consists of three watermarking algorithms named as Affine Invariant Embedding (AIE), Vertex Flood Algorithm (VFA) and Normal Bin Encoding (NBE). Paul J. Besl [12] described two techniques: iterative closest point (ICP) and manages the complete 6-degrees of freedom and the adjusting point on a numerical object to a given point. Allan M. Bruce [13] applied digital watermarking to many digital documents to shelter aligned with copyright infringements, including image, text and video formats. In this paper, numerous aspects of watermarking have been reviewed. Jillian Cannons [14] developed a combined hashing/watermarking scheme. This scheme uses small hash of the host signal which is available to a detector. Prospective applications comprise content tracking on forensic recognition and community networks. Chen Y. and Medioni G [15] proposed a novel approach based on range data unswervingly, and registered success views with sufficient overlapping area to get an accurate renovation connecting views. These techniques used to perform minimizing a well-designed it does not require point to point matches. Cho Jae-Won et al. [16] proposed two conscious digital watermarking methods for three dimensional polygonal mesh models. In first method shifting of the mean value of the distribution happens and in second its variance is changed. Cotting Daniel. et al.[17] presented a simple method for digital watermarking which is known as point-sampled geometry. This scheme is based on spectral analysis. Craver S. et al. [18] addressed the ability of imperceptible data embedding system to resolve patent possession. The author shows that, in assured applications, rightful patent possession cannot be determined by current data embedding mechanism alone. Fabien A.P. Petitcolas [19] have used a duality approach to the digital watermarking assessment problem. Duality approach has used by splitting the evaluation criteria into two (independent) groups: functionality and assurance. Farin G. [20] presented a unified approach for the non-uniform rational B-spline approximation used in the non-uniform rational. Florence Denis et al. [21] presented a strong watermarking algorithm applied to 3D compressed polygonal meshes. patent defendion of 3D models becomes extremely important for many applications using public networks. Guskov I., Sweldens W. and P. Schroder [22] presented a method to get a close nearby of any surface randomly with a normal semi-regular mesh. Jian-qiu, et al[24] introduced a watermarking algorithm for three dimensional mesh. They used a Circular wavelet transform in this algorithm. The author uses a Spherical Wavelet Transform (SWT) to decompose the actual mesh into a sequence of particulars at singular balance. Jones and Desbrun M.[25] proposed a thoroughly different technique, based on local first-order predictors of the surface and robust statistics rather than choosing the preceding work which was based on diffusion-based iterative techniques for smoothing that prevents features. The author proposes a new technique known as "triangle soups" . Kanai.S., Date H., Kishinami T. [26] introduced two different methods: Discrete Wavelet Transform (DWT) and multiple resolution representation (MRR) for inserting the watermark of a polygonal model. Lorensen W. E. and Cline H. E. [27] presented a new algorithm, which is known as "Marching cubes". It generates a triangular model of stable density surfaces from medical data in 3D form. Michael R.T., Wah C.P. and Lyu [28] proposed the new combined video digital watermarking method which is based on the error correction code, genetic algorithm and scene change analysis. The author claims that his video digital watermarking is robust against various attacks such as statistical analysis, frame dropping and averaging. Jae-Won Cho, Prost R. and Ho-Youl Jung [29] proposed a method for digital data embedding of three dimensional surface meshes. The author first analysis the irregular wavelet and secondly the watermark is used for embedding in the scalar coefficients. Jaipuria, S.J. [31] proposed the method called as Depth

Image Based Rendering (DIBR). The author focuses on the reimbursement of this novel approach on three dimensional TV. Yang Qin, Liujie Sun, Wenju Wang[32] presented a data embedding and hiding techniques for 3D model which is based on encrypted holographic digital watermarking technique to defend the inserted watermark data (such as a specific identity of the copyright information, etc.) and to recover the security and robustness of the digital watermark information. Akter, A., Nur-E-Tajnina, Ullah, M.A [33] uses two techniques, "Discrete Wavelet Transform" (DWT) and "Discrete Cosine Transform" (DCT). Foisal Hossain, M. Atal [34] identified that inserting gray scale data into RGB colour image can be used for a robust image watermarking scheme. The author applied three methods for robust watermarking that is discrete wavelet transform (DWT), chaotic system and singular value decomposition. Deb, Kaushik [35] identified that a digital watermarking is used for protecting the prohibited maneuvering of digital signal. In this paper, author uses low frequency with weighted correction using a combination of the DWT and DCT watermarking technique. Umaamaheshvari, A., Thanushkodi, K.[36] proposed a watermarking technique that combined both Discrete Wavelet Transform and Discrete Cosine Transform technique with low frequency weighted correction. It is similar to the subjective models of the human visual system. DWT offer scalability whereas DCT offer compression. Furqan, A.; Kumar, M [38] implemented an algorithm of digital watermarking which is a combined approach of discrete wavelet transform and singular value decomposition techniques. Rajawat, M., Tomar, D.S [39] have discussed a novel algorithm for digital data embedding and tampering detection technique and author also described that when these two techniques get combined then what is its impact in terms of security of image. Mehta, S., Nallusamy[40] identified that to improve citizen's health care, Information and Communication Technologies are being used widely. In this paper, the author analyses three wavelet based watermarking algorithms singular value decomposition, discrete wavelet transform and combination of DWT and SVD on the basis of their performance.

III. PROPOSED HYBRID DWT-SVD BASED BLIND WATERMARKING ALGORITHM

In the modern scenario, security is the essential part of digital media. Although various techniques have been applied, but they are not providing the required effectiveness in all the cases. To protect the content for the piracy and the copyright protection, digital watermarking has been applied.

3.1: Preprocessing

The Watermarking is not applied directly on the cover image. On the cover image, DWT is applied to get the four sub bands and on a single sub band apply SVD to form approximate cofficients.

There are several reasons to decompose cover image into singular value decomposition

- SVD is robust and stable method to split the image into the sub parts which are linearly independent to each other. Each subpart carries its own information to contribute the image information. This property of SVD is used for noise filtering and watermarking.
- Among the other transformation SVD provides the maximum energy packing. With the multi resolution property at each of the several level of resolution: spericity of principal components, isotropy and self-similarity under scaling the important characteristics of the image properties are measured.
- SVD is powerful technique in matrix decomposition.

3.2: Creation of Singular value decomposition of approximate coefficients

Digital images are generally represented as the low rank matrices so it can be described as the sum of a relatively sub parts of Eigen images. To obtain the approximate coefficient, firstly perform the DWT on the cover image to decompose it into non-overlapping multi resolution coefficients set: LL, HL, LH, HH by the following function

[LL, HL, LH, HH]=dwt2 (cover_object,'haar');

Then apply the singular value decomposition on the LL by the following function:

[U, S, V]=svd (LL);

As a result, the matrix has been broke into three matrices: an orthogonal matrix U, a diagonal matrix S, and the transpose of orthogonal matrix.

3.3: Watermark Insertion Algorithm

Create the dummy matrix where all the elements are zero according to the size of approximate coefficients. Embed the encrypted watermark elements into the dummy matrix.

Algorithm of Hybrid DWT-SVD based Blind Watermarking

Step-1 Import the cover image on which we want to do watermarking.
Step-2 Convert the cover image into the gray scale image.
Step-3 Calculate the size of cover image which is converted into the gray-scale image.
Step-4 Import the watermark image.
Step-5 Convert the watermark image into binary form.
Step-6 Calculate the size of watermark image.
Step-7 Calculate the total number of elements in the watermark image.
Step-8 Accept the cipher key from the user. The user can enter the key between 0 and 1.

After applying the above steps, for doing watermark we got the gray-scale cover image, gray-scale watermark image and the cipher key. Now, the following steps are applied for the encryption and hiding of watermark image.

Step-9 Generate the random sequence of watermark image according to the size of watermark image.
Step-10 Convert the random sequence matrix into the binary form.
Step-11 For encrypting the watermark image, take XOR of binary random sequence and binary watermark.
Step-12 Apply DWT on resulting value component of cover image to decompose into four sub bands approximate coefficient sets: LL, HL, LH, HH.
Step-13 Get the singular value decomposition U, S, V of the non-overlapping approximate coefficients.
Step-14 Calculate the size of approximate coefficients.
Step-15 Create the dummy matrix where all elements are zero according to the size of approximate coefficients.
Step-16 Insert the encrypted watermark elements into dummy matrix.
Step-17 Mix the watermark matrix with decomposed singular value of approximate coefficients of cover image.
*Temp= S + af * WW;*
Step-18 Mix the watermarked matrix with decomposed singular value of approximate coefficients of cover image to generate the new decomposed value *U1*, *S1*, *V1*.
Step-19 Mix the new decomposed values with old decomposed values.
*CW= U * S1 *V;*
Step-20 Perform the inverse discrete wavelet transforms on the DWT transformed image, including the modified coefficients sets, to produce the watermarked digital image.

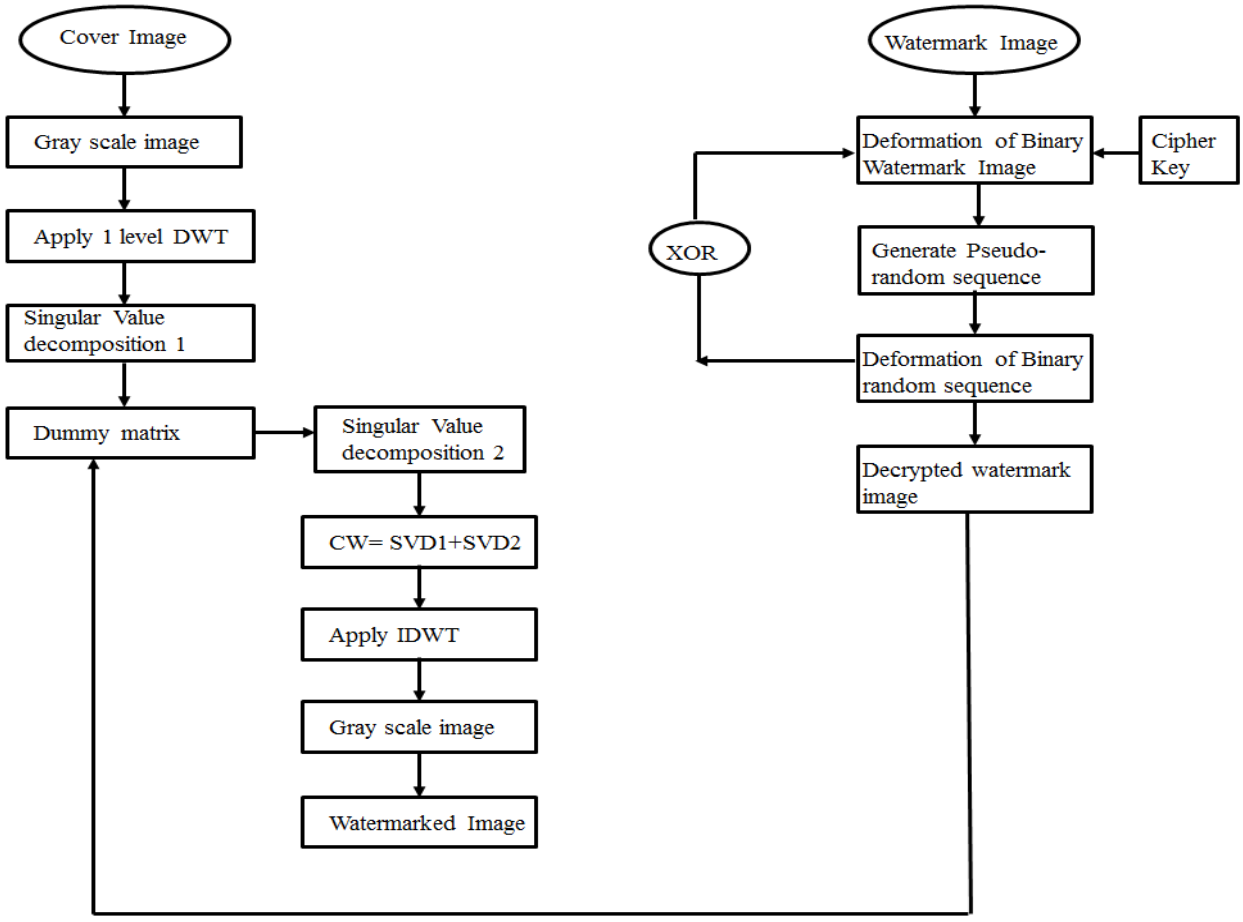

Fig. 1: watermark embedding process of the proposed technique

3.4: Watermark Extraction

This watermarking algorithm has been blind in nature, as it requires only the original model at the time of extraction. Watermark information can easily be obtained by subtracting the approximate coefficients of old singular value decomposition to the new approximate coefficients of new singular value decomposition. The result has been compared to the secure code for authentication.

Algorithm for extraction of hybrid DWT-SVD based watermarking

Step 1 Take the watermarked image and convert it into gray scale image.
Step-2 Perform the DWT on the watermarked image to decompose into sub band approximate cofficients: *LL1*, *HL1*, *LH1*and HH1.
Step-3 Get the singular value decomposition *U2, S2, V2* of the non-overlapping approximate coefficients.

Step-4 Mix the diagonal matrix *S2* with nonnegative diagonal elements and unitary matrices *U1* and *V1* obtained previously.

*SN=U1*S2*V1';*

Step-5 Extract the encrypted watermark from mixed matrix SN.

WN= (SN-S)/af;

Step-6 Create the dummy matrix where all the elements are zero according to the size of watermark matrix.

Step-7 Embed the extracted watermark elements into dummy matrix.

Now, the following steps are for the decryption of watermark.

Step-8 Take the encrypted watermark image.

Step-9 Accept the decipher key from the user. The user can enter the key between 0 and 1.

Step-10 Generate the random sequence of watermark image according to the size of watermark image.

Step-11 Convert the random sequence matrix into the binary form.

Step-12 For decrypting the watermark image, take XOR of binary random sequence and binary watermark.

Step-13 Estimate the similarity between the de watermark and original watermark.

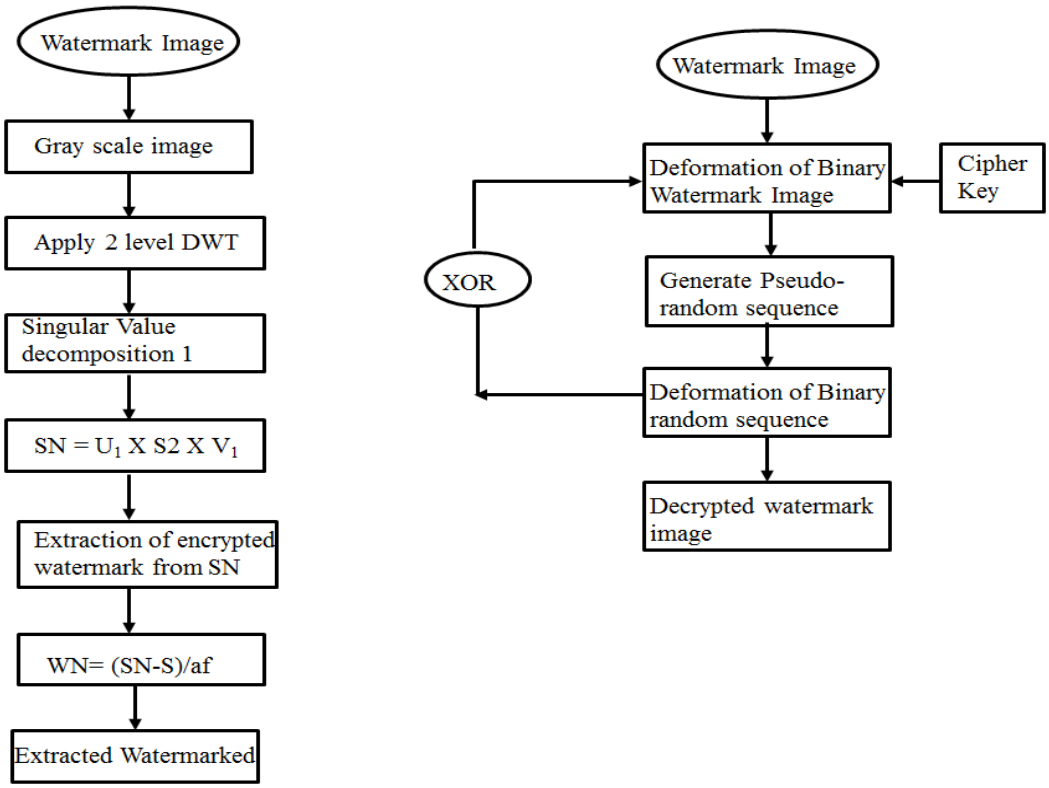

Fig.2: watermark extraction process of the proposed technique

The proposed method has four modules; each of the modules is described as follows:

Watermark: In this module digital image is used for the watermark. This image is now converted into the binary form. A key is inserted to the binary form. Binary random sequence matrix has been formed. At last XOR operation is used on Binary matrix and the binary random sequence matrix. This XOR operation provides the encrypted watermark binary matrix.

Dummy Matrix: By applying the DWT-SVD, the gray scale cover image produces the singular value decomposition of approximate cofficients. Depending on the size of the approximate cofficients, dummy matrix is created where all the elements are zero.

Watermarked Host Image: By embedding the encrypted watermark binary matrix into the dummy matrix, watermarked host image can be formed.

Secured Watermarked Host Image: By applying the 2 level Singular value decomposition, the watermarked host image can be protected for piracy and copyright.

IV. PERFORMANCE ANALYSIS

To evaluate the performance of the proposed algorithm, in a first stage, a series of adequate subjective experiments should be carried out to assess and to quantify the characteristics of perceptible distortions which are generated by watermarking operations. Then, mathematical operators capable of quantifying the most important characteristics must be designed. Finally, additional subjective tests will be needed in order to validate the degree of accuracy of the objective metric when compared to a subjective assessment.

A novel method for blind watermarking using an advanced method has been proposed in this research work. The proposed watermarking algorithm is tested on a standard host or cover image "Lena. Jpg" and a watermark image "watermark. Png", shown in fig.3.

Fig.3: Images used to obtain the results

The size of cover image is 1024 x 1024 and that of watermark is 512 x 256. Dual Singular value decomposition (SVD) and discrete wavelet transform (DWT) has been used for the decomposition of cover image. The hybrid DWT-SVD based blind watermarking algorithm has been tested on various attacks. The various tested attacks are Gaussian noise, Salt & Pepper, Speckle noise**.**

To evaluate the performance of the proposed method, evaluation metrics used are MSE (Mean Square Error), PSNR (Peak Signal to Noise Ratio) and NC (Normalized Correlation). In order to measure imperceptibility between the original image and watermarked image, PSNR value is widely used. PSNR is defined by the eqn. (1).

$$PSNR = 10\ log_{10}(255^2/MSE) \quad (1)$$

The error between the original watermark (w) and extracted watermark (w1) from the attacked image is evaluated by using MSE given by the eqn. (2).

$$MSE=\frac{1}{M*N}\sum_{m=1}^{M}\sum_{n=1}^{N}[w(m,n)-w1(m,n)]^2 \quad (2)$$

Where: M=maximum number of rows, N=maximum number of colouns, m=current row, n=current column.

The similarity between the original watermark (w) and extracted watermark (w1) from the attacked image is evaluated by using NC given by the eqn. (3).

$$NC=\frac{\sum i\sum j\, w(i,j)w'(i,j)}{\sum i\sum j Iw(i,j)I^2} \quad (3)$$

The above said three parameters has been calculated and compared with that of existing method for all types of attacks and given in table 1. Table 1 is the proof of better performance of proposed method as compared to existing method.

Table-1: Comparison with Existing method

NOISE ATTACK	**MSE**		**PSNR**		**CORRELATION**	
	Existing Algorithm	**Proposed Algorithm**	**Existing Algorithm**	**Proposed Algorithm**	**Existing Algorithm**	**Proposed Algorithm**
Gaussian white noise [m=0v= 0.01]	0.2505	4.4250e-04	65.77823	81.7056	0.9445	0.9986
Gaussian white noise [m=0v= 0.02]	0.2364	3.8910e-04	73.7353	82.2642	0.9245	0.9988
Gaussian white noise [m=0.01v= .01]	0.2459	4.3488e-04	83.3573	81.7812	0.9346	0.9987
Salt & Pepper [d=0.1]	0.1943	5.4932e-04	78.5476	80.7666	0.9185	0.9983
Salt & Pepper [d=0.3]	0.2136	4.3488e-04	82.7509	81.7812	0.9267	0.9987
Salt & Pepper [d=0.5]	0.2492	3.5095e-04	83.4980	82.7123	0.9296	0.9989
Speckle Noise [v=0.1]	0.1893	5.0354e-04	79.9438	81.1445	0.9586	0.9984
Speckle Noise [v=0.2]	0.2596	5.5695e-04	82.4749	80.7067	0.9476	0.9983
Speckle Noise [v=0.5]	0.2490	4.0436e-04	84.9492	82.0971	0.9379	0.9987

By using Table 1 the graphs have been plotted for the various attacks:

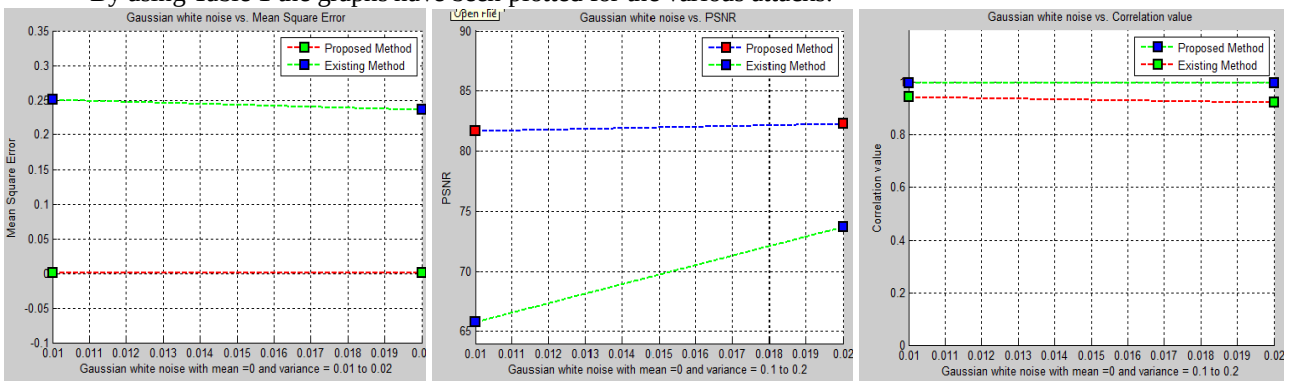

Figure 4: Comparative graph on Gaussian Noise vs. MSE, Gaussian Noise vs. PSNR & Gaussian Noise vs. NC

On comparing the different values of MSE, PSNR and NC at Gaussian attack by applying the two techniques DWT-DCT and DWT-SVD, it is concluded that DWT-SVD is much better than DWT-DCT technique. At every value of scaling factors, peak signal to noise ratio and normalized correlation values is increasing in case of proposed technique and mean square error is decreasing. This shows that the quality of the original image is not degrading after watermarking.

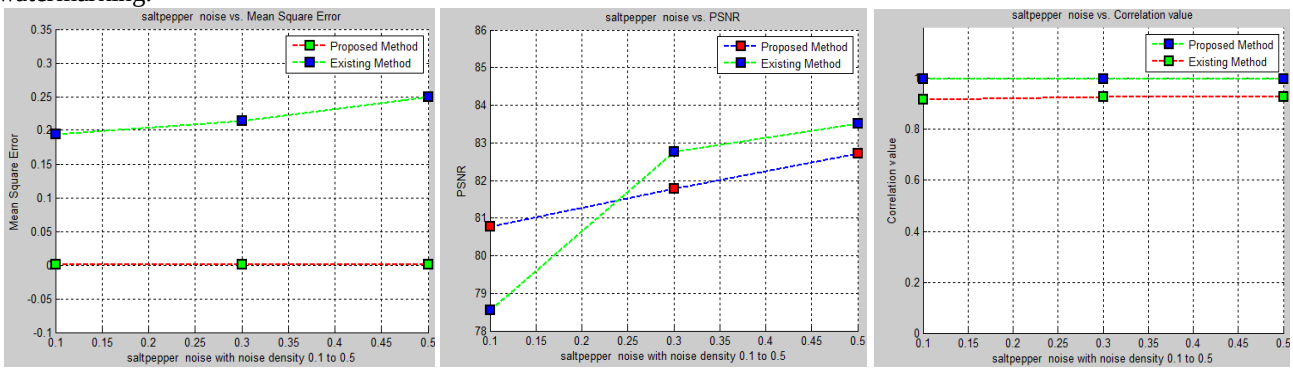

Figure 5: Comparative graph on Salt & Pepper Noise vs. MSE, Salt & Pepper vs. PSNR & Salt & Pepper vs. NC

On comparing the different values of MSE, PSNR and NC at Salt & Pepper attack by applying the two techniques DWT-DCT and DWT-SVD, it is observed that the proposed method gives the more accurate result than previous technique. At every value of scaling factors, peak signal to noise ratio and normalized correlation values is increasing in case of proposed technique and mean square error is decreasing. This shows that the quality of the original image is not degrading after watermarking.

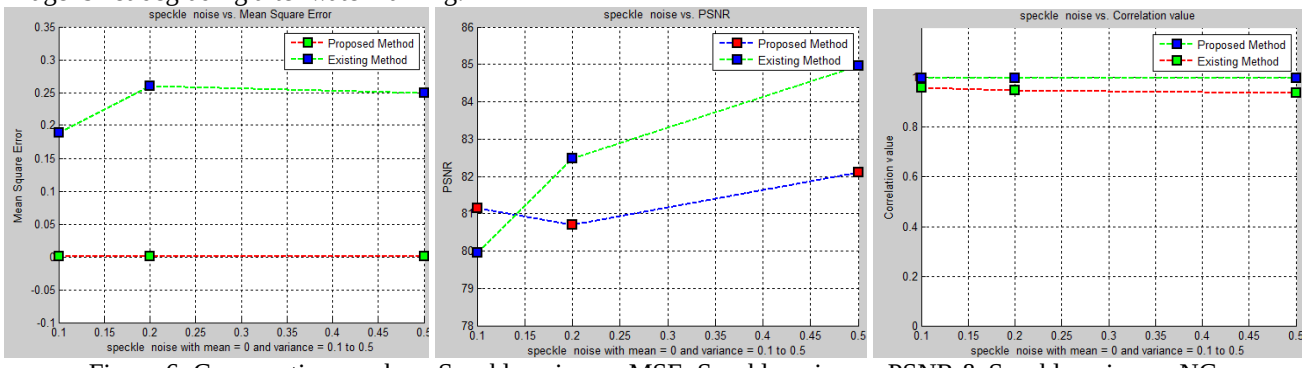

Figure 6: Comparative graph on Speckle noise vs. MSE, Speckle noise vs. PSNR & Speckle noise vs. NC

On comparing the different values of MSE, PSNR and NC at Speckle attack by applying the two techniques DWT-DCT and DWT-SVD, it is concluded that DWT-SVD is much better than DWT-DCT technique. Both NC and PSNR increased gradually with increasing variance of different parameters. MSE decreased gradually with increasing variance of different parameters.

By observing these graphs in fig. 5, 6, 7, it is concluded that the quality of the original image is not degrading after applying the watermark.

On comparing the different values of MSE, PSNR and NC at various attacks by applying the two techniques DWT-DCT and DWT-SVD, it is concluded that DWT-SVD is much better than DWT-DCT technique. Both NC and PSNR increased gradually with increasing variance of different parameters. MSE decreased gradually with increasing variance of different parameters. By observing this table, it is concluded that the quality of the original image is not degrading after applying the watermark.

V. CONCLUSIONS

In this paper a new robust blind watermarking scheme has been proposed for the digital image. Our observations of the proposed worked is summarized as follows:

- SVD is a very effective tool for watermarking in DWT environment. We observed that in the proposed method by using DWT, the digital image is converted into the four non-overlapping wavelet cofficients and on the single sub-band or on the detailed cofficients LL, SVD is applied so that it produces the singular value approximate cofficients. The approximate value is 0.1 as we increase the value in that case the image will become blurred.
- To enhance the robustness, watermark has also encrypted. Encrypted watermark inserted at the dummy matrix. This dummy matrix created by calculating the size of the approximate cofficients matrix. Dummy matrix is the matrix where all elements are zero.
- One main benefit of SVD-based watermarking is that there is no need insert all singular values of a watermark. We can embed the watermark on any single vector. In our proposed method, we embedded the watermark on the diagonal vector with dummy matrix.
- By applying dual SVD on the watermarked image has enhanced the most robustness and security of the proposed algorithm.
- The quality of the constructed watermark can be evaluated by the observers whether it is subjectively or objectively. In subjectively observation, the original watermark is compared with the constructed watermark after attacks. In objectively observation, statistical measures like PSNR, MSE, and NC can be used.
- The proposed algorithm introduces a very minute distortion, which can be easily neglected. The algorithm provides a great flexibility in achieving desired results in the watermarked image considering the tradeoff between originality and robustness.

REFERENCES

[1] Kejariwal Arun, "Watermarking," *Magazine: IEEE Potentials*, pp. 37-40, October/November 2003,

[2] Ohbuchi R., Masuda H., Aono M., "Watermarking three dimensional polygonal models," *in Proceedings of the ACM Multimedia '97, Seattle, Washington, USA*, pp. 261-272, November 1997.

[3] Koller, David and Levoy Marc, "Protecting 3D graphics content," *Communications of The ACM,* Vol. 48, No. 6, pp. 74-80, June 2005.

[4] Levoy, M.et al., "The Digital Michelangelo Project," *in Proceedings of ACM SIGGRAPH ACM Press, New York*, graphics.stanford.edu/projects/mich, pp. 131–144,*July 23–28,* 2000.

[5] Nikolaidis N. and Pitas I., "Digital watermarking: an overview," *in proceedings of IEEE International Conference on Multimedia Computing and Systems*, Vol. 1, pp 1-6, 1999.

[6] Kejariwal Arun and Jeno poul P., "Protection of Depth image based rendering 3-D images using bling watermarking,". *in proceedings of IEEE International Conference on Computing, Communications and Networking Technologies (ICCCNT),pp 1-6.* July 2013.

[7] Benedens Oliver, "Watermarking of 3D polygon based models with robustness against mesh simplification," *in Proceedings of SPIE: Security and Watermarking of Multimedia Contents*, vol. 3657, pp. 329–340, 1999.

[8] Benedens Oliver, "Geometry based watermarking of 3D models," *IEEE Magazine*, pp 46-55, Jan/Feb1999.

[9] Benedens Oliver, "Two high capacity methods for embedding public watermarks into 3D polygonal models," *in Proceedings of the Multimedia and Security-Workshop at ACM Multimedia 99, Orlando, Florida*, pp 95–99, 1999.

[10] Benedens Oliver , "Affine invariant watermarks for 3D polygonal and NURBS based models," in proceedings of the Third International Workshop on Information Security ISW2000, pp 15 – 29, 2000.

[11] Benedens Oliver and Busch Christoph, "Towards blind detection of robust watermarks in polygonal models," *in proceedings Euro graphics 2000*, Vol. 19, no 3, pp.C199-C208, 2000.

[12] Besl P. and McKay N. , "A method for registration of 3D shapes," *IEEE Trans. on Pattern Analysis and Machine Intelligence*, Vol.18 (14), pp. 239–256, 1992.

[13] Bruce M. Allan, "A review of digital watermarking," *Department of Engineering, University of Aberdeen*, 2nd November 2001.

[14] Cannons Jillian and Moulin Pierre, "Design and statistical analysis of a hash-aided image watermarking system," *IEEE Transactions on Image Processing,* Vol. 13, No. 10, PP. 1393-1408, October 2004.

[15] Chen Y. and Medioni G., "Object modelling by registration of multiple range images," *Image and Vision Computing*, Vol.10(3), pp. 145–155, April 1992.

[16] Cho Jae-Won et al., "An oblivious watermarking for 3-D polygonal meshes using distribution of vertex norms," *IEEE Transactions on Signal Processing*, Vol. 55(1), pp. 142-155, Jan 2007.

[17] Cotting Daniel, Weyrich Tim, Pauly Mark & Gross Markus, "Robust watermarking of point-sampled geometry," *Appeared in the proceeding of the International Conference on Shape and Modeling and Application*, 2004.

[18] Craver S. et al., "Resolving rightful ownerships with invisible watermarking techniques: limitations, attacks and implications," *IEEE Journal on Selected Areas in Communications*, vol. 16, no. 4, pp. 573-586, 1998.

[19] Fabien A.P. Petitcolas, "Watermarking schemes evaluation," *IEEE Signal Processing Magazin*, pp. 58-64, Sep 2000.

[20] Farin G., "Curves and surfaces for CAGD: a practical guide," *Academic Press* Fourth edition, 1996.

[21] Florence Denis et al., "Digital watermarking of compressed 3D meshes," *Dans International Conference on Machine Intelligence (ACIDCA-ICMI), Tozeur, Tunisia, 2005.*

[22] Guskov I., Sweldens W. and P. Schroder, "Normal meshes," *in Proceedings of the 27th annual conference on Computer graphics and interactive techniques. ACM Press/Addison-Wesley Publishing Co.,* pp.95-102, 2000.

[23] Hartung F. and Kutter M., "Multimedia watermarking techniques," *In Proceeding of IEEE,* vol. 87, no. 7,June 1999.

[24] Jian-qiu, Min-ya, Hu-jun and Qun-sheng, "Watermarking on 3D mesh based on spherical wavelet transform," *J Zhejiang Univ SCI,* Vol. 5(3) pp 251-258, 2004.

[25] Jones T. R., F. Durand and Desbrun M., "Non-iterative feature-preserving mesh smoothing," *ACM Transactions on Graphics,* Vol. 22, no. 3, pp. 943-949, 2003.

[26] Kanai S., Date H., Kishinami T., "Digital watermarking for 3D polygons using multiresolution wavelet decomposition," in *Proceedings of the Sixth IFIP WG 5.2 International Workshop on Geometric Modeling: Fundamentals and Applications (GEO-6)*, pp. 296-307, December 1998.

[27] Lorensen W. E. and Cline H. E., "Marching cubes: A high resolution 3D surface construction algorithm," *in Proceedings of the 14th annual conference on Computer graphics and interactive techniques. ACM Press*, pp.163-169, 1987.

[28] Michael R.T., Wah C.P. and Lyu, "Digital video watermarking technique for secure multimedia creation and delivery," *Deptt. of Computer Science and Engineering, Chinese Univ., Hong-Kong,* 2002.

[29] Min-Su Kim, Jae-Won Cho, Ho-Youl Jung and Prost R., "A robust blind watermarking for 3D meshes using distribution of scale coefficients in irregular wavelet analysis," *in Proceedings of Acoustics, Speech and Signal Processing*, Volume: 5, 14-19 May 2006.

[30] Podilchuk C.I. and Delp E.J., "Digital watermarking: algorithms and applications," *IEEE Signal Processing Magazine*, pp. 33-46, July 2001.

[31] Smita Jagdishprasad Jaipuria "Watermarking for Depth Map Based 3D images using wavelet transform" in proceedings of IEEE International Conference on Communications and Signal Processing (ICCSP),pp. 181-185,3-5April 2014

[32] Yang Qin; Liujie Sun; Wenju Wang "A robust watermarking scheme for 3D models based on encrypted holographic algorithm" in proceedings of IEEE International Conference on Intelligent Computing and Internet of Things (ICIT),pp.85-89,2015.

[33] Akter, A.; Nur-E-Tajnina; Ullah, M.A., "Digital image watermarking based on DWT-DCT: Evaluate for a new embedding algorithm." in proceedings of IEEE International Conference on Informatics, Electronics & Vision (ICIEV),pp 1-6,2014.

[34] Moniruzzaman, M.; Kayum Hawlader, M.A.; Foisal Hossain, M., "Robust RGB color image watermarking scheme based on DWT-SVD and chaotic system," in proceedings of IEEE International Conference on Software, Knowledge, Information Management and Applications (SKIMA), pp.1-6,2014.

[35] Deb, Kaushik; Al-Seraj, Md.Sajib; Kowsar, Mir Md.Saki; Sarkar, Iqbal Hasan, "A joint DWT-DCT based watermarking technique for avoiding unauthorized replication," in proceedings of International Forum on Strategic Technology (IFOST), pp.1-5,2012.

[36] Umaamaheshvari, A.; Thanushkodi, K., " Robust image watermarking based on block based error correction code," in proceedings of IEEE International Conference on Current Trends in Engineering and Technology (ICCTET), pp.34-40,2013.

[37] Naderahmadian, Y.; Beheshti, S., " Robustness of wavelet domain watermarking against scaling attack," in proceedings of Canadian Conference on Electrical and Computer Engineering (CCECE), pp. 1218-1222,2015.

[38] Furqan, A.; Kumar, M., "Study and Analysis of Robust DWT-SVD Domain Based Digital ImageWatermarking Technique Using MATLAB," in proceedings of IEEE International Conference on Computational Intelligence & Communication Technology (CICT), pp.638-644,2015.

[39] Rajawat, M.; Tomar, D.S., " A Secure Watermarking and Tampering Detection Technique on RGB Image Using 2 Level DWT," in proceedings of IEEE International Conference on Communication Systems and Network Technologies (CSNT), pp. 638-642,2015.

[40] Mehta, S.; Nallusamy, R.; Marawar, R.V.; Prabhakaran, B. "A Study of DWT and SVD Based Watermarking Algorithms for Patient Privacy in Medical Images" in proceedings of IEEE International Conference on Healthcare Informatics (ICHI), pp.287-296,2013.

