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Robust Image Watermarking Algorithm DWT-SVD-AES for Telemedicine Application

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ABSTRACT: *In this paper, the effects of various error rectification codes on the robustness of (DWT) discrete wavelet transform, (SVD) singular value decomposition based hybrid watermarking scheme and AES encryption is investigated. The performance of the proposed system is calculated in terms of number of signal processing attacks by changing the strength of watermarking and covers image modalities. The experimental results demonstrate that this proposed system provides better robustness without affecting the quality of watermarked image. This proposed system combines the advantages and removes the disadvantages of the two transform techniques. It demands serious protection of user's privacy for all applications. Therefore image encryption and decryption techniques are usually used to avoid intrusion attack. It is found that the hybrid code achieves better results in terms of robustness. This paper provides a detailed analysis of the obtained experimental results.*

I. INTRODUCTION:

1) Watermarking: -

A **watermark** is an identifying image or pattern in paper that appears as various shades of lightness/darkness when viewed by transmitted light (or when viewed by reflected light, atop a dark background), caused by thickness or density variations in the paper. A watermark is a more or less transparent image or text that has been applied to a piece of paper, another image to either protect the original image, or to make it harder to copy the item. Watermarks vary greatly in their visibility; while some are obvious on casual inspection, others require some study to pick out. Various aids have been developed, such as watermark fluid that wets the paper without damaging it. Watermarks are often used as security features of banknotes, passports, postage stamps, and other government documents to

prevent counterfeiting. A watermark is very useful in the examination of paper because it can be used for dating, identifying sizes, mill trademarks and locations, and determining the quality of a sheet of paper.

There are two main ways of producing watermarks in paper; the dandy roll process, and the more complex cylinder mould process.

a) Dandy roll process

A watermark is made by impressing a water-coated metal stamp or **dandy roll** onto the paper during manufacturing. While watermarks were first introduced in Fabriano, Italy, in 1282, the invention of the dandy roll in 1826 by John Marshall revolutionised the watermark process and made it easier for producers to watermark their paper.

The dandy roll is a light roller covered by material similar to window screen that is embossed with a pattern. Faint lines are made by laid wires that run parallel to the axis of the dandy roll, and the bold lines are made by chain wires that run around the circumference to secure the laid wires to the roll from the outside. Because the chain wires are located on the outside of the laid wires, they have a greater influence on the impression in the pulp, hence their bolder appearance than the laid wire lines.

This embossing is transferred to the pulp fibres, compressing and reducing their thickness in that area. Because the patterned portion of the page is thinner, it transmits more light through and therefore has a lighter appearance than the surrounding paper. If these lines are distinct and parallel, and/or there is a watermark, then the paper is termed laid paper. If the lines appear as a mesh or are indiscernible, and/or there is no watermark, then it is called wove paper. This method is called line drawing watermarks.

b) Cylinder mould process

Another type of watermark is called the cylinder mould watermark. A shaded watermark, first used in 1848, incorporates tonal depth and creates a greyscale image. Instead of using a wire covering for the dandy roll, the shaded watermark is created by areas of relief on the roll's own surface. Once dry, the paper may then be rolled again to produce a watermark of even thickness but with varying density. The resulting watermark is generally much clearer and more detailed than those made by the Dandy Roll process, and as such Cylinder Mould Watermark Paper is the preferred type of watermarked paper for banknotes, passports, motor vehicle titles, and other documents where it is an important anti-counterfeiting measure.

2) Digital watermarking

The term "Digital Watermark" was coined by Andrew Tirkel and Charles Osborne in December 1992. The first successful embedding and extraction of a steganographic spread spectrum watermark was demonstrated in 1993 by Andrew Tirkel, Charles Osborne and Gerard Rankin.

Watermarks are identification marks produced during the paper making process. The first watermarks appeared in Italy during the 13th century, but their use rapidly spread across Europe. They were used as a means to identify the papermaker or the trade guild that manufactured the paper. The marks often were created by a wire sewn onto the paper mold. Watermarks continue to be used today as manufacturer's marks and to prevent forgery.

A digital watermark added to a photo, is more or less visible information in the form of a text or some other photo/image that has been added to the original photo. The added information can be more or less transparent to make it either easy or hard to notice the watermark. Digital watermarking is some embedding in formation in a digital signal. It is used to verify the digital signal authenticity or the

identity of its owners. Common medium on digital watermarking is audio, picture, or video. Several different digital watermarks can be embedding in one signal at the same time, and if the signal is copied, then the information on it will also be copied and carried in the copy.

Now days, technology is developing more and more fast, it is playing an important role in people's life and work. With the rapid development of network and digital technology, we widely use the Internet and digital signal to transmit information. Digital watermarking is used for a wide range of applications, such as: copyright protection, source tracking, broadcast monitoring, covert communication, bills security and authenticity identification.

Digital watermarking is not a novel technology, there are some traditional algorithms and applications, but with the emergence of new digital signal, application and attack, corresponding digital watermarking will appear.

Like traditional watermarks, digital watermarks are only perceptible under certain conditions, i.e. after using some algorithm, and imperceptible otherwise. If a digital watermark distorts the carrier signal in a way that it becomes perceivable, it is of no use. Traditional Watermarks may be applied to visible media (like images or video), whereas in digital watermarking, the signal may be audio, pictures, video, texts or 3D models. A signal may carry several different watermarks at the same time. Unlike metadata that is added to the carrier signal, a digital watermark does not change the size of the carrier signal.

The needed properties of a digital watermark depend on the use case in which it is applied. For marking media files with copyright information, a digital watermark has to be rather robust against modifications that can be applied to the carrier signal. Instead, if integrity has to be ensured, a fragile watermark would be applied.

Visible/invisible digital watermarking

Visible and invisible are the two basic types of digital watermarking, and every digital watermark can be considered as either visible or invisible.

Visible digital watermarking is a way by which anybody can put visible information in digital signal; the information is often a logo, which identifies the owner of the digital signal. For example, a television broadcaster usually adds its logo to the corner of its video; this is a typically visible digital watermark.

Invisible digital watermarking is a way by which anybody can hide information in digital signal and the information will not be perceived. Since it is invisible, invisible digital watermarking has a widespread use. It can be used to add identification of owner in signal and is more difficult to detect and remove. It is also possible to use embedded information to share secret or communicate in a hidden way. The invisible digital watermarking can be detected and validated by some specific technology or the people share secret with the owner. The research on digital watermarking algorithm, application and attack are most about invisible digital watermarking.

Common medium on watermarking

Generally, a digital watermark can be embedded into all forms of media. The most common medium are audio, video and picture. It is easy to add a visible digital watermark on a digital signal; it just needs to add some data on original signal. But to make an invisible digital is not so easy as visible digital watermarking. Different medium has different data structure, so according to different medium, various algorithms are used to add digital watermarks in signal without changing the way which original signal looks like.

- **Classification**

A digital watermark is called robust with respect to transformations if the embedded information may be detected reliably from the marked signal, even if degraded by any number of transformations. Typical image degradations are JPEG compression, rotation, cropping, additive noise, and quantization. For video content, temporal modifications and MPEG compression often are added to this list. A digital watermark is called imperceptible if the watermarked content is perceptually equivalent to the original, unwatermarked content. In general, it is easy to create either robust watermarks or imperceptible watermarks, but the creation of both robust and imperceptible watermarks has proven to be quite challenging. Robust imperceptible watermarks have been proposed as a tool for the protection of digital content, for example as an embedded no-copy-allowed flag in professional video content.

Digital watermarking techniques may be classified in several ways.

- **Robustness: -**

Robustness is one of the most important attributes of a digital watermark. A fragile digital watermark is a digital watermark that fails to be detected after the slightest modifies. A semi-fragile digital watermark is a digital watermark that resists benign transformation but fails to be detected after malignant transformations. A robust digital watermark is a digital watermark that resists a designated class of transformations. It does not mean that a robust digital watermark is better than a fragile digital watermark. Fragile and semi-fragile digital watermarks are commonly used to detect malignant transformations and protect the integrity of the digital signal. Robust digital watermarks are often used in copy protection applications.

- **Capacity**

It is a way to determines two different main classes of digital watermarking schemes by the length of the embedded message. In zero-bit or presence watermarking schemes, the message is conceptually zero-bit long, it is designed to detect the presence or the absence of the digital watermark in the marked object. In multiple-bit watermarking or non-zero-bit watermarking schemes, the n-bit-long stream message is modulated in the watermark.

- **Blindness**

If a digital watermarking requires the original data for watermark, it is called non-blind watermarking. If a digital does not require the original data for watermark, it is called blind watermarking.

- **Perceptibility**

A digital watermark is called imperceptible if the original cover signal and the marked signal are perceptually indistinguishable.

A digital watermark is called perceptible if its presence in the marked signal is noticeable (e.g. Digital On-screen Graphics like a Network Logo, Content Bug, Codes, Opaque images). On videos and images, some are made transparent/translucent for convience for people due to the fact that they block portion of the view.

This should not be confused with perceptual, that is, watermarking which uses the limitations of human perception to be imperceptible.

- **Embedding method**

If the marked signal is obtained by an additive modification, this kind embedding method is called spread-spectrum. If the marked signal is obtained by quantization, this kind embedding method is

called quantization type. If the marked signal is embedded by additive modification in the spatial domain, this kind embedding method is called amplitude modulation. Spread-spectrum digital watermarks have the best robustness but weak in capacity. Quantization digital watermarks are known to be weak in robustness but have great capacity.

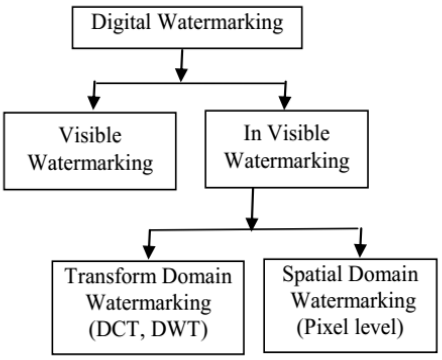


Fig.1 Classification of Watermarking Techniques

The Future of Digital Watermarking

A number of companies, such as the Digimarc Corporation, Sony and IBM have introduced digital watermarking software applications that allow individuals to imbed watermarks within image, audio and video files to protect them from copyright infringement. The watermarks may be viewed with software and can reveal either a unique identification code that can be traced to the copyright owner or specific information about the copyright owner.

Companies are also offering on-line tracking services so that the copyright owner can see how the owner's materials are used via the Web. These processes will continue to help the fight against electronic copyright infringement.

Algorithm in digital watermarking

DWT (Discrete Wavelet Transform): -

The DWT (Discrete Wavelet Transform) is a powerful and useful multi-resolution decomposition method in digital watermarking. It is often applied on image processing, and has been applied to such as noise reduction, edge detection, and data compression. It is consistent with the visual perception process of human eyes. Discrete Wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image. It is useful for processing of non-stationary signals. The transform is based on small waves, called wavelets, of varying frequency and limited duration. Wavelet transform provides both frequency and spatial description of an image. Unlike conventional Fourier transform, temporal information is retained in this transformation process. Wavelets are created by translations and dilations of a fixed function called mother wavelet. DWT is the multiresolution description of an image the decoding can be processed sequentially from a low resolution to the higher resolution. The DWT splits the signal into high and low frequency parts. The high frequency part contains information about the edge components, while the low frequency part is split again into high and low frequency parts. The high frequency components are usually used for watermarking since the human eye is less sensitive to changes in edges.

DWT is currently used in a wide variety of signal processing applications, such as in audio and video compression, removal of noise in audio, and the simulation of wireless antenna distribution. Wavelets have their energy concentrated in time and are well suited for the analysis of transient, time-varying

signals. Since most of the real life signals encountered are time varying in nature, the Wavelet Transform suits many applications very well.

Wavelet transform decomposes an image into a set of band limited components which can be reassembled to reconstruct the original image without error. Since the bandwidth of the resulting coefficient sets is smaller than that of the original image, the coefficient sets can be down sampled without loss of information. Reconstruction of the original signal is accomplished by up sampling, filtering and summing the individual sub bands. For 2-D images, applying DWT corresponds to processing the image by 2-D filters in each dimension. The filters divide the input image into four non-overlapping multi-resolution coefficient sets, a lower resolution approximation image (LL1) as well as horizontal (HL1), vertical (LH1) and diagonal (HH1) detail components. The sub-band LL1 represents the coarse-scale DWT coefficients while the coefficient sets LH1, HL1 and HH1 represent the fine-scale of DWT coefficients. To obtain the next coarser scale of wavelet coefficients, the sub-band LL1 is further processed until some final scale N is reached. When N is reached we will have 3N+1 coefficient sets consisting of the multiresolution coefficient sets LLN and LHX, HLX and HHX, where x ranges from 1 until N. Due to its excellent spatiofrequency localization properties, the DWT is very suitable to identify the areas in the host image where a watermark can be embedded effectively. In particular, this property allows the exploitation of the masking effect of the human visual system such that if a DWT coefficient is modified, only the region corresponding to that coefficient will be modified. In general most of the image energy is concentrated at the lower frequency coefficient sets LLx and therefore embedding watermarks in these coefficient sets may degrade the image significantly. Embedding in the low frequency coefficient sets, however, could increase robustness significantly.

On the other hand, the high frequency coefficient sets HHx include the edges and textures of the image and the human eye is not generally sensitive to changes in such coefficient sets. This allows the watermark to be embedded without being perceived by the human eye. The agreement adopted by many DWT-based watermarking methods, is to embed the watermark in the middle frequency coefficient sets HLX and LHX is better in perspective of imperceptibility and robustness.

Wavelet Transform is a modern technique frequently used in digital image processing, compression, watermarking etc. The transforms are based on small waves, called wavelet, of varying frequency and limited duration. A wavelet series is a representation of a square-integrable function by a certain ortho-normal series generated by a wavelet. Furthermore, the properties of wavelet could decompose original signal into wavelet transform coefficients which contains the position information. The original signal can be completely reconstructed by performing Inverse Wavelet Transformation on these coefficients. Watermarking in the wavelet transform domain is generally a problem of embedding watermark in the sub bands of the cover image.

Wavelet transform is a time domain localized analysis method with the windows size fixed and form convertible. There is quite good time differentiated rate in high frequency part of signals DWT transformed. Also there is quite good frequency differentiated rate in its low frequency part. It can distill the information from signal effectively. The basic idea of discrete wavelet transform (DWT) in image process is to multi-differentiated decompose the image into sub-image of different spatial domain and independent frequency district. Then transform the coefficient of sub-image. After the original image has been DWT transformed, it is decomposed into 4 frequency districts which is one low-frequency district(LL) and three high-frequency districts(LH,HL,HH).

Advantages of DWT

- No need to divide the input coding into non-overlapping
- D blocks, it has higher compression ratios avoid blocking artifacts
- Allows good localization both in time and spatial frequency domain
- Transformation of the whole image introduces inherent scaling
- Better identification of which data is relevant to human perception higher compression ratio
- Higher flexibility: Wavelet function can be freely chosen.

Disadvantages of DWT

- The cost of computing DWT as compared to DCT may be higher.
- The use of larger DWT basis functions or wavelet filters produces blurring and ringing noise near edge regions in images or video frames
- Longer compression time.

Due to its excellent spatio-frequency localization properties, the DWT is very suitable to identify the areas in the host image where a watermark can be embedded effectively. In particular, this property allows the exploitation of the masking effect of the human visual system such that if a DWT coefficient is modified, only the region corresponding to that coefficient will be modified. In general most of the image energy is concentrated at the lower frequency sub-bands LLx and therefore embedding watermarks in these sub-bands may degrade the image significantly. Embedding in the low frequency sub-bands, however, could increase robustness significantly. On the other hand, the high frequency sub-bands HHx include the edges and textures of the image and the human eye is not generally sensitive to changes in such sub-bands. This allows the watermark to be embedded without being perceived by the human eye. The compromise adopted by many DWT-based watermarking algorithm, is to embed the watermark in the middle frequency ub-bands LHx and HLx where acceptable performance of imperceptibility and robustness could be achieved.

II. RELATED WORK:

Digital Image Watermarking Using DWT and Shift Invariant Edge Detection [01],Adding robustness and invisibility to digital image watermarking method for copyright protection is a challenging task. In this paper a robust invisible watermarking algorithm is proposed using discrete wavelet transform based edge detection. Image is decomposed to sub-band coefficients using the wavelet transform. The shift invariant edge detection is applied to high frequency sub-band to find the edge coefficients. The watermark is embedded within the selected sub-band coefficients near the edges. Morphological dilation is used along with the edge coefficients for improving the robustness of the watermarking. As adding the watermark in high frequency sub-bands may degrade the invisibility thus, scaled dilated edge coefficients are used to improve the invisibility. Performance of the method is tested on the different images and evaluated based on MSE, PSNR and NCC. It is found that the proposed method improves the invisibility of the watermark and is robust to various attacks such as compression, cropping and resizing.

Secured Color Image Watermarking Technique In Dwt-Dct Domain [02],The multilayer secured DWT-DCT and YIQ color space based image watermarking technique with robustness and better correlation is presented here. The security levels are increased by using multiple pn sequences, Arnold scrambling, DWT domain, DCT domain and color space conversions. Peak signal to noise ratio and

Normalized correlations are used as measurement metrics. The 512x512 sized color images with different histograms are used for testing and watermark of size 64x64 is embedded in HL region of DWT and 4x4 DCT is used. 'Haar' wavelet is used for decomposition and direct flexing factor is used. We got PSNR value is 63.9988 for flexing factor k=1 for Lena image and the maximum NC 0.9781 for flexing factor k=4 in Q color space. The comparative performance in Y, I and Q color space is presented. The technique is robust for different attacks like scaling, compression, rotation etc.

A Robust Watermarking Approach using DCT-DWT [03],This paper presents a robust watermarking technique for color and grayscale image. The proposed method involves many techniques to conform a secure and robust watermarking. In the proposed technique the watermark is embedded in 3rd level of DWT (Discrete Wavelet Transform) and before embedding the watermark image is passed through chaotic encryption process for its security, other important thing is that in the proposed method watermark is embedded in the form of DCT (Discrete Cosine Transform) with special coefficient shifting algorithm to minimize the impact on main image. The performance of the proposed watermarking is robust to a variety of image processing techniques, such as JPEG compression, enhancement, resizing, and geometric operations.

DWT Based Invisible Watermarking Technique for Digital Images [04],The two most aspects of any image based steganographic system are the quality of the stego-image & the capacity of the cover image. A lossless data hiding scheme is presented based on quantized coefficients of discrete wavelet transform (DWT) in the frequency domain to embed secret message. Using the quantized DWT based method, we embed secret data into the successive zero coefficients of the mediumhigh frequency components in each reconstructed block for 3- level 2-D DWT of cover image. The procedures of the proposed system mainly include embedding & extracting. The original image can be recovered losslessly when the secret data had been extracted from stego-image.

Digital Image Watermarking Technique Using Discrete Wavelet Transform And Discrete Cosine Transform [05],Digital watermarking has been proposed as a viable solution to the need of copyright protection and authentication of multimedia data in a networked environment, since it makes possible to identify the author, owner, distributor or authorized consumer of a document. In this paper a new watermarking technique to add a code to digital images is presented: the method operates in the frequency domain embedding a pseudo-random sequence of real numbers in a selected set of DCT coefficient. And a new method for digital image watermarking which does not require the original image for watermark detection. The watermark is added in select coefficients with significant image energy in the transform domain in order to ensure non- erasability of the watermark. Advantages of the proposed method include: improved resistance to attacks on the watermark, implicit visual masking utilizing the time-frequency localization property of wavelet transform and a robust definition for the threshold which validates the watermark.. Experimental results demonstrate that this proposed technique is robust to most of the signal processing techniques and geometric distortions.

"Digital Watermarking Using DWT-SVD [06],This project proposes the embedding is done by modifying the specific bits of the singular values of the transformed host image with the bits of the watermark image's singular values. First, the DWT-SVD transform is applied to each sub-band of the transformed image and the singular values of each sub-band and the singular values of the watermark image are converted to semi-binary arrays. Finally, the bits of the singular values of the watermark image are inserted into the selected bits of the singular values of decomposed host image's sub-bands. The experimental results show that the proposed method is more robust against different geometric and non geometric attacks and the watermarked image looks visually identical to the original one. Resizing of the geometric and non geometric attacks to the image.

Image Watermarking Using 3-Level Discrete Wavelet Transform (DWT) [07],We have implemented a robust image watermarking technique for the copyright protection based on 3-level discrete wavelet transform (DWT). In this technique a multi-bit watermark is embedded into the low frequency sub-band of a cover image by using alpha blending technique. The insertion and extraction of the watermark in the grayscale cover image is found to be simpler than other transform techniques. The proposed method is compared with the 1-level and 2-level DWT based image watermarking methods by using statistical parameters such as peak-signal-to-noise-ratio (PSNR) and mean square error (MSE). The experimental results demonstrate that the watermarks generated with the proposed algorithm are invisible and the quality of watermarked image and the recovered image are improved.

Combined DWT-DCT Digital Image Watermarking [08], The proliferation of digitized media due to the rapid growth of networked multimedia systems, has created an urgent need for copyright enforcement technologies that can protect copyright ownership of multimedia objects. Digital image watermarking is one such technology that has been developed to protect digital images from illegal manipulations. In particular, digital image watermarking algorithms which are based on the discrete wavelet transform have been widely recognized to be more prevalent than others. This is due to the wavelets' excellent spatial localization, frequency spread, and multi-resolution characteristics, which are similar to the theoretical models of the human visual system. In this paper, we describe an imperceptible and a robust combined DWT-DCT digital image watermarking algorithm. The algorithm watermarks a given digital image using a combination of the Discrete Wavelet Transform (DWT) and the Discrete Cosine Transform (DCT). Performance evaluation results show that combining the two transforms improved the performance of the watermarking algorithms that are based solely on the DWT transform.

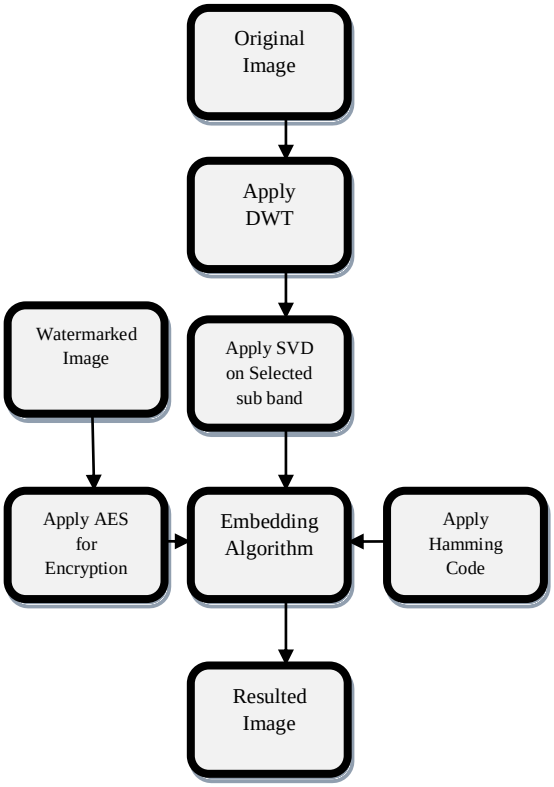
Comparison of Digital Image watermarking Methods DWT & DWT-DCT on the Basis of PSNR [09],the authenticity & copyright protection are two major problems in handling digital multimedia. The Image watermarking is most popular method for copyright protection by discrete Wavelet Transform (DWT) which performs 2 Level Decomposition of original (cover) image and watermark image is embedded in Lowest Level (LL) sub band of cover image. Inverse Discrete Wavelet Transform (IDWT) is used to recover original image from watermarked image. And Discrete Cosine Transform (DCT) which convert image into Blocks of M bits and then reconstruct using IDCT. In this paper we have compared watermarking using DWT & DWT-DCT methods performance analysis on basis of PSNR, Similarity factor of watermark and recovered watermark.

Performance Comparison of DCT and Walsh Transforms for Watermarking using DWT-SVD [10],this paper presents a DWT-DCT-SVD based hybrid watermarking method for color images. Robustness is achieved by applying DCT to specific wavelet sub-bands and then factorizing each quadrant of frequency sub-band using singular value decomposition. Watermark is embedded in host image by modifying singular values of host image. Performance of this technique is then compared by replacing DCT by Walsh in above combination. Walsh results in computationally faster method and acceptable performance. Imperceptibility of method is tested by embedding watermark in HL2, HH2 and HH1 frequency subbands. Embedding watermark in HH1 proves to be more robust and imperceptible than using HL2 and HH2 sub-bands.

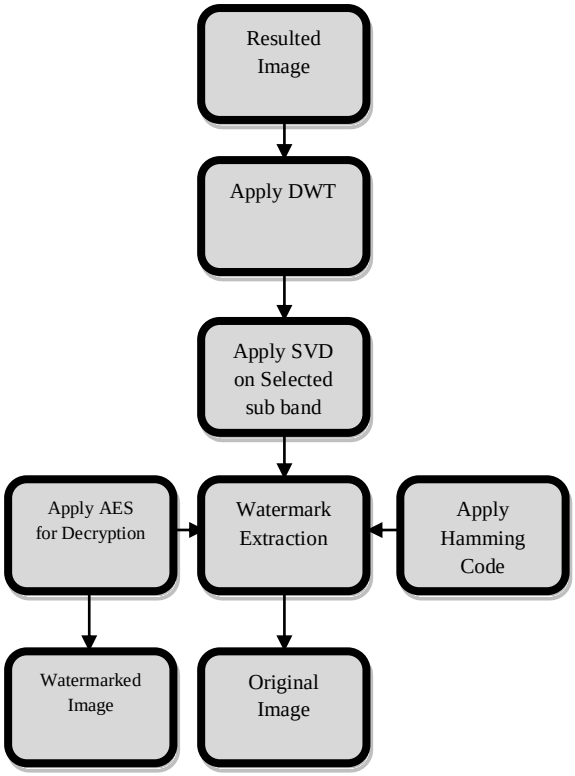
III. PROPOSED METHODOLOGY:

In the modern technology digital images plays more significant role than the traditional texts. It demands serious protection of user's privacy for all applications. Therefore image encryption and decryption techniques are usually used to avoid intrusion attack

Encryption Process:



Decryption Process:



IV. CONCLUSION:

In this paper, we proposed a new approach for watermarking. We have developed a robust hybrid watermarking algorithm based on DWT-SVD-AES. The DWT and SVD are novel techniques used for watermarking so their fusion makes a very attractive watermarking technique. The DWT is very suitable to identify areas in the cover image where a watermark can be imperceptibly embedded. So, the proposed hybrid technique improves the robustness and imperceptibility as compared to DWT and SVD applied individually. In order to make the data secure, AES was added for encryption. Proposed algorithm combines the advantages and removes the disadvantages of these two most popular transforms namely DWT and SVD. We have embedded two watermarks instead of single watermark into same multimedia object which have great advantages on many applications such as telemedicine. We would like to further improve the performance, which will be reported in future communication.

REFERENCES:

[1]. Apeksha Tiwari, Virendra Singh, **"Digital Image Watermarking Using DWT and Shift Invariant Edge Detection",** International Journal of Computer Technology and Electronics Engineering (IJCTEE), Volume 3, Issue 6, December 2013,

[2]. Baisa L. Gunjal and Suresh N.Mali**, "Secured Color Image Watermarking Technique in Dwt-Dct Domain",** International Journal of Computer Science, Engineering and Information Technology (IJCSEIT), Vol.1, No.3, August 2011,

[3]. Surya Pratap Singh, Paresh Rawat, Sudhir Agrawal**, "A Robust Watermarking Approach using DCT-DWT",** International Journal of Emerging Technology and Advanced Engineering, Website: www.ijetae.com (ISSN 2250-2459, Volume 2, Issue 8, August 2012),

[4]. Pallavi Patil, D.S. Bormane, **"DWT Based Invisible Watermarking Technique for Digital Images"**, International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958, Volume-2, Issue-4, April 2013,

[5]. Bhupendra Ram, Member, **"Digital Image Watermarking Technique Using Discrete Wavelet Transform And Discrete Cosine Transform"**, International Journal of Advancements in Research & Technology, Volume 2, Issue4, April-2013 19 ISSN 2278-7763,

[6]. P.Tejaswini, K.Manjunath, A Mahendran, **"Digital Watermarking Using DWT-SVD",** International Journal of Scientific & Engineering Research Volume 3, Issue 8, August-2012, ISSN 2229-5518,

[7]. Nikita Kashyap, G. R. SINHA, **"Image Watermarking Using 3-Level Discrete Wavelet Transform (DWT)",** I.J.Modern Education and Computer Science, 2012, 3, 50-56, Published Online April 2012 in MECS (http://www.mecs-press.org/) DOI: 10.5815/ijmecs.2012.03.07,

[8]. Ali Al-Haj, **"Combined DWT-DCT Digital Image Watermarking",** Journal of Computer Science 3 (9): 740-746, 2007 ISSN 1549-3636 © 2007 Science Publications

[9]. Navnidhi Chaturvedi, Dr.S.J.Basha, **"Comparison of Digital Image watermarking Methods DWT & DWT-DCT on the Basis of PSNR",** International Journal of Innovative Research in Science, Engineering and Technology, Vol. 1, Issue 2, December 2012, ISSN: 2319 – 8753,

[10]. Dr. H. B. Kekre, Dr. Tanuja Sarode, Shachi Natu, **"Performance Comparison of DCT and Walsh Transforms for Watermarking using DWT-SVD",** International Journal of Advanced Computer Science and Applications, Vol. 4, No. 2, 2013,

[11]. Anuradha, Rudresh Pratap Singh, **"DWT Based Watermarking Algorithm using Haar Wavelet",** International Journal of Electronics and Computer Science Engineering, Available Online at www.ijecse.org ISSN- 2277-1956,
[12]. Sharda Vashisth, Malika Narang, **"Digital Watermarking using Discrete Wavelet Transform",** International Journal of Computer Applications (0975 – 8887), Volume 74– No. 20, July 2013,
[13]. Swamy T N, Dr. K Ramesha, Dr. Cyril Prasanna Raj, **"A New Technique to Digital Image Watermarking Using DWT for Real Time Applications ",** Swamy T N et al Int. Journal of Engineering Research and Applications www.ijera.com, ISSN : 2248-9622, Vol. 4, Issue 8(Version 2), August 2014, pp.102-107www.ijera.com 102 |
[14]. Sabyasachi Padhihary, **"Digital Watermarking Based on Redundant Discrete Wavelet Transform and Singular Value Decomposition,** International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 2, February 2013 ISSN: 2277 128X,
[15]. Nidhi Bisla, Prachi Chaudhary,**"Comparative Study of DWT and DWT-SVD Image Watermarking Techniques",** International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 6, June 2013 ISSN: 2277 128X.

