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A Technical Paper on Quantum Watermarking Techniques Based on DWT-DCT and DCT-DWT Using PN Sequence

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Abstract— Computational methods derived from digital signal processing are playing an vital role in the safety and copyrights of audio, video, and visual arts. In context of the quantum computing, the equivalent algorithms are becoming a new and innovative research direction in today's high-technology era. The nature of quantum computer let us assures the security of quantum information, so a more secure and well-organized quantum watermarking algorithm is in demand. Quantum watermarking is the process that embeds the invisible quantum info into quantum multimedia signal for copyright safety. Unlike from the bulk of traditional algorithms, we set forward innovative algorithms that apply a quantum or a pseudo quantum watermarking in wavelet region. Guaranteed by the Heisenberg uncertainty principle and quantum no-duplicating standard, the protection of quantum watermark can turn up at a very high-level standard. In other way we can say that, these watermarking algorithms can hit nearly all attackers, no matter by means of classical computer or quantum computer.

Keywords – "Discrete Cosine Transform(DCT)","Frequency Domain"," PN Sequence", "Discrete Wavelet Transform", Robust", "PSNR", "MSE".

I. INTRODUCTION

The idea of a watermark is to make safe the authentication of a multimedia information or visual art work. There are always some unauthorized people that want to hit or destroy the watermark by all means likely possible. So it's significant to look after the product sand art works from being derivative or stolen. The most significant indicators of watermarked pictures are the protection and strength. A watermark with bad toughness can be attacked or damaged with no trouble, that will makes it worthless. Traditional digital watermarking algorithms which is based on the Principle Component Analysis (PCA) and wavelet transforms, separately or joint, are used broadly on classical computers, for example in [1]-[3].Also, some algorithms are joint in other ways, such as Discrete Cosine Transform, Discrete Wavelet Transform, and Principle Component Analysis[4],[5].Of course, these algorithms have good security and robustness on classical computers. On the other hand, with the growth of quantum computer, traditional watermarking algorithms may not be at all times secure particularly when facing attacking from (future) quantum computers. Fortunately enough, we can resolve this trouble by the method of quantum watermarking. Different from most traditional algorithms, we suggested a new algorithm which applies quantum watermarking using PN sequence by combining the two methods of Discrete cosine transform and Discrete wavelet transform(as DCT-DWT),and another method as a combination of Discrete wavelet transform and Discrete cosine transform(or we can called as DWT-DCT).And in the proposed methodology which will be used for quantum watermarking algorithm can reach a high-level standard for security. In other terms, the watermarking algorithm which we are using can defeat almost all attackers, no matter by means of classical computer or quantum computer. Even though it still produces pseudo random numbers and the calculation speed is believed to be much slower than on a quantum computer, the results appear incredible. As well, our algorithm can get relieve of the difficulty that may happen when applying earlier algorithm on classical computers: the computation is too complex. As far as we know, our attacking experiments showed that our method is much secured with better robustness as compared to existing algorithms.

II. WATERMARKING BASIC PRINCIPLE

The basic scheme in watermarking is to attach a watermark signal to the host information to be watermarked such that the watermark signal is unobtrusive and safe in the signal fusion however can partially or completely be recovered from the signal mixture afterward on if the right cryptographically safe key required for recovery is taken. To make sure imperceptibility of the change caused by watermark embedded, a perceptibility condition of some kind is used. As a consequence of the needed imperceptibility, the individual samples (e.g., pixels or transform coefficients) that are taken for watermark embedding can only be changed by an quantity somewhat small to their average amplitude.

To make sure robustness regardless of the small allowed change, the watermark data is usually redundantly dispersed over no of samples (e.g., pixels) of the host data, therefore providing a "holographic" toughness, which means that the watermark can generally be recovered from a minute fraction of the watermarked data, except the recovery is more strong if more of the watermarked information are obtainable for recovery[6].

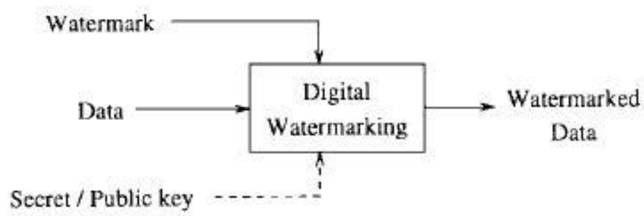


Fig.1. Basic Digital watermarking methodology [6]

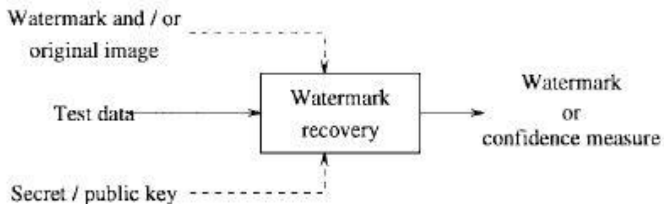


Fig.2. Basic Digital watermarking recovery scheme [6]

III. DISCRETE WAVELET TRANSFORM

A. Wavelet

Wavelet is a bounded energy function that has exactly a zero mean as well as it has normalized too. A family unit of wavelets can be obtained by scaling and to convert it. In order for the wavelet transformation to be computed by means of computers the data/information have got to be discretized compulsory. A continuous signal having data has to be sampled and tested so that a value is recorded following to a discrete time gap. If the sampling of the data is carried out at Nyquist rate, no information would be misplaced. Subsequent to sampling the discrete wavelet sequence could be taken. On the other way, this can still be very slow to compute. The cause is that the data available through estimate of wavelet sequence is still extremely redundant and the result needs a large amount of calculation time. In order to create the wavelet computationally easy, a discrete algorithm is required. The Discrete Wavelet Transform (DWT) gives sufficient information both for investigation and synthesis of the original information with a important decline in the computation time. In adding up, DWT is significantly easier to implement in contrast to the CWT [7].

The DWT of a 1-D (one dimension) information x is computed by passing it throughout a sequence of filters. First of all in the initial stage the samples x[k] are allowed and accepted through a low-pass filter with an impulse response ‘g’ which gives outcomes in a convolution of the both. The data is too decomposed at the same time by means of a high-pass filter with impulse response h. The consequences will again give the detail coefficients (from the high-pass filter) and as well as approximation coefficients (from the low-pass filter)which is shown in Figure 3 below.

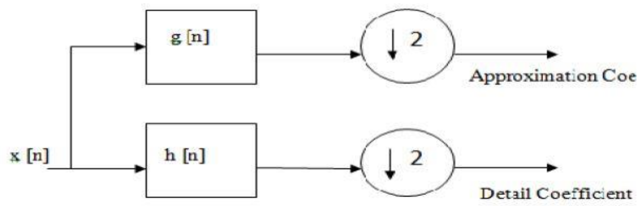


Fig.3. Basic block diagram of filter analysis [7]

It is significant that the two filters are linked to each other and they are called as a Quadrature Mirror Filter (QMF). Though, since half the frequencies of the data have now been detached, half the samples can be useless according to Nyquist rule. The filter outcomes are then down sampled by a part of 2. This breakdown is cyclic to supplementary amplify the frequency resolution and the approximation coefficients are decomposed with high as well as low pass filters and after that next process is down sampled. DWT is one of the popular method for sub-band picture coding. It decomposes the original picture iteratively into a group of transform coefficients and these coefficients are known as sub-bands. DWT sub-band decomposition of picture separate image info into high as well as low frequency bands by means of high-pass and low-pass filter subsequent by down sampling to get rid of redundant data. Decoding process on the other hand has up-sampling process so that it adjust dimensionality as well as recombining info from different bands. For a two-dimensional signal for instance picture, first level decomposition will provide consequence into four elements which is shown below in Figure 4.

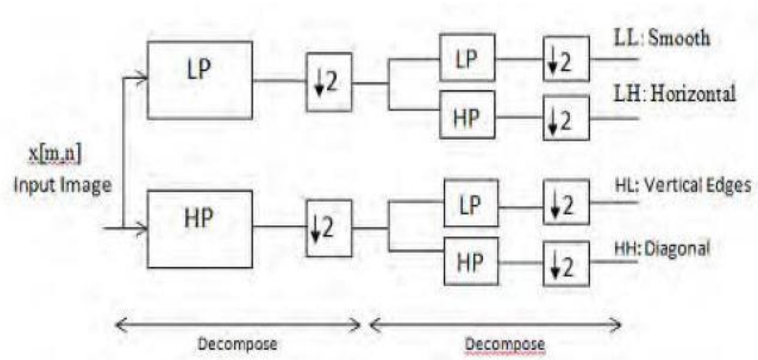


Fig.4. One-level sub-band decomposition [7]

Application of DWT to an picture involves fusion of the filters (mixture of the scaling function and the wavelet function) to create unique sub-bands. The LL (low-low or rough calculation) sub-band is formed by low- pass filtering all along the rows and columns, and it is generally referred to as a coarse picture estimation. The LH (low-high or vertical details) sub-band is created by low pass filtering all along the length of rows and high pass filtering all along the columns, consequently capture the horizontal ends. The HL (high-low or horizontal details) sub-band is formed by high-pass filtering all along the length of rows as well as low pass filtering the length of the columns, as a consequence capturing the vertical ends. The HH (high-high or diagonal information) sub-band is formed by high pass filtering by the side of the rows and columns, thus recording the diagonal edges. The LH and HL both the sub-bands are believed to be the band-pass sub-bands and the LH, HL, and HH all the three sub-bands together are known as the detail sub-bands [8]. The four sub-bands are shown in Figure 5.

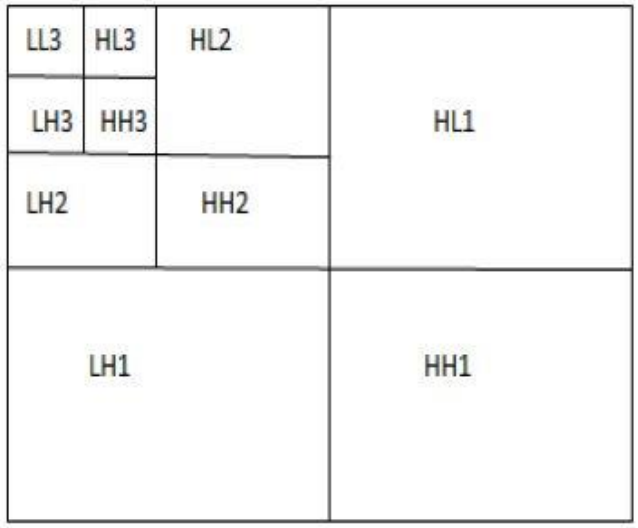


Fig.5. Pyramid Structure of Three level DWT [7]

B. Haar Wavelet

The Haar wavelet make uses a rectangular window to check the time succession so as to the first pass over the time succession that make uses a window size of two that is doubled at each and every step until the window comprise of the complete time succession. Every pass over the time sequence produces a new time sequence and a group of coefficients. The new time series is the normal of the prior time sequence over the sampling window. The coefficients represent the normal alter in the sample window. There are a large range of well-known wavelet algorithms, taking together with Daubechies wavelets, Mexican Hat wavelets and Morlet wavelets. These wavelet algorithms have the benefit of superior resolution for easily altering time sequence. Other than they have the drawback of being more computationally difficult than the Haar wavelets. In adding together, the Haar wavelet transform is quick, memory efficient and accurately reversible exclusive of the edge effects which are there in other wavelet transforms.

IV. DISCRETE COSINE TRANSFORM

A signal is transformed into elementary frequency elements which has to be represented as the summation of sinusoids in various magnitudes and frequencies of an picture illustration. For instance the different process like signal processing, image compression, processing of an image, etc. are a range of applications that can be produced by the help of this transform [9,10,11,12]. An picture which is to be processed with Discrete cosine transform low-, mid- as well as high frequency sub-bands.

Significant and main observable areas of the image are within the low-frequency sub-bands whereas high frequency field of the image can be removed when attacks (compression and noise for example) are used. When these center frequency sub-band coefficients are custom-made or altered slightly, watermark is after that embed in this sub-band so as to the watermark keeps strong when compressed and the preferred or noticeable value of the image will not be affected or distorted simultaneously. [13,14,12]

one-dimensional DCT (1D-DCT)" given by:

$$= \alpha(u) \sum_{x=0}^{N-1} f(x,y) \cos\left[\frac{\prod(2x+1)u}{2N}\right]$$

Series of 2D-DCT is described as follows:

$$Z(x,y) = \alpha(u)\alpha(v) \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} \alpha(u)\alpha(v) Z(u,v) \cos\left[\frac{\prod(2x+1)u}{2M}\right] \cos\left[\frac{\prod(2y+1)v}{2N}\right]$$

$$0 \le x \le M-1,$$
$$0 \le y \le N-1$$

Wherein (u) and (v) are defined as

$$\alpha(u) = \begin{cases} \sqrt{1/N} & for \quad u = 0 \\ \sqrt{2/N} & for \quad u \ne 0 \end{cases}$$

$$\alpha\ (v) = \begin{cases} \sqrt{\frac{1}{M}} for\ v = 0 \\ \sqrt{\frac{2}{M}}\ for\ v \ne 0 \end{cases}$$

u and v are discrete frequency variables (x, y) pixel index.

V. LITERATURE SURVEY

Inside the area of watermarking, image watermarking mainly has attracted lot of interest in the research area. The majority of the research work is devoted to image watermarking in comparison to audio and video. There may be 3 reason for this. Firstly, since of ready accessibility of the test images, secondly because it carry sufficient unnecessary data to give an opportunity to embed watermarks with no trouble, and last of all, it may be assumed that any successful image watermarking algorithm may be enhanced for the video also.

In the year 2016, MajdiFarag Mohammed El Bireki, M. F. L. Abdullah, Ali Abdrhman M. Ukasha and Ali A. Elrowayati [15] give their ideas in the field of watermarking techniques using combined algorithm of DWT-DCT. The researcher has adopted a digital watermarking method that operates in the frequency area: a hybrid watermarking system based on combined discrete wavelet transform – discrete cosine transform – (DWT-DCT). Its main motive is to analysis whether this process can endure attacks (its toughness) and invisibility (its imperceptibility), acquired by letting DCT of the DWT coefficients of the LL mid-frequency sub-bands from its band. These joint methods and their projected algorithms showed good consequences once experienced on its imperceptibility and robustness except for when subjected to noise attack (salt and pepper). Comparative consequences demonstrate that the projected algorithm is strong and imperceptible, giving better outcomes.

In the year 2015, Arisudan Tiwari, Anoopa Arya, Shubham Shukla [16] shares the interesting thoughts on the development computationally well-organized and effective method and algorithm for digital watermarking by making use of wavelets. Through their paper the MATLAB simulation has been performed for the purpose of digital watermarking by taking an use of both the procedure DCT as well as DWT algorithms. It is noted that when comparison is done then it is shown that the simulation time for the DCT is 1.48 seconds and for DWT it is 0.9 seconds for the identical size of picture. It is experienced on 10 images. So, it can be predictable that DWT is much quicker than DCT.

VI. PROPOSED METHODOLOGY

Quantum watermarking is something different from the regular watermarking techniques, hence needs special methods and techniques to handle the same, in this paper, three PN sequences are taken as a sample data and has been embedded into a RGB color space image. A simple color image consists of the RGB color space and hence to use them for watermarking they are needed to be separated out and processed individually.

(a) Watermark Embedding Algorithm

Step I :The very first step is to call the inputs such as the PN sequences and the Images.

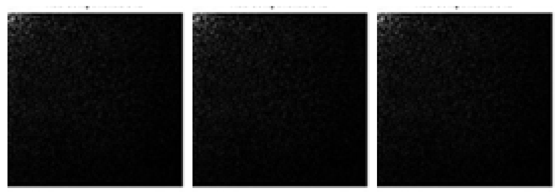
Step II :secondly we need to know their data types and dimensions so as to make them system and code compatible.

Step III :The next step is to suggest and ask the user about the methodology whichever is suitable to the current scenario may get selected form the options, the two methodologies are very different from each other but comprises themselves into the same piece of code.

Step IV: First technique follows the DCT-DWT approach where the image is first exposed to the DCT equation and is processed. under its influenced as explain in figure 10(b). Second approach follows the DWT-DCT approach as shown in figure 10(c).

Fig.6. RGB Components of an Image

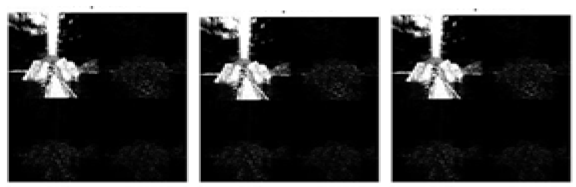
Step V :Let's talk about the first approach first, very step of this will be to check the dimensions of the image and it should be 512X512, afterwards the image will be separated on the basis of the RED, GREEN and BLUE component and will be processed individually but under the same process. Then components will be first exposed to the DCT operation and will generate a result shown in figure 7.



(a) (b) (c)

Fig.7. DCT Operated Images (a)Red component DCT2 (b) Green component DCT2 (c) Blue component DCT2

Step VI: After the DCT operation has been implemented the next step is to process all the DCT processed components through DWT.



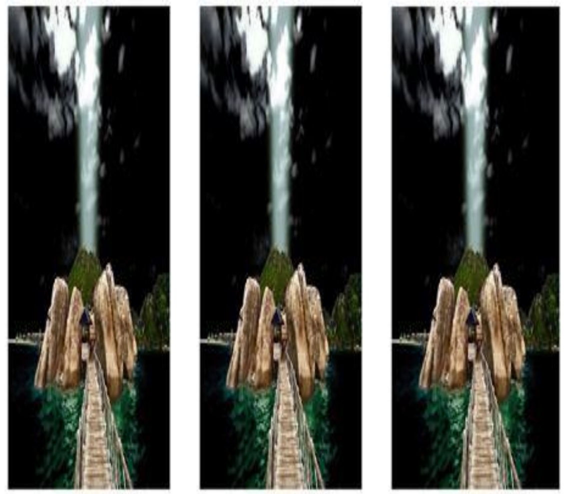
(a) (b) (c)

Fig.8. DWT Operated Images (a)Red component DWT2 (b)Red component DWT2 (c) Red component DWT2

Step VII :Afterwards the three sub bands other than the low-low frequency band will be transferred to the embedding equations and hence the embedding will be performed, now repack the images as they were opened and save them.

Fig.9. DCT-DWT processed Watermark image

Step VIII : Finally, A DWT-DCT process is rather an easy affair and just require three simple steps, first will be to process the image with DWT and recombine the generated sub-bands geometrically only and then process it by DCT operation, use any three equations to embed the secrete PN sequences and repack the images as they were unfolded.



(a) (b) (c)

Fig.10. Final Image after processing on the image (a) Original Image (b) DCT-DWT undergone performed Image(c) DWT-DCT undergone performed Image

VII. RESULT

Result by far has been the best feature of this paper, they are overwhelming, results in terms of MSE, PSNR, JND and SSIM are good enough and hence produces better graphs as shown below. The code has been simulated over 150 RGB Images.

TABLE I: REPRESENTATION OFRESULT OBTAINED FROM THE IMPLEMENTED ALGORITHM

Parameter	**Our Method**	**DWT Based**	**DCT Based**
MSE	0.954	0.9142	0.90121
PSNR(in db)	75.36dB	49.36dB	40.254dB
JND	10.256	18.3654	28.245
SSIM	0.0254	0.01247	0.01478

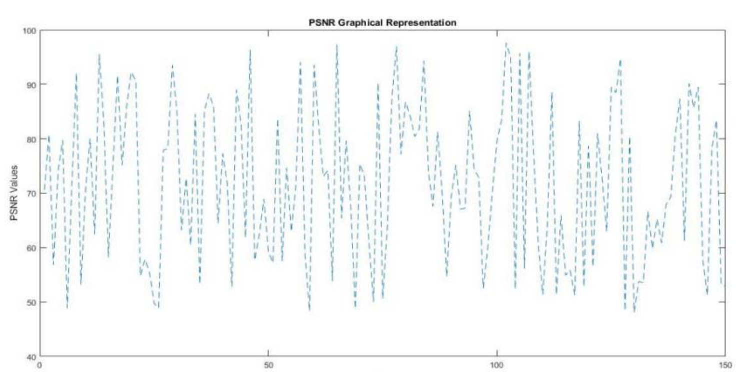


Fig.11. Graphical representation(PSNR values v/s no. of images taken)

VIII. CONCLUSION

In this paper, we investigate the dynamic quantum watermark strategy for quantum images based on DCT-DWT and DWT-DCT. We find that the watermarking algorithm claimed by the authors is incorrect. At last, we give a possible improvement strategy. It should be pointed out that when we try to generalize classical watermarking idea to quantum scenarios, we should clearly be aware of the difference between classical watermarking theory and its quantum counterpart and cannot generalize the classical watermarking algorithm to quantum scenario directly.

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