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# A New Hybrid DWT-DCT Algorithm for Digital Image Watermarking

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**Abstract** -Watermarking is the requirement of today's digital media. Embedding of watermark provides security against piracy & attacks .Watermarking is also useful for provide owner identification to digital media. Inthis Research papera new algorithm, for digital image, based on Hybrid DWT-DCT Transformation is proposed. A host image (grey scale) is initially DWT transformed up to 3-level.Thencomputation of DCT transform on selected sub bands from DWT transform is done. Watermark image is embedded in the 4*4 block of DCT blocks. The reverse procedure is use to extraction watermark. Resultsshowsthathighimperceptibilityis achieved during whole experiment which is applied to different formats of images. As compare of same kind of hybrid algorithms it has higher perceptible.

**Keywords-** Watermark, DCT-DWT, MAE, PSNR, Attacks

## I. INTRODUCTION

The vast use of digital media and internet technology in recent years requires the additional security features in it. All the communication and transmission done through internet madeitpossibletoeasily done attacks, piracy anddistribute of digitaldata. So the transmissions of digital data need a securecopyright protection technique [1]. This requirement or demand fulfill bydigital watermarking techniques. This technique embeds copyright information to identify the owner, creator and distributor of all type of digital data. Watermark may be visible or invisible. Visible watermark used in protect the copyright law, as example in the broadcasting of any video channels a logo is present at any place in video in such a way that it is difficult to remove . In Invisible watermarking secret information is embeds with host data withoutvisiblymodifyingit, to provide them security against different visual and geometrical attacks. If anyone tries to remove watermark or secret information the image the quality of image degrades. Inorderto implement this, thewatermark shouldbe invisibleand perceptible [2].

Watermarking techniquescanbeclassifiedin differentways depending upon the application.Theearlier watermarking techniques were done in spatial domain.LSB insertion [3] is an example of spatial domain watermarking. Spatialdomaintechniquesare not enough resistant against imagecompression andotherimage processing operations. So that Transform domain based watermarking techniques are introduced. The transform domain base algorithms generally use DWT, DFT, DCT and SVD transformations. DWTtransform is maximum using in digitalimage watermarking. Quality of watermarking is generally analyzed by the four matrices robustness, imperceptibility, capacity, and blindness. Good quality watermarking algorithms should have maximum PSNR.

Every watermarking algorithm in a particular transform domain has own advantages and disadvantages. To overcome these disadvantages and achieve better performance DWTbaseddigitalimagewatermarking algorithms joinswithDCT and other techniques [4].

As the threats for watermarking techniques increases developers try to develop new and effective algorithms to overcome these threats. In recent years many researchers developed new algorithms to find solution to gain greater perceptibility and robustness.

Resulted there are so many hybrid algorithms developed. There are so many types of combinations that researchers trying to developed new algorithms like.

1. DWT-DCT
2. DCT-SVD
3. SVD-DWT
4. DCT-DWT-SVD

All these combinations are use in any order.

Fotopoulos and Skodras [5] decompose (DWT) by Haarwavelet filter, andthenperform DCToneachofthebands then thewatermarkisembeddedintotheDCTcoefficients of eachband.

Ali Al-Haj [6]uses the combined DWT-DCT digitalimage watermarkingalgorithm for watermarking. In that watermark is embed in the first andsecond level of DWT coefficient sets of the host image,followed by selected DWT coefficientsets.

Nidal F. Shilbayeh, Belal Abu Haija[7] uses the combined DWT-DCT transforms to searching the best sub-band for better perceptibility.

Like as Liu Ping Feng, Liang Bin Zheng[8 ] uses the DWT-DCT transforms for watermarking but they have done DWT up-to only single level.

Saeed K. Amirgholipour, Ahmad R. Naghsh-Nilchi [9]done same things but they uses slightly different approach in perform DCT transform after 3'rd level of DWT.

Vijaya K. Ahire, VivekKshirsagar[10] performs the DWT transform up to 3 levels and selected four particular Sub-bands for next processing.

## II. TRANSFORM DOMAINMETHODS

These two transform (DCTandDWT) havebeen mainly in watermarking algorithms.

### A. The DCT Transform

DCT is technique which transforms the signal of data from space domain to frequency domain. Itrepresentsanimageasasumof sinusoids ofdifferentmagnitudes and frequencies. A 2-D transform of an image of m*n pixels are defines as follows:

$$B_{pq} = \alpha_p \alpha_q \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} A_{mn} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix}$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p = 0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \quad \alpha_q = \begin{cases} 1/\sqrt{N}, & q = 0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

*Figure 1: 2-Dimensional DCT transform of image (M x N)*

The inverse transform defined as follows:

$$A_{mn} = \sum_{p=0}^{M-1} \sum_{q=0}^{N-1} \alpha_p \alpha_q B_{pq} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le m \le M-1 \\ 0 \le n \le N-1 \end{matrix}$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p = 0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \quad \alpha_q = \begin{cases} 1/\sqrt{N}, & q = 0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

*Figure 2: Inverse 2-Dimensional DCT transform of image (M x N)*

The DCT transform broken up an image into different non overlapping frequency bands shown in figure 2.3 and then watermark is embed in these three bands. Image is first divided into equal dimension blocks of size 8x8 for DCT computation. Then the modifications of coefficients of particular selected blocks are done. Generally middle frequency band used for watermarking because low frequencies sub-band contains the most important visual parts of the image. Embedding the watermark in this band may affect the image quality. Embedding of watermark in high frequency sub-band easily allows attackers to remove watermark through compression and noise attacks. So the watermark is therefore embedded by modifying the coefficients of the mid frequency sub-band. Resulted the visibility of the image will be safe and the watermark will not be removed by compression.

| | | | |
|---|---|---|---|
| L | L | M | M |
| L | M | M | H |
| M | M | H | H |
| M | H | H | H |

*Figure 3: DCT Regions for embedding*

### B. The DWT Transform

DWT is very attractive and useful transform because it can perform watermark embedding and extraction without minimal error. In the last few years wavelet transform is very much used in signal processing in general and image compression. For 2-D images DWT is applying toimageby2-Dfiltersin eachdimension.Thefilters like Haar filter dividethe digital imageinto fournon-overlapping DWT components,lowerresolution(LL), horizontal (HL), vertical(LH) anddiagonal(HH) detailcomponents. Coarse-scaleDWTcoefficients is represented by LL,whilethe componentsetsLH,HLandHH represent thefine- scaleofDWTcoefficients[6]. This process is proceeds up to any level for a particular component according to the requirement of watermarking algorithm. The 3 level of DWT decomposition is shown in figure 2.4.

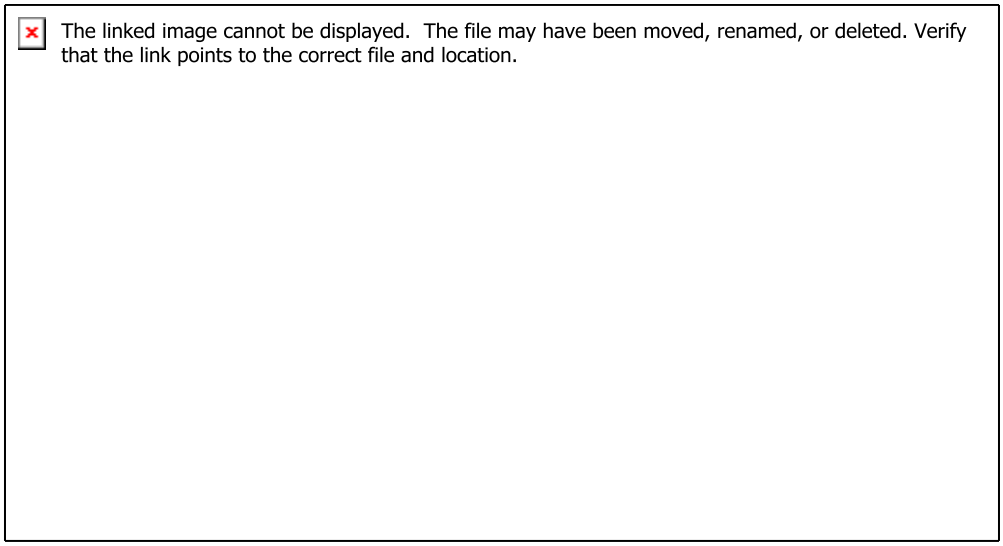



*Figure 4: DWT decomposition of an Image up to 3 levels*

In DWT technique if aDWTcoefficient is modified,onlytheregioncorresponding tothat coefficient willbemodified. Lower frequency (LL) bands containmostofenergy of Image. So embedding ofwatermarks inthesecoefficient regions maydegradethe imagequality.Embedding inthelowfrequency coefficientsetsincreases robustness of an image. Ontheotherhand,thehighfrequency coefficient setsHHincludetheedgesandtextures of theimageandthehumaneyeisnotgenerally sensitive to those changesin suchcoefficientsets.Thisallowsthewatermarktobeembeddedwithout beingperceived by the humaneye. Thus many DWT-basedwatermarking methods,istoembedthe watermark inthemiddlefrequency coefficient setsHL andLH isbetterinperspectiveof imperceptibilityandrobustness.

## III. PROPOSED HYBRID DWT-DCT ALGORITHM

In the Proposed algorithmcoefficients of HH sub band of a 3'$^{rd}$ level of DWT are selected for watermark embedding for achieving better the robustness and perceptibility without any major change in image quality. Then on the selected sets of HH coefficients of DWT, DCT is applied and watermark is embedded.

The Complete embedding and Extraction process is as follows.

## A. Embedding Algorithm

STEP 1: DWT is applied on the selected host image to 4 sub-bands namely LL, LH, HL and HH.

STEP 2: DWT is again applied to all sub-bands got from 1'st level DWT for decomposingimage into 16 sub-bands.

STEP 3: DWT is once again applied to selected four sub bands HH21,HH22,HH23,HH24 for decomposing all into 16 sub-bands and select four HH3 (HH sub-bands at level 3 i.e. HH31, HH32, HH33 and HH34 sub-band) sub-bands. Selected sun-bands shown in figure 3.1.

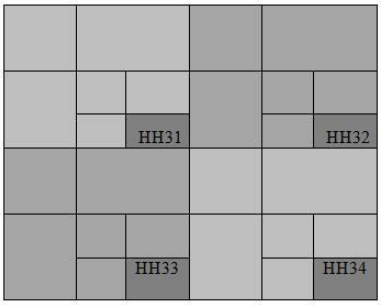



*Figure 5: Selected Sub-Band for DCT transformation*

Figure 3.1: DWT Sub-bands selected for proposedalgorithm

STEP 4: DCT is performed at 4x4 block level on all above selected HH3 sub-bands.

STEP 5: Watermark image or logo is converted into binary format and embedding of bits of watermark with DCT coefficients as follows:

```
 Loop for i = 1 to n
 {
If Bit of watermark = =0
   {
IfB_img (2,3) >= B_img(1,4)
      {
B_img(2, 3) = B_img(1,4)
       }
   }
else
  {
ifB_img(2,3) <B_img(1,4)
     {
B_img(1,4) =B_img(2,3)
  }
 }
}
```

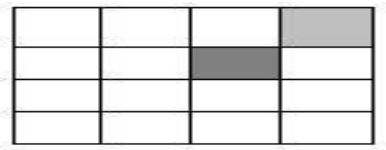


*Figure 6: Sub-blocks ((1, 4), (2, 3)) in 4*4 Block is swapped*

STEP 6:Applyinverse Discrete Cosine Transform on each 4x4 bock.

STEP 7: Apply inverse Discrete Wavelet Transform to get watermark embedded image.

**B. Extraction Technique of proposed Hybrid DWT-DCT Watermarking Technique**

The Extraction procedure is mentioned as follows:

STEP 1: DWT is applied on watermarked image for decomposing into sub-bands i.e. LL1, HL1, LH1, and HH1.

STEP 2: DWT is applied again on all above sub-bands for decomposing into 16 sub-bands.
STEP 3: DWT is applied again on selected four HH2 sub-bands for decomposing into 16 sub-bands. After that four HH3 (i.e. HH31, HH32, HH33 and HH34 sub-bands) sub-bands are selected. These diagonal HH sub-bandsare selected for achieving better imperceptibility.

STEP 4: Divide the sub-bands HH31, HH32, HH33, and HH34 in 4x4 blocks. DCT is perform at 4x4 block level on all above selected HH3 sub-bands and then 4x4 blocks of DWT-DCT domain is achieved.

STEP 5: Extract the watermark bit as follows

```
 Loop for i = 1 to n,
{ ifB_w_img(2,3 ) <B_w_img(1,4)
{
Wi=0
  }
else
  {
Wi=1
  }
}
```

Step 6: Reconstruct watermark image or logo using extracted Bits from watermarked image.

## IV. IMPLEMENTATION AND RESULTS

The proposed hybrid DWT-DCT watermarking algorithm is applied to some of the gray scale host images and with a Binary Watermark. Host images are of dimension of 512 x512 and watermark logo is 32×32 binary image. By using an algorithm watermark logo image is transformed into a binary sequence of length 1024. Host image is DWT transform up to three levels using ‘Haar’ Wavelet filter. After that four selected 64×64 DWT sub-band selected and divided into 4×4 blocks giving a total of 1024 blocks. 1024 bits of Watermark vector can be embedded in these 1024 blocks with the embedding algorithm.After embedding the reverse process is done to get watermarked image. The performance evaluation of algorithm is done by measuring their imperceptibility. Peek Signal-to-Noise Ratio (PSNR)

calculates the fidelity between the original image and the watermarked image. A larger PSNR indicates that the watermarked image more closely resembles the original image and changes happening in image are not detectable by naked human eyes.If the PSNR value is greater than 30dB the watermarked image is within acceptable position.

The proposed technique was implemented With GUI tool in MATLAB 12b. Input images are of various formats. The GUI tool shown in figure 4.1. In this tool all options will be given like selection of host image, selection of watermark logo, embedding and extraction of watermark, option for calculations results.

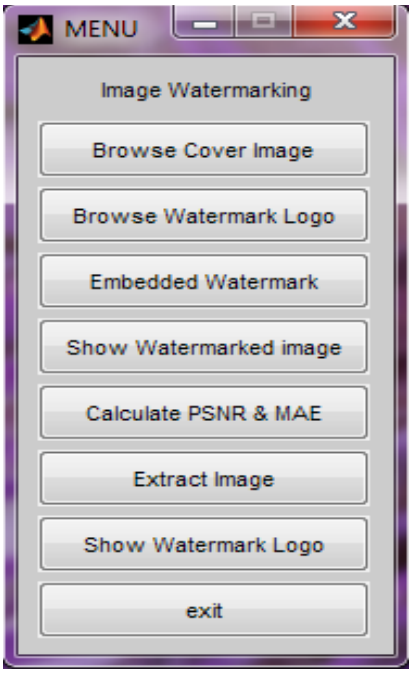
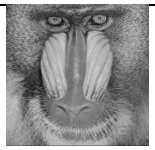



*Figure 7: GUI tool main window for watermarking*

The Table 1 shows the quality metrics values for various host images.

*Table 1: Experiment Results of Proposed hybrid DWT-DCT algorithm for various images.*

| S.no | Image | Host Image | Extracted Watermark | MAE | PSNR | WPSR |
|---|---|---|---|---|---|---|
| 1. | Peepers |  |  | 0.0023 | 44.9719 | 61.7741 |
| 2 | Baboon |  |  | 3.0518e-05 | 40.4234 | 56.5938 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | Barbara |  |  | 2.2888e-05 | 40.6197 | 58.4135 |
| 4 | Boat |  |  | 4.9591e-05 | 43.3826 | 59.8389 |
| 5 | Leena |  |  | 1.0681e-04 | 44.0007 | 60.2275 |

## V. CONCLUSION AND FUTURE ASPECTS

The Hybrid DWT-DCT digital image watermarking algorithm is implemented in this paper with the GUI tool designed in MATLAB 12b. The Calculations are done for the perceptibility and find that the PSNR for various images are above 40db which is acceptable. As thought about future aspects of this algorithm, then this technique can be used in integer wavelet transform image watermarking with cryptography and various attack can be performed on proposed technique for calculation of robustness.

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