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Restraining color image forgery by watermarking in DCT domain with Full Counter Propagation Neural Network

Chitralekha Dwivedi*
ME Scholar, Computer Science and Engineering,
Shri Vaishnav Institute of Technology and Science
Indore, M.P
41, Kirti Nagar, Indore Road, Ujjain, M.P, India
chitralekha.svits@rediffmail.com

Ashish Bansal
Professor & Head, Department of Information Technology
Shri Vaishnav Institute of Technology and
Science, Indore, M.P
14, Azad Nagar, Ujjain, M.P, India
ashshi@rediffmail.com

Abstract- Images are an indispensable part of one's life .Sharing images of various types on the internet has become a trend as well as mandatory requirement for almost all of us. The digital media provides a worldwide platform for the same. There is always a threat of our private images being illegally reproduced or distributed elsewhere. Colour image watermarking is of utmost importance as colourful figures carry a lot more information than their gray counterparts. To prevent the misuse and protect the copyrights, an efficient solution has been given that can withstand many attacks. This paper aims at encoding of the host image prior to watermark embedding for enhancing the security. The fast and effective full counter propagation neural network helps in the successful watermark embedding without deteriorating the image perception. Earlier techniques embedded the watermark in the image itself but is has been observed that synapses of neural network provide a better platform for reducing the distortion and increasing the message capacity.

Keywords— Watermarking , Full Counter Propagation Network, Transform Domain, Discrete Cosine Transform, Encoding

I. INTRODUCTION

The digitization of our world has expanded the concept of watermarking to include immaterial digital impressions for use in authenticating ownership claims and protecting proprietary interests. Digital watermarking is the process of computer-aided information hiding in a carrier signal; the hidden information should but does not need to contain a relation to the carrier signal. Digital watermarks may be used to verify the authenticity or integrity of the carrier signal or to show the identity of its owners. It is prominently used for tracing copyright infringements and for banknote authentication. Like traditional watermarks, digital watermarks are only perceptible under certain conditions, i.e. after using some algorithm, and imperceptible anytime else. If a digital watermark distorts the carrier signal in a way that it gets perceivable, it is of no use.

There has been an extraordinary growth of techniques for copyright protection of different types of data, especially multimedia information since the 1990s. This has become necessary because of the simplicity in digital copying and dissemination: digital copies can be made similar to the original signal and later be reused or even manipulated. Perceptible marks of ownership or authenticity have been used for centuries in the form of stamps, seals, signatures. But, with the current situation of data manipulation technologies, imperceptible digital marks are required.

Digital watermarks are proposed for the authentication and copyright protection of audio, video and still images . In such applications, the watermark is embedded within a cover image, audio sequence or video frame such that subsequent alteration to the watermarked image can be detected with high probability. A digital watermark is a visible or invisible identification code that is permanently embedded in the data and remains present within the data even after any decryption process. If the data is copied, then the information is also carried in the copy.

II. RELATED WORK DONE IN THE PAST

There are basically two main methods for watermark embedding namely embedding in spatial domain and embedding in transform domain .We present here some of the popular techniques in each of the domain ,followed by researchers worldwide for securing the images on the digital media.

A. Spatial Domain Embedding:

Images are represented/stored in spatial domain as well as in transform domain. The transform domain image is represented in terms of its frequencies; whereas, in spatial domain it is represented by pixels. In simple terms, transform domain means the image is segmented into multiple frequency bands. To transfer an image to its frequency representation, we can use several reversible transforms like Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), or Discrete Fourier Transform (DFT). Each of these transforms has its own characteristics and represents the image in different ways. Watermarks can be embedded within images by modifying these values, i.e. the transform domain coefficients. In case of spatial domain, simple watermarks could be embedded in the images by modifying the pixel values or the Least Significant Bit (LSB) values. However, more robust watermarks could be embedded in the transform domain of Images by modifying the transform domain coefficients.

Kao et al., [1] came out with the watermark technique based on spatial domain in color image by embedding watermark in saturation on the HSI space.

Zeki A.M, Manaf A. A,[2] aimed at replacing the watermarked image pixels by new pixels that can protect the watermark data against attacks and at the same time keeping the new pixels very close to the original pixels in order to protect the quality of watermarked image. The technique is based on testing the value of the watermark pixel according to the range of each bit-plane.

Zhijua and jiping[3]came out with color image digital watermarking method based on valve-value surface. The valve value of curve surface of the original image is found to get the outline information of the original image; then embedding watermarks into the edge of the outline. This method has strong resistance to attacks like filtering and zooming.

Krishna V.V et al., [4] presented a novel fact , that by inserting the watermark using Least Significant Bit (LSB), the grey value of the image pixel either remains same or increases or decreases to one. Ambiguity of grey level values by LSB method comes between successive even and odd grey level values only. This approach allows high robustness, embedding capacity and enhanced security.

Ganeshan and Gupta [5] gave a scheme in which 12 binary images can be embedded in the spatial domain using LSB substitution technique in a single RGB image. The proposed scheme also provides an extra level of security to the watermark image by scrambling the image before embedding it into the host image.

Hussein Jamal A. [6]gave the idea of selecting 16 blocks of 8X8 from the center of colored RGB image converted to YCbCr color space , to embed the monochrome image. The selected blocks are chosen spirally among the blocks that have log-average luminance higher than or equal the log-average luminance of the entire image. Each byte of the monochrome watermark is added by updating a luminance value of a pixel of the image. If the byte of the watermark image represented white color (255) a value α is added to the image pixel luminance value, if it is black (0) the α is subtracted from the luminance value.

Dinu Coltuc[7]reduced the distortions due to watermarking by embedding the expanded difference into the current pixel and its prediction context.

Surekha and Swamy [8] in their paper explored the possibility of embedding multiple binary images simultaneously in the host image also they gave the way to iteratively embed the watermark in different locations of cover image for enhancing robustness.

Bamatraf et al.,[9] also emphasised the manipulation of least significant bit for watermarking because of the least possible effect on the quality of cover image. They inversed the binary values of the watermark text and shifting the watermark according to the odd or even number of pixel coordinates of image before embedding the watermark. There is a flexibility depending upon the length of the watermark text. If the length of the watermark text is more than ((MxN)/8)-2 ,there is a way to embed the extra of the watermark text in the second LSB.

B. Transform Domain Embedding:

Barni M et al.,[10] expressed the idea of hiding the watermark within the color image by modifying a subset of full frame DCT coefficients of each color channel .The extraction was only possible by comparing the correlation with a threshold.

Ahmadi and Safabaksh [11] converted the original image into the NTSC color space for separating the grayscale information from color data followed by dividing the luminance component Y into 8X8 blocks and transforming it to DCT. To prevent tampering or unauthorized access, watermark permutation function was present.

Yang and Jin [12] took the advantage of DCT and DWT coefficients for color image watermarking. Firstly, the green components of an original image are divided into blocks, for each of which DCT is calculated and from each of which DC components are chosen to make up a new image, and new images are transformed with Haar wavelets. Then, a binary image of scrambling chaotic encryption is embedded into a low frequency sub-band.

Poljicak, et al.,[13] used the magnitudes of the fourier transform for embedding. The PSNR values were chosen the means for evaluating the quality degradation. The method was robust enough to handle the print scan , print cam and the attacks from Stir Mark benchmark software.

Chin man-Pun [14] protected the image copyrights by DFT coefficients based watermarking. First, the original image was decomposed into DFT coefficients using a fast Fourier transform. For minimal loss in image fidelity, the watermark was embedded in those DFT coefficients with highest magnitudes except for those in the lowest one. Extraction did not require the cover image.

Manimaran et al., [15] devised a unique way of encrypting the watermark by DES method after compressing it and the cover image is DCT transformed , followed by embedding.

Xie Bin [16]extended the idea of DCT transform of blocks of Y component of image but here its converted into Y C_b C_r color space.

Gao Chang[17]embedded authentication information into color JPEG format images based on discrete wavelet transforms. Firstly acquiring the gray values matrix from the color image, then identifying low and high frequency coefficients by using a two-dimensional discrete wavelet transform. The authentication information was embedded into the low coefficients by modifying the low coefficients' mean values.

C. Contribution of Neural Networks in Image watermarking:

The transform domain embedding when combines with the ultimate secure and fast to train artificial neural networks such as FCNN or RBF etc are surprisingly very efficient for the purpose of image watermarking.

Kutter [18] proposed a watermarking scheme embedding the watermark bits into the blue channel of a color image. In Kutter's system, embedded watermark bits can be extracted with a threshold by considering the neighbor pixels relation.

However, the watermarking system is vulnerable since the reference information, which decides the threshold, can be easily destroyed.

In order to improve the robusmess of Kutter's system, Yu et al. [19] proposed an adaptive way to decide the threshold by applying neural network. Yu et al. hide an invisible watermark into the blue channel of a color image, and then cooperate with neural network to learn the characteristics of the embedded watermark related to the watermarked image.

Bansal and Bhadauria[20] solved the issues such as 'Proprietary Net' and 'Sure Win' by enhancing the security of images through DCT transform and encoding the secret bits in the high energy region ,thereafter presenting the encoded image to FCNN for embedding watermark.

Xu He, Chang Shujuan [21] proposed an adaptive image watermarking algorithm after studying the characteristics of Human Visual System and the association memory ability of neural network. The watermarking signal was embedded in higher frequency, which is in the lower frequency of original image by DWT joined with DCT.

Yi et al.,[22] proposed a novel digital watermarking scheme based on improved Back-propagation neural network for color images. The watermark was embedded into the discrete wavelet domain of the original image and extracted by training the BPN which learnt the characteristics of the image. To improve the rate of learning and reduce the error, a momentum coefficient is added to the traditional BPN network.

A novel blind watermarking technique based on back propagation neural networks was proposed by Huang Song et al.,[23] in 2008. The scheme hides a scrambled watermark into an image, and takes HVS characteristics into consideration during the watermark embedding process, then uses a back propagation neural network to learn the characteristics of the embedded watermark related to the watermarked image. With the aid of the learning and adaptive capabilities of neural network, the trained neural network can exactly recover the watermark from the watermarked image.

Ramamurthy and Varadarajan (2012) [24] came up with a novel image watermarking approach based on quantization and back propagation neural network. The cover image was decomposed up to 3-levels using quantization and DWT. The bitmap was selected as a watermark. The back propagation neural network was implemented while embedding and extracting the watermark.

III. PROPOSED METHOD OF WATERMARK INSERTION

In the previous techniques there were problems related to robustness and imperceptibility. In the proposed approach we have reduced the distortion to a negligible level. As the cover image is not directly exposed for embedding the secret information instead we have suggested that synapses of neural network play a better platform for the watermark insertion.

There was a chance of an unauthorized person claiming his ownership by extracting watermark for an unauthenticated image . The problem was "Proprietary FCNN". A network can be trained in various ways to extract a watermark to prove ownership which is a threat to authentication.

With each different image, the competitive layer of the full counter propagation network chooses a winner that produce some or the other output watermark . It is quite possible that more than one input images resemble the weight pattern of the same neuron at the input layer. Thus, this neuron must be the winner in all the cases to produce the same watermark at the output layer for all the images. This raises problem of 'Authenticity', when one unauthentic image produces the correct watermark. The above problems require the need of an additional safety against counterfeiting. We have successfully encoded the cover image before actually directing it towards the real watermark embedding phase.

The following algorithm explains each step in detail:

The cover image (color image) size is given by mc x nc, mc being the no of rows and nc being number of columns.

The watermark image is of size mw x nw.

The blocks are of 8x8. ie blocksize = 8

The mid band matrix is chosen by user .

In our algorithm it is a binary matrix of size 8x8. It will help in encoding.

The midband coefficients selection matrix is given asmidband= [mid11,mid12.......midij,..,mid88] for 1<=i<=8, 1<=j<=8 and midij = 0 or 1.

Sum_midband= ∑∑midband(i,j)

The message to be inserted is of the

Message = (mc x nc)/(blocksize)^2

mm represents the number of rows in the encoding binary message matrix.

nm represents the number of columns in the encoding binary message marix.

This message is generated by using random integer function of matlab.

p=mc /8

q= nc/8

R = p*q where R is total no of blocks of size 8x8

Pn_sequence = round(2*rand(1,sum_midband)-0.5)

This will generate the random numbers equal to number of Midband coefficients.

Repeat the following steps for k=1 to total no of blocks.

x=1, y=1,k=1// x is for progressing in the column wise direction.

// y is for progressing in the row wise direction

// k is the variable which takes the blocks one by one

Step 1- The cover image is divided into blocks of 8x8 one by one.

Step 2- Each block is then transformed into its equivalent DCT coefficient block . Lets say the block is dct_block.

Step 3- If message(k)= 0 then

```
 {
    for i=1 to 8
{
      for j=1 to 8
  {
      if (midband(i,j) =1)
          {
                dct_block(i,j)= pn_sequence(pos);
                pos=pos+1;
}end of if
      }end of for
          }end of for
              }// end of if
```

Step 4- Now convert the dct_block back to idct ie inverse dct .

Step-5 Now x is incremented . If x exceeds the total number of columns , its reinitialized and next row is taken.

x= x + blocksize if (x+8)<nc

x=1 and y = y + blocksize for (x+8)>nc

Step 6- Increment k =k+1(until k=p*q ie total no of blocks in the host image)for encoding next block

Step 7- Go to step 1 while (k<=R)

Step 8- The encoded image is converted to column vector in the following form

Cover_Image= [X_1, X_2,X_3,..............,X_{mcxnc}]

Where mcxnc is the total number of pixels in the cover image.

Also the watermark W= [Y_1, Y_2, Y_3,……………,Y_{mwxnw}]

Is converted to the column vector .

Step 9- The cover image and watermark are then supplied to the input layer of FCNN , followed by training the network to produce watermarked image and desired watermark at the output layer.

(Here to improve the imperceptibility we have chosen only the blue channel for encoding the message. Researchers round the globe agree that human eyes are less sensitive towards the blue color as compared to the red and green channels of a RGB image.)

Thus we observe that the problems related to unauthentic image giving correct watermark accidentally and the issue of generation of any watermark for every image is solved by encoding the cover image in DCT domain prior to neural network training.

We have chosen lenna and scenary color images as our cover images to train the network.


Lenna.jpg


Scenary.jpg

The watermark is the following color image


Fruit .jpg

The full counter propagation network has got the following architecture. It consists of three layers namely input layer, competitive layer and the output layer.

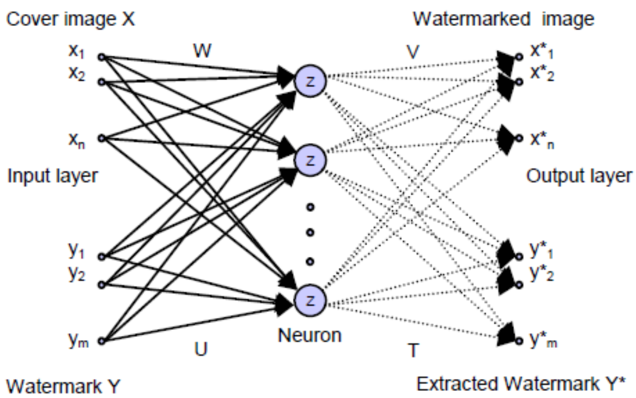

Figure 1 The architecture of Full Counter Propagation Neural Network.

In the above figure W is the set of weights from Input layer cover image neurons to competitive layer.

U is the set of weights from input layer watermark neurons to competitive layer.

V is the set of weights from competitive layer neurons towards the output layer watermarked image neurons.

T is the set of weights from competitive layer neurons to the output layer extracted watermark image neurons.

The training is carried out till the error is greater than predefined threshold otherwise the weights of every layer are adjusted

The entire training procedure of the full counter propagation network can be understood from the research paper of Chuan-Yu Chang, Sheng-Jyun Su, Hung-Jen Wang (2004)[25].

Lets understand the complete algorithm for watermark insertion through the following block diagram.

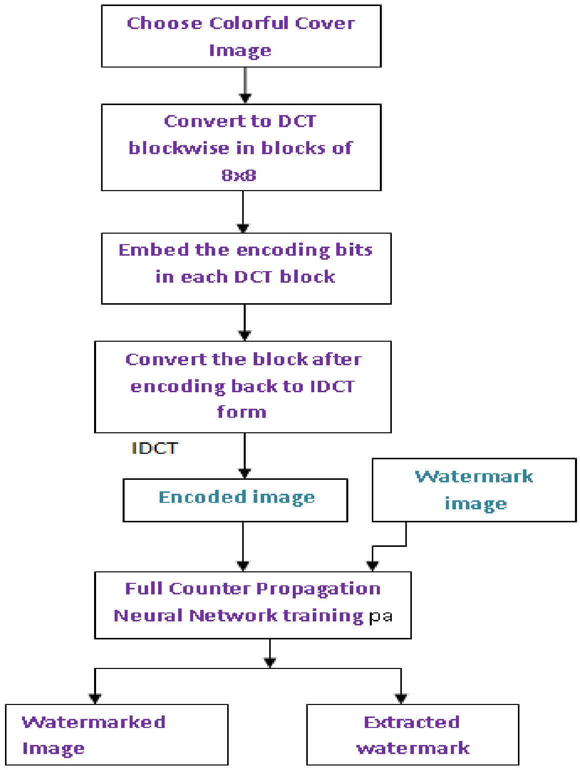

Figure 2 Block Diagram for Watermark Embedding

IV. METHOD FOR WATERMARK EXTRACTION

The Full counter propagation network is particularly useful in watermarking as it yields a more robust watermarking solution. Also FCNN possesses higher embedding capacity without much degradation of the original information. It can remember the watermark image in itself and is helpful in extracting the same image for every authentic input cover image.

An unauthorized person will not be able to claim his rights over the image as he would not be able to decode the original cover image which is the first step towards proving the authority .

Once the decoding is done successfully there after the IDCT image is supplied to the FCNN for watermark extraction.

Algorithm for extracting the watermark image form the FCNN is explained step wise below:-

Midband matrix and blocksize is the same as the embedding algorithm.

R= total no of blocks of size 8x8 in the cover image which will be required in the dct domain embedding.

Watermarked image is of size mw x nw

The binary message is of size mm x nm

The pn_sequence_zero is the same as in the embedding algorithm.

Initialize the variables x=1,y=1

Let enco_image(l1:l2) be defined to select the block containing all elements(l1:l2) such that

x<=l1<=x+blocksize-1,

y<=l2<=y+blocksize-1,

Repeat the following steps R times to check the R blocks of the watermarked image for getting the decoding bits

Step 1- The DCT coefficient block of watermarked image is obtained blockwise as under

Dct_block = DCT(enco_image(l1:l2))

The initial index of dct_block is set ind=1

Embedded sequence is obtained as given below:

Sequence(pos)= Dct_block(i,j),

for 1<i< blocksize, 1 <j < blocksize, midband (i,j)=1

where, for all new pair (i,j) , pos=pos+1

Step 2- Correlation of the above obtained sequence is done with zero sequence

Correlate(k)= corr(pn_sequence_zero, sequence)

//Predefined function for correlation exists in matlab

Now x is incremented if x exceeds the total number of columns , it is reinitialized and next row is taken.

x=x+blocksize for (x+8)<nw

x=1 and y=y+blocksize for (x+8)>nw

Step 3- K = k+1 Go to step 1 while (k<=R)

Step 4- Now after all the sequence is with us .Lets find out the message from the correlation of the two sequences as given below-

Message_ex (ee)= 0 for correlate(ee)>0.5

Message_ex(ee)=1 otherwise

For every ee: 1<=ee<=mm xnm

Step 5- A Boolean variable flag is checked ie if flag =1 , for every i such that message_ex(i)=message(i) then we can say that our decoding is successful.

for 1<=i<=mm x nm (range of i)

Step 6- if flag=0

Then image is not authentic and it is not supplied to counter propagation network for extracting the watermark.

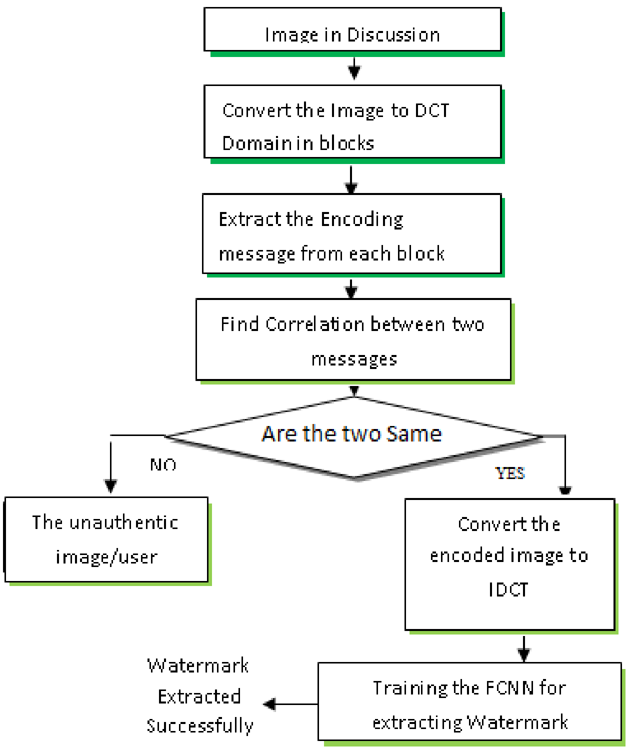

Figure 3 Block Diagram for watermark extraction

V. EXPERIMENTS AND RESULTS

We have calculated the Peak Signal to Noise Ratio(PSNR) and Normalized Correlation(NC) which are measures of imperceptibility and robustness. To find out Peak Signal to Noise Ratio we need to calculate some figures first. Mean Square Error between the gray level versions of the original cover image and the watermarked image.

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Mean Square Error MSE calculates the mean square difference between the pixel values of Cover image I and Watermarked Image K.

The PSNR is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$
$$= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$
$$= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE)$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255.

For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE is the sum over all squared value differences divided by image size and by three. Alternately, for color images the image is converted to a different color space and PSNR is reported against each channel of that color space, e.g., YCbCr or HSL.

Normalized Correlation NC is given by-

NC= ∑∑ K(i,j)K'(i.j)

K(i,j)K(i,j)

Attacks were also performed on the watermarked image to check the level of robustness ie the watermark can be extracted successfully even after trying to remove by illegal parties.

Given below is a comparative study of PSNR with some of the popular attacks.

Table 1 PSNR and NC values after performing attacks

Name of the attack	**PSNR in Db**	**NC**
No Attack	106.38 Db	0.9476
Salt & Pepper(SP) Noise, d=0.0001	97.9 Db	0.0025
(SP)Noise density d=0.001	82.83 Db	0.0025
d = 0.02	52.18 Db	0.0025
d = 0.05	43.33 Db	0.0025
Speckle Noise	62.56 Db	0.0025
Compression (resizing the image to 200x200 from 256x256)	84.62 Db	0.9476
Compression(resizing the image to 180x180 from 256x256)	92 Db	0.9476

The experiments were conducted on a system which has following system properties:-

Intel Core i5-2430 M CPU @ 2.40 GHz

4.00 Gb RAM, 64 bit operating system.

Windows 7 Home Basic, Copyright 2009 Service Pack 1

Matlab version 7.9 was used.

The constants chosen for training the Full Counter Propagation

Neural Network for embedding the watermark and extraction.
Number of neurons in the hidden layer= 10
The learning rate for input layer α=0.4
The Learning rate for the output layer β=0.3
k=0
e=infinity

The mid band matrix of 8x8 for selecting the blocks to be encoded is
[0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1]

This matrix is useful in selecting the DCT block for encoding the secret message. We have chosen a value =1 ie if midband(i,j)=1 then only encode that respective DCT block.

The idea of encoding can further be proceeded for all the three channels that is red, green, blue. We can also embed a colorful watermark in all of them. These are certain modifications in the strategy suggested here which I am working on currently.

VI. CONCLUSION

The idea of securing our private and confidential images on the common media ie internet is widely practiced worldwide. Image watermarking however is not limited to authenticating the digital information online but it has made its entry and is popular in fields like medicinal science, criminal investigation remote education , secured electronic voting system, health and insurance companies. In short we can implement watermarking to secure any sensitive image of importance in any sense.

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I was always keen for achieving knowledge and excellence. I am pursuing my Master of Engineering in Computer Science from Shri Vaishnav Institute of Technology and Science, Indore, M.P. I am submitting my ME thesis on watermarking color images for authentication through the use of full counter Propagation neural networks . I am lucky enough to have Dr Ashish Bansal, Head of the Department, Information Technology, SVITS, Indore, as my guide. I thank him for always showing confidence in me and encouraging me. I thank my parents too for being there with me all throughout the journey of my education. I thank my college for supporting me to pursue the research. Sincere thanks to all.

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