International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 4, Issue 12 [August 2015] PP: 23-30

An imperceptible blind image watermarking scheme for image authentication using DNA encoding and multi-resolution wavelet decomposition

Pearl Antonette Mendez[1], Rithu James[2]
[1]*Mtech student, Dept. of Electronics & Communication, Rajagiri school of engineering & Technology, Kakkanad, Cochin, Kerala*
[2]*Assistant Professor, Dept. of Electronics & Communication, Rajagiri school of engineering & Technology, Kakkanad, Cochin, Kerala*

***Abstract**:* Digital storage, transmission and manipulation of video signals and still images exhibited a tremendous growth in the last few years, mainly due to the expansion of computer networks and the introduction of multimedia technologies to the information market. Copyright protection techniques are in great demand due to the widespread illegal copying and communication of digital media. One way to protect images against illegal recordings and retransmissions is to embed a signal, called digital signature or copyright label or watermark, that completely characterizes the person who applied it and, therefore, marks it as being his intellectual property. Various watermarking methods have been proposed lately for digital images. Wavelet-based embedding techniques gained a lot of attention since they provide the perfect balance between imperceptibility and robustness. In this project, we introduce an algorithm for hiding the complement of a DNA-encoded watermark data into the 3rd level resolution of the wavelet decomposition of a true colour image. It applies a quantization operation on the sorted detail coefficients for an enhanced invisible embedding

Keywords: *DNA encoding, DWT, Multi-resolution decomposition, wavelets, watermarking*

I. INTRODUCTION

The success of the Internet introduces a new set of challenging problems regarding security. One of many issues that has arisen is the problem of copyright protection of electronic information. Here we address the problem of watermarking digital image content. For instance, in the case of image data, editing the picture or illegal tampering should not destroy or transform the watermark into another valid signature. Equally important, the watermark should not alter the perceived visual quality of the image. From a signal processing perspective, the two basic requirements for an effective watermarking scheme, robustness and transparency, conflict with each other.

A digital watermark is intended to complement cryptographic processes. It is a visible, or preferably invisible, identification code that is permanently embedded in the data and remains present within the data after any decryption process. [1] A digital watermark is a kind of marker covertly embedded in a noise-tolerant signal such as audio or image data. It is typically used to identify ownership of the copyright of such signal. "Watermarking" is the process of hiding digital information 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 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.

Several digital watermarking algorithms have been proposed and these can be categorized according to their casting/processing domain, signal type of the watermark, and hiding position. Two processing-domain categories, the spatial-domain and the frequency-domain watermarking, have been proposed. The earlier watermarking techniques are almost spatial-based approaches; the simplest example is to embed the watermark in the least significant bits (LSBs) of image pixels[2]. A variety of improvements were proposed against image compression and filtering. However, these techniques still have relative low-bit capacity and are not resistant enough to lossy image compression and other image processing.
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. Both steganography and digital watermarking employ steganographic techniques to embed data covertly in noisy signals. But whereas steganography aims for imperceptibility to human senses, digital watermarking tries to control the robustness as top priority. Since a digital copy of data is the same as the original, digital watermarking is a passive protection tool. It just marks data, but does not degrade it or control access to the data. Wavelet-based techniques are gaining popularity since they provide an effective way of imperceptible embedding while maintaining a high level of robustness against attacks. Another concern is raised regarding the ability to retrieve the hidden watermark without the need to refer to the original image. The answer to this question can be used to categorize various techniques into two classes: blind and non-blind schemes. In blind schemes the embedding process is carried out in such a way that allows the hidden data to be extracted directly from the watermarked image without knowledge of the original one. On the contrary, in non-blind schemes the original cover is needed to reveal the hidden information. Obviously, blind techniques are preferred over the non-blind ones since they are more practical and reliable. [3]

II. DISCRETE WAVELET TRANSFORM

Discrete wavelets transform is a method of signal analysis theory which has arisen in recent years. It is a frequency domain analysis method which can localize frequency domain and has widely used in many fields. The basic idea of DWT is the detailed frequency separation of signal, namely multi-resolution decomposition. The host image is decomposed to four sub-images in size of one quarter: one low frequency approximating image and three medium and high frequency detail sub-images in horizontal, vertical and diagonal direction. The high frequency part of discrete wavelets represents the edge, outline and texture information and other detail information. Embedding watermark is difficult to be detected in these parts, but it is easy to be destroyed and has a poor stability after image processing. The low frequency part concentrates the most energy of image, the amplitude of coefficient is larger than the one of detail sub-graph. [4]

Wavelet transform cuts up the data or function into different frequency components to study each component with resolution matched to its scale due to better frequency and time localization. Wavelets have become main tool for image processing as process of creating edge sub-images at multiple resolutions are analogous to a process performed by mammalian vision system including human visual system(HVS). DWT has a number of advantages over other transforms (DFT or DCT) e.g. progressive and low bit rate transmission, quality scalability and region of interest (ROI) coding demand more efficient and versatile image. The decomposition of an image using DWT involves a pair of waveform, one for high frequencies corresponding to detail part of image (wavelet function($\psi(t)$)) and another for low frequencies or smoother part (scaling function($\phi(t)$)). Wavelet function is high pass filter and allows high frequencies components of signal and HVS is less sensitive to it. It is represented as differences in Haar transform. Scaling function is a low pass filter that allows low frequencies and sensitive to HVS. It is represented by averages of the data in Haar transform[5].

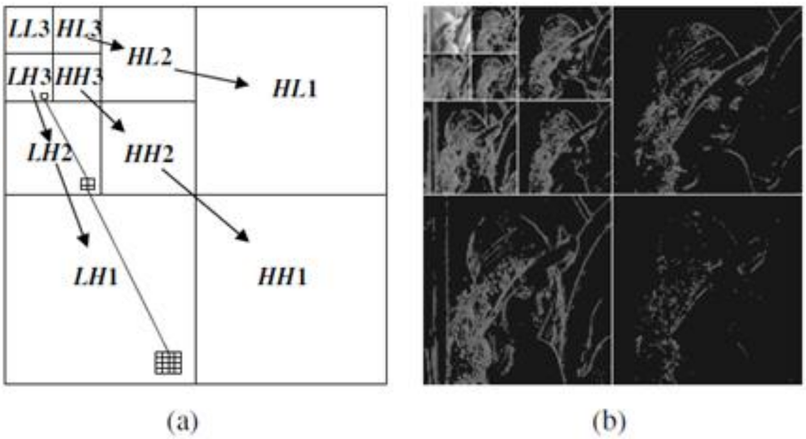


Fig 1 (a) Layout of the image subbands from the three level dyadic decomposition. (b) An example of DWT decomposition of the Lena image

The basic idea in the DWT of a 2-D image is as follows. An image is firstly decomposed into four parts of high, middle, and low frequencies (i.e., LL1, HL1, LH1, HH1) subbands, by cascading horizontal and vertical two-channel critically sub-sampled filter banks. The sub-bands labeled HL1, LH1,and HH1 represent the finest scale wavelet coefficients. To obtain the next coarser scale of wavelet coefficients, the subband LL1 is further decomposed and critically sub-sampled. This process is continued an arbitrary number of times, which is determined by the application at hand. Each level has various band-information such as low-low, low-high,

high-low, and high-high frequency bands. Furthermore, from these DWT coefficients, the original image can be reconstructed. The reconstruction process is called the inverse DWT (IDWT) [6].

III. PROPOSED WATERMARKING ALGORITHM

The hiding process is based on a quantization operation on the detail coefficients of the discrete wavelet transforms. In an earlier work [7] the robustness of the quantization approach was proved to be efficient at the 3rd resolution level of Haar wavelets. Here, we present an additional step concerning the embedded data [6]. In this step, the watermark data are encoded into DNA alphabets for an added security level. In fact, this encoding step can be replaced by any recent DNA-based ciphering technique.

As shown in figure 2, the algorithm proceeds by first encoding the binary watermark into a DNA sequence. Next, the host image needs to be decomposed into multi-resolution levels using Wavelet (WLT) transform. The DNA encoded data are then embedded the Wavelet coefficients of the image using some quantization operation. Finally, the embedded coefficients are inverse transformed resulting in the watermarked image. On the other side, the extraction process implements the same steps but in reverse order using the same secret key. Each one of these steps are described in details through the following subsections. We refer to the original host image as *I*, the resultant watermarked image as *I'*, the secret key as *Key*, and the watermark as *W*. The length of the watermark is denoted by *Nw*.

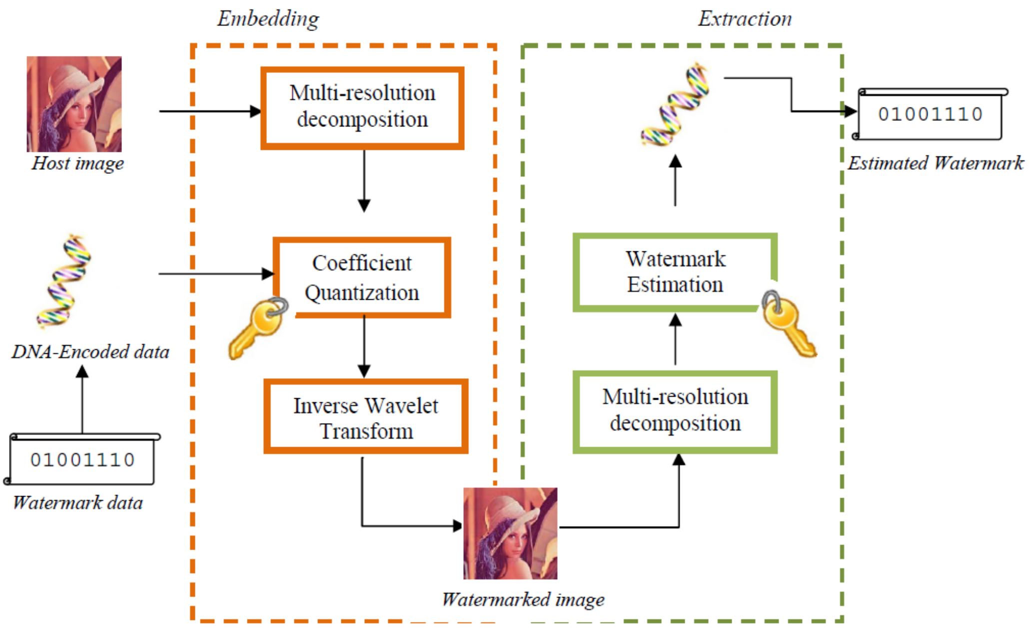


Fig 2: Proposed watermarking algorithm

III.1 DNA encoding

DNA is a double stranded structure consisting of four types of building blocks or nucleotides: adenine (A), guanine (G), thymine (T) and cytosine (C). In nature, these bases pair up in a unique complementary way, where A pairs with T and G pairs with C. Hence, a sequence of DNA base pairs can be viewed as a string made of these four characters such as **AAGTCGATCGATCATCGA.** This "genetic code" is read and eventually translated by the cellular machinery to form proteins in a long and complex process called Central Dogma[13]. The code is read and transcribed from the DNA into messenger RNA (m-RNA) three bases at a time. Each three adjacent mRNA (C, A, U, G) bases form a single unit known as a codon. This triplet code allows for a total of 64 different codons that are mapped to 20 different amino acids (the building blocks of proteins).

BITS	BASES
00	A
01	C
10	G
11	T

Fig 3: DNA coding of digital data

Looking at DNA as a coding medium lead to attempts to convert DNA strings into binary data and vice versa. Figure 3 shows one of these rules that maps a 2-digit binary number to a base. That is, 00, 01, 10, and 11 are mapped into the bases A; C; G and T respectively. Similarly, the same rules can be applied on RNA sequences where the (T) nucleotide is replaced by the (U).

III.2 MULTIRESOLUTION

The wavelet transform is identical to a hierarchical subband system, where the sub-bands are logarithmically spaced in frequency. In one dimensional wavelet transform (DWT), the input signal (*s*) is convolved with a low pass filter to produce a smoothed version of the input (*A*) and a high pass filter to capture the detail coefficients (*D*). Since images are two dimensional signals, they are transformed by applying the one dimensional transform to the rows and columns of the image successively.

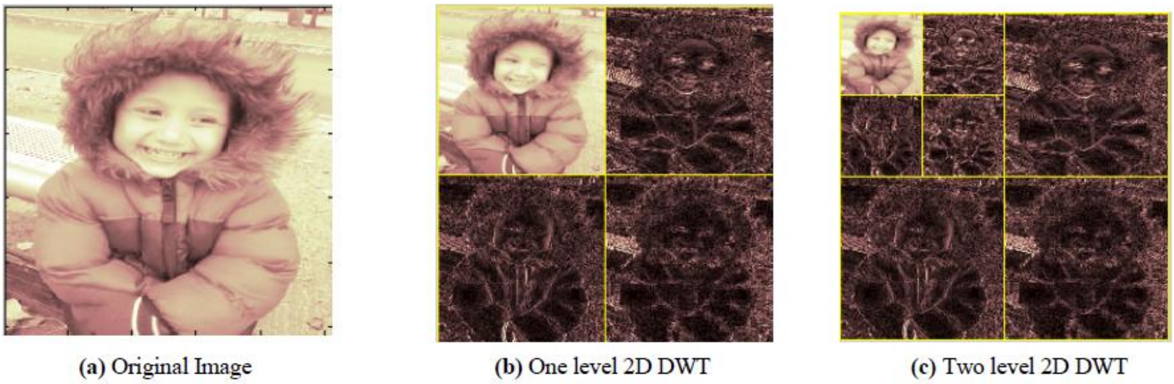


Fig 4: Two dimensional wavelet decomposition

The result is shown in figure 4(b) which is decomposed into four quadrants with different interpretations: the upper left quadrant (LL) represents the approximated version of the image at half the resolution. The lower left and the upper right blocks (HL and LH) reflect vertical and horizontal details respectively. Finally, the (HH) block represents the diagonal features of the image. The same two dimensional wavelet transform can be recursively applied on the (LL) quadrant to generate more detail coefficients at different scales, as shown in figure 4(c). In this case, the subbands in the l^{th} transform level can be denoted by LL^l, LH^l, HL^l, and HH^l. Afterwards, the reconstruction process can be made using the inverse of the DWT in order to synthesize the original image from the coefficients belonging to different subbands.

IV. EMBEDDING

Applying the L^{th} level discrete wavelet decomposition on an image results in 3L detail sub-bands and one approximation image. Therefore, the k^{th} detail coefficient of the image at the l^{th} decomposition level will be denoted by $I_{k,l}$ (x, y) where k = h, v, d (corresponding to horizontal, vertical, and diagonal respectively) and the (x, y) coordinate identifies the coefficient location in the specified sub-band. In addition, $I_{a,L}$ (x, y) refers to the approximation coefficients. Decomposing the host image at three levels using the Haar wavelet provides the optimal performance balancing between invisibility and robustness. The algorithm assumes that the order by which the coefficients will be selected for embedding depends on the value of a secret key. As long as the details of secret key are kept secret, an attacker will not be able to extract the watermark even if the details of the algorithm were exposed.

V. EXTRACTION

The steps of extraction process are exactly the inverse of those followed during the embedding phase. The objective is to reliably obtain an estimate (W') of the original watermark (W) from a possibly distorted version of the watermarked image. In order to correctly extract the watermark data, the key is required to visit the exact locations of the coefficients in the same order used for embedding. So, the extraction process starts by computing the 3^{rd} level of the Haar wavelet decomposition of watermarked image (I'). At each visited location, the inverse of the quantization process is carried out and the complement of the estimated nucleotide is appended to the watermark.

VI. INDENTATIONS & EQUATIONS

VI A. Embedding Process

1. Convert the watermark (W) from its binary form into a single-stranded chain of DNA nucleotides (W_{DNA}) based on some rule (such as the one shown in Fig. 3).

2. Initialize I' to be I

3. Decompose I' into the 3rd level of the Haar wavelet transform.

4. For each selected coefficient location (x, y); based on the randomness imposed by the *key*, do the following:

4.1. Sort the detail coefficients in ascending order such that:

$I_{k1,3}(x, y) \leq I_{k2,3}(x, y) \leq I_{k3,3}(x, y)$

Where k_1, k_2, k_3 are distinct and belong to the set $\{ h, v, d\}$

4.2. If the range between $I_{k1,3}(x, y)$ and $I_{k3,3}(x, y)$ is below a given threshold value, skip the following steps and get another coefficient location.

4.3. Embed the next base in W_{DNA} as follows:

4.3.1. find the value of Δ which is the difference between the largest coefficient and smallest coefficient divided by 3.

4.3.2 Let b' be the complement of the base to be embedded.

4.3.3 Quantize the middle coefficient $I'k2,3(x, y)$ as follows:

if (b' equals A *) then*

$I'_{k2,3}(x, y) = I'_{k1,3}(x, y)$

else if (b' equals C *) then*

$I'_{k2,3}(x, y) = I'_{k1,3}(x, y) + \Delta$

else if (b' equals G *) then*

$I'_{k2,3}(x, y) = I'_{k1,3}(x, y) + 2\Delta$

else

$I'_{k2,3}(x, y) = I'_{k1,3}(x, y) + 3\Delta$

5. Apply the 3^{rd} level inverse wavelet transform to get the watermarked image (I').

The embedding procedure is done using the complement of the nucleotide base (b') not the base itself (b). This step adds more security on the embedding process since the complementary rule can take many forms other the biological base pairing rule. Furthermore, this coding step can also be replaced by any suitable DNA-encryption algorithm.

VI.B The Extraction process- Algorithm

1. Decompose I' into the 3rd level of the *Haar* wavelet transform.

2. Initialize W_{DNA} to be an empty string

3. For each selected coefficient location (x, y); based on the randomness imposed by the *key*, do the following:

3.1. Sort the detail coefficients in ascending order such that:

$I_{k1,3}(x, y) \leq I_{k2,3}(x, y) \leq I_{k3,3}(x, y)$

Where k_1, k_2, k_3 are distinct and belong to the set $\{h, v, d\}$

3.2. If the range between $I_{k1,3}(x, y)$ and $I_{k3,3}(x, y)$ is below a given threshold value, skip the following steps and get another coefficient location.

3.3. Extract the next base in W_{DNA} as follows:

3.3.1. Find the value of Δ which is the difference between the largest coefficient and smallest coefficient divided by 3.

3.3.2 Estimate the embedded base (b) as follows:

if $I'_{k2,3}(x, y)$ lies near from $I'_{k1,3}(x, y)$ *then*

$b \leftarrow$ A

else if $I'_{k2,3}(x, y)$ lies Δ apart from $I'_{k1,3}(x, y)$ *then*

$b \leftarrow$ C

else if $I'_{k2,3}(x, y)$ lies 2Δ apart from $I'_{k1,3}(x, y)$ *then*

$b \leftarrow$G

else

$b \leftarrow$T

3.3.2 find b', the complement of b

3.3.3 Append b' W_{DNA}

4. Convert (W_{DNA}) into binary to get estimated the watermark (W').

VII. FIGURES & TABLES

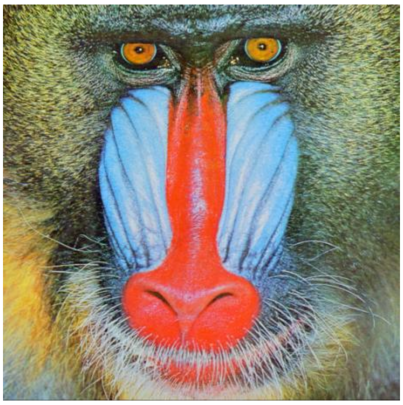


Fig VII. a. Host image

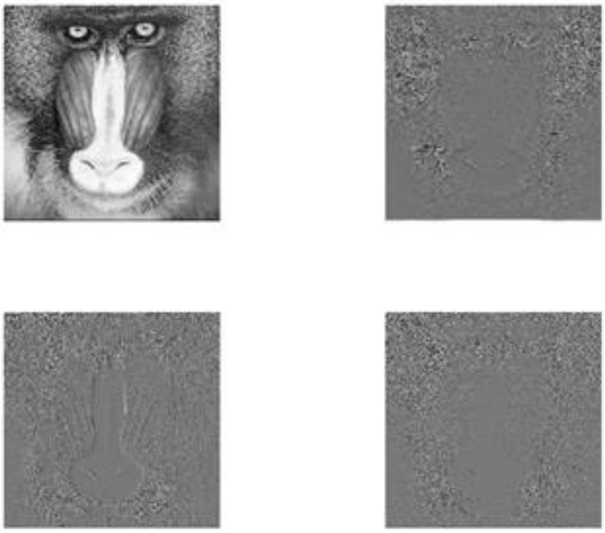


Fig VII. b. First level decomposition of host image

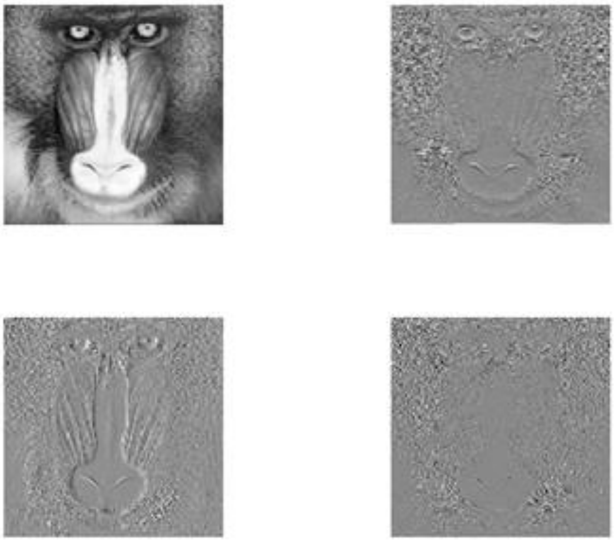


Fig VII. c. Second level decomposition of host image

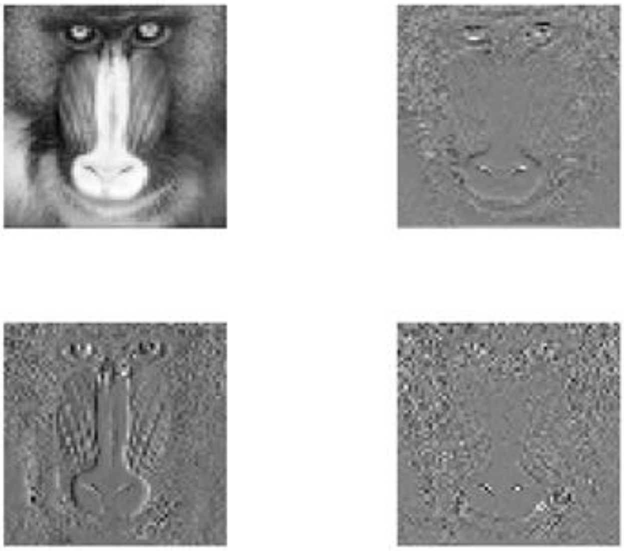


Fig VII. d. Third level decomposition of host image

The text watermark to be encoded and embedded is the word data. The output of encoding is as follows.

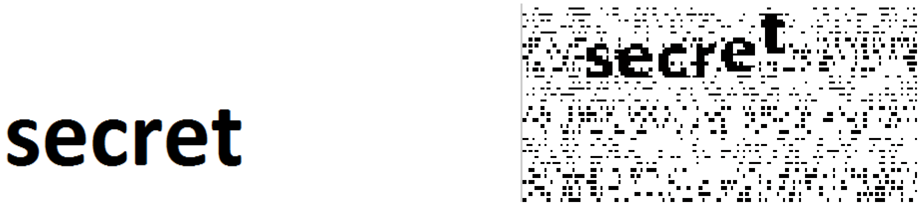
```
text =     data
asciiValue =    100    97   116    97
binary =     0    0    1    0    0    1    1
             1    0    0    0    0    1    1
             0    0    1    0    1    1    1
             1    0    0    0    0    1    1
len =     28
encodedData = CCAAGGAAAGTTTT
```

This encoded data is to be embedded into the third level decomposed host image.
The output of the extraction procedure is as given:

```
wbits =
    0    0    1    0    0    1    1
    1    0    0    0    0    1    1
    0    0    1    0    1    1    1
    1    0    0    0    0    1    1

wde =
  100
   97
  116
   97

wtext =
d
a
t
a

Extracted key =data
```

The text watermark data is successfully retrieved after the extraction procedure.

Using the same algorithm, images are also being watermarked into the host image and the results obtained are shown below.



(a) (b)

Fig VII. e (a) Watermark image (b) Watermark retrieved after image decomposition using DWT

(a) (b)

Fig VII. f (a) Second Watermark image (b) Watermark retrieved after image decomposition using DWT

VIII. CONCLUSION

With rapid development of information techniques and network, more and more bugs of traditional encryption techniques have appeared in digital media copyright protection. An efficient approach for copyright protection is the digital watermarking technique. In this paper, a blind watermarking technique is being used since they are more reliable & practical. Here instead of embedding the watermark directly into the host image, the complement of the watermark is being embedded after encoding it using the DNA encoding technique making it more difficult for the intruder to retrieve the watermark back increasing the security of the watermark technique. The watermarks retrieved are legible and hence can be used to prove the ownership of digital data.

REFERENCES

[1]. Ingemar J. Cox, Joe Kilian, F. Thomson Leighton, and Talal Shamoon, “Secure Spread Spectrum Watermarking for Multimedia”,

[2]. IEEE transactions on image processing, vol. 6, no. 12, DECEMBER 1997, pp 1673-1687

[3]. R. G. van Schyndel, A. Z. Tirkel, and C. F. Osborne, “A digital watermark,” *Proc. IEEE Int. Conf. Image Processing*, vol. 2, pp. 86–90, 1994.

[4]. Safwat Hamad & Amal Khalifa, “Robust Blind Image Watermarking using DNA encoding and Discrete Wavelet Transforms”, *8th International conference on computer engineering and systems (ICCES), pp221-227, 2013*

[5]. Gursharanjeet Singh Kalra, Dr. Rajneesh Talwar & Dr. Harsh Sadawarti, “Robust Blind Digital Image Watermarking Using DWT and Dual Encryption Technique”, *Third International Conference on Computational Intelligence, Communication Systems and Networks*, pp 225-230, 2011.

[6]. Gurparkash Singh Kang, “Blind Digital Image Watermarking Using Adpative Casting Energy In Different Resolutions Of Wavelet

[7]. Transform”, *International Conference on Computer & Communication Technology,* pp 210-215, 2010.

[8]. Ming-Shing Hsieh, Perceptual copyright protection using multiresolution wavelet based watermarking and fuzzy logic, “*International Journal of Artificial Intelligence & Applications (IJAIA)*”, Vol.1, No.3, pp 45-57, July 2010.

[9]. Safwat Hamad, Amal Khalifa, "Quantization-based Image Watermarking using multi-resolution wavelet decomposition," *The Egyptian Computer Science Journal (ECS),* vol. 37, no. 3, pp. 26-36, 2013.