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# A Nature Based Computing Technique for Image Watermarking using Bacterial Foraging Optimization, Wavelet and Cosine Transform

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***Abstract:*** ***The Watermarking technique is used for the purpose of broadcast monitoring, copyright protection, integrity verification and authentication. Its application extends in fingerprinting and content description. In literature several methods like DWT, DCT are presented and embedded which occupies maximum energy. The watermarking techniques use lossy data compression due to strong energy compaction. The new methods and optimization techniques are required. The paper presents a new design and implemented by nature based computing. The proposed method combines the advantage of the wavelet transform and cosine transform. The proposed Bacterial Foraging Optimization technique hybrid with DWT and DCT increase the performance of watermarking of digital images. The high-frequency area of the image is used in this methodology. The method is comparable for Genetic Algorithms (GAs). Selected type of image of PSNR & NCC is processed in MATLAB. The effective results are compared with DWT-DCT algorithm, DWT and multiple images. NCC (normalized cross correlation), PSNR (Peak signal to noise ratio) value and IF (image fidelity) for different techniques are compared. The DWT-DCT-BFO based watermarking performance is found best.***

***KeyTerms: DWT, DCT, BFO, Image watermarking, PSNR, NCC, copyright protection, data compression.***

## I. INTRODUCTION

Internet and mobile devices are growing faster that become larger usage for certain purposes such as, sharing of digital images and creation. The digital image can be shared by usage of internet and it cannot be re-used or downloaded because it has some drawback relating to transmission, storage and the copyright protection plays. This process can prevent the personal images by third parties without owner consent. The watermarking techniques are based on the spatial domain process in which it is categorized based on processing domain and extraction requirement. The processing domain contains frequency domain and spatial domain. The process domain can be extracted by non-blind, blind and semi-blind watermarking schemes. The spatial domain based techniques has some natural limitations that is high perceptibility of a fragility and host image.

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The watermarking technique has some various applications which are processed by image with their limitation such as, copyright protection, broadcast monitoring, authentication & integrity verification, fingerprinting, content description and convert communication.

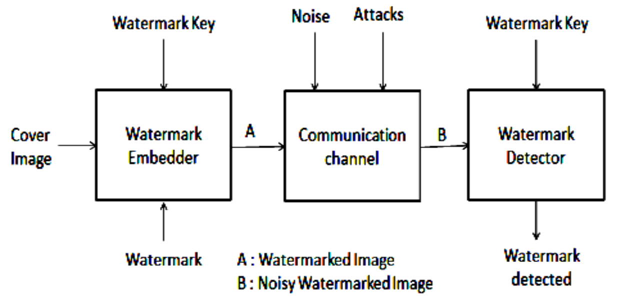


**Fig 1. Digital Watermarking System**

## II. LITERATURE SURVEY

The gray scale watermark image can convert normal image into color image using a novel digital image water-marking method. The image is embedded by gray scale image decomposition to binary image in digital ordering. The quantization technique can efficiently embedded in order from Least Significant Bit (LSB) to Most Significant Bit (MSB) in binary bits to have optimal wavelet coefficient blocks [1]. The digital watermarking algorithm can uses the correct level of image based on Integer Wavelet Transform and color space transform. The process is embedded into the color host image to extract the watermark without the original watermark. The basic correction is solved by applying the digital watermark. Hence the result is taken by processing the image [2]. The image watermarking method is used to process the digital watermark. This technique is used embedded into the affine invariant colored LER to process the image. The watermarking image utilizes the robust feature points and uniform image to extract in the color invariance. Thus the methodology is based on the image histograms and static theory is invariant to support better results [3].The geometric attack is used for processing the color image by zero watermarking. This method exist some challenge on cropping and random bending attack (RBA). This methodology is based on 2D color histogram from two different color components to extract. Thus the results are taken by the common image that is processed by various geometric attacks [4]. The DCT and PCA transform is the two low frequency band used for processing the image. This system will combine two low frequency bands to have high capacity of digital watermarking system. The watermark is processed and embedded in PCA.

Thus the DCT components are compared to other system and the image is transformed from RGB color to YCbCr [5]. The image watermark is process highly in recent years. Y. Zhang et al, (2011)[6] presented watermarking technique with existing digital watermark algorithms for gray images to color images. K. Thongkor and T.
Amornraksa (2017) [7] describe HSL color model using image watermarking method. This method uses watermark embedding system in S component of HSL color model to convey a binary watermark image.

J. Gao and J. Li (2009) [8] explains the computer network communication technology with convenient for transmission and digital information storage. This technique focuses on digital information using an algorithm with gray image as watermark. C. Yongqiang et al, (2009) analyze the watermarking properties such as; robustness, imperceptibility and security [9]. These properties are processed by a novel optimal color image watermarking in DWT domain. Hence the corresponding Genetic Algorithm (GA) is also the similar way to improve the imperceptibility of watermarked image. S. H. Shoron et al, (2018) describes the new digital watermarking model to improve the image enhancement and segmentation [10]. The SMQT and OTSU thresholding both are used for image enhancement and segmentation. This methodology is used to exhibiting higher PSNR, lower MSE and improved CC values and the result is taken. J. J. Chen et al, (2009) describes the adaptive visible watermarking for embedding strength of the watermark using Otsu's threshold by selective image [11]. This method is based on the analysis of the threshold value at a particular position. Thus the image is extracted from a watermarked image to process a particular character of digital image. Y. Chen et al, (2018) analyze medium-high frequency sub-band using reversible watermarking algorithm [12]. This technique is based on the integer wavelet transform (IWT) which has histogram shifting to get watermarking signals with correct extraction. Hence this can also improve the capacity of algorithm with more than 10% usage. J. Zhang and J. Hu (2008) analysis the image by image segmentation and also compute the computer vision system [13]. This method uses the automatic thresholding technique for time saving and simple implement. The Otsu method is one of thresholding methods and frequently. Thus by using these methodologies gives an improvement than the traditional Otsu method. R. P. Singh et al, (2014) presented an implementation and efficacy of Extreme Learning Machine (ELM) algorithm [14]. This technique is used for watermarking of an image in Discrete Wavelet Transform (DWT). This method has a better generalization performance against common image processing attacks. N. Otsu et al, (1979) use an automatic threshold selection for picture segmentation in a nonparametric and unsupervised method [15]. This process can have zero-th and the first-order cumulative moments which has the gray-level histogram. Thus by using the support of this method gives the better results.

## III. BACKGROUND METHODOLOGY

### 3.1. DWT based Image Watermarking Using Selective MSB-LSB Embedding And 2D Otsu Thresholding

#### 3.1.1. Watermark Embedding Process

Figure 2 shows the digital watermarking system by gray-scale at first watermark image W which is decomposed to eight binary images wb1:b8 by ordering from LSB to MSB as binary bits. The host color image is embedded by the binary bits I in which the quantization technique is refered in HL-LH coefficient with differences in $\Delta_{i,k}= |HL^k_i-LH^k_i|$ of i[th] wavelet block in k[th] color channel. The corresponding coefficient is done by wavelet alerting that are quantized to predefined thresholds $\delta_0$ and $\delta_1$ for 0-bits and 1-bits respectively. These wavelet coefficient are the difference blocks to store the data in ascending order which is represented as $\Delta^S_{i,k}$, to encode 0-bits for smallest difference blocks and 1-bits for greatest difference blocks. The pre-defined threshold and difference block are the two optimal color channels to minimize the differences between $\Delta^S_{i,k}$ and $\delta_0$ chosen for binary embedding. This technique has binary bit $w_i = 0$ and $\delta_1$ for $w_i = 1$ and the watermark bits of four binary images $w^{k\#1} = \{w_{b2}, w_{b4}, w_{b6}, w_{b8}\}$ are encoded to the first optimal channel k #1 and remaining images are $w^{k\#2} = \{w_{b1}, w_{b3}, w_{b5}, w_{b7}\}$ are encoded to the second optimal channel k #2.

$$k^{\#1}=\begin{cases}\arg\min_k\left(\left|\Delta^S_{i,k}-\delta_0\right|\right) & \forall w_i\in w_{k\#1}=0\\ \arg\min_k\left(\left|\Delta^S_{i,k}-\delta_1\right|\right) & \forall w_i\in w_{k\#1}=1\end{cases}$$
$$k^{\#2}=\begin{cases}\arg\min_k\left(\left|\Delta^S_{i,-k\#1}-\delta_0\right|\right) & \forall w_i\in w_{k\#2}=0\\ \arg\min_k\left(\left|\Delta^S_{i,-k\#1}-\delta_1\right|\right) & \forall w_i\in w_{k\#2}=1\end{cases} \quad (1)$$

During the extraction process the associative key will generate and maintains the information which is Inverse Discrete Wavelet Transform (IDWT) by recovered information. Thus it completes the coefficient differences of either less than $\delta_0$ or greater than $\delta_1$ as modified.

**For encoding 0-bits**

$$\begin{aligned}&if\quad \Delta^S_{i,k*}>\delta_0\\ &\quad LH_i^{K*}\geq HL_i^{K*}\rightarrow\begin{cases}LH_i^{K*}=LH_i^{K*}-\nabla_i^0/2\\ HL_i^{K*}=HL_i^{K*}+\nabla_i^0/2\end{cases}\\ &\quad LH_i^{K*}<HL_i^{K*}\rightarrow\begin{cases}LH_i^{K*}=LH_i^{K*}+\nabla_i^0/2\\ HL_i^{K*}=HL_i^{K*}-\nabla_i^0/2\end{cases}\\ &if\quad \Delta^S_{i,k*}\leq\delta_0\\ &\quad LH_i^{K*}=LH_i^{K*}\\ &\quad HL_i^{K*}=HL_i^{K*}\end{aligned} \quad (2)$$

**For encoding 1-bits**

$$\begin{aligned}&if\quad \Delta^S_{i,k*}<\delta_0\\ &\quad LH_i^{K*}\geq HL_i^{K*}\rightarrow\begin{cases}LH_i^{K*}=LH_i^{K*}+\nabla_i^0/2\\ HL_i^{K*}=HL_i^{K*}-\nabla_i^0/2\end{cases}\\ &\quad LH_i^{K*}<HL_i^{K*}\rightarrow\begin{cases}LH_i^{K*}=LH_i^{K*}-\nabla_i^0/2\\ HL_i^{K*}=HL_i^{K*}+\nabla_i^0/2\end{cases}\\ &if\quad \Delta^S_{i,k*}\geq\delta_0\\ &\quad LH_i^{K*}=LH_i^{K*}\\ &\quad HL_i^{K*}=HL_i^{K*}\end{aligned} \quad (3)$$

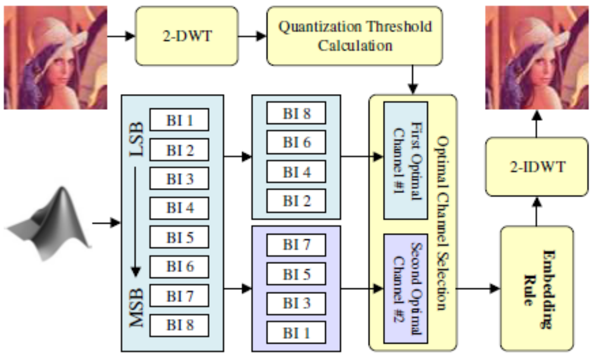


**Fig. 2 The workflow of embedding process.**

Thus the 8-bit image to 8 binary images (BIs) is ordered from LSB to MSB with the gray-scale watermark decomposition.

### 3.1.2. Watermark Extraction Process

Processing the channel and block information created in embedded stage in extraction process, which is to find the difference between the encoded block with key to calculate the DWT coefficient. The classification 2D Otsu threshold is denoted by $\delta_\Delta$ where, $\delta_0 < \delta_\Delta < \delta_1$ are the watermark bits to perform the comparison rule to recover.

$$w_i = \begin{cases} 1 & \forall \Delta_{i,k*} \geq \delta_\Delta \\ 0 & otherwise \end{cases}$$

The unknown quantization threshold is determined by an important $\delta_\Delta$ of $\delta_0$ and $\delta_1$. Thus, an adaptive two-dimensional (2D) Otsu threshold is used for image segmentation to calculate the DWT blocks which present 0-bits and 1-bits embedment. By maximizing the trace between the class variance matrix $S_b$ and threshold vector (s = $\delta_\Delta$, t) is selected.

$$(s,t) = \arg\max(T_r(S_b)) \qquad (4)$$
$$0 \leq s \leq L$$
$$0 \leq t \leq L$$

Where, $L = \max(\Delta_{i,k*})$

$$T_r(S_b) = \frac{(\mu T_i \omega_0 - \mu_i)^2 + (\mu T_j \omega_0 - \mu_j)^2}{\omega_0(1-\omega_0)} \qquad (5)$$

The discrete matrix is employed to obtain the optimal threshold S by a fast recursive algorithm of 2D Otsu. This method is compared to 1D and 2D Otsu algorithm for noise segmentation challenge which is handled by ordering the binary images which are reconstructed in a gray-scale watermark image.

### 3.2. Combined DWT-DCT watermarking

This method is used to improve the embedding and extraction of images as algorithm which are normally processed when the changes are utilized by combined Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT). This combination of Watermark Embedding Process is similar to the DWT method by decomposing Original 256×256 image into 1-level sub bands. This can method contains the maximum energy which is embedded using DWT which generate four sub-bands (LL, LH, HL and HH) out of which the Lowest Level is selected. When the LL is embedded by calculating the DCT of Watermark 128×128 when DCT transformed watermark, then Inverse DWT is calculated of obtained image called Watermarked Image.

### 3.2.1. Discrete Wavelet Technique

The mathematical expression for decomposing the image is used in Discrete Wavelet transform (DWT) works by varying the frequency that can transform wavelets based on small waves. This technique is processed by three different directions during wavelet transforms decomposing such as, horizontal, vertical and diagonal which are shown in Fig 5.1.

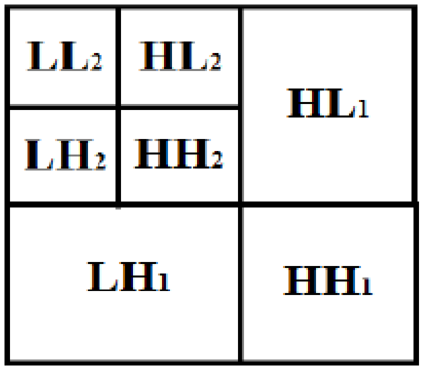


**Fig 3. 2-level DWT**

Thus the DWT application provides both frequency spread and simultaneous spatial placed inside the host image and also be used as audio and video compression. This simulation is done by wireless antenna distribution. The process of HH, LH and HL bands could be smaller when compare to magnitude of DWT coefficients in the lowest bands (LL) at each level of decomposition.

### 3.2.2. Discrete Cosine Transform

The Discrete Cosine Transform is the watermarking technique which is used to compare the spatial domain technique. The data represents DCT in the form of frequency that is rather than an amplitude space. The corresponding DCT watermarking techniques uses lossy data compression due to strong energy compaction which is divided into Global DCT and Block based DCT watermarking.

$$X_k = \sum_{n=0}^{N-1} x_n \cos\left[\frac{\Pi}{N}(n + n/2)k\right] \qquad (6)$$
$$k = 0,1,\ldots\ldots\ldots N-1$$

Where, $X_k$ denoted as discrete cosine transform.

## IV. PROPOSED METHOD COMBINED DWT, DCT AND BFO.

Combining the DWT-DCT watermarking will not get possible performance, so that BFO is introduced which can increase the performance of digital images has been implemented. When the watermark is inserted in image, the BFO algorithm can find the high-frequency areas of the image.

The Bacterial Foraging Optimisation (BFO) algorithm is one in which it can increase the performance in digital image which are nature-inspired optimization algorithms.

This optimization technique is used to control the dominion algorithms which can improve the growth and normal genetics which are comparable for Evolutionary Programming (EP), Evolutionary Strategies (ES) and Genetic Algorithms (GAs). The Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) also similar to the optimization process that have been established their dominion and showed efficiency. The BFO algorithm applications process the multi-optimal for assembly searching approach called E.coli bacteria swarm function by using the novel algorithm. This swarm function is used to achieve the energy exploited in bacteria nutrients which can explore per unit time by signal transfer that is connected with separate bacterium. The BFO algorithm has the term used for transfer the data which are difficult to explore by chemo-taxis and simulating chemo-tactic for basic idea of BFOA movement of effective bacteria.

The embedding message plays the vital role on optimization in which NCC (normalized cross correlation), IF (image fidelity) and PSNR (Peak signal to noise ratio) are used. The value of NCC and PSNR are high when compare to the IF during the embedding of message. The message should be recovered at the receiver end which are clearly being validated with a constraint message that are high done by the NCC which are normalized by cross correlation between the original message and recovered message. The depth of the message is processed by using gain factor which could use the embedding process which is presented and discussed by hiding and retrieval. The PSNR and NCC are managed between the selected gain factor that is high value of watermarked image and the transmission of image could be invisible and robust while processing the embedded message. E. coli bacteria is the objective function used in the longer distance of communication in which the optimum value is set to gain the factor of bacterial foraging optimization. The process is done by the BFO to locate the minimized function of objective value with inverse of normalized cross correlation has been considered the parameter. Thus the process is used to select the value of initially random gain value with the retrieval process and embedding of message using DCT and DWT watermarking process.

## V. RESULTS & DISCUSSION

Thus the selected type of image of PSNR & NCC is processed and message can be proved by the developed graphical user interface (GUI) of all embedding system in MATLAB. Hence the message is hidden into the image that can improve the efficiency and compare the results with DWT-DCT, DWT-DT-BFO and DWT algorithm and also multiple images. Fig 4 shows the output of DWT based watermarking. In this method received message is not clear. Performance of DWT-DCT based watermarking is shown in Fig 5 and Fig 6. Shows the DWT-DCT-BFO based watermarking performance.

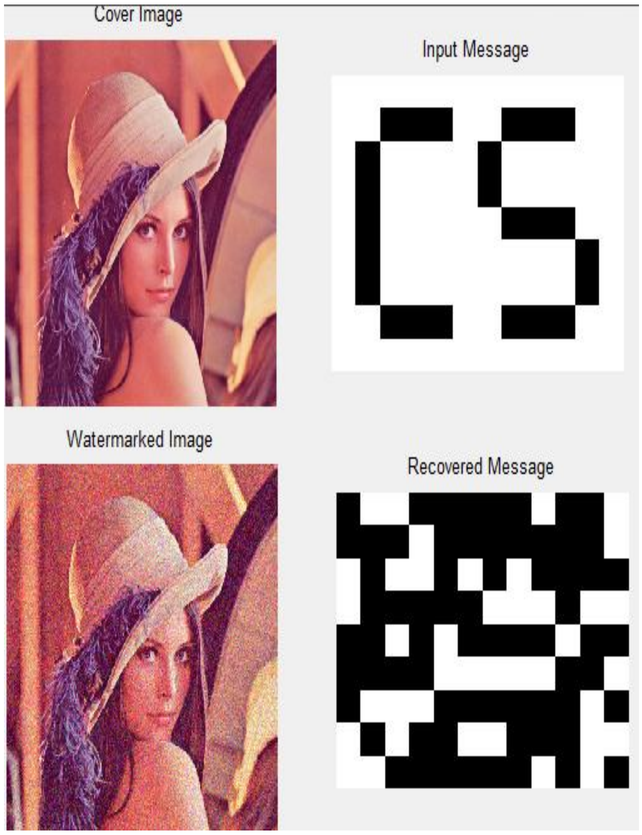


**Fig 4. DWT based watermarking**

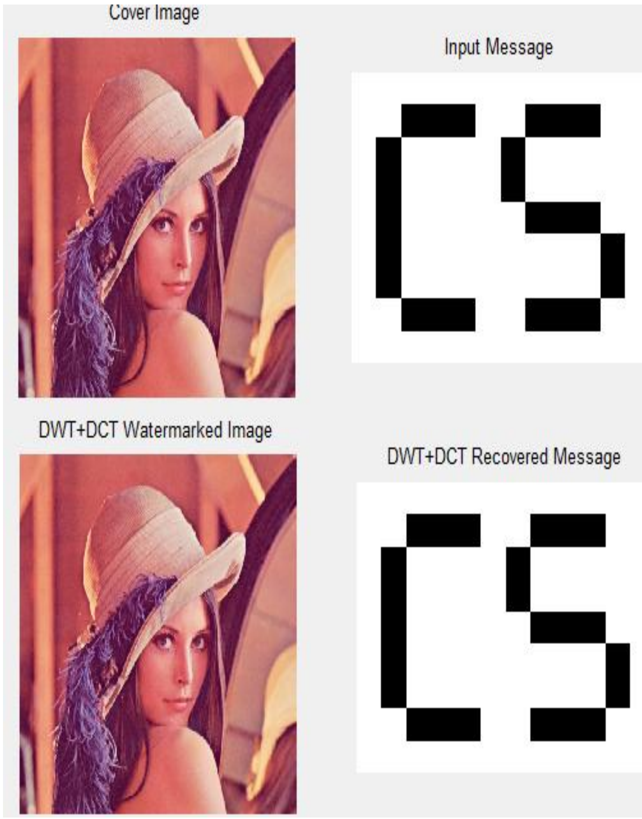


**Fig 5. DWT-DCT based watermarking**

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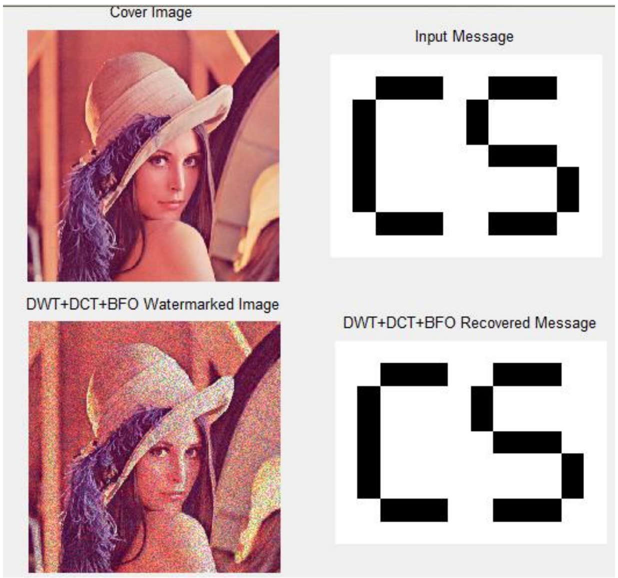


**Fig 6. DWT-DCT-BFO based watermarking output**

The NCC (normalized cross correlation), PSNR (Peak signal to noise ratio) and IF (image fidelity) are all compared by different techniques which is shown in table 1. Figure 7 shows the comparison chart for NCC and fig 8 shows the comparison chart for PSNR. From this we can say that DWT-DCT-BFO based watermarking performance is best.

**Table 1: Comparison Table**

| | DWT | DWT+DCT | DWT+DCT+BFO |
|---|---|---|---|
| PSNR | 25.4916 | 44.8953 | 54.5673 |
| NCC | 0.0016 | 0.0039 | 0.0039 |
| IF | 0.0366 | -6.0290e-05 | -6.5017e-06 |

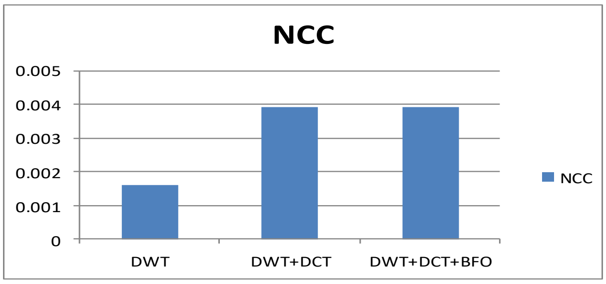


fig 7: Comparison chart of NCC values

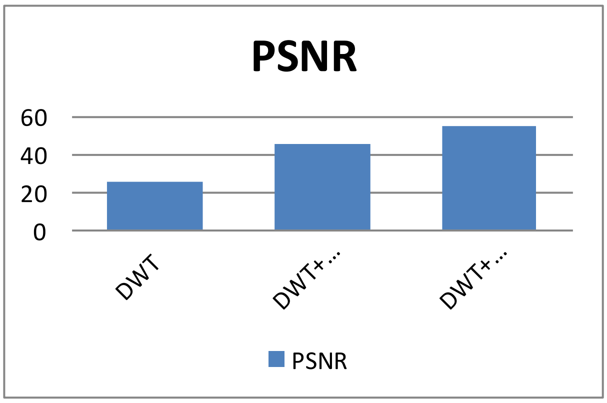


**Fig 8: Comparison of PSNR values**

## VI. CONCLUSION

The paper presents a new methodology for image watermarking using nature based computing. The proposed method combines the best features of wavelet transform, cosine transform and Bacterial Foraging Optimization. This method has better performance by reducing the energy. When the watermark is inserted in image, the BFO algorithm can find the high-frequency areas of the image and controls. The performance is evaluated with the PSNR & NCC in MATLAB. DWT, DWT-DCT and DWT-DT-BFO algorithms were implemented and tested using multiple images.

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