Digital Image Watermarking Using BFO Optimized DWT and DCT & Comparison between DWT, DWT+DCT, DWT+DCT+BFO

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Abstract— **Watermarking has been invoked as a tool for the protection of Intellectual Property Rights (IPR) of multimedia contents. Because of their digital nature, multimedia documents can be duplicated, modified, transformed, and diffused very easily. In this context, it is important to develop a system for copyright protection, protection against duplication, and authentication of contents. For this, a watermark is embedded into the digital data in such a way that it is indissolubly tied to the data itself. Later on, such watermark can be extracted to prove ownership to trace the dissemination of the marked work through the network, or simply to inform users about the identity of the rights-holder or about the allowed use of data. This thesis deals the developing the watermarking schemes for digital images stored in both, spatial and transformed domain. In this thesis we mainly focus on the Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) based development. To increase the undetectability and to increase the claim, gain of embedding algorithm is optimized with the help of bacterial foraging optimization (BFO) so that security is increased. For this every watermark is given a unique identification, same as the principle of Code Division Multiple Accessing (CDMA) technique. To prove its commercial usability, we take special care so that at least one attack, having huge financial implications, can be sustained due to the in-built capacity of the watermarking scheme. Apart from this, since JPEG is the most commonly used image format over WWW, we pay special attention to robustness against noise attack. We propose to increase the robustness against some attacks by pre-processing the images. In this thesis, we also present a correlation between the performance of the watermarking scheme against some attacks and the original image characteristics. All presented watermarking schemes are robust against common image manipulations and attacks**.

Keywords— **DWT, DCT, BFO, Image Processing.**

I. Introduction

A watermark is a recognizable image or pattern in paper that appears as various shades of lightness/darkness when viewed by transmitted light (or when viewed by reflected light, a dark background), caused by thickness or density variations in the paper. There are two main ways of producing watermarks in paper; the dandy roll process and complex cylinder mold process. Watermarks are often used as security features of bank notes, passports, postage stamps and other documents to prevent counterfeiting. Watermark is very useful in the examination paper because it can be used for dating, identifying sizes, mill trademarks and locations, and the quality of a paper. We are living in the era of information where billions of bits of data is created in every fraction of a second and with the advent of internet, creation and delivery of digital data (images, video and audio files, digital repositories and libraries, web publishing) has grown many fold. Since copying a digital data is very easy and fast too so, issues like, protection of rights of the content and proving ownership, arises. Digital watermarking came as a technique and a tool to overcome shortcomings of current copyright laws for digital data. The specialty of watermark is that it remains intact to the cover work even if it is copied. So to prove ownership or copyrights of data watermark is extracted and tested. It is very difficult for counterfeiters to remove or alter watermark. As such the real owner can always have his data safe and secure. Our aim is to study different watermarking techniques and all types of attack. Counterfeiters try to degrade the quality of watermarked image by attacking an image (generally attacks are scaling, compression and rotation of watermarked image). By attacking watermarked image it becomes very difficult to recover watermark back from the watermarked image and even if it extracted one may no longer use it to prove the ownership and copyrights. So our main idea is to find such regions, also known as patches, in an image which are very stable and resistant to attacks. The term watermark may have been derived from the German term, sermarke. The term is actually a misnomer, in that water is not especially important in the creation of the mark. It was probably given because the marks resemble the effects of water on paper. At the beginning of 1990 the idea of digital watermarking has emerged, it embedding imperceptible information into audio visual data. The first watermarking methods were proposed for digital images by Caronni in 1993. Digital watermarks have mainly three application fields: data monitoring, copyright protection and data authentication. The art of watermarking was invented in China over one thousand years earlier. The marks were made by adding thin wire patterns to the paper moulds. The paper would be slightly thinner where the wire was thicker and hence more transparent. The meaning and purpose of the earliest watermarks are uncertain. They may have been used for practical functions such as identifying the moulds on which sheets of papers were made, or as trademarks to identify the paper maker

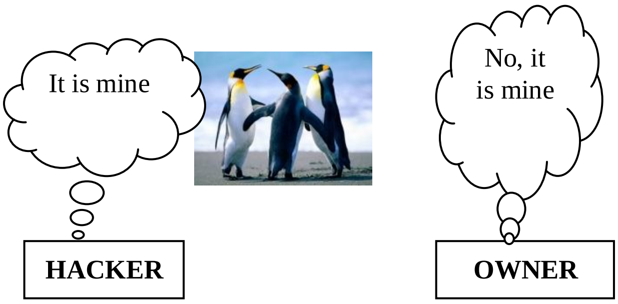

Figure: 1 Motivation Behind Digital Watermarking

II. Discrete Wavelet Transform

In numerical analysis and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency *and* location information (location in time). The discrete wavelet transform has a huge number of applications in science, engineering, mathematics and computer science. Most notably, it is used for signal coding, to represent a discrete signal in a more redundant form, often as a preconditioning for data compression. Practical applications can also be found in signal processing of accelerations for gait analysis, in digital communications and many others. It is shown that discrete wavelet transform (discrete in scale and shift, and continuous in time) is successfully implemented as analog filter bank in biomedical signal processing for design of low-power pacemakers and also in ultra-wideband (UWB) wireless communications.

III. Discrete Cosine Transform

DCT breaks the image into two different frequency components: low frequency and high frequency. Low frequency component contains high energy and can be considered as luminance part of image whereas reflectance is constituted by high frequency component as it contains the low energy. A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio (e.g. MP3) and images (e.g. JPEG) (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical for compression, since it turns out (as described below) that fewer cosine functions are needed to approximate a typical signal), whereas for differential equations the cosines express a particular choice of boundary conditions. In particular, a DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common. The most common variant of discrete cosine transform is the type-II DCT, which is often called simply "the DCT", its inverse, the type-III DCT, is correspondingly often called simply "the inverse DCT" or "the IDCT". The discrete cosine transform (DCT) helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is similar to the discrete Fourier transform: it transforms a signal or image from the spatial domain to the frequency domain.

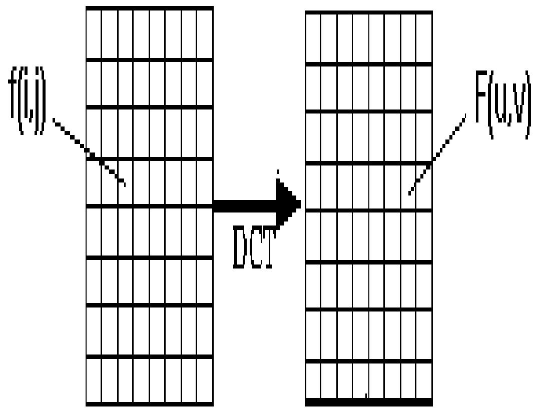

Figure 2: Discrete cosine transform

IV. Bacterial Foraging Optimisation

Bacteria Foraging Optimization Algorithm (BFOA), is a new comer to the family of nature-inspired optimization algorithms. For over the last five decades, optimization algorithms like Genetic Algorithms (GAs),Evolutionary Programming (EP), Evolutionary Strategies (ES), which draw their inspiration from evolution and natural genetics, have been dominating the realm of optimization algorithms. Recently natural swarm inspired algorithms like Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) have found their way into this domain and proved their effectiveness. Application of group foraging strategy of a swarm of *E.coli* bacteria in multi-optimal function optimization is the key idea of the new algorithm. Bacteria search for nutrients in a manner to maximize energy obtained per unit time. Individual bacterium also communicates with others by sending signals. A bacterium takes foraging decisions after considering two previous factors. The process, in which a bacterium moves by taking small steps while searching for nutrients, is called chemotaxis and key idea of BFOA is mimicking chemotactic movement of virtual bacteria in the problem search space. Since its inception, BFOA has drawn the attention of researchers from diverse fields of knowledge especially due to its biological motivation and graceful structure. Researchers are trying to hybridize BFOA with different other algorithms in order to explore its local and global search properties separately. It has already been applied to many real world problems and proved its effectiveness over many variants of GA and PSO.

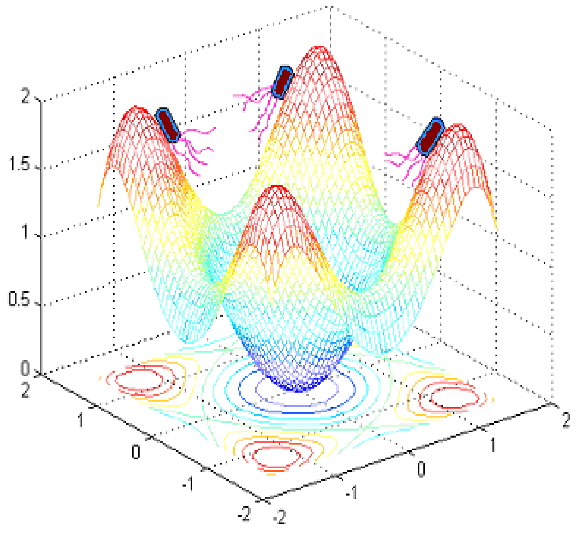

Figure3: A bacterial swarm on a multi-modal objective function surface

During foraging of the real bacteria, locomotion is achieved by a set of tensile flagella. Flagella help an *E.coli* bacterium to tumble or swim, which are two basic operations performed by a bacterium at the time of foraging. When they rotate the flagella in the clockwise direction, each flagellum pulls on the cell. That results in the moving of flagella independently and finally the bacterium tumbles with lesser number of tumbling whereas in a harmful place it tumbles frequently to find a nutrient gradient. Moving the flagella in the counter clockwise direction helps the bacterium to swim at a very fast rate. In the above-mentioned algorithm the bacteria undergoes chemotaxis, where they like to move towards a nutrient gradient and avoid noxious environment.

V. PROPOSED WORK

In our proposed work the message is hide in the cover image. Objective is to achieve invisible watermarking such that after embedding the message, message shouldn't be observable. The method adopted for this purpose is the combination of three methods which are used in watermarking individually. But every method has its own limitations so in our work these are combined to overcome their limitations. The method adopted here is Discrete Wavelet transform (DWT) along with Discrete cosine transform (DCT), optimized with bacterial foraging optimization (BFO). The performance criteria's for image watermarking are PSNR (Peak signal to noise ratio) value, NCC (normalized cross correlation) and IF (image fidelity). The value of PSNR and NCC must be high for good embedding of message. The embedding of message by any selected method comes with a constraint that the message should be recovered at the receiver end clearly and in that case validation can be done by the NCC as normalized cross correlation between the original message and recovered message must be high. So, a gain factor in the proposed embedding process is introduced, discussed in next section, which decides the depth of message hiding and retrieval also. But it is also required that embedding should be invisible and robust also to any type of attack or noise introduced during transmission of image. High PSNR value guarantees robustness of watermarked image. So gain factor value must be selected so that a balance between the PSNR and NCC can be managed. To set the optimum value of gain factor bacterial foraging optimization is used in our work. The BFO as discussed in previous chapter minimize the objective function value to get the best location of E.Coli bacteria. So the task is to formulate the objective function to achieve the best gain value. For this purpose inverse of normalized cross correlation has been considered the parameter which is to be minimized. Initially random gain value is selected and that is passed to the embedding and retrieval process of message using DWT and DCT watermarking process. At the watermarked image by this process various noises like Gaussian noise, salt & pepper noise, speckle noise and Poisson noise have been added and message is recovered from these noisy images. NCC between the original message and recovered from these noisy watermarked images have been found out. Then the inverse of sum of all these NCCs is considered as the objective function of BFO.

VI. RESULTS & DISCUSSION

In our work we have developed a graphical user interface (GUI) in MATLAB which provides the freedom to select any type of image and message to be hidden in to image. To prove the efficiency of proposed work we have compared the results with DWT and DWT-DCT algorithm. As discussed above parameters for comparison considered here are; PSNR and NCC

Table1: Comparison between techniques of watermarking and proposed technique

	DWT	DWT+DCT	DWT+DCT+B FO
PSNR	28.00 3	47.059	48.91
NCC	0.0018	0.0039	0.0039
IF	-0.0242	1.0045e-04	-6.5441e-05

VII. CONCLUSION & FUTURE SCOPE

The effectiveness of the whole scheme is proven through simulation results like 1) PSNR quality assessment objectives are achieved 2) watermarked image have very good visual quality 3) no auxiliary data is required for quality estimation (only embedded watermarks and test images are needed). In this work, a still image watermarking scheme with high robustness in the frequency domain is applied. The proposed scheme tests only image rather than audio or video. This algorithm can be used for data hiding in many applications such as authentication and copyright protection.

In this paper, a general coding-type framework which provides useful and constructive tools in the analysis and design of watermarking system is used. That particularly demonstrates the effectiveness of watermarking approach in achieving design objectives such as robustness, capacity, security, and implementation efficiency.

*The watermarking technique that is given in this paper can be further extended by implementing at Swarm optimization method after the DWT.

*In future, work may be extended on different media like video, audio etc by using this approach.

VIII. References

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