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Daya K. Lobiyal
Durga Prasad Mohapatra
Atulya Nagar
Manmath N. Sahoo
Editors

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Preface

International Conference on Signal, Networks, Computing, and Systems (ICSNCS 2016), organized by School of Computer and Systems Sciences, Jawaharlal Nehru University, India, during February 25–27, 2016, certainly marks a success toward bringing researchers, academicians, and practitioners in the same platform. It is indeed a pleasure to receive overwhelming response from researchers of premier institutes of the country and abroad for participating in ICSNCS 2016, which makes our endeavor successful. Being the first conference of its series, it was challenging for us to broadcast the conference among researchers and scientists and to receive their valuable works for review. A very systematic workflow by the committee has made it possible. We have received 296 articles and have selected 73 articles of the highest quality among them for presentation and publication through peer review done by at least two experts for each article. We are unable to accommodate many promising works as we restricted our selection to limited articles which can be elaborately presented in a three-day conference. We are thankful to have the advice of dedicated academicians and experts from industry to organize the conference. We thank all researchers participating and submitting their valued works in our conference. The articles presented in the proceedings discuss the cutting-edge technologies and recent advances in the domain of the conference. We conclude with our heartiest thanks to everyone associated with the conference and seek their support to organize the next editions of the conference in subsequent years.

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About the Editors

Dr. Daya K. Lobiyal is currently serving as a professor in School of Computer and Systems Sciences in Jawaharlal Nehru University, India. His research works have been published in many journals and conference proceedings. He is a fellow of Institution of Electronics and Telecommunication Engineers, India.

Prof. Durga Prasad Mohapatra received his Ph.D. from the Indian Institute of Technology Kharagpur and is presently serving as an associate professor in NIT Rourkela, Odisha. His research interests include software engineering, real-time systems, discrete mathematics, and distributed computing. He has published more than 30 research papers in these fields in various international journals and conference proceedings. He has received several project grants from DST and UGC, Government of India. He has received the Young Scientist Award for the year 2006 by Orissa Bigyan Academy. He has also received the Prof. K. Arumugam National Award and the Maharashtra State National Award for outstanding research work in software engineering for the years 2009 and 2010, respectively, from the Indian Society for Technical Education (ISTE), New Delhi. He is going to receive the Bharat Shiksha Ratan Award for significant contribution in academics awarded by the Global Society for Health and Educational Growth, Delhi.

Prof. Atulya Nagar holds the foundation chair as a professor of mathematical sciences at Liverpool Hope University where he is the dean of Faculty of Science. He has been the head of the Department of Mathematics and Computer Science since December 2007. A mathematician by training, he is an internationally recognized scholar working at the cutting edge of applied nonlinear mathematical analysis, theoretical computer science, operations research, and systems engineering, and his work is underpinned by strong complexity–theoretic foundations. He has an extensive background and experience of working in the universities in the UK and India. He has edited volumes on intelligent systems and applied mathematics; he is the editor in chief of the International Journal of Artificial Intelligence and Soft Computing (IJAISC) and serves on editorial boards for a number of prestigious journals such as the Journal of Universal Computer Science (JUCS). Professor Nagar received a prestigious Commonwealth Fellowship for pursuing his doctorate (D.Phil.) in applied nonlinear mathematics, which he earned from the University of York in 1996. He holds B.Sc. (Hons.), M.Sc., and M.Phil. (with distinction) from the MDS University of Ajmer, India.

Dr. Manmath N. Sahoo received his M.Tech and Ph.D. degrees in computer science in the year 2009 and 2014, respectively, from the National Institute of Technology (NIT) Rourkela, India. He is an assistant professor in the Department of Computer Science and Engineering, NIT Rourkela, India. He has served as reviewer, guest editor, track chair, and program chair in many reputed journals and conferences. His research interests include mobile ad hoc networks, fault tolerance, and sensor networks. He is a professional member of prestigious societies such as IEEE, CSI, and IEI.

Part I
Signal Processing Systems and Applications

DFT-DCT Combination Based Novel Feature Extraction Method for Enhanced Iris Recognition

Anunita Raghu, Meghana Gundlapalli and K. Manikantan

Abstract Iris Recognition (IR) using conventional methods is a challenging domain, and incorporating a combination of two transforms along with proposed novel extraction technique possesses the efficacy to address the problem at hand. This paper throws light upon the proposed unique *Combined DFT-DCT* feature extraction along with the inclusion of a *disc shaped morphological structuring element* in the preprocessing stage. Two novel methods, namely *astroid* and *astroid ring shaped extraction* techniques are proposed, and Binary Particle Swarm Optimization (BPSO) based algorithm for feature selection has been employed to procure the optimal subset of features from the feature space. Experimental results that have been obtained by implementing the proposed technique on two standard iris databases, IITD and MMU, lucidly outline the promising performance of the astroid shaped feature extraction resulting in a significant increase in rate of recognition accompanied by considerably lower number of features for iris recognition.

Keywords Iris recognition · Discrete cosine transform · Discrete fourier transform · Binary particle swarm optimization · Feature selection · Feature extraction

1 Introduction

Biometric Systems involve recognition of human physiological features namely face, retina, palm print, voice, fingerprint and iris, which are unique to an individual. Apart from its inherent accuracy, an added advantage of biometric systems is that existing

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technology, such as hand-held devices and electronic gadgets, can incorporate it with ease (Ref. [1]).

Iris Recognition has gained immense importance in recent times due to its age invariant features (unlike fingerprints which are eventually smoothed) and fast recognition. References [2, 3] proposes circular sector and triangular feature extraction using DCT while Ref. [4] introduces the concept of Binary Particle Swarm Optimization (BPSO) applied for Face Recognition. Reference [5] presents the role of the Golden Ratio in BPSO, assigning values to the cognitive and social factors. Reference [6] is a path-breaking work regarding the introduction of iris recognition in the field of biometrics and Ref. [7] proposes an algorithm to identify the iris using circular detection operator method. References [8, 9] are recent surveys carried out in the field of biometrics.

2 Problem Definition and Contributions

Reference [2] proposes a DCT based circular sector and triangular feature extraction. However, with the usage of DCT alone, recognition rate cannot be increased and the maximum number of features extracted for both the shapes is high, which in turn results in increased processing time.

To combat these limitations, our proposal consists of a *Combination of DFT and DCT* embodied feature extraction which results in a significantly higher recognition rate. Two novel approaches to considerably reduce the computation time are the *astroid* and *astroid ring shaped feature extraction*. The introduction of a *morphological structuring element* in the preprocessing stage enhances the features of the iris, ameliorating the recognition rate. The preprocessing stage also consists of Gaussian Blurring, Gamma Intensity Correction (GIC) along with Histogram Equalization (HE). Applying *Binary Particle Swarm Optimization (BPSO)* with *Euclidean Classifier* results in further diminution of the number of features extracted.

The subsequent portion of the paper is structured in the following manner: Sect. 3 addresses image preprocessing based on illumination and Sect. 4 introduces the proposed DFT-DCT Combination. Section 5 throws light upon the proposed shape of feature extraction while Sect. 6 deals with BPSO based feature selection. The proposed IR system with its experimental outcomes are illustrated in Sects. 7, and 8 summarizes the results obtained.

3 Image Preprocessing

Preprocessing an image is a fundamental step used to reduce information loss in the image in order to improve its suitability for subsequent procedures. The grayscale Iris image is not well suited for feature extraction due to non-uniform illumination, improper focus or insufficient lighting. Figure 1 represents the block diagram of our

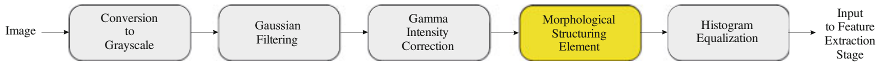

Fig. 1 Block diagram of the preprocessing system

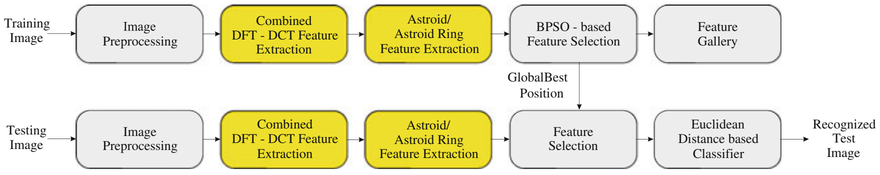

Fig. 2 Block diagram of the proposed IR system

suggested preprocessing system while Fig. 2 depicts the block diagram of the proposed IR system.

Gaussian Filtering: Gaussian blurring is used to obtain smooth edges using a filter of optimum dimensions 4×4 along with a standard deviation value of $\sigma = 1.2$.

Gamma Intensity Correction (GIC): According to the Power Law, the relation between the original image and gamma intensity corrected image is given by Eq. 1.

$$I(x, y) = I(x, y)^{1/\gamma} \tag{1}$$

where the exponent is gamma (γ), which determines the degree of brightness of the corrected image (Ref. [10]). Applying GIC with an optimum value of $\gamma = 0.78$ aided the enhancement of the iris' features.

Histogram Equalization (HE): HE is a graphical representation of the normalized number of pixels versus various values of intensity. It is a non-linear transformation that balances brightness of the image, giving a high contrast image which is visually distinguishable from the original image by the human eye.

3.1 Proposed Morphological Structuring Element

Constructed by employing a family of techniques referred to as structuring element decomposition, structuring elements are those wherein morphological operations by sizable structuring elements can be computed rapidly with a smaller sequence of structuring elements. The shape of the structuring element can be well defined, such as a polygon, or arbitrary. It contributes to obtaining sequiturs on how this shape misses or fits the shapes in the image. Since the iris profile is circular, the proposed concept involves the utilization of a flat, disk-shaped structuring element of radius R = 23. It is to be noted that the disk and ball shaped structuring elements are obtained by approximations, while the other structuring elements are exact.

4 Proposed Combination of DFT-DCT for Feature Extraction

Discrete Fourier Transform (DFT) is obtained by decomposing a sequence of values into components of various frequencies. Fast Fourier Transform (FFT), as the name suggests, is a fast and more efficient algorithm to compute the DFT of an image. DFT is mathematically represented as shown in Eq. 2 where $W_N = e^{-j2\pi/N}$.

$$X(k,l) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} x(m,n) W_N^{mk} W_N^{nl} \quad , \qquad 0 \le k,l \le N-1 \tag{2}$$

On applying DFT, the *low frequency components*, constituting majority of the distinguishable features in the image, get *amassed at the four corners* of the DFT spectrum. Since DCT coefficients are real, we consider the absolute value of the DFT terms.

Discrete Cosine Transform (DCT) enunciates a finite sequence of multiple points of data in terms of a sum of cosine functions that oscillate at diversified frequencies. DCT is mathematically expressed as Eq. 3. The application of DCT to the absolute value of the DFT coefficients obtained previously results in the *accumulation of the low frequency components at the top left corner* of the DCT spectrum. The high frequency components that correspond to the minutiae are inconsequential in recognition and hence, are discarded.

$$F(u,v) = \alpha(u)\alpha(v) \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{\pi(2x+1)}{2M}\right] \cos\left[\frac{\pi(2y+1)}{2N}\right] \tag{3}$$

where

$$\alpha(u) = \begin{cases} \frac{1}{\sqrt{M}}, u = 0 \\ \sqrt{\frac{2}{M}}, u = 1,2,\ldots,M-1 \end{cases} \quad , \quad \alpha(v) = \begin{cases} \frac{1}{\sqrt{N}}, v = 0 \\ \sqrt{\frac{2}{N}}, v = 1,2,\ldots,N-1 \end{cases}$$

5 Proposed Shape of Feature Extraction

Any geometrical shape can be used to extract the top left corner features of the DCT spectrum. Conventionally, square extraction yields N^2 features where N is the number of pixels on each side of the square measured from the origin of the DCT spectrum. However, this has a relatively low recognition rate and extremely large number of features which leads to substantial computation time. As stated in Sect. 2, an alternative method involves the usage of circular sector and triangular shaped extraction, which consider $\pi N^2/4$ and $N^2/2$ features respectively. While recognition rate increases when compared to square extraction, it is found that the same can be significantly increased along with abatement in the number of features extracted by applying the proposed extraction techniques. This paper presents two novel techniques for the shape of the region of extraction, namely the astroid and astroid ring. The equation of the astroid is given by Eq. 4.

$$x^{\frac{2}{3}} + y^{\frac{2}{3}} = a^{\frac{2}{3}} \tag{4}$$

where ‘a’ is a constant.

5.1 Astroid Feature Extraction

An astroid is a hypocycloid with 4 cusps. We propose to extract the top left corner features of the DCT spectrum using one quadrant of the astroid. If N is the number of pixels measured from the origin and is equal to the constant ‘a’, then the number of features extracted, A, is given by Eq. 5.

$$\mathrm{A} = \frac{3}{32}\pi a^2 = \frac{3}{32}\pi N^2 \approx 0.29452N^2 \tag{5}$$

5.2 Astroid Ring Feature Extraction

Astroid ring feature extraction involves extracting the pixels enclosed in the non-overlapping regions between two concurrent astroids of different constants, say ‘a’ and ‘b’. If N_1 and N_2 are the number of pixels measured from the origin for each astroid and are equal to the constants ‘a’ and ‘b’ respectively such that b > a, then the number of features extracted, A, is given by Eq. 6.

$$\mathrm{A} = \frac{3}{32}\pi\left(b^2 - a^2\right) = \frac{3}{32}\pi\left({N_2}^2 - {N_1}^2\right) \approx 0.29452\left({N_2}^2 - {N_1}^2\right) \tag{6}$$

Table 1 presents a theoretical comparison between the maximum number of features extracted for different shapes, where N is the number of pixels measured from

Table 1 Comparison between different shapes for feature extraction

Shape of extraction	Square	Circular sector	Triangular	Astroid	Ring of astroid
Max. No. of features	N^2	$0.79N^2$	$0.5N^2$	$0.29N^2$	$0.29(N_2^2 - N_1^2)$

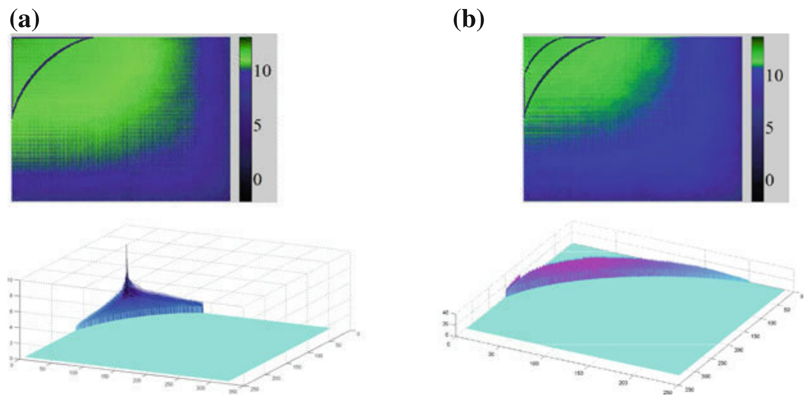

Fig. 3 DCT-DFT spectrum and surface plot of **a** Proposed astroid **b** Proposed astroid ring

the origin. From Fig. 3, it is observed that the proposed shapes of extraction provide the least number of features, providing satisfactory reduction in computation time.

6 Feature Selection Using Binary Particle Swarm Optimization

Introduced by Eberhart and Kennedy in the year 1995, Particle Swarm Optimization (PSO) is based on the behavioral pattern of birds, bees and fishes flocking to search for food. Velocity (represented as v_t^i) and position (represented as x_t^i) of the particles are the two variables under consideration and these are regularly updated until optimum convergence is achieved. Binary Particle Swarm Optimization (BPSO) maps the continuously varying position into binary bits. This process of mapping uses the binary sigmoidal function given by Eq. 7. With a swarm size of 35, inertial damping factor $\omega = 0.9$ is set. c_1 is the cognitive factor and c_2 is the social factor. From Ref. [5], c_1 is assigned the value of the golden ratio 1.618 and c_2 is assigned the inverse golden ratio 0.618. Velocity is updated as shown in Eq. 8.

$$f(x) = \frac{1}{1 + e^{-v_i^{t+1}}} \quad , \qquad x_{id} = \begin{cases} 1 & \text{if} \quad \text{rand}_3 < f(x) \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

$$v_i^{t+1} = \omega \times v_i^t + c_1 \times rand_1 \times \left(p_{best}^i - x_i^t\right) + c_2 \times rand_2 \times \left(g_{best} - x_i^t\right) \tag{8}$$

The Fitness Function characterizes the rate of misclassified patterns. Let $rand_1$, $rand_2$, $rand_3$, and v_i^t lie in the range (0,1). p_{best}^i and g_{best} indicate the previous best position visited and global best position visited by any particle, respectively. They are assigned on the basis of the highest value of the Fitness Function, represented by Eq. 9 where W_j and N_i symbolize the number of subjects, and the number of image samples for each subject. M_i and M_0 correspond to the means of the respective subjects and overall mean in the feature space. In Eq. 9, *E* denotes the Euclidean Classifier which calculates the N-dimensional distance vector, where N is the number of features extracted, q_i is the test image feature vector and p_i is the feature vector under consideration.

$$F = \sqrt{\sum_{i=1}^{L} \left(M_i - M_o\right)^t \left(M_i - M_o\right)} \quad , \qquad E = \sqrt{\sum_{i=1}^{N} \left(p_i - q_i\right)^2} \tag{9}$$

where,

$$M_i = \frac{1}{N_i} \sum_{j=1}^{L} W_j^{(i)} \quad , \qquad M_0 = \frac{1}{N} \sum_{i=1}^{L} N_i M_i$$

7 Discussion of Proposed IR System and Experimental Results

The experiments have been performed on 2 standard iris databases, Multi Media University (MMU) and Indian Institute of Technology—Delhi (IITD). Tabulated results for various values of N for both the proposed shapes of extraction are as indicated by Tables 2 and 3 for astroid and astroid ring respectively using (Ref. [11]). Any system having the ratio of training to testing images less than 1, is said to be intelligent and is more preferable. It was found that results with preprocessing were much better than those without. Both databases are in the Bitmap (BMP) format.

The MMU database (Ref. [12]) consists of 45 subjects with 5 images each and the images contain the iris as well as the eyelashes. The image size is 240 × 320.

Table 2 Recognition rate (RR) and number of features extracted for different values of constant ‘a’ of proposed astroid IR system

Constant a	No. of features	MMU RR (%)	IITD RR (%)
9	33	51.41	77.26
19	106	66.15	87.10
44	429	75.93	91.27
59	804	80.15	93.25
74	1130	82.00	93.55
99	2020	84.67	93.73
119	2961	85.19	93.88
139	3716	84.37	94.75

Table 3 Rate of recognition (RR) and number of features extracted for distinct values of constants ‘a’ and ‘b’ of proposed astroid ring IR system

Constant a	Constant b	No. of features	MMU RR (%)	IITD RR (%)
9	44	424	79.11	92.28
9	59	790	81.70	93.75
14	74	1107	81.93	92.98
14	84	1527	84.07	93.08
19	99	1974	82.22	93.31
19	119	2906	81.70	93.16

Fig. 4 Samples images of **a** MMU database **b** IITD database

Specimen images are as shown in Fig. 4a and Tables 2, 3 indicate the results for various value of constants for training to testing ratio of 2:3.

The IITD database (Ref. [13]) contains 224 subjects with 10 images each. The images contain the iris and the eyelashes. The image size is 240 × 320. Specimen images are as shown in Fig. 4b and Tables 2, 3 include the results obtained for training to testing ratio of 4:6.

As observed from Table 2, the number of features extracted increases along with increase in constant ‘a’. Best results were obtained for ‘a’ = 119 for MMU database and ‘a’ = 139 for IITD database.

Considering Table 3, the values of ‘a’ and ‘b’ must be chosen with utmost care to obtain good recognition rate. Best results were obtained for ‘a’ = 14, ‘b’ = 84 for MMU database and ‘a’ = 9, ‘b’ = 59 for IITD database.

With increase in the value of the constant(s), the performance of the system improves and eventually saturates for high values. However, near saturation, simply increasing the value of the constant(s) results in higher computation time and more number of features extracted with a negligibly marginal increase in recognition rate. Thus, it is a trade-off between computation time (number of features extracted) and rate of recognition.

Figure 5a compares the rate of recognition and number of features extracted for distinct shapes. The proposed IR System is found to produce optimum results in terms of both, the rate of recognition and the number of features extracted when compared to Ref. [2] and conventional shape of feature extraction. Figure 5b, c indicate the results for dissimilar training to testing ratios for MMU and IITD databases respectively. In both cases, the recognition rate saturates beyond a certain training to testing ratio and increase in recognition rate is minimal. It can also be observed that increasing the number of images used for training leads to increase in recognition rate.

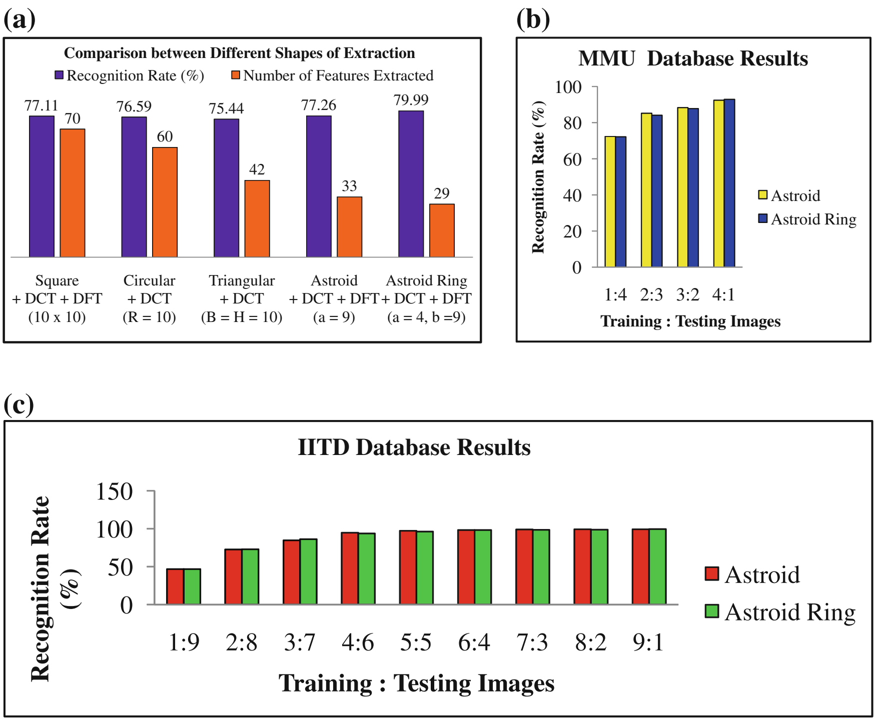

Fig. 5 Illustration of performance of the proposed IR system

8 Conclusions

A novel Iris Recognition System which incorporates a unique Combination of DFT-DCT, along with the application of a disc shaped morphological structuring element in the preprocessing stage, in addition to astroid and astroid ring shaped feature extraction has been proposed.

The application of this system in conjugation with Binary Particle Swarm Optimization (BPSO) based feature selection and the Euclidean Classifier was found to significantly decrease the number of features selected from the optimum feature subset along with a noteworthy increase in the recognition rate. The experimental results were found to be in accordance with the expected outcomes for two prominent iris databases, namely the MMU and IITD databases.

Integrating classifiers, such as the Support Vector Machine (SVM) and Random Forest, is expected to improve the existing results. This work is currently in progress and seems promising for creating improved IR systems in the future.

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Novel Digital Image Watermarking in SWT+SVD Domain

Nikhil Purohit, M. Chennakrishna and K. Manikantan

Abstract In this paper, Digital Watermarking is carried out in the frequency domain and the technique proposed uses single level Stationary Wavelet Transform (SWT) along with Singular Value Decomposition (SVD). SWT is used over other transformations because of its non-decimation and shift invariance property. The singular values of SWT transformed watermark image is embedded into the singularly decomposed HH sub-band (sub-image) of R, G or B channel of a Host color image. The experimental results of watermarked images shows increase in Peak Signal to Noise Ratio (PSNR) and the extracted watermark image is highly correlated with the original watermark for various types attacks.

Keywords Digital watermarking · Stationary wavelet transform · Singular value decomposition · Peak signal to noise ratio

1 Introduction

Digital watermarking is used extensively in this digital era wherein the sensitive information is merged with a carrier which acts like a camouflage and only the proper decoding algorithm is able to extract the information which is hidden inside the carrier. It is also used for various applications like authentication, copyright protection [1], information hiding [2], broadcast monitoring, content identification [3] and filtering i.e. for instance if a person is watching a movie scene, pop ups like promotions and advertisements are triggered by identifying the content being watched.

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Similarly, it is also used for content blocking by recognising a specific part of the content. Hence watermarking is widely used for security purposes. The information can be in the form an image, video or audio and corresponding to it the carrier is chosen [4–6]. The multimedia industry are still facing a lot of challenges and trying find algorithms that are more robust and the watermarks which cannot be removed or altered, thereby eliminating piracy. Watermark can be visible or invisible [7] depending on the application.

2 Problem Definition and Contribution

Watermarking in the frequency domain [8, 9] is preferred since it alters the coefficients obtained after using different transformations rather than pixels which is done in spatial domain [10]. Many techniques and combinations have been implemented using DWT, DFT and SVD based [11–14]. But the PSNR values obtained are very low even though the correlation between the original and the extracted watermark is better. To improve the PSNR values this paper proposes.

SWT+SVD domain watermarking using HH sub-band:
Combination of SWT and SVD technique is used to embed the information into the host image and the use of HH sub-band instead of LL, HL, LH sub-bands provides better PSNR values for R, G and B channels.

3 Fundamental Concepts

This section provides the basic ideas about the mathematical functions used in the proposed algorithm, they are described as follows

3.1 Stationary Wavelet Transform (SWT)

The single level two dimensional SWT [15] disintegrates the image into four sub-bands (sub-images) each having size same as that of the original image as shown in Fig. 1, i.e. LL, LH, HL, HH. It is also known as undecimated transform since there is no downsampling of the images. LL is the approximate image of input image it is low frequency sub-band. LH sub-band, HL sub-band and HH sub-band gives the horizontal, vertical and diagonal features of original image respectively. These sub-bands are used for integrating the watermark.

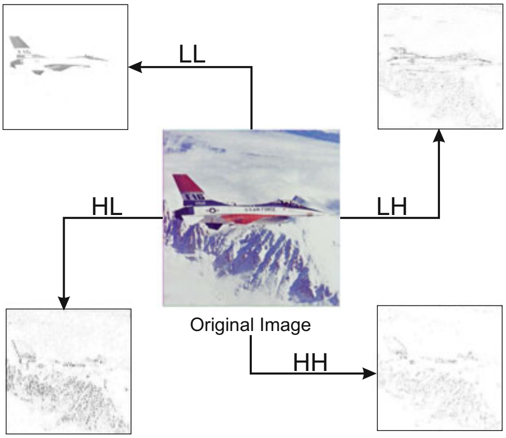

Fig. 1 Decomposition of the image into four components (LH, HL and HH sub-images are in negative form for better clarity) when SWT is applied

3.2 Singular Value Decomposition (SVD)

Singular value decomposition (SVD) [16] uses a rectangular matrix of an image ($m \times n$) where m is the number rows and n is the number of columns of the image. The mathematical equation for SVD is given below

$$A = U_{n\times n} \times S_{m\times n} \times V^{T}_{m\times m} \tag{1}$$

where U is the left singular vector, V is the right singular vector and S is diagonal matrix and it is singular. The U and V matrix are orthogonal to each other. The mathematical equation is given below

$$U \times U^{T} = I_{n\times n} \tag{2}$$

$$V \times V^{T} = I_{m\times m} \tag{3}$$

The S matrix is in descending order and it is always real. If A matrix is real, then U and V are also real. SVD can be calculated by finding eigenvector and eigenvalue of $A^{T}A$ and AA^{T}. The eigenvector $A^{T}A$ is given by columns of U and eigenvalue is given by columns of V.

4 Proposed SWT+SVD Domain Watermarking Using HH Sub-band

The combination of SWT+SVD along with their properties serve as a good alternative over other transforms. The host is separated into R, G and B channels and to one of the channels 2D-SWT (single level) is applied. The HH sub-band is chosen since it