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EFFECT OF VANISHING MOMENTS ON THE QUALITY ATTRIBUTES OF AN IMAGE IN DIGITAL WATERMARKING SYSTEM

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ABSTRACT: Good localisation in time and frequency, perfect compaction of energy are the key features in selecting the transform domain for the analysis of signal. Also, it is known that higher the sparse representation of transforms, better will be the efficiency. Wavelet transforms .used from basic physics for harmonic analysis of a pendulum to present day signal processing applications, has been characterised with the above attributes. The vanishing moments strongly affects the sparsity of the transform. Growth in the field of Internet of things, have made possible to exchange any digital data with malicious practises acted on them. Hence, providing authenticating methods are needed to the exchange data with no subtle changes in the content of data. Here, in this work, we measure the quality attributes of the image when digital watermarking is performed using discrete wavelet transforms up to certain vanishing moments.

Keywords: Localisation, Vanishing moments, watermarking, sparsity

I. INTRODUCTION

In general, Signal is the term used to describe the evolution of physical phenomena. These physical phenomena are mathematically formulated and mapped to real world applications. Typical signals include the sound generated from musical instruments, the voice signal, nothing but the speech received at microphone is air pressure converted to electrical form with the help of suitable transducer. When light intensity is mapped to gray scale levels on a photographic paper, termed as photography, image signal is obtained. The difference one could find between the image signal and the electrical signal is the image signals are mapped in space whereas electrical signals are mapped in time. The mapping of data in space started with plotting the data in the Cartesian plane, a trend towards calculus and now allowing us to process the data in vector spaces. Vector spaces allow us to view data in one's own perspective for his/her analysis via change of basis for the real world applications.

Revolutionary changes from analog to digital domain and evolutional changes in the digital world has made such an impact on today's communication technology that one can exchange any amount as well as any type of data with each other, so called, multimedia communication.In the era of Internet of Things,it is crucial to provide an electronic signature to the exchanged data between users for the purpose of copyright protection. The electronic signatures may be visible or invisible. When image data is considered, watermarking techniques are the powerful tools in authenticating the original data and in copyright protection of data since attacks are quite common on the data. The attacks can be on the geometric entities or on the variables defining the signal entities.

II. SELECTION OF TRANSFORM DOMAIN:

As stated by Yues Meyer, it is hardly an exaggeration to say that we will introduce almost as many analysis algorithms as there are signals.....Signals are so rich and complex that single analysis method cannot serve them all. Hence, an appropriate selection of a transform domain needs to be chosen according to the requirement of the application. Fourier transforms, Windowing techniques, Wavelet transform rule the transform domain of the signals. Speaking with regards to speed of the signal, we require a transform domain which has the perfect localization in time, space and frequency.Also, Localised processing is an important concern when image data are considered. Self similarity structures are also need to be revealed in image processing applications, hence for our digital watermarking techniques, wavelet transforms are employed .Linear phase is also seen which helps in easy reconstruction of the images.

Wavelet, in simple words, can be quoted as variable size windows i.e. long time intervals for more precise low frequency information and short intervals for the high frequency information. Strictly speaking, wavelet is a waveform of limited duration with the average value equal to zero. Wavelet's finds their applications in areas like coherent states, group theory, renormalisation group, calderson-zygmund operators, harmonic analysis and also in the field of medicine to time localise the electrical activity of the heart in ECG wires. It is not an exaggeration to say that the speech signal interpreted by the human brain is wavelet transformed signal from ear drum.

As with any transforms, wavelet transforms consists of analysis and synthesis equations. These equations are physically realized with the help of filters, up samplers and downsamplers.The transform coefficients are computed over running averages and differences via scalar products with scaling signals and the wavelets. The wavelet with which scaling is performed is termed as mother wavelet. In general, the two dimensional analysis equation is given by [8],

$$\mathbf{W_{\Phi}(j_0, m, n)=\frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\Phi_{j_0,m,n}(x,y)} \quad (1)$$

$$\mathbf{W_{\psi}^{i}(j, m, n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\phi_{j,m,n}^{i}(x,y)} \quad (2)$$

i=H, V, D

And

The synthesis equation is given by

$$\mathbf{f(x,y) = \frac{1}{\sqrt{MN}} \sum_m \sum_n W_\Phi(j_0, m, n)\, \Phi_{j_0,m,n}(x,y) + \frac{1}{\sqrt{MN}} \sum_{i=H,V,D} \sum_{j=j0}^{\infty} \sum_m \sum_n W_\psi^i(j,m,n)\, \phi_{j,m,n}^i(x,y)} \quad (3)$$

2D-wavelet analysis consists of one scaling function and three wavelet functions. Since we deal with image data, only a subset of scales and positions are considered .Thus, signal is decomposed into HL, HH, LL, LH sub bands. Here, HL corresponds to variation along x-axis, LH corresponds to variation along y axis and power compaction is seen more in the LL band. The decomposition of the signal can be indefinitely continued in an iterative manner. When separable property holds, 2D wavelets can be obtained as tensor products of one dimensional wavelets. Thus, wavelet analysis is breaking down of a signal into shifted and scaled version of original wavelet.

Various wavelet families have been defined since 1909.The first wavelet designed was the Haar wavelet. A lot amount of work has been done to construct orthogonal wavelets. Various design equations have been proposed for each family of wavelets. The general example one could quote would start with Haar, Daubechies, Symlets, Coiflets, Meyer, Shannon, Gaussian and so on. Apart from analysis and synthesis equations, other supporting design issues also need to be considered such as criterion about the function decay towards infinity, filter length and their mutual support. Thecriterion, generally defined for mother wavelet, which tells about the function decay towards infinity is termed as vanishing moments and is given by[6]

$$\mathbf{m(\mu) = \int_{-\infty}^{+\infty} t^{\mu}\, \Psi(t) dt} \quad (4)$$

It is believed that high order vanishing moments have higher filter length and thus giving higher smoothness. In our simulation, we use only daubechies and coiflets wavelets. Both are orthogonal as well as biothogonal too. Daubechies are far from symmetry whereas coiflets are near from symmetry.Daubechies has N vanishing moments for psi for order N with filter length 2N .Coiflets have 2N vanishing moments for psi and (2N-1) for phi for order N with filter length 6N.

III. ALGORITHM FOR WATERMARKING AND QUALTIY ATTRIBUTES OF IMAGE

The aim of the experiment is to insert invisible keysay an image to the original image so that once the original image is recovered at destination, there should be any subtle changes in the original data. At the very first step, the discrete wavelet transform is applied to image data and HH, HL, LH, LL coefficients are obtained. The key image is altered by multiplying the image by a constant. The DWT coefficients are manipulated by key image by some arithmetic operations thus introducing watermark into original image data. At the destination, with the help of same key, original image is extracted from the watermarked image by calculating Inverse DWT coefficients.

The similarity between any two images can be found either based on their intensity or on geometrical features of images. Peak signal to noise ratio(PSNR) and Pearson's correlation coefficient (PRC) are the necessary attributes that define the similarity between any two images based on their intensity.PSNR for any two images is given by[4]

$$\mathbf{PSNR = 20\log \frac{255}{MSE}} \quad (5)$$

Where MSE is termed as Mean Square Error between two images,

If F(i,j) and G(i,j) denotes two images then, the Pearson's correlation coefficient(PRC) between them is calculated as[4]

$$\mathbf{PRC = \frac{\sum_i \sum_j F(i,j) G(i,j)}{\sqrt{\sum_i \sum_j F(i,j)^2 \sum_i \sum_j G(i,j)^2}}} \quad (6)$$

IV.RESULTS AND DISCUSSIONS

The experiment is carried out completely in a digital domain. Intel Core i3-2.4GHz processor is used in a windows platform. Matlab version 7 with image processing tool box as well as wavelet toolbox was used to perform the digital watermarking and performance metrics were calculated with daubechev's and coiflets wavelet family up to five vanishing moments. .The results are tabulated from table 1 to 3.

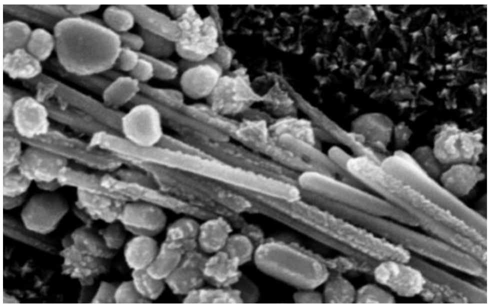

Fig 1.Original Image of size 1017x695

Fig 2. .key Image of size3985x1761

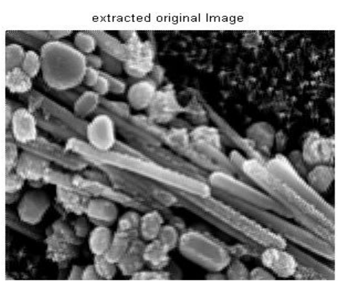

Fig 3.Extracted original image when daubechiev wavelet with vanishing moment two was applied

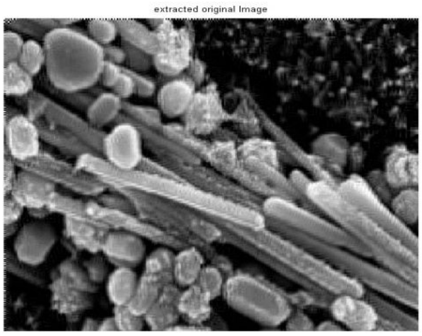

Fig 4.Extracted original image when coiflet wavelet with vanishing moment two was applied

TABLE I.COMPARSION METRIC BETWEEN THE ORIGINAL IMAGE AND THE EXTRACTED ORIGINAL IMAGE.

DAUBECHIES			COIFLETS		
ORDER OF VANISHING MOMENT	PSNR in dB	PEARSON’S COORELATION COEFFICIENT	ORDER OF VANISHING MOMENT	PSNR in dB	PEARSON’S COORELATION COOEFFICIENT
1	718.295	1.000	1	32.8974	.6983
2	40.2529	.8527	2	26.5683	.4450
3	33.3365	.7074	3	24.4962	.3363
4	30.1770	.5999	4	23.4139	.2775
5	28.375	.5217	5	22.6156	.2369

TABLE II .COMPARSION METRIC BETWEEN THE KEY IMAGE AND THE EXTRACTED KEY IMAGE

DAUBECHIES			COIFLETS		
ORDER OF VANISHING MOMENT	PSNR in dB	PEARSON;S COORELATION COEFFICIENT	ORDER OF VANISHING MOMENT	PSNR in dB	PEARSON’S COORELATION COOEFFICIENT
1	0.1533	1.0000	1	.0056	-0.0239
2	.0979	-0.206	2	-.1921	-0.0361
3	-.0052	-0.0213	3	-.3064	-0.0321
4	-0.0894	-0.0261	4	-.4189	-.0316
5	-.1640	-.0265	5	-.4189	-.0151

TABLE III. .COMPARISON METRIC BETWEEN THE ORIGINAL IMAGE AND THE WATERMARKED IMAGE

DAUBECHIES			COIFLETS		
ORDER OF VANISHING MOMENT	PSNR in dB	PEARSON;S COORELATION COEFFICIENT	ORDER OF VANISHING MOMENT	PSNR in dB	PEARSON’S COORELATION COOEFFICIENT
1	138.2884	1.0000	1	39.0629	-.0239
2	47.5809	-.0206	2	30.9379	-0.0361
3	39.3364	-.0213	3	27.8833	-0.0321
4	35.4306	-.0261	4	26.0235	-.0316
5	32.9496	-0.0265	5	24.9783	-0.0151

The watermarking was successfully done with various image formats. The same observations were made irrespective of the image formats. There is a gradual decrease in PSNR from original images to extracted images as well as watermarked images.The PSNR less than 30 dB is quite unacceptable. One can prefer daubechies wavelets over coiflets if he wants to work with higher order vanishing moments. The value of PRC is in the range of +1 to -1.Only positive values are observed in PRC between original & extracted image,thus,indexing positive correlation. InTable 2 & 3,we observe only negative values in PRC column thus indicating negativecorrelation. The perfect recovery of the key was observed only in the case of Haar wavelet. The high rate of decrease in PSNR was found in daubechies when compared to coiflets, thus daubechies are far away from symmetry. Also, the lesser the vanishing moment, one can observe a greater decrease in the elements of filter bank design. Thus, when perfect recovery of both key image and original image from watermarked image is needed, daubechies wavelet with order unity is preferred.

VI. REFERENCES

[1]. WaveletToolbox™4User’sGuideMichelMisiti,Yves Misiti, Georges Oppenheim, Jean-Michel Poggi

[2]. Literature Review of Wavelet Based Digital Image Watermarking Techniques International Journal of

Computer Applications (0975 – 8887) Volume 31– No.1, October 2011

[3]. DIGITAL IMAGE PROCESSING,THIRD EDITION, Rafael C. Gonzalez University of Tennessee Richard E. WoodsMedData Interactive 2008 by Pearson Education, Inc.Pearson Prentice Hall Pearson Education, Inc.Upper Saddle River, New Jersey 07458

[4]. Invisible Watermarking Based on Creation and Robust Insertion-Extraction of Image Adaptive Watermarks Sarah P. Mohanty, Bharat K. Bhargava ACM Journal Name, Vol. V, No. N, February 2008, Pages 1–24.

[5]. I.Daubechies, Ten Lectures on wavelets,Soc.Indus.Aplll.Math.,Philadelphia,PA,199 2

[6]. I.Daubechies,”Orthonormal bases of compactly supported wavelets”, Commun.Pure Appl.Math., vol41,

[7]. ”The world According to wavelets”, A.K.Peters, Wellesly, 1996

[8]. S.Mallat; A wavelet Tour of Signal processing, Academic Press, San Diego 1998

[9]. D.Stanhill and Y.Y Zeevi, “Two-dimensional orthogonal wavelets with vanishing moments”, IEEE trans.Signal Processing, vol, 44, no.10,

[10]. Mr. Manjunatha Prasad. R, Dr.Shivaprakash Koliwad “A Comprehensive Survey of Contemporary Researches in Watermarking for Copyright Protection of Digital Images”, International Journal of Computer Science and Network Security (IJCSNS), Vol.9 No.4, April 2009,pp.91-102.

[11]. Literature review of wavelet based Digital image watermarking techniques,Interntaional journal of computer applicationvolume 31-october 2011