Image Quality Estimation of Tree Based DWT Digital Watermarks

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Abstract—A new and novel semi-fragile-watermarking technique has been proposed in this paper. The watermark is embedded in the tree structure of the colored digital image. Three different watermarks are embedded in a single cover picture in order to enhance the security of the digital media. But these digital images incorporating watermarks may get tampered many a times while traveling from sender's end to the receiver's end. Hence, the paper also addresses the Image Quality Assessment (IQA) problem using the objective metrics of the watermarks. Here, a general Digital watermarking based quality evaluation framework is proposed which shows how three watermarks are embedded in a tree structure of an image using "*wavelet packet decomposition (wpdec)*". The proposed framework also evaluates the level degradation in original image. The added parameters wPSNR and MSSIM (compared with MSE and PSNR) in the proposed framework makes the quality evaluation procedure more flexible. The experimental results suggest that the proposed framework works effectively and efficiently.

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Keywords— Digital watermarking, wpackets, Quality evaluation, Tree-structure, IQA, MSE, PSNR, wPSNRand MSSIM

I. INTRODUCTION

With the advent of digital media and advances in digital technology, media is often created or recorded, stored and distributed in digital domain. But since these are digital, once available on the network it is difficult to protect them unless they have a copyright protection or secured by some technique. Thus, protecting content against unauthorized access is considered as a major task. Among such new challenges of multimedia computing many mechanisms were introduce to protect this media. One such discovery is Digital Watermarking. It is a well-known protection and identification technique in which a visible/invisible mark is hidden in the multimedia information such as audio, image, video, or text. It is developed to protect the digital signal which is information, **against illegal reproduction, modifications**.

Watermarks are broadly classified in two categories: visible or invisible watermarks. Major property of an unseen watermark must be that it must be inseparable from the host image and unbreakable i.e. strong enough to resist any manipulations while keeping up with the image quality. This way, properties of the image remains accessible.

Keeping the above criteria's in mind, algorithms related to watermarking are proposed. Two domains where most commonly watermarking is applied are- a) Spatial domain & b) Transform domain. Former one is a normal image space in which a change in the position of image (I) directly projects a change in the scene of the image. It can be presumed that this technique works directly on pixels and used where robustness is not necessary. And the later one is based on modifying the Fourier transform of the image. It first changes the original image into frequency domain using Fourier Transform (FT), Discreet Wavelet Transform (DWT), and Discreet Cosine Transform (DCT) etc. With this watermark is not embedded in the image but to the values of its transform coefficient then inverse transforming coefficients forms watermarks.

Image quality assessment of watermarked images is one of the supreme needs in today's internet era. The speed at which images are exchanged over internet, there seems to be a threat of security amongst the media owners. Images undergo many transformations right from the sender's end to the receiver's end. The quality of an image may get deteriorated in between a several times. To add a watermark, compression and various other steps takes place during which many a time the quality of image degrades. This can mainly be due to compression and/or when travelling through the channel which is already corrupted. In order to keep up with the original features or characteristics of the image its quality evaluation at the receiver end becomes necessary. Human eye is considered to be the best evaluator for quality estimation but it isn't feasible to make out all the flaws between the images i.e. the original and the distorted one. Such way of picking up the flaws is known as subjective metric and the other one in which algorithms and calculations are involved is known as objective metrics [2]. Usually, the later one is used in order to evaluate the quality of an image. Numerous quality metrics are proposed in the literature to evaluate image quality. The commonly used quality metrics for signals are the Mean Squared Error (MSE) and Peak-Signal-to-Noise Ratio (PSNR). Objective quality metrics can be classified depending upon the amount of information required to evaluate a given quality measurement. Depending on this, three criteria's for objective evaluation has been made and they are [3]:

- **Full reference** (FR) image quality: meaning that a complete reference image is assumed to be known.
- **Reduced reference** (RR) image quality: In a third type of method, only partial information is available in the form of a set of extracted features as side information to help evaluate the quality of the distorted image.

- **No reference** (NR) image quality: In many practical applications, however, the reference image is not available, and a no-reference or "blind" quality assessment approach is desirable.

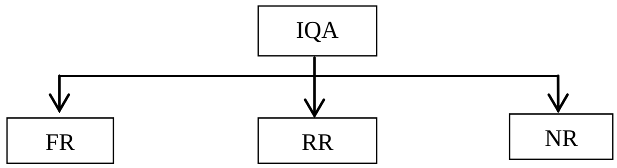

Figure1: IQA Classification

II. IMPLEMENTATION STRATEGIES

The previous work is based on the single image decomposition using wavelet tree. In the previous approach grey images are taken into account for watermarking. This will be possible only if one takes a single frame of the transmitted color image or if the color image can be converted into grey image. Here the watermarking is performed using one image and the quality estimation is performed using MSE and PSRN. Set Partitioning Hierarchical Tree Structure (SPIHT) is the algorithm used most commonly these days for the tree based wavelet decomposition. It basically is an image compression method which works on the concept of spatial orientation of tree where it defines the spatial relationship between the sub-bands in the form of pyramid formed from those four band split. A node of the tree corresponds to the pixel and identified by its pixel coordinate. Each node has four offspring.

Figure2: L-level DWT

An image in the form of signal is made to pass through the high-pass and low-pass filter. The output achieved is comprised of low-pass and high-pass sub-bands. The procedure is repeated to achieve one low-pass and three high-pass components. DWT may repeat this process for as many levels required.
To understand better let us consider an N*M image. Each row is filtered and down-sampled in order to obtain two N*(M/2) images. Then filter each column and subsample the filtered output to obtain four (N/2)*(M/2) images. All the resultant four images are named as LL, LH, HL, HH. LL is the one obtained by low pass filtering of row and column; LH is the one obtained by low pass filtering of row and high pass filtering of column; HL is the one obtained by high pass filtering of row and low pass filtering of column and in the same vain HH is obtained by high pass filtering of both row and column.
The successors of a pixel are four other pixels in the same space location of the same sub-band ant the next level. When they reach at the most finest level of the wavelet they are then said to be leaves and have no children. Pixels are of 2x2 block size. These are the independent resultant of hierarchical trees because each one of them comes from the same parent as they belong to same block. The pixel at the upper left of the block has no children.

III. PROPOSED ALGORITHM

In normal tree based wavelet decomposition, the generic step splits the approximation coefficients in two parts. The next step is again splitting of the new approximation coefficients; in this entire process the successive detailed coefficients are never re-analyzed. So, the *wpdec* has been chosen as a strategy for embedding watermarks. Basically, *wpdec* are a generalization of tree based wavelet decomposition (WD) which offers much richer signal analysis. The only difference between two is WD only keep splitting the approximation field every time whereas *wpdec*also splits detailed sub-bands as well. .

a). cover image b). watermark

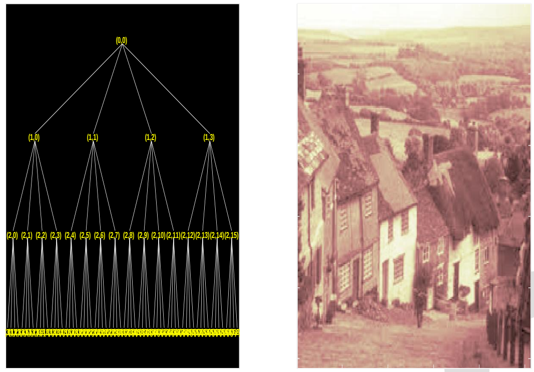

Figure 5: Wpdec

Figure6: Detailed components

Now the idea is to embed the watermarks in the diagonal detailed coefficients of the original image. This is because most of the information of any image is concentrated in their sharp edges that constitute the image. Looking at these edges one can realize that they are predominantly oriented horizontally and vertically. This explains why algorithm has chosen diagonal detailed coefficients for embedding as they have least information in them.

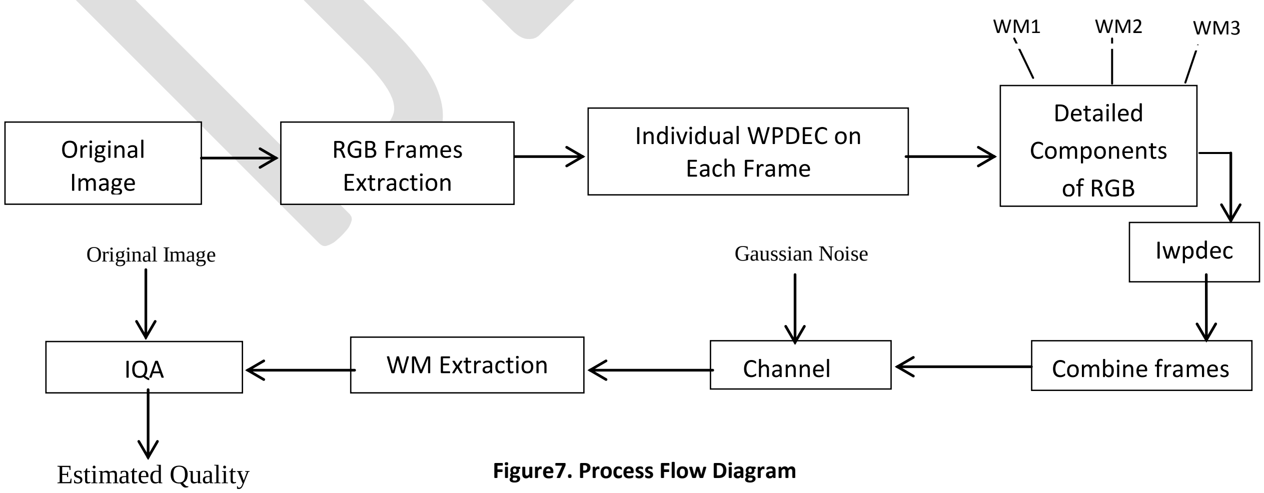

Figure7. Process Flow Diagram

First the cover image is loaded where the watermark is made to hide. Frame extractorextracts the RGB color features individually are extracted out of the image using the fame extractor and respectively are sent to the next phase. Wavelets energy is concentrated in time and is well suited for the study of the ephemeral, time varying signals. Thus, the wavelet decomposition is performed in order break down an image into its n-level wavelet decomposition coefficients. These coefficients are used to embed the watermark more firmly and perceptually in most significant parts of the original image using *wpdec* function. In the next phase, the watermark image is embedded in the detailed component of the cover image where the coefficients are left vacant by taking the mean value of the pixels. This process is performed for green and blue components also and in the same lane all the components are added together to form a watermarked image. This watermarked image is then transferred through a channel where Gaussian noise is added resulting in a distorted watermarked image. Watermark is extracted by applying the inverse process of decomposition using watermark extractor. Quality evaluator checks the amount of distortion present in the received image and this is evaluated by quality evaluator using different metrics. For IQA wPSNR and MSSIM has been chosen. They are the emerging IQA matrices as they explore a digital image more in terms of their structure and symmetry then pixel differences like traditional metrics MSE and PSNR. In the Estimated quality phase the evaluated quality is displayed.

IV. EXPERIMENTS & RESULTS

A. System Parameters for Simulation

S.No.	Parameters	
1.	Cover image	Baboon
2.	Size of Cover Image	256*256
3.	Watermark Images	Lena, Kid and Horse
4.	Size of Cover Image	32*32
5.	Method of Watermarking	Tree based DWT
6.	No. of Decompositions	3
7.	Noise Introduced	Gaussian Noise

B. Embedding Phase

NOISE LEVEL	IMAGES	MSE	PSNR	MSSIM	wPSNR
0.001	kid	138.136	26.7277	0.61893	84.0105
	Lena	64.0728	30.0641	0.775771	85.6561
	Horse	99.1728	28.1669	0.707571	83.8964

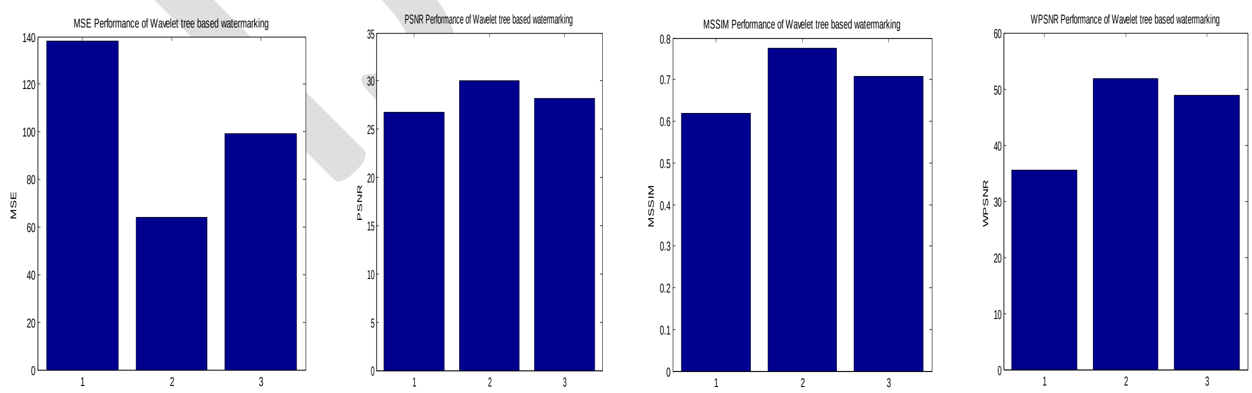

Figure 7: The experimental results tested on 3 images against Gaussian noise.

C. Extreaction Phase

NOISE LEVEL	IMAGES	MSE	PSNR	MSSIM	wPSNR
0.001	kid	91.4352	8.5197	0.851898	35.4686
	Lena	13.128	36.948	0.943895	51.803
	Horse	16.1828	36.0403	0.947405	4.781

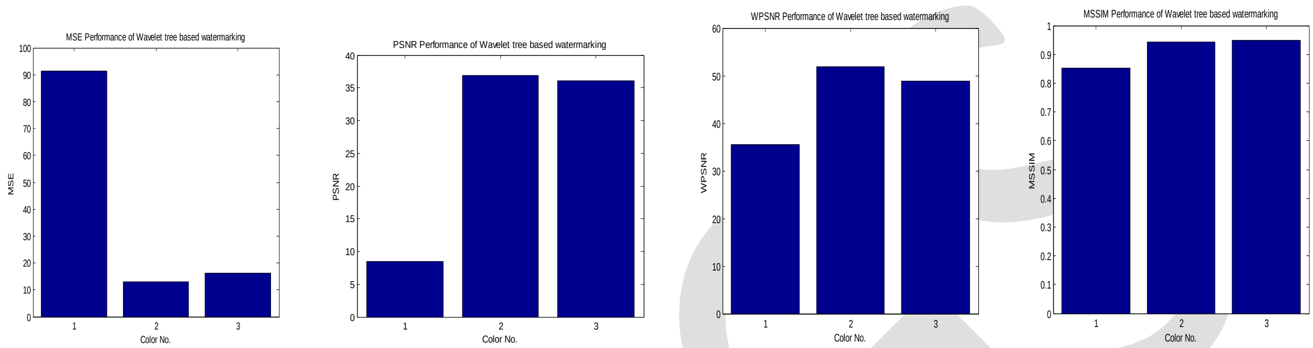

Figure 8: The experimental results tested on 3 images against Gaussian noise.

V. CONCLUSION & FUTURE WORK

The main aim of the research work is to design a framework for watermarks which is capable of assessing the degradation in the original and the watermarked image as well. After extensive research it was observed that the PSNR must range between 20db to 40db, MSSIM must result closer to 1db, MSE must be close to The estimated quality by wPSNR and MSSIM shows better results. With this approach user can find if the image at the receiver end is distorted or not. The proposed method promises to provide the more accurate search results then previously designed techniques.

In the future, emphasis will be made to incorporate more feature based information into the proposed approach. Secondly, efforts will be made to incorporate more objective based metrics like JND in the implementation. We believe the proposed scheme will perform well as expected.

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