Robust Lossless Data Hiding Using Clustering And Statistical Quantity Histogram

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***Abstract*—Alongside the quick advancement of multimedia innovation, digital picture is turning into an essential vector of system data communication. Be that as it may in the interim, the security and fidelity of the data are more also more not able to be ensured. Pictures frequently endure certain degree annihilation in the transmission process which impacts the right extraction of concealing data and in addition the picture verification. As a decent advanced media copyright insurance technique, data concealing engineering as of now has turned into an exploration hotspot. In medical, legal and some other delicate fields, although, somewhat adjust to carrier picture may cause hopeless harm. Thus, robust reversible watermarking(RRW) engineering appears to be more essential. Although, regular RRW systems have a few disadvantages like- unsuitable reversibility, restricted robustness, and invisibility for watermarked pictures. Along these lines, it is important to have a technique to address these issues. So we proposed a novel strategy utilizing integer wavelet transform(IWT), Histogram Shifting and clustering for watermark embedding and extraction.**

***Index Terms*– EPWM,Integer Wavelet Transform, PIPA,SQH, K-Means Clustering.**

I. INTRODUCTION

As of late the development of Internet and multimedia frameworks has made the need of the copyright insurance for different advanced medium (Ex: pictures, audio, video,etc.).To secure the computerized medium (Images) from unlawful access and unapproved transform Digital Image watermarking is utilized. It is a limb of data concealing, which conceals proprietorship data inside the spread picture as organization logos, proprietorship representations,etc. Watermarking can be comprehensively ordered into visible or invisible watermarking [1]. By and large invisible watermarking is utilized as a part of computerized multimedia communication frameworks.In visible watermarks, watermarks are by and large clearly visible after normal picture operations are connected. Visible watermarks pass on ownership data openly on the media and can focus challenges of copyright violation. The invisible watermarks expects to embed copyright data subtly into host media such that in instances of copyright violations, the concealed data can be recovered to distinguish the responsibility for secured host. It is vital for the watermarked picture to be impermeable to basic picture operations to guarantee that the concealed data is still retrievable after such adjustments. Embedding of watermarks, either visible or invisible, lower the quality of the host media in general. A gathering of procedures, named reversible watermarking, permit true blue clients to displace the embedded watermark and restore the first substance as required. The Robust Reversible Watermarking (RRW) procedures are utilized for watermark embedding and extraction without twisting for the lossless channel, additionally oppose unintentional assaults furthermore extract whatever number watermarks as could reasonably be probable for the noised channel.

Computerized watermarking can be performed in the spatial area or frequency space. Procedures in the spatial area alter pixel values in a spread picture with different algorithms. In spatial area,Chan C.K, et al. L.M. [2] proposed LSB substitution can be utilized to embed the unknown information in spread picture.In LSB method 1 bit of mystery message replaces the slightest noteworthy bit of spread picture pixel. LSB method is generally simple and has low computational difficulty. A winding based LSB approach for concealing message in pictures was proposed by Math kour Hassan et al. in [3]. They utilized LSB substitution method to insert the watermark and request of insertion of watermark focused around winding substitution algorithm.

In the frequency space methods, the spread picture is transformed into a frequency space by a transform, for example, Discrete Cosine Transform (DCT) also Integer Wavelet Transform (IWT). At that point, the transform coefficients of sub-groups with little sensibility to the human visual system (HVS) are adjusted to implant secret messages. As per study, the known lossless data hiding (LDH) algorithms can be characterized into two classes: histogram revolution (HR)-based plans and histogram distribution constrained(HDC) plans.

HR-based plans were proposed by De Vleeschouwer et al. in [4] that are considered as the begin of robust lossless information hiding. By utilizing a roundabout translation of bijective transforms, their plan can attain to reversibility and strong point against great JPEG layering. In [4] a host picture is initially separated into the non-covering squares. At that point, two zones, indicated as A and B, are picked arbitrarily from each one square and their histograms are mapped into a circle. Vectors indicating from the focal point of the circle to the focuses of the mass of zones A and B are pivoted clockwise and anticlockwise, individually. By controlling the bearing of the pivot, a bit of watermark, '0' or '1', is inserted into the host picture. In the information implanting process, one may experience the overflow and underflow issue. To avoid the overflow and underflow of pixels, the modulo-256 operation is used which prompts "salt-and-pepper"noise in the watermarked pictures.

Expecting to cure this issue Zou [5], Ni [6], [7] considered the HDC embedding plans in the spatial and wavelet transform area, separately. HDC plans embed the watermark by adjusting the factual qualities of the spread picture as indicated by the histogram distribution of the picture squares. Ni et al. calculate the arithmetic average difference of each one square; a bit 1 is embedded by moving the arithmetic average difference value away from 0 by a shift amount. If a bit 0 is to be inserted, this square stays unaltered. Zou et al. compute the integer wavelet transform of spread picture. After calculating the mean value of the HL1 or LH1square coefficients, a bit 1 is embedded by moving the mean esteem far from 0 by a movement amount. If a bit 0 is to be implanted, this square stays unaltered. To handle the overflow and underflow, some watermark bits are changed from '1'to '0'.

This considered blunders is revised by the error correction coding (ECC) in the watermark extraction. In light of this, the limit of HDC plans is diminished significantly. Hui-Yu Huang [8] exhibited a lossless information concealing methodology based on quantized coefficients of discrete wavelet transform (DWT) in the frequency area to implant secret message. They utilize the quantized coefficients for 9/7 wavelet channel in DWT and implant secret information into the progressive zero coefficients of the medium high frequency segments. In, [9], Zhao et al. proposed a system in 2011 that misused the procedure of the multilevel histogram transform to produce a integer number pointer called "embedding level" (EL) for showing the implanting container. Initially, the privilege containers of the pointer were moved EL + 1 levels to the right, and the left containers of the pointer were moved EL levels to the left to make the implanting space that utilized the various levelled idea to embed secret information level by level. Consequently, a bigger EL showed that more secret information could be implanted.

In the above histogram-moving system, paying little respect to high part of the way limit, this algorithm causes genuine obliteration in the picture quality. So to give a RRW structure with Reversibility, Robustness, and Invisibility is needed.

In this paper, we improve a novel RRW framework in the wavelet domain. This structure uses the statistical quantity histogram (SQH) as the inserting carrier inspired by our preceding work, the generalized SQH(GSQH) driven technique, and creates new watermark embedding and extraction procedures by histogram shifting and clustering. In this structure, we carefully design the three key components, which are the property inspired pixel adjustment (PIPA), the SQH shifting and clustering, and the enhanced pixel-wise masking (EPWM), to successfully resolve the above-mentioned three difficulties.

II. PROPOSED FRAMEWORK

The proposed work has two steps: watermark Embedding and watermark Extraction.Fig.1. Shows steps for watermark embedding.

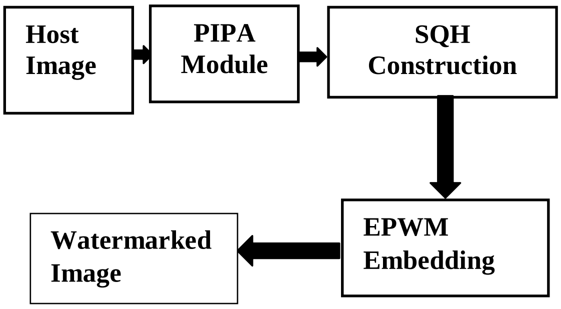

Fig.1. Watermark embedding.

2.1 Watermark Embedding :

To embed watermark, steps indicated in Fig.1 should be done. They are PIPA**(**Property Inspired Pixel Adjustment),SQH(statistical quantity of histogram),EPWM(Enhanced Pixel-Wise Masking.

2.1.1PIPA(Property Inspired Pixel Adjustment):

One of the issue in reversible watermarking is to stay away from overflow and underflow of pixels. At times, the pixel values in a square are near to the endings of histogram, for example, 0 or 255 in the 8-bit case. The transform of the pixel values may prompt overflow and underflow issue, which implies the transformed pixel qualities are past the extent of [0,255]. So pre-processing on the first picture should be completed. Pixel qualities ought to be balanced.

Given a t-bit host picture I with the extent of 2M ×2N, the pixel modification is performed utilizing,

$$I'(i,j)=\begin{cases} I(i,j)-\eta, \text{if } I(i,j) > 2^t-1-\eta \\ I(i,j)+\eta, \text{if } I(i,j) < \eta \end{cases} \quad (1)$$

Where

$\eta > \lambda$ is the modification scale.

I(i, j) is the grayscale estimation of the pixel at (i, j) in the picture I.

I'(i, j) is the balanced one ($1 \le i \le 2M$, $1 \le j \le 2N$)

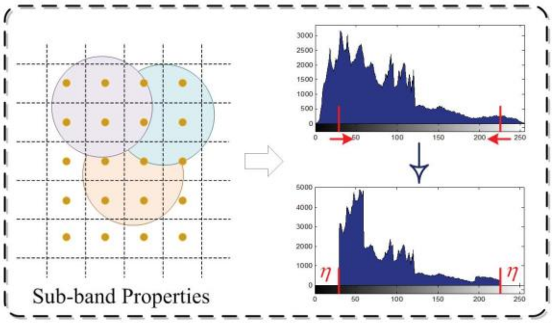

Fig.2.process of PIPA

The Fig.2 shows the process of PIPA.To make a plan non-oblivious in regards to some degree the areas of the transformed pixels need to be saved as a some part of side data and transmitted to the recipient side so as to recoup the first grayscale estimations of pixels. Area map with the same size as host picture is utilized to stamp the changed pixels position as,

$$\text{Location map}=\begin{cases} 1; \quad \text{changed pixel} \\ 0; \text{unchanged pixel} \end{cases} \quad (2)$$

2.1.2 IWT and SQH Construction:

IWT (Integer to Integer Wavelet Transform) is utilized,the whole number wavelet transform maps integers to integers, and considers invertibility with limited accuracy math. Cohen et al. [12] proposed a novel procedure named lifting plan to build quick and compact transform steps for wavelet transform. From that point on, lifting plan has been gotten more consideration as it can offer not just quick transform, however "you can build your manager wavelet in home". Hypothetically, lifting plan is outlined focused around network variable based math hypothesis what's more stage filter bank theory, for example, great remade filter bank theory. Lifting plan incorporates three steps

1. Splitting
2. Prediction
3. Update

It has turned out that each wavelet can be deteriorated into lifting steps. The quantity of lifting steps is limited by the length of the first channels.

In [10] GSQH(generalized statistical quantity histogram) driven system utilized SQH(statistical quantity histogram)has its advantages and disadvantages. On one hand, it consolidates GSQH furthermore histogram moving together to get great execution.Then again, on the other hand, it has three weaknesses: 1) it utilizes the AADs of the greater part of the squares, both reliable and unreliable, to produce the SQH of the host picture, which rises difficulty of watermark embedding; 2) it neglects to consider the streamlining of watermark quality also 3) it endures from flimsy robustness against JPEG layering.

So here we are joining PIPA, SQH shifting, clustering, and EPWM into a novel RRW structure, which successfully beats the above shortfalls and makes work usually not the same as existing RRW systems. SQH (statistical quantity histogram) with threshold constraint is utilized to embed the watermark. The watermark inserting is carried out by moving the histogram in both the directions, which gives supreme strength likewise makes watermark inserting and extraction process humble. In this technique MWC (mean of wavelet coefficients) histogram is created. We concentrate on the mean of wavelet coefficients (MWC) histogram by taking the next two properties into record: 1) it is outlined in high-pass sub-groups of wavelet deterioration, to which HVS is less touchy, prompting to high invisibility of watermarked pictures and 2) it has just about a zero-mean and Laplacian-like circulation

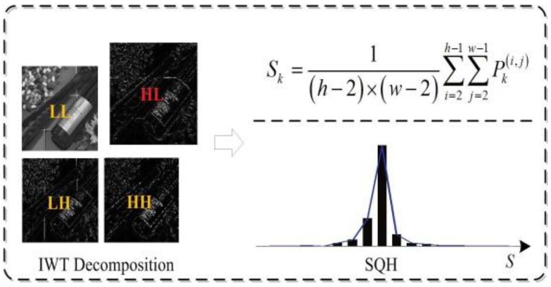

Fig.3.Process of SQH Construction

Let S = [S_1. . . S_k, . . . , S_n] be the MWCs in the subband,at that point the MWC of the k^{th}square, S_k, is characterized as,

$$S_k = \frac{1}{(h-2)\times(w-2)} \sum_{i=2}^{h-1}\sum_{j=2}^{w-1} P_k(i,j) \quad (3)$$

Where, P_k (i, j) - speaks to the wavelet coefficient at (i, j) in the k^{th}square, and $h \times w$-size of squares of HL sub-band of 5/3 IWT picture.

To develop the MWC histogram, our concern is the likelihood of using the squares of enthusiasm for a subband, which will be useful for improving the inserting procedure. In perspective of the histogram dispersion of MWC shown in Fig.3, just the top and its neighbours in the histogram are basically helpful for the embedding assignment. Along these lines, threshold constraint is connected to the squares to hold those of investment, each of which fulfils the accompanying condition,

$$d(x, S_k) \le \delta,\ 1 \le k \le n \quad (4)$$

where d (•) figures the Euclidean distance of two components, $x \in \{x_l, x_r\}$ speaks to the previously stated two crest focuses, and δ is a predefined steady for threshold control. At the point when $\delta \geq \max\{d(x_l, \min(S)), d(x_r, \max(S))\}$, the majority of the squares will be held for implanting, which is an extraordinary instance of this requirement. Moreover, with the help of the threshold constraint,the ability can be organised flexibly.

2.1.3 Enhanced Pixel-Wise Masking (EPWM):

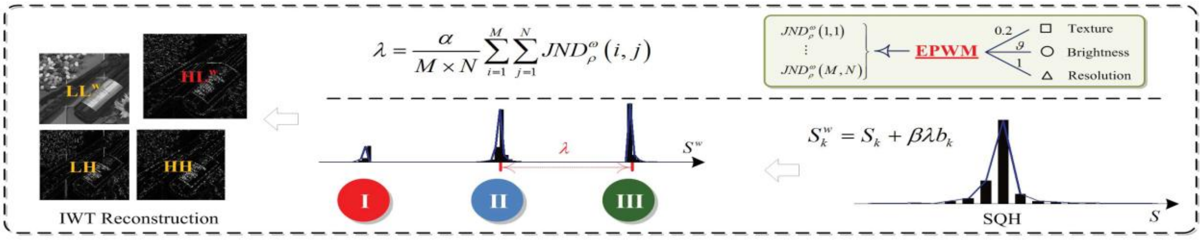

Fig.4.Process of EPWM embedding

The previous years have seen the witnessed of HVS(human visual system) in different applications [13], [14] what's more numerous visual veiling algorithms uncovering the perceptual qualities of HVS have been connected to computerized watermarking [15]–[17]. Specifically, a PWM algorithm proposed by Barni et al. [18] has gotten much reputation, which processes the JND edge of every wavelet coefficient focused around resolution sensitivity, brightness sensitivity, and texture sensitivities, respectively, Be that as it may, it is not exact enough since the low-pass sub-band at the forth resolution level, has less picture content, which winds up with the surmised estimation of texture and brightness.

To tackle this issue, we plan the EPWM to better delineate nearby affectability of HVS, which not just enhances texture and brightness sensitivities yet likewise advances the affectability weight. To adequately equalization robustness and invisibility, the nearby affectability of human visual system (HVS) in wavelet area is considered in the configuration of an EPWM. Lingling An et.al. [19]. It assesses the just noticeable distortion (JND) limits as far as composition, brightness,texture and resolution of wavelet coefficients, which from that point are utilized to streamline watermark quality (λ). JND limit can be gotten by,

$$JND_\rho^\omega(i,j) = \Theta(\omega)\psi(\rho,i,j)^\vartheta \pi(\rho,i,j)^{0.2} \quad (5)$$

Where Θ(ω)-Resolution sensitivity can be defined by,

$$\Theta(\omega) = \begin{cases} \sqrt{2}, & \text{if } \omega = HH \\ 1, & \text{otherwise} \end{cases} \quad (6)$$

Ψ(ρ,i,j)-Brightness can be characterized by utilizing [17],

$$\psi(\rho,i,j) = \max\left\{f_v^\rho\left(l_b^\rho(i,j)\right), f_s^\rho\left(l_b^\rho(i,j), l_m^\rho(i,j)\right)\right\} \quad (7)$$

Here

$$f_v^\rho\left(l_b^\rho(.)\right) = \begin{cases} \left(\frac{3}{128}\right).\left(l_b^\rho(.) - 127\right) + 3, & l_b^\rho(.) > 127 \\ 17.\left(1 - \sqrt{\frac{l_b^\rho(.)}{127}}\right) + 3, & l_b^\rho(.) \leq 127 \end{cases} \quad (8)$$

And

$$f_s^\rho\left(l_b^\rho(.), l_m^\rho(.)\right) = l_m^\rho(.)d_1\left(l_b^\rho(.)\right) + d_2\left(l_b^\rho(.)\right) \quad -(9)$$

$\pi(\rho,i,j)^{0.2}$-Texture can be characterized by utilizing [18],

$$\pi(\rho,i,j) = \sum_{k=0}^{3-\rho} \frac{1}{16^k} \sum_{\omega\in\{LH,HL,HH\}} \sum_{x=0}^{1} \sum_{y=0}^{1} \left[C_{k+\rho}^\omega\left(y + \frac{i}{2^k}, x + \frac{j}{2^k}\right)\right]^2 \times \frac{1}{\gamma_\rho{}^3} \gamma_\rho^3(i,j) \quad (10)$$

Where γ_ρ^{-3}, is mean of the estimate sub-pictureγ_ρ^3.

we use the achieved JND thresholds to regulate watermark strength during the embedding procedure. To be specific, given the MWC of the k^{th}square of interest, i.e.,S_k, $1 \leq k \leq m$, the watermark embedding is given by

$$S_k^W = S_k + \beta\lambda b_k \quad (11)$$

Here $S_K^W$is the acquired MWC after the k^{th} watermark bit $b_k \in \{0, 1\}$ is embedded, β is a factor defined as

$$\beta = (S_k - S^*)/abs(S_k - S^*) \quad (12)$$

$$S^* = \underset{x\in\{x_l,x_r\}}{argmin}\, d(S_k, x) \quad (13)$$

and

$$\lambda = \frac{\alpha}{M\times N}\sum_{i=1}^{M}\sum_{j=1}^{N} JND_\rho^\omega(i,j) \quad (14)$$

represents the watermark strength, where α is a global factor and $M \times N$ is the subband size. Because the novel embedding model shown in (11) expands the additive spread spectrum to a reversible embedding model, we term it a generalized additive spread spectrum. By applying (11) to the squares of interest in the subband, watermarks can be embedded into the wavelet coefficients shown in Fig.4. Thereafter, the IWT reconstruction is performed to obtain the watermarked picture.

2.2.Algorithm for watermark Embedding

By utilizing above modules watermark can be inserted or extracted utilizing following methodology,

Watermark Embedding Algorithm

Input:A t-bit host picture I with the size of 2M×2N, a watermark sequence b = [b_1, . . . , b_m], and square size h × w.

Output: The watermarked picture I^w.

1.Apply Pixel Adjustment(PIPA) Strategy to host picture I to get the balanced picture I', and record the areas of the pixels changed by this handling and build area map.

2. Decompose I' utilizing 5/3 IWT and separation the subband c_0^{HL} into n nonoverlapping squares with the size of h×w;

3. Process the MWCs of the all part of the squares with(3) and acquire S = [s_1, . . . , S_k , . . . , S_n];

4. Hold squares of enthusiasm with the threshold constraint (4) and build SQH;

5. Perform EPWM to process the watermark quality

$$\lambda = \frac{\alpha}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} JND_{\rho}^{\omega}\,(i,j)$$

6. For k = 1 to m do

7. Implant the k^{th} watermark bit b_k with $S_k^w = S_k + \beta\lambda b_k$;

8. End for

9. Remake the watermarked picture I^w with reverse 5/3 IWT.

2.3 Watermark Extraction:

If watermarked pictures are transmitted through a perfect channel, we can specifically embrace the reverse operation to recuperate host pictures and watermarks. If watermarked pictures are transmitted through channel, debasement may be forced on watermarked pictures because of unintentional assaults, e.g. lossy compressing and arbitrary noise. Accordingly, it is key to discover a powerful watermark extraction algorithm with the goal that it can oppose unintentional assaults in the lossy environment. To concentrate the implanted watermarks, the key issue is to segment these parts rapidly. In the lossy environment, this is extremely troublesome in light of the fact that the histogram dispersion of MWC is devastated by unintentional assaults. By exploring the impacts of unintentional assaults on histogram, we treat the parcel as a grouping issue with a specific number of clusters what's more embrace the k-means clustering algorithm [21],[22]to handle this issue for simplicity.The following Fig.5 shows an example of MWC histogram in the watermark embedding.

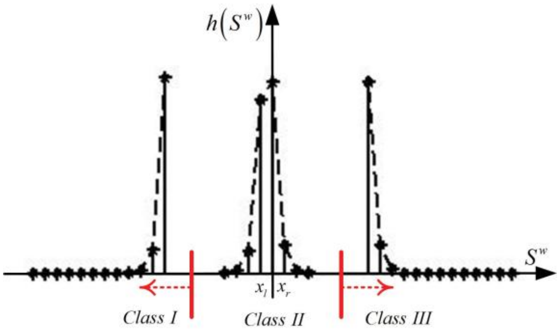

Fig.5.Example of MWC histogram

2.3.1 Classification Process For Watermark Extraction:

Input to order procedure are MWCs; and the number of clusters μ, and output will be the set of clusters
g = {g_1, . . . , g_μ}.

1. Initialize the bunch focuses$f_1^{(1)}, \ldots\ldots\ldots . f_\mu^{(1)}$, and cycle time ε;

2. Do

3. For k = 1 to m do

4. Relegate the k^{th} $S_k^w$to one of the clusters as indicated by the separation in the middle of it and cluster focuses;

$S_k^w \epsilon g_j, if\ d(S_k^w, f_j^{(\varepsilon)}) \leq d(S_k^w, f_l^{(\varepsilon)})$ for all l = 1, 2, . . . μ;

5. End for

6. Upgrade the bunch focuses with$f_j^{(\varepsilon+1)} = \left(\frac{1}{|g_j^{(\varepsilon)}|}\right) . \sum_{S_k^w \epsilon g_j^{(\varepsilon)}} S_k^w$

7. While $\underset{g}{arg\,min} \sum_{S_k^w \epsilon g_j} \parallel S_k^w - f_j^{(\varepsilon+1)} \parallel^2$

2.4 Watermark Extraction Algorithm

Input: watermarked picture I^w with the size of 2M ×2N, square size h × w, watermark quality λ and the area map.

Output: The recuperated watermark arrangement $b^r$and picture I^r.

1. Decompose I^w utilizing 5/3 IWT and split the sub-band C_0^{HL}into n non-covering squares with the extent of h×w;

2. Calculate MWCs of squares of enthusiasm with and get $S^w = [S_1^w, \ldots\ldots S_k^w \ldots\ldots . S_m^w]$;

3. Order S^w with k-means clustering;

4. For k = 1 to m do

5. Extract the embedded watermarks

$$b_k^r = \begin{cases} 0, & \text{if } S_k^w \epsilon \text{ Class II} \\ 1, & \text{if } S_k^w \epsilon \text{ Class I or Class III} \end{cases}$$

for μ = 3

6. Recuperate the MWCs with $S_k^r = S_k^w - \beta\lambda b_k^r$;

7. End for

8. Perform reverse IWT emulated by PIPA to get the recouped picture I^r .

9. Give back where its due watermarks b^r and picture I^r.

III. EXPERIMENTAL RESULTS

These algorithms are tried on three sorts of pictures, natural, medical and SAR pictures. As we see in, Fig.6and Fig.8.original picture and watermarked picture are same, so it satisfy the invisibility property.Fig.7.shows the IWT 5/3 Decomposed image in the embedding procedure Likewise we tried proposed system under distinctive assaults, for example, jpeg compression, pivot and salt and pepper noise, and is demonstrated strong against unintentional assaults. Watermarked picture quality is tried by utilizing MSE(mean square error) and PSNR(peak signal to noise ratio),as indicated in Fig.9 and Fig.10.If we increase threshold value, more squares will be chosen and PSNR will decay and MSE will increment. Fig.11 and Fig.12shows impact of square size on yield picture quality.

Fig.6.Original picture

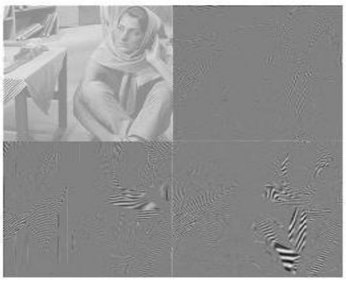

Fig.7.IWT 5/3 Decomposed image

Fig.8. Watermarked picture

The following graphs Fig.9 and Fig.10 shows the relation between the MSE,PSNR with the threshold constraint for natural,medical,and SAR pictures.If the threshold value is low the PSNR value is high and the MSE value is low.

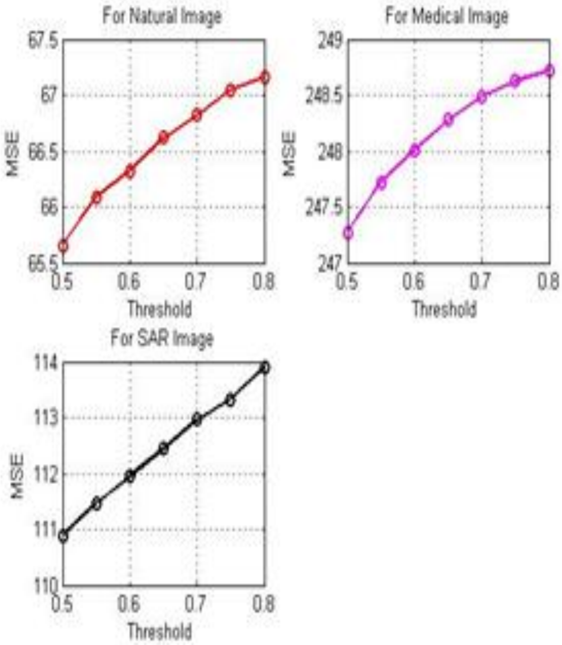

Fig.9. Impact of Threshold values on MSEs of distinctive sort of pictures.

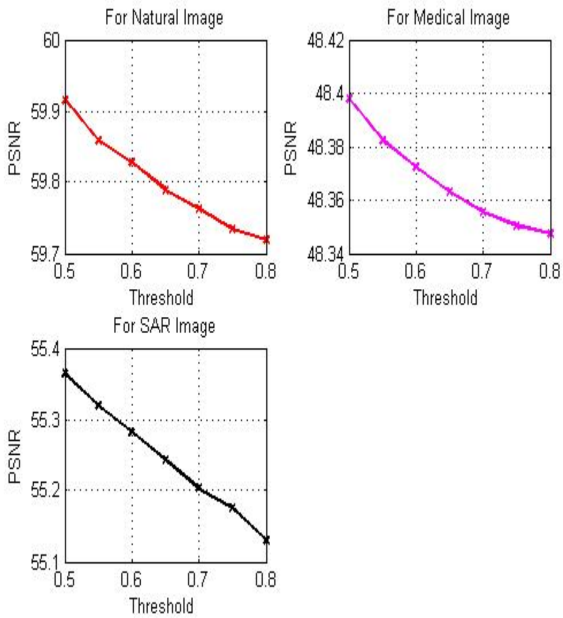

Fig.10. Impact of limit Threshold on PSNR of distinctive sort of pictures.

In Fig.11 and Fig.12 shows the relation between the MSE,PSNR with the block size.If the block size is less the PSNR value is high and the MSE value is low.

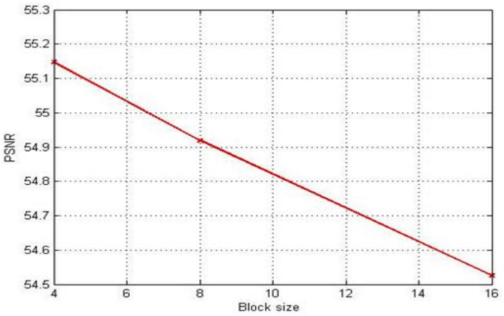

Fig.11. Impact of Block size on PSNR.

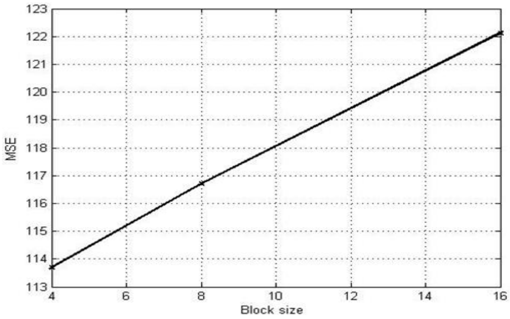

Fig.12. Impact of Block size on MSE.

The experimental results are presented in the following TABLE I,TABLE II,TABLE III ,which shows that the comparison of PSNR,MSE,Run-time complexity of HR(histogram rotation) and WSQH methods.The proposed WSQH(wavelet statistical quantity histogram) can perform well for natural,medical,and SAR pictures with good robustness and invisibility.

TABLE I

Comparison of PSNRs for different kind of images

TYPE OF IMAGE	HR METHOD	WSQH(Proposed Method)
NATURAL	54.3525	60.4233
MEDICAL	56.8385	63.3374
SAR	51.5482	55.2402

TABLE II

Comparison of MSEs for different kind of images

TYPE OF IMAGE	HR METHOD	WSQH(Proposed Method)
NATURAL	0.6990	0.2429
MEDICAL	0.5183	0.1736
SAR	0.6747	0.4411

TABLE III

Comparison of Run-Time Complexity for different kind of images

TYPE OF IMAGE	HR METHOD	WSQH(Proposed Method)
NATURAL	1.600438	0.572189
MEDICAL	1.551505	0.468074
SAR	1.577575	0.960862

IV. CONCLUSION

In proposed plan Integer Wavelet Transform (IWT) is utilized so it can reproduce the unique picture without any distortion. PIPA pre-processes host images by adjusting the pixels into a reliable range for satisfactory reversibility.SQH shifting and clustering constructs new watermark embedding and extraction processes for good robustness and low run-time complexity.EPWM gives invisibility and robustness for the robust and lossless watermark embedding. Consequently this technique gives upgraded execution regarding reversibility, robustness, invisibility, limit and run-time complexity. It is promptly appropriate to various types of pictures. In future, we will include security to the watermark by scrambling it.we will combine the proposed framework with the local feature to further improve robustness.In addition, it is valuable to integrate the merits of sparse representation and probabilistic graphical model into the designing of image watermarking.

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