An Empirical Evaluation Of Video Quality Using Watermark

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Video applications are much common as a result of their repeat on web nowadays. The watermarking can be used to evaluate the video quality by estimating the watermark degradation. The image watermarking system for the video quality estimation is built up on 3-level discrete wavelet change (DWT). Here additionally propose a quad tree decomposition of video for watermarking embedding algorithm to keep the balance between gradual changes in watermarks and its ability to adjust up with errors. The watermark is embedded into the tree structure of a video with fitting embedding quality picked by quantifiably analyzing the attributes of the image. The correlated DWT coefficients over the DWT subbands are characterized into Set Partitioning in Hierarchical Trees (SPIHT). Those SPHIT trees are again decomposed into an arrangement of bitplanes. The insertion and extraction of the watermark in the cover video is found to be less troublesome than other techniques. The True Detection Rates (TDR) focuses the video quality by looking at original watermark and extracted watermark. The precision of the quality estimation is made to approach that of Full-Reference estimations by referring True Detection Rate. In this way proposed arrangement has incredible computational viability for pragmatic applications.

***Keywords*: —Quad tree decomposition, DWT based watermark embedding, HVS masking, SPIHT tree structure, Watermarking based image quality estimation.**

A digital watermark is a kind of marker secretly embedded in a noise-tolerant signal such as an audio, video or image data. It is frequently used to identify ownership of the copyright of such signal. Here we are using the embedded watermark to estimate the quality of the video. Rising popularity of video based applications such as Internet multimedia, wireless video, videophone, personal video recorders, video-on-demand, set-top box and videoconferencing have a demand for much higher compression to meet the best video quality as possible. Watermark embedding represents the method of inserting information into multimedia data also called original media or cover media for example text, audio, image, video. The embedded information or watermark can be a random number sequence, serial number, ownership identifiers, copyright messages, transaction dates, information about the creators of the work, gray level images, text or other digital data formats. Here the watermark is embedded into the video. Both the embedded watermark and the video will undergo the same distortion. The video quality can be estimated by evaluating the watermark degradation. Watermark degradation is measured using the True Detection Value. The watermarking based quality estimated by referring the quality metric. The accuracy evaluates the correlation of the estimated quality and the quality calculated using the existing objective Full-Reference quality metrics, such as PSNR. Full Reference (FR) metrics evaluate the quality difference by comparing the original video signal against the received video signal.

In this scheme, to assess the video quality compare the embedded watermarked video with the original video. The quad tree decomposition method supports to identify strength of the video for the watermark embedding process. Then the HVS masking are used to control the watermark embedding process and this scheme is based on the tree structure in the DWT domain. The Set Partitioning in Hierarchical Trees (SPIHT) has become one of the most popular image and video coding method. Its efficiency which is accomplished by exploiting the inherent similarities across the sub bands in the wavelet decomposed image. The DWT and SPIHT together provide a good summarization of local region characteristics of an image which is important for watermark embedding. Here all the correlated DWT coefficients across the sub bands are grouped together using the SPIHT tree structure. The scheme is tested in terms of PSNR and also the quality can be estimated using “Ideal Map”.

The rest of the paper is organized as follows. Section II specifies the literature review. Section III and Section IV present the proposed watermark embedding scheme in detail. Section V describes the watermark extraction and quality evaluation scheme. Section VI explains generation of Ideal Map. Experiment result describes in Section VII. Section VIII concludes the paper and discusses future work.

II LITERATURE REVIEW

In [11], introduce a practical quality-aware image encoding, decoding and quality analysis system. Here use a reduced-reference image quality assessment algorithm based on a statistical model of natural images and a previously developed quantization watermarking-based data hiding technique in the wavelet transform domain. An effective way for digital watermarking, copyright protection, a process which embeds (hides) a watermark signal in the host signal to be protected is suggest in [2]. A new method introduce for assessing perceptual image quality. Here proposed SSIM indexing approach, which are analyses on structural similarity of the images. It depends on the image formation point of view and also for quality estimation scheme in [7]. Here [8], explains challenges in the video watermarking. LSB replacement does not provide robustness therefore it is not applicable for digital watermarking. Using different techniques it is easy to extract LSB embedded watermarks. The DCT domain watermarking, is extremely challenging to JPEG compression and random noise. In case of wavelet domains, this is highly resistant to both compression and noise. There will be minimal amounts of visual degradation. Also suggest HVS masks are tremendously preferred to analyze video sequences of frames to embed watermark.

III THE PROPOSED WATERMARK SYSTEM

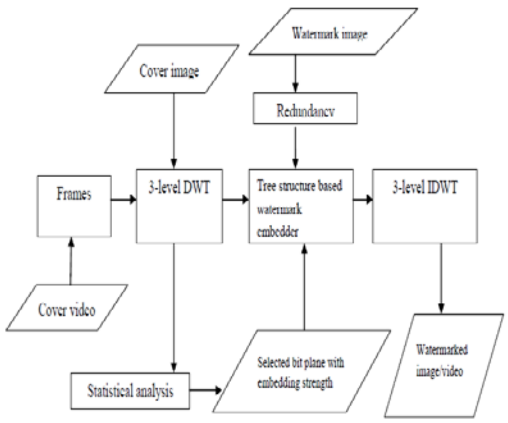

Fig 1 Watermark embedding process

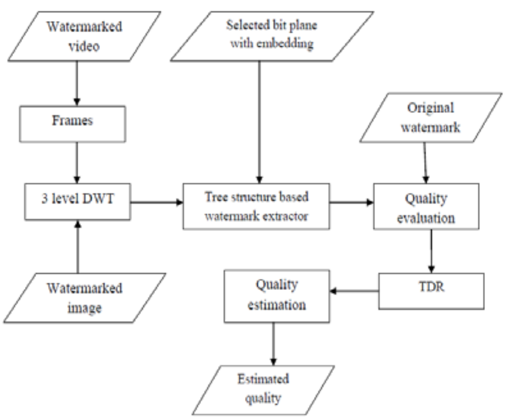

Fig 2.Watermark extraction and quality estimation.

Fig. 1, present the proposed watermark embedding. Digital video is a sequence of still images and the selected cover video covert into frames. Also select a text image for watermarking. The length of the original watermark sequence denoted as *len*. For the accuracy of watermark bit extraction at the receiver side, every bit in the real watermark is repeated a few times to get a redundant watermark sequence for watermark embedding. In this scheme, set *Redundancy=3* and the real watermark sequence is repeated *Redundancy-1* times to get the redundant watermark sequence with *Redundancy * len* bits long. The watermark embedding process mainly consists of three steps:

(1) The DWT decomposed image obtains by applying 3-level DWT. The three-level DWT decomposition is shown in Fig.3.
(2) Based on tree structure embed the watermark with embedding strength and gets the output as the watermarked DWT image.
(3) By applying 3-level IDWT to the watermarked DWT image to obtain the watermarked image.

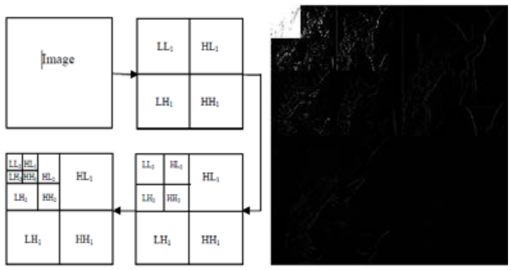

Fig 3. The three-level DWT decomposition

WATERMARK EMBEDDING STRENGTH

The watermark embedding strength is mainly controlled by the observed watermark bit assignment and the bit plane selection.

The Analysis of Image Content Complexity

The quad-tree decomposition is better match with the DWT for the complexity analysis. Threshold is specified as a value between 0 and 1. The content complexity of the cover image is assessed using the following equation

$$complexity = \sum_{i=1}^{n}(N_i * 2^i) \quad (1)$$

where i is the current quad-tree decomposition level, n is the highest decomposition level, N_i is the number of quad-tree decomposition nodes on level. Then calculate the complexity values of every image. Here the quad-tree decomposed images are achieved using the threshold T_{int}=0.17, where the maximum intensity value of the cover image is not bigger than 1.

The Watermark Bits Assignment

With the complexity indices, the watermark bits are empirically assigned to the images using the following steps:

(a) The complexity indices are divided into 6 groups. One integer index is associated with one group.

$$Gindex = \begin{cases} 1, & V_c > t_1 \\ 2, & t_1 \geq V_c > t_2 \\ 3, & t_2 \geq V_c > t_3 \\ 4, & t_3 \geq V_c > t_4 \\ 5, & t_4 \geq V_c > t_5 \\ 6, & t_5 \geq V_c > 0 \end{cases} \qquad (2)$$

where Gindex is the group index, V_c is the complexity index. t_1 ,t_2 ,t_3 ,t_4 ,t_5 and t_6 are the empirical grouping thresholds. These thresholds may be different for different distortions.

(b) With the group indices, the watermark bits are assigned to the images.

$$A_{\omega b} = \begin{cases} [27\,0\,0], & Gindex = 1 \\ [19\,7\,1], & Gindex = 2 \\ [13\,12\,2], & Gindex = 3 \\ [8\,15\,4], & Gindex = 4 \\ [1\,16\,4], & Gindex = 5 \\ [0\,8\,4], & Gindex = 6 \end{cases} \qquad (3)$$

And

$$\sum A_{\omega b} = \begin{cases} 27, & when\ Gindex = \varepsilon[1,2,3,4] \\ 21, & when\ Gindex = 5 \\ 12, & when\ Gindex = 6 \end{cases} \qquad (4)$$

Using the equation $W_{seg} = \lfloor Rlen / \sum A_{wb} \rfloor$ trees are selected for the watermark embedding. The Rlen represents the length of the redundant watermark sequence. Images having different complexity value so the number of selected trees, W_{seg} and the position separation key, N_{sep} , may be different.

The HVS Masking:

The four factors greatly affect the behavior of the HVS mask are band sensitivity, background luminance, edge proximity and texture sensitivity. The product of the four factor results the human visual system masking.

(a)Band sensitivity or frequency masking

In high resolution subands, intensity variations are less visible. In 3-level DWT apply the subsequent equations.

$$M_F(l,\theta) = M_1(\theta).M_2(l) \qquad (5)$$

Where

$$M_1(\theta) = \begin{cases} \sqrt{2}, & if\ \theta = 2 \\ 1, & o.w \end{cases} \qquad (6)$$

$$M_2(l) = \begin{cases} 1, & if\ l = 1 \\ 0.32, & if\ l = 2 \\ 0.16, & if\ l = 3 \end{cases} \qquad (7)$$

$$\theta = \begin{cases} 1, & for\ HL\ blocks \\ 2, & for\ HH\ blocks \\ 3, & for\ LH\ blocks \end{cases} \qquad (8)$$

(b) Background luminance:

Luminance is an indicator of how bright the surface will appear. The luminance masking is denoted as M_L.

$$M_L(l,i,j) = 1 + I(l,i,j) = \begin{cases} 2 - \frac{1}{256} I_{LL}\left(\left\lceil \frac{i}{2^{L_e - l}} \right\rceil, \left\lceil \frac{j}{2^{L_e - l}} \right\rceil\right), & if\ I(i,j,k) < 0.5 \\ 1 + \frac{1}{256} I_{LL}\left(\left\lceil \frac{i}{2^{L_e - l}} \right\rceil, \left\lceil \frac{j}{2^{L_e - l}} \right\rceil\right), & o.w \end{cases} \qquad (9)$$

(c) Spatial masking or edge proximity

Mask or filter can be used for edge detection in an image and to increase sharpness of the image. This factor, M_E , is evaluated using the empirically scaled local energy of the DWT coefficients in all detail subbands.

$$M_E(l,i,j) = \sum_{k=0}^{L_e - l} \rho \sum_{\theta=1}^{3} \sum_{x=0}^{1} \sum_{y=0}^{1} \left[I_{k+l}^{\theta}\left(x + \left\lceil \frac{i}{2^k} \right\rceil, y + \left\lceil \frac{j}{2^k} \right\rceil \right) \right]^2 \qquad (10)$$

Where ρ is a weighting parameter and the suggested value for ρ is presented in the following equation.

$$\rho = \begin{cases} \frac{1}{4}, & if\ k = 0 \\ \frac{1}{16^k}, & if\ o.w \end{cases} \qquad (11)$$

(d) Texture sensitivity

An image texture is a set of metrics calculated in image processing designed to quantify the perceived texture of an image. This masking factor, M_T, is estimated using the local variance of the corresponding DWT coefficients in the LL subband.

$$M_T(l,i,j) = \mathrm{var}\left\{ I_{LL}\left(x + \left\lceil \frac{i}{2^{L_e - l}} \right\rceil, y + \left\lceil \frac{j}{2^{L_e - l}} \right\rceil \right) \right\} \qquad (12)$$

where $x = \{0,1\}$ and $y = \{0,1\}$.

Finally the HVS mask calculated

$$M_{HVS} = \alpha \cdot M_F \cdot M_L \cdot M_E^{\beta} \cdot M_T^{\gamma} \qquad (13)$$

where M_{HVS} denotes the HVS mask; α is a scaling parameter. The value for α is 1/2, which implies that intensity variations having values lower than half of $M_F.M_L.M^{\beta}_E.M^{r}_T$ are assumed invisible. The suggested value for β and r is 0.2. The binary watermark bits are not embedded in the LL subband. Therefore, one HVS mask calculated for one DWT subband. So for a single frame there will be nine HVS mask generated.

Mapping From HVS Mask to Bitplane Indices:

To use the HVS mask in the watermark embedding process, a mapping relationship from the coefficients of the HVS mask to the bitplane indices is experimentally defined using the multiple-band-thresholding method.

The thresholds calculation and the mapping procedure are listed as follows:

(a) The HVS mask is first normalized using its maximum coefficient so that the mapping relationship can be consistent with different HVS masks.

(b) The coefficients of the HVS masks are sorted in an ascending order and the sorted sequence is denoted as *Sortmask*.

(c) The thresholds are calculated using following equation

$$T_n(l,\theta) = Sortmask\left(\left\lfloor \frac{n \cdot N_{mask}(l,\theta)}{5} \right\rfloor \right) \qquad (12)$$

Where n={1,2,3,4}, N_{mask} is the total number of the coefficients of one HVS mask, the denominator indicates that 5 bitplanes are used for the watermark embedding.

(d) The mapping is done using (14).

$$I_{bp}(l,\theta,i,j)=\begin{cases}1, & v(l,\theta,i,j)\le T_1(l,\theta)\\ 2, & T_1(l,\theta)<v(l,\theta,i,j)\le T_2(l,\theta)\\ 3, & T_2(l,\theta)<v(l,\theta,i,j)\le T_3(l,\theta)\\ 4, & T_3(l,\theta)<v(l,\theta,i,j)\le T_4(l,\theta)\\ 5, & T_4(l,\theta)<v(l,\theta,i,j)\le 1\end{cases} \quad (13)$$

where (i,j) are the coordinates of a selected DWT coefficient $I_{bp}(l,\theta,i,j)$ means the bitplane index achieved for the pixel located at (i,j) on DWT level with orientation θ is the value of the HVS mask coefficient.

In each selected tree, for all the selected coefficients, the watermark bits will be embedded on the same bitplane. Thus, the bitplane indices, I_{bp} , are updated using the following equation:

$$I_{bp}(l,\theta,i_{tree},j_{tree})=\left\lfloor\frac{\sum_{i_r=0}^{2(Le-l+1)-1}\sum_{j_r}^{2(Le-l+1)-1} I_{bp}(l,\theta,i,j)}{\left(2^{(Le-l+1)}\right)^2}\right\rfloor \quad (14)$$

Where $I_{bp}(l,\theta,i_{tree},j_{tree})$ is the averaged bitplane of the DWT coefficients located in a specific tree on level *l* and θ orientation.

$$i=i_{tree}+i_r=\left\lceil\frac{i}{2^{Le-l+1}}\right\rceil+rem\left(i-1,2^{Le-l+1}\right) \quad (15)$$

$$j=j_{tree}+j_r=\left\lceil\frac{j}{2^{Le-l+1}}\right\rceil+rem\left(j-1,2^{Le-l+1}\right)$$

With the calculated thresholds, the coefficients of the HVS mask which correspond to the selected DWT coefficients are mapped to the bitplane indices. In this way, the bitplanes of the selected coefficients for the watermark embedding are located.

IV TREE STRUCTURE BASED WATERMARK EMBEDDER

The tree structure based watermark embedder is designed to embed the binary watermark bits into the selected bitplanes of the selected DWT coefficients of the selected trees.

The Formation of the Tree Structure

The tree structure is formed by categorizing the DWT coefficients with inherent similarities across all the DWT subbands. The correlated coefficients build up the parent-descendants relationship and form a tree.

The Selection of Trees and DWT Coefficients

According to the length of the watermark sequence, the trees for watermark embedding are chosen using the position separation key. To keep the embedded watermark invisible and limit the image quality degradation caused by the watermark embedding, the watermark bits are not embedded into the LL subband of the DWT decomposed image and the watermark bits are not embedded into the bitplanes higher than 5, where the least significant bitplane is bitplane 1. The watermark bit assignment is denoted as A_{wb} = [a1,a2, a3], where a1, a2 and a3 are the number of watermark bits to be embedded in the DWT level 1, 2 and 3 in every selected tree. For watermark embedding, the redundant watermark sequence is divided into W_{seg}. where *len* is the length of the watermark sequence.

$$\omega_{segs}=\left\lfloor\frac{\text{Redundancy}*len}{\sum A_{wb}}\right\rfloor=\left\lfloor\frac{\text{Redundancy}*len}{a_1+a_2+a_3}\right\rfloor \quad (16)$$

To minimize the quality degradation of the cover image caused by the watermark embedding, two strategies are used for the tree selection:

(a) The trees selected from the three DWT orientations are non-overlapping in position.

(b) The trees are selected throughout the DWT decomposed image.

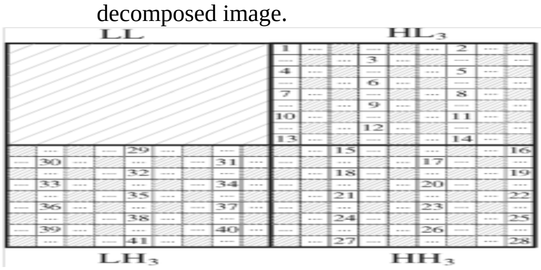

Fig 4 The tree selection from the three DWT orientations.

THE WATERMARK EMBEDDING

The binary watermark bits are embedded into the selected bitplanes of the selected DWT coefficients. Here, the watermark bit denoted as ω, the DWT coefficient bit on the selected bitplane represent as *c* and the watermarked DWT coefficient bit as c_ω . Then, the watermark bit will be embedded using the following

$$c_\omega=\begin{cases}c, & if\ c=\omega\\ \omega, & if\ c\ne\omega\end{cases} \quad (17)$$

V THE WATERMARK EXTRACTION AND QUALITY ESTIMATION

Fig. 2, explain watermark extraction and quality estimation.The image group index transmitted from the sender side is used to retrieve the watermark bit. The bitplane indices for watermark extraction is obtained by calculating the HVS masks of the distorted watermarked image. In one tree, the bitplane indices for all the DWT coefficients on each DWT level are averaged. This strategy effectively reduces the watermark extraction error caused by the bitplane selection in the watermark extraction scheme. Recall that *Redundancy=3*. The extracted redundant watermark sequence is used to recover the three distorted watermarks. Then, the three distorted watermarks are compared bit by bit and the watermark is extracted using equation.

$$\omega_e(i,j)=\begin{cases}1, & N_1\ge N_0\\ 2, & N_1<N_0\end{cases} \quad (18)$$

Where $\omega_e(i,j)$ is the extracted watermark bit with coordinates (i,j), N_1 is the number of extracted 1 s and N_0 is the number of extracted 0 s.

Then, the extracted watermark is compared with the original watermark bit by bit and the True Detection Rates (TDR) is calculated using equation

$$TDR=\frac{Number\ of\ correctly\ detected\ watermark\ bits}{Total\ number\ of\ watermark\ bits} \quad (19)$$

The image quality is estimated by mapping the calculated TDR to a quality value by referring to a mapping function.

$$\hat{Q}=f(TDR) \quad (20)$$

where $\hat{Q}$ is the estimated quality, $f(\bullet)$ is the mapping function, which is the "Ideal Map". When the calculated TDR is mapped onto the "Ideal Map", it could possibly lie between two neighboring TDR values on the curve. In this case, linear interpolation is used to estimate the image quality.

VI THE GENERATION OF IDEAL MAP

As shown in Fig. 5, the "Ideal Map" is generated by adding distortion to the watermarked videos. When the distortion increases, watermark gets high degradation. Video quality estimated by watermarked degradation and it represents in TDR-Quality Ideal Map.

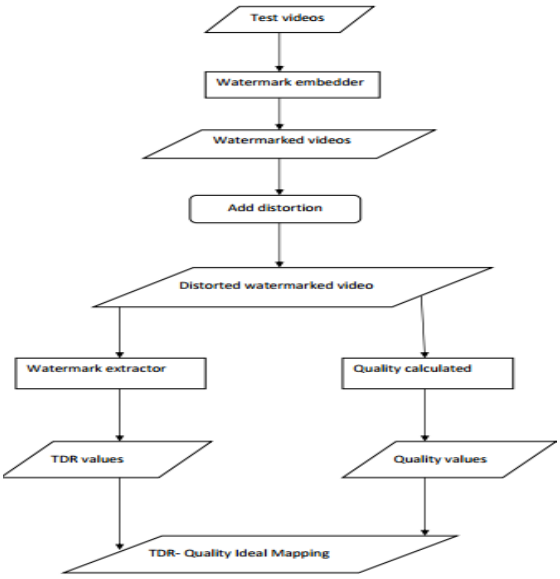

Fig 5. The Ideal Map generator

VII EXPERIMENTAL RESULTS

The experiment results Fig 6, shows that when the noise level is zero the quality of information is .988667 where good quality represents 1. When distortion is added both the watermark and the quality of information degraded. So the quality of the video can be estimated using watermarked degradation. In the Fig 7, the x-axis is the gives the watermarked degradation. The y-axis is the correspondingly calculated quality.

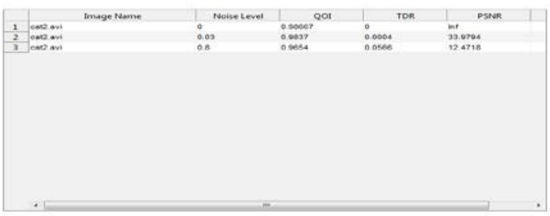

	Image Name	Noise Level	QOI	TDR	PSNR
1	cat2.avi	0	0.98867	0	Inf
2	cat2.avi	0.03	0.9837	0.0004	33.9794
3	cat2.avi	0.8	0.9654	0.0566	12.4718

Fig 6. Experiment results

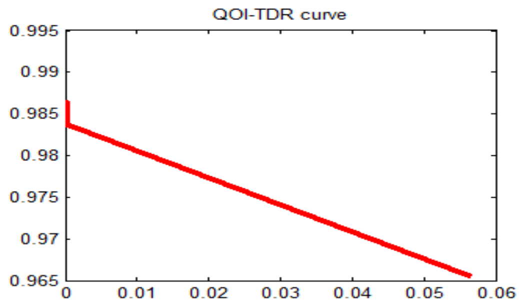

Fig 7. TDR-Quality Ideal Map

VIII CONCLUSION

The proposed scheme has good computational efficiency to estimate the video quality. Based on the tree structure, the binary watermark is embedded into the selected bit planes of the selected DWT coefficients with watermark embedding strength. The watermark embedding strength is assigned to an video by analyzing its content complexity in the spatial domain and the perceptual masking effect of the DWT decomposed image in the DWT domain. To reduce the loss of video quality, watermark is not embedded in the approximation sub band during watermark embedding. In future work, the proposed scheme will be further developed to estimate the quality of an video distorted by multiple distortions.

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