AN EFFICIENT HILBERT AND INTEGER WAVELET TRANSFORM BASED VIDEO WATERMARKING

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Abstract
In this paper, an efficient, highly imperceptible, robust, and secure digital video watermarking technique for content authentication based on Hilbert transform in the Integer Wavelet Transform (IWT) domain has been introduced. The Hilbert coefficients of gray watermark image are embedded into the cover video frames Hilbert coefficients on the 2-level IWT decomposed selected block on sub-bands using Principal Component Analysis (PCA) technique. The authentication is achieved by using the digital signature mechanism. This mechanism is used to generate and embed a digital signature after embedding the watermarks. Since, the embedding process is done in Hilbert transform domain, the imperceptibility and the robustness of the watermark is greatly improved. At the receiver end, prior to the extraction of watermark, the originality of the content is verified through the authentication test. If the generated and received signature matches, it proves that the received content is original and performs the extraction process, otherwise deny the extraction process due to unauthenticated received content. The proposed method avoids typical degradations in the imperceptibility level of watermarked video in terms of Average Peak Signal – to – Noise Ratio (PSNR) value of about 48db, while it is still providing better robustness against common video distortions such as frame dropping, averaging, and various image processing attacks such as noise addition, median filtering, contrast adjustment, and geometrical attacks such as, rotation and cropping in terms of Normalized Correlation Coefficient (NCC) value of about nearly 1.

Keywords: IWT, Hilbert Transform, PCA, Robust, Imperceptible, PSNR, NCC, BER, Watermark.

1. Introduction
With the advent of internet technologies as well as digital multimedia processing, a large amount of data is easily accessible to everyone these days. In parallel to
the growing diversity in the multimedia applications, technology also facilitated unauthorized copying, tampering, and distribution of digital video. The ease of such manipulations emphasizes the need for data authentication techniques. Therefore, various authentication schemes have recently been proposed for verifying the authenticity of the image, video or text content. The authentication techniques are basically classified as: digital watermark based and digital signature based schemes. A digital signature based technique dealt with either an encrypted or a signed hash value of image contents or image characteristics [1]. This digital signature scheme has its own drawback is that; it can detect the modification of data, but cannot locate the regions where the image has been modified [2]. To solve the problem of locating the region of modification, digital watermarking techniques have been proposed by many researchers [3]. Digital watermarking is a technique which involves two steps: (i) an algorithm to embed small authentication information called watermark content on the host content. (ii) An algorithm to retrieve or extract the embedded watermark with less distortion. Watermarking techniques can be broadly categorized into two groups: spatial domain methods and transform domain methods. The spatial domain methods embed by modifying directly on the pixels of an image [4]. The transform domain method involves modifying the transform domain coefficients [5-6].

A new robust, imperceptible and secure video watermarking scheme based on the two powerful transforms: Integer Wavelet Transform (IWT) and Hilbert [8] was developed in combination with PCA and investigated here. In the proposed scheme, the cover video is converted into the video frames and apply 2-level IWT followed by this perform Hilbert transform. Then, apply Hilbert on the gray watermark image and its amplitude coefficients are embedded into the Hilbert phase coefficients of all the IWT subbands of the cover video frames. In addition to this, in order to increase the level of imperceptibility, we also used Principal Component Analysis (PCA) based subband block selection procedure to find the region of embedding. The scheme used in this approach generates a digital signature using hash function and a special secret key (used by both sender and receiver), and the resultant signature is embedded into the DWT subbands of the watermarked video, which is used for authentication test. The receiver or the intended owner of the content will extract the digital signature from the watermarked video using the shared secret key. If the extracted digital signature and the generated one matches, the extraction process is carried out, otherwise no extraction. The high robustness, security and good imperceptibility of our proposed approach made it suitable for content authenticate applications and the simulation results demonstrates that it is high resistant to image processing, video processing and geometrical attacks.

The rest of the paper is organized as follows. In Section 2 the related works is discussed. Section 3 provides the background information. The detailed explanation of the proposed watermarking scheme is presented in Section 4. The experimental results are shown in Section 5. Finally, the conclusion is drawn in Section 6.

2. Related Works

A numerous video watermarking algorithms have been proposed in either spatial or frequency domain. In this section we discussed some of the famous existing watermarking techniques. Mobasseri [9] proposed spatial domain watermarking on compressed videos. Authors have showed that the possibility of embedding a
watermark in the raw video and also the possibility of recovering it from the MPEG decoder by exploiting the inherent processing gain of DSSS (Direct Sequence Spread Spectrum). Tsai & Chang [10] proposed a compressed video sequence via VLC decoding and VLC code substitution. They used Watson’s DCT – based video watermarking to achieve better imperceptibility.

Novel adaptive approaches to video watermarking have been proposed by Ge et al. [11]. In order to guarantee the robustness and perceptual invisibility of the watermark, he uses both intra-frame and inter-frame information of video content. The main advantage of this method is that the extraction of watermark can be done without using the original video, since the embedding was done adaptively based on the signal characteristics and human visual system. The MPEG-based technique for digital video watermarking has been proposed by Hsu & Wu [12]. They embedded watermarks in both intraframe and non-intraframe with different residual masks. The embedding process involves, first the degradation of the original watermark using pixel based permutation and block-based permutation, followed by this embedding can be done in the middle frequency coefficients in DCT domain, which is collected in zig-zag order.

The DWT based algorithm proposed by Hong et al. [13] where the middle frequencies are modified and a flag is generated for the extraction process. During the extraction process another flag is generated from the watermarked image in order to compare with the original flag. Here, authors used the generated flag as watermark instead of original watermark image. Doerr & Dugelay [14] have proposed video watermarking based on spread spectrum techniques in order to improve robustness. Here each watermark bit is spread over a large number of chip rate (CR) and then modulated by a pseudo-random sequence of binary. This algorithm’s robustness increases with the increase of the variance of the noise sequence. As a result, the increase of (CR) will reduce the embedding rate of watermark information; whereas, the increase of variance may result in the perceptibility of the watermark.

The wavelet transform based video watermarking scheme was proposed by Liu et al. [15] which dealt with embedding multiple information bits into the uncompressed video sequences. The embedding in LL sub-band used for reducing error probabilities of detection of BHC code. A new type of watermarking scheme proposed by Niu et al. [16] using two-dimensional and three-dimensional multi-resolution signal decomposing. The watermark image which is decomposed with different resolution is embedded in the corresponding resolution of the decomposed video. The robustness of watermarking is enhanced by coding the watermark information using the Hamming error correction code. This approach is robust against attacks such as frame dropping, averaging and lossy compression.

The digital video watermarking algorithm using Principal Component Analysis by Sanjana et al. [17] proposed the imperceptible high bit rate watermark. It was robust against various attacks such as filtering, contrast adjustment, noise addition and geometric attacks.

Haneih [18] have proposed a multiplicative video watermarking scheme with Semi-Blind maximum likelihood decoding for copyright protection. They first divide the video signal into non-overlapping pixel cubes. Then, the 2D Wavelet transform is applied on each plane of the selected cubes. For extraction, a semi-
blind likelihood decoder is employed. This method was robust against linear collusion, frame swapping, dropping, noise insertion, median filtering.

Nisreen et al. [19] proposed a comprehensive approach for digital video watermarking is introduced, where a binary watermark image is embedded into the video frames. Each video frame is decomposed into sub-images using 2 level discrete wavelet transform then the Principle Component Analysis (PCA) transformation is applied for each block in the two bands LL and HH. The watermark is embedded into the maximum coefficient of the PCA block of the two bands.

Agilandeeswari et al. [20] proposed a video in video watermarking algorithm using Discrete Wavelet Transform and Singular Value Decomposition. The experimental result shows that the average PSNR value and correlation coefficient is good compared to the other existing methods. A robust video watermarking for content authentication proposed by [21] proves that the systems works well in terms of visual perception and robustness against various image processing attacks. A side view based video in video watermarking presented by [22] converts the original video into the side view based on the mathematical form and each embedding includes the part of every frame in a video, this scheme increases the robustness level and security.

Faragallah [23] proposes a technique for efficient video watermarking using the DWT and SVD. Here, the author embeds the watermark image in three subbands namely, HL, LH and HH bands to improve the visual perception and robustness. A highly secured watermarking scheme has been introduced by [24], where the author uses the concept of visual cryptography and scene change detection to identify the motion frames, which helps to avoid collusion attack. [25] Introduces the theoretical framework allowing for the binary quantization index modulation (QIM) embedding techniques to be extended towards multiple symbols QIM. The underlying technique is optimized.

3. Background: Integer Wavelet Transform (IWT)

It is a kind of novel wavelet construction method. It is proved that all classical wavelets can be implemented using lifting schemes [26]. When compared with Discrete Wavelet Transform (DWT), IWT has the following advantages: (i) The transform coefficients of the DWT are the floating point values, rounding these values to integer results in losing their perfect reconstruction property. However, the lifting schemes in IWT maps integer to integer without rounding errors [27, 28], (ii) They are easy to understand, implement and invert [29]. They are also fast where all calculations are performed in place, and auxiliary memory is not required [29]. These properties of IWT can be utilized to preserve the level of imperceptibility and enhance the robustness. The IWT has three common lifting steps as: splitting, prediction and updation.

• **Split** — the original signal is divided into even and odd polyphase components. This is also known as the lazy wavelet.

• **Predict** — the new odd polyphase component is determined based on a linear combination of samples of the even polyphase component. The samples of the odd polyphase component are replaced by the difference
between the odd polyphase component and the predicted value. The predict operation is also referred to as the dual lifting step.

- Update — the new even polyphase component are produced based on a linear combination of difference samples obtained from the predict step. The update step is also referred to as the primal lifting step.

Figure 1 represents the steps for lifting transform and the inverse lifting transform is accomplished via reversing the steps of lifting and replacing the split by merging. The 2-level IWT on the sample videos (‘akiyo.avi’, ‘grandma.avi’ and ‘hall_monitor.avi’) is shown in Fig. 2.

![Fig. 1. Lifting steps of IWT.](image1)

![Fig. 2. 2-level IWT on the sample videos (akiyo.avi, grandma.avi and hall_monitor.avi).](image2)

4. Proposed Watermarking Algorithm

In this section, the proposed watermarking algorithm based on the combination of IWT and Hilbert Transform using PCA based block selection scores is discussed in terms of Embedding Algorithm (Fig. 3.) and Extraction Algorithm (Fig. 4.). Before, discussing the above said procedures, the proposed authentication scheme will be demonstrated. The content authentication is also achieved by generating the signature for the watermarked frame using the shared secret key (Signature generation) and embedded it on the watermarked frame in the sender side (signature embedding) and the same is verified by comparing the extracted signature with the computed signature at the receiver side (Signature verification). If matches found, the received watermarked image is authenticated, begin watermark extraction process (Extraction algorithm) else unauthenticated one, No extraction process.

4.1. Watermark embedding process

Step 1: Consider the color cover video C of dimension M×N and the gray watermark image W of size M/4×N/4.
**Step 2:** Perform video to frame conversion and apply RGB to YC_b_C_r conversion on each cover video frames CF_i, where i = 1, 2, 3, ..., total number of frames.

**Step 3:** Perform 2-level IWT on Y component of CF_i as,
\[
\text{IWT}(C) = \{LL1, HL1, LH1, HH1\}
\]
\[
\text{IWT}(LL1) = \{LL2, HL2, LH2, HH2\}
\]
The above expression shows the four multi-resolution subbands as LL1, HL1, LH1 and HH1 for the first level and eight multi-resolution subbands for the second level as LL2, HL2, LH2 and HH2.

**Step 4:** Let’s represent the IWT frame IF_i with elements IF_ij and the watermark image W with elements W_ij.

**Step 5:** Apply PCA based subband selection algorithm on IF_i as,

(i) Find zero mean A_z for each subband \( A_z = E(B_z \cdot m_z) \) \hspace{1cm} (1)

(ii) Calculate covariance matrix \( C_{m_z} = A_z \times A_z^T \) \hspace{1cm} (2)

(iii) Transform each block into PCA components by calculating the eigenvectors corresponding to eigenvalues of the covariance matrix as, \( C_{m_z} \phi = \gamma_z \phi \) \hspace{1cm} (3)

**Step 6:** Choose the subband with highest score and named it as subband S_1 for the ith frame.

**Step 7:** Perform Hilbert transform on subband S_1 of the frame IF_i and W as,
\[
IF_{ij} = p_{ij} \cos \theta_{ij}
\]
\[
W_{ij} = q_{ij} \cos \Phi_{ij}
\]
where, \( p_{ij} \) and \( q_{ij} \) are amplitude components of IF_i and W respectively. \( \theta_{ij} \) and \( \Phi_{ij} \) are phase components of IF_i and W respectively.

**Step 8:** Embedding the Watermark image in the subband which has highest score as,

(i) Divide the selected sub bands into non-overlapping blocks of size equal to the size of the watermark image.

(ii) Compute the score for each block using Step 5.

(iii) Extract the phase component and the amplitude component of the Hilbert cover frame and watermark image respectively.

(iv) Modify the coefficients of the selected Hilbert block of the subbands with watermark image as follows,
\[
\psi_{ij} = \theta_{ij} + \alpha q_{ij}
\]
where,
- \( \alpha \) represents robustness factor
- \( q_{ij} \) represents amplitude component of the Watermark image
- \( \theta_{ij} \) represents phase component of the original image.

**Step 9:** Reconstruction of modified subband IWT Coefficient using inverse Hilbert.
Step 10: Obtain the watermarked frame IF$^{w}$ using Inverse IWT as,
$$IF^{w} = p_{ij} \cos \psi_{ij}$$

Step 11: Convert the resultant YCbCr Frame into RGB Watermarked Frame WF.

Step 12: Repeat the Steps 3 to 11 for every other frames in a cover video by varying the values of ‘i’ from 1, 2, 3, 4,………, total number of frames.

Step 13: Generate the Watermarked Video ‘WV’ by grouping the results of Step 12.
4.2. Signature generation and embedding process

In this section, the digital signature generation and its embedding procedure is explained in detail. The embedding of digital signature into a watermarked video frame should be in a location which is robust against all attacks and at the same time it should not affect the visual perception of a video. These both can be achieved by placing the signature in the DWT sub bands using PCA based location selection.

The generation of digital signature for the watermarked video ‘WV’ is described as,

**Step 1:** For the watermarked video (without any attack) ‘WV’, perform the video to frame conversion and each frame is denoted as WF, where i = 1, 2, 3 …..n and ‘n’ is the total number of frames in the video.

**Step 2:** Compute Hash Value for the first frame using SHA-1 as,

\[ \text{DigSign}_i = \text{SHA-1} (WF_i) \]  

\[ (8) \]

**Step 3:** Repeat Step 2 for every other frames of watermarked video, by varying the values of ‘i’.

**Step 4:** Now, grouping the Digital signature values of different frames using XOR operation as,

\[ \text{Final}_{\text{DigSign}} = \text{XOR} (\text{DigSign}_i), \text{where } i=1, 2, 3, 4, ......n \]

\[ (9) \]

**Step 5:** Then, compute the length of the digital signature as,

\[ \text{DigSign}_{\text{len}} = \text{Length} (\text{Final}_{\text{DigSign}}) \]

\[ (10) \]

**Step 6:** Divide the Final_{DigSign} into two equal sets Signature\_1 and Signature\_2 using the signature length DigSign\_len

**Step 7:** Perform RGB to YCbCr conversion on each watermarked frame and extract its Y component as WFy\_i. Apply 1-level DWT on the WFy\_i and then apply PCA on such LH and HL mid subbands to determine the uncorrelated DWT coefficient blocks namely LH\_sb\_i and HL\_sb\_i.

**Step 8:** Now, modify the coefficients of the selected PCA blocks of WFy\_i as,

\[ \text{LH}_{\text{sb}\_i}'' = \text{LH}_{\text{sb}\_i} + \alpha \times \text{Signature\_1}, \]

\[ \text{HL}_{\text{sb}\_i}'' = \text{HL}_{\text{sb}\_i} + \alpha \times \text{Signature\_2} \]

These signature embedded sub bands are named as WFS\_i.

**Step 9:** Repeat Step 7 and 8 for every other WFy\_i frame by varying the ‘i’ value.

**Step 10:** Finally, covert the YCbCr frames into RGB and by grouping all signature embedded frames SEF\_i forms the signature embedded video SEV.

4.3. Extraction algorithm

4.3.1. Signature extraction

**Step 1:** From the received signature embedded video SEV\_i, we can extract the signature Signature\_1 and Signature\_2, if we know, LH\_i, HL\_i for all the values of \(i\) and the robustness factor \(\alpha\).
**Step 2:** Perform the video to frame conversion on $SEV'$ as $SEF_i$ then apply RGB to YCbCr Conversion on each such frames and extract its Y component as $WFy_i$.

**Step 3:** Perform 1-level DWT on the resultant $WFy_i$.

**Step 4:** Apply PCA based sub band selection procedure.

**Step 5:** Extract the owner digital signature as,

\[
Signature_{ij}^{'} = \left[ LH_{sb}^{i'} - LH_{sb} \right] / \alpha \\
Signature_{ij}^{'} = \left[ HL_{sb}^{i'} - HL_{sb} \right] / \alpha 
\]

Group these two signatures and named it as $DigSig_{recv_i}$ (12)

**Step 6:** Repeat the steps 3, 4 and 5 for every other frames of $WFy_i'$ to extract the signatures.

**Step 7:** After the extraction of the embedded signature, repeat steps 2, 3, and 4 of section 4.2 to generate the digital signature $DigSig_{gen_i}$ on the received noisy video frames.

**Step 8:** Now compare, the generated signature with the extracted one as,

\[
result = compare \left( DigSig_{recv}, DigSig_{gen} \right) 
\]

**Step 9:** If $result$ is TRUE,

received video is authenticated and can proceed with the extraction process (section 4.4),

Else,

received video is unauthenticated and no extraction process.

### 4.3.2. Watermark extraction algorithm

**Step 1:** From the received watermarked video $WV'$, we can extract watermark $W'$, if we know, $p_i$, $\theta_i$, $\Phi_i$ for all the values of $i$ and $j$ and the robustness factor $\alpha$.

**Step 2:** Apply RGB to YCbCr Conversion and extract its Y component as $WFy_i'$.

**Step 3:** Perform 2-level IWT on $WFy_i'$ as,

\[
IWT \left( WFy_i' \right) = \{ LL1', HL1', LH1', HH1' \} \\
IWT \left( LL1' \right) = \{ LL2', HL2', LH2', HH2' \}
\]

**Step 4:** Let’s represent the IWT frame $WIF_i'$ with elements $WIF_{ij}$.

**Step 5:** Apply PCA based subband selection procedure on $WIF_i$.

**Step 6:** Perform Hilbert transform on selected subband $S_i$ of the frame $WIF_i$ and extract its phase component $\psi_{ij}$ using the below equation,

\[
WIF_{ij} = p_{ij} \cos \psi_{ij} 
\]

Now divide both sides of equation (14) by $p_{ij}$ and also replace it by equation (12), we get,

\[
\psi_{ij} = \cos^{-1} \left( WIF_{ij} / p_{ij} \right) \\
\theta_{ij} + \alpha q_{ij}' = \cos^{-1} \left( WIF_{ij} / p_{ij} \right) \\
q_{ij}' = \frac{\cos^{-1} \left( WIF_{ij} / p_{ij} \right) - \theta_{ij}}{\alpha} 
\]

**Step 7:** Thus the extracted watermark can be created using the equation below,

\[
W_{ij}' = q_{ij}' \cos \Phi_{ij} 
\]

\[
\text{March 2016, Vol. 11(3)}
\]
5. Results and Discussion

The performance of the proposed watermarking technique has been measured in terms of its imperceptibility and robustness against the possible attacks like noise addition, filtering, geometric attacks etc. We used 10 sample videos as ‘akiyo.avi’, ‘container.avi’, ‘hall_monitor.avi’, ‘mother_daughter.avi’, ‘mobile.avi’, ‘tennis.avi’, ‘rhinos.avi’, ‘baby.avi’, ‘grandma.avi’ and ‘deer.avi’ of standard dimension 128 × 128 as cover images and the watermark as ‘fingerprint.jpg’ of dimension 32 × 32. The cover images are shown in Fig. 5 and the binary watermark image is shown in Fig. 6. The watermarked videos akiyo, container, hall_monitor, mother_daughter, mobile, tennis, rhinos, baby, grandma and deer are shown in Fig. 7. Figure 8 represents the extracted watermark image. For embedding the watermark, the scaling factor \( \alpha \) is set to 0.08. We used 2 level Haar filter coefficients for wavelet decomposition. The choice of mother wavelet can be based
either on the cumulative energy over some interval of interest or based on similarity between original and reconstructed image. We choose to select the mother wavelet based on similarity. We used haar for better reconstruction.

The imperceptibility level of the algorithm is measured in terms of PSNR value and the robustness of the algorithm is measured in terms of correlation co-efficient.

![Sample cover video frames](akiyo, container, hall_monitor, mother_daughter, mobile, tennis, rhinos, baby, grandma and deer)

![Original watermark image](akiyo, container, hall_monitor, mother_daughter, mobile, tennis, rhinos, baby, grandma and deer)

![Watermarked video frames](akiyo, container, hall_monitor, mother_daughter, mobile, tennis, rhinos, baby, grandma and deer)
5.1. Peak signal-to-noise ratio

The Peak Signal-to-Noise Ratio (PSNR) is used as a common measure to evaluate the degradation caused by various attacks. Low PSNR values indicate higher degradation and high PSNR values indicate lower degradation hence high PSNR values indicating that the watermarking technique is more robust to that type of attack. The PSNR between the cover image and the attacked watermarked image is calculated using the equation (17) and (18).

\[
PSNR = 10 \log_{10} \left( \frac{255 \cdot 2}{MSE} \right) \tag{17}
\]

where, Mean Square Error (MSE) between the original frame \(O(t)\) and attacked watermark frame \(A(t)\) is defined as,

\[
MSE = \frac{1}{T} \left( \sum_{t=1}^{T} (O(t) - A(t))^2 \right) \tag{18}
\]

where, \(T\) is total number of pixels per frame.

5.2. Normalized Correlation Co-Efficient (NCC)

The normalized correlation co-efficient is another measure used to measure the robustness of the watermarking algorithm against the possible attacks. Its peak value is 1. If two images are identical then correlation co-efficient value will be 1. If two images are uncorrelated then correlation co-efficient value will be 0. The correlation co-efficient between the original watermark and extracted watermark after possible attack is computed using the Eqn. 19.

\[
\text{Correlation Co-Efficient} = \frac{\sum (X_i - X_m)(Y_i - Y_m)}{\sqrt{\sum (X_i - X_m)^2} \sqrt{\sum (Y_i - Y_m)^2}} \tag{19}
\]

where, \(X_i\) the intensity of the \(i\)th pixel in image 1 is, \(Y_i\) is the intensity of the \(i\)th pixel in image 2, \(X_m\) is the mean intensity of image 1, and \(Y_m\) is the mean intensity of image 2.

Table 1 shows the average PSNR and normalized correlation coefficient (NCC) of the tested sample videos after embedding and extraction of the watermark respectively when no attack is done (No Noise) condition.
Table 1. Average PSNR of the watermarked videos and NCC values of the extracted watermarks (No noise).

<table>
<thead>
<tr>
<th>Video</th>
<th>Avg. PSNR</th>
<th>NCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>akiyo</td>
<td>48.94</td>
<td>0.9999</td>
</tr>
<tr>
<td>container</td>
<td>47.78</td>
<td>0.9996</td>
</tr>
<tr>
<td>hall_monitor</td>
<td>48.32</td>
<td>0.9998</td>
</tr>
<tr>
<td>mother_daugther</td>
<td>48.56</td>
<td>0.9999</td>
</tr>
<tr>
<td>mobile</td>
<td>48.72</td>
<td>0.9996</td>
</tr>
<tr>
<td>tennis</td>
<td>48.65</td>
<td>0.9996</td>
</tr>
<tr>
<td>rhinos</td>
<td>48.11</td>
<td>0.9997</td>
</tr>
<tr>
<td>baby</td>
<td>47.87</td>
<td>0.9992</td>
</tr>
<tr>
<td>deer</td>
<td>48.58</td>
<td>0.9997</td>
</tr>
<tr>
<td>grandma</td>
<td>48.23</td>
<td>0.9995</td>
</tr>
</tbody>
</table>

5.3. Image processing attacks

5.3.1. Gaussian Noise

When the gaussian noise is added to the sample watermarked videos akiyo, container, hall_monitor, mother_daugther, mobile, tennis, rhinos and baby with factor 0.003 we obtain Fig. 9, it also shows its corresponding extracted watermark image.

Fig. 9. Gaussian Noise on watermarked Frames (akiyo, container, hall_monitor, mother_daugther and tennis) with factor 0.003.

5.3.2. Poisson noise

The addition of poisson noise to the watermarked frame samples akiyo, container, hall_monitor, mother_daugther, mobile, tennis, rhinos and baby and its extracted watermark image is given in Fig. 10.

Fig. 10. Poisson Noise on watermarked Frames (akiyo, container, hall_monitor, mother_daugther and tennis).
5.3.3. Salt and pepper noise

When the salt and pepper noise is added to the watermarked frame samples with factor 0.05, we obtain Fig. 11 and it also represents the corresponding extracted watermark.

Avg.PSNR = 36.11  Avg.PSNR = 35.90  Avg.PSNR = 36.67  Avg.PSNR = 36.99  Avg.PSNR = 36.90
NCC = 0.8881  NCC = 0.8589  NCC = 0.8789  NCC = 0.8778  NCC = 0.8645

Fig. 11. Salt and Pepper Noise on watermarked Frames (akiyo, container, hall_monitor, mother_daughter and tennis) with factor 0.05.

5.3.4. Median filtering

Figure 12 shows the result of median filtering over the watermarked video samples and its corresponding extracted watermark.

Avg.PSNR = 47.33  Avg.PSNR = 45.20  Avg.PSNR = 45.35  Avg.PSNR = 46.58  Avg.PSNR = 45.89
NCC = 0.5234  NCC = 0.5503  NCC = 0.5156  NCC = 0.5378  NCC = 0.5748

Fig. 12. Median Filtering on watermarked Frames (akiyo, container, hall_monitor, mother_daughter and mobile).

5.3.5. Contrast Adjustment

Figure 13 shows the result of contrast adjustment on your watermarked frame samples and the resultant extracted watermark.

Avg.PSNR = 38.48  Avg.PSNR = 43.12  Avg.PSNR = 39.21  Avg.PSNR = 31.81  Avg.PSNR = 41.78
NCC = 0.9997  NCC = 0.9545  NCC = 0.9767  NCC = 0.9878  NCC = 0.9690

Fig. 13. Contrast adjustment on watermarked frames (akiyo, container, hall_monitor, mother_daughter and tennis).
5.3.6. Rotation

Figure 14 shows the rotation of angle about 5° on the watermarked frame and the resultant extracted watermark respectively.

\begin{align*}
\text{Avg.PSNR} &= 34.31 \\
\text{Avg.PSNR} &= 33.76 \\
\text{Avg.PSNR} &= 31.51 \\
\text{Avg.PSNR} &= 32.98 \\
\text{Avg.PSNR} &= 32.27 \\
\text{NCC} &= 0.9281 \\
\text{NCC} &= 0.8523 \\
\text{NCC} &= 0.8834 \\
\text{NCC} &= 0.8734 \\
\text{NCC} &= 0.8814
\end{align*}

Fig. 14. Rotation - 5° on watermarked frames (akiyo, container, hall_monitor, mother_daughter and tennis).

5.3.7. Cropping

The cropping of the watermarked frame samples and the watermark extraction is shown in Fig. 15.

\begin{align*}
\text{Avg.PSNR} &= 38.19 \\
\text{Avg.PSNR} &= 39.45 \\
\text{Avg.PSNR} &= 39.21 \\
\text{Avg.PSNR} &= 39.53 \\
\text{Avg.PSNR} &= 38.43 \\
\text{NCC} &= 0.8854 \\
\text{NCC} &= 0.8732 \\
\text{NCC} &= 0.8512 \\
\text{NCC} &= 0.8445 \\
\text{NCC} &= 0.8378
\end{align*}

Fig. 15. Cropping on watermarked frames (akiyo, container, hall_monitor, mother_daughter and tennis).

5.3.8. Frame dropping

The frame dropping is the dropping of intermediate frames on the received watermarked video and its corresponding watermark extraction is shown in Fig. 16.

\begin{align*}
\text{Avg.PSNR} &= 45.19 \\
\text{Avg.PSNR} &= 45.34 \\
\text{Avg.PSNR} &= 44.21 \\
\text{Avg.PSNR} &= 45.53 \\
\text{Avg.PSNR} &= 44.43 \\
\text{NCC} &= 0.9854 \\
\text{NCC} &= 0.9832 \\
\text{NCC} &= 0.9812 \\
\text{NCC} &= 0.9845 \\
\text{NCC} &= 0.9878
\end{align*}

Fig. 16. Frame Dropping on watermarked frames (akiyo, container, hall_monitor, mother_daughter and tennis).
5.3.9. Frame averaging

The averaging is the grouping of successive frames on the received watermarked video and the watermark extraction during such averaging is shown in Fig. 17.

![Fig. 17. Averaging on watermarked frames (akiyo, container, hall_monitor, mother_daughter and tennis).](image)

From the inspection, we found that the proposed watermarking technique is significantly more robust to attacks than the existing watermarking techniques. These finding is summarized in Table 2.

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Avg. PSNR</td>
<td>NCC</td>
<td>Avg. PSNR</td>
</tr>
<tr>
<td>Gaussian</td>
<td>27.0321</td>
<td>0.7134</td>
<td>42.2860</td>
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<td>Poisson</td>
<td>24.1342</td>
<td>0.6241</td>
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<tr>
<td>Salt &amp; Pepper</td>
<td>24.2685</td>
<td>0.7905</td>
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<tr>
<td>Contrast</td>
<td>29.0145</td>
<td>0.5017</td>
<td>43.2845</td>
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<tr>
<td>Median filtering</td>
<td>35.6041</td>
<td>0.8011</td>
<td>42.9956</td>
</tr>
<tr>
<td>Cropping</td>
<td>28.3454</td>
<td>0.6506</td>
<td>40.9067</td>
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<tr>
<td>Rotation</td>
<td>28.0145</td>
<td>0.6490</td>
<td>9.16300</td>
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<tr>
<td>Frame Dropping</td>
<td>-</td>
<td>-</td>
<td>45.7632</td>
</tr>
<tr>
<td>Frame Averaging</td>
<td>-</td>
<td>-</td>
<td>44.1762</td>
</tr>
</tbody>
</table>

6. Conclusions

In this paper, we have presented a robust and imperceptible image watermarking algorithm based on IWT and Hilbert using PCA based region selection. Here, we introduced additional authentication mechanism, which tests the received content for its originality by comparing the extracted digital signature from the signed watermarked video with the generated signature. If
matches, extraction will be performed due to authenticated content, otherwise no extraction, because of unauthenticated content. Due to this, it is best suited for content authentication applications. The experimental analysis shows that our approach is robust against various attacks such as, Gaussian attack, Poisson Attack, Salt and Pepper attack, Median filtering, Contrast Adjustment, Rotation, Cropping, Frame dropping, and averaging. The comparison shows that our approach is good enough when compared to the existing watermarking algorithm except for the median filtering attack.

References


