CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents the setup simulated in chapter 3, the results has been presented in the form of tables, graphs and images, the comparison of the results has also been presented.

To evaluate the performance of the proposed watermarking scheme, experiments have been conducted on various standard 8-bit grayscale frames of size 3*3 matrices. Proposed watermarking methods have been exposed to several tests in order to check up and compare their qualities and robustness. The test results are summarized in this chapter. The test scripts have been executed on several video sequences with different characteristics.

Video-watermarking method with results is applied with original video and prepared video from original video for water-marking. As it is well known that complete video consist of no. of pictures or frames.

Video = No of picture or frames

In following diagrams (4.2, 4.3, 4.6, 4.7, 4.10, 4.11), we have considered 20 frames or pictures with one prepared video from original video for water-marking and second watermarked video. In watermarked video, using detector response earlier discussed in chapter 1, it is detected the feature corner point on watermarked video frames. See in Watermarked Video picture no-1, where written Director: Sandeep Sharma. At corner of Director word feature point is detected, where watermarked is to be embedded.

4.1 Corner point detection: The common Harris corner detector Bas et al. [47] evaluate the performance of three commonly used detectors (i.e., the Harris corner detector [48]. That is, for different distorted versions of the same scene, the detector should be able to extract similar, if not
identical, points, despite variations due to a change of orientation or sharpness. The results of these studies prove the Harris detector is the most stable. The commonly used Harris corner detector refines the detection function [49] by using the following shape factor-based matrix.

\[ M(x,y) = \begin{pmatrix} A_{x,y} & C_{x,y} \\ C_{x,y} & B_{x,y} \end{pmatrix} \]

\[ = \begin{pmatrix} \left[ \frac{\partial I(x,y)}{\partial x} \right]^2 & \left[ \frac{\partial I(x,y)}{\partial x} \right] \left[ \frac{\partial I(x,y)}{\partial y} \right] \\ \left[ \frac{\partial I(x,y)}{\partial x} \right] \left[ \frac{\partial I(x,y)}{\partial y} \right] & \left[ \frac{\partial I(x,y)}{\partial y} \right]^2 \end{pmatrix} \]

4.1

where \( I(x, y) \) is the gray level intensity in x-axis and y-axis,

The corner points are located at the positions with large corner response values, which are determined by the corner response function \( R(x, y) \):

\[ R(x, y) = (\det(M(x,y)) - k[\text{trace}M(x,y)]^2 = (A_{x,y}B_{x,y} - C_{x,y}^2) - k [A_{x,y} + B_{x,y}]^2 \]

4.2

where \( k \) is a constant that is set to be 0.04.

The following four steps detail the image content extraction procedure:

- Apply a Gaussian low-pass filter to original image \( I(x, y) \) to avoid corners due to image noise.
- Apply a rotationally symmetric 33 Gaussian low-pass filter with the standard deviation of 0.5 to three derivative images, namely, \( A_{x,y} \), \( B_{x,y} \) and \( C_{x,y} \) to achieve additional resistance to possible image noise.
- Calculate \( R(x, y) \) within a circular window, which is at the image center and covers the largest area of the original image. The resulting function reduces the effect of image-center-based rotation attacks.
• Apply a threshold $T$ on $R(x, y)$ and search for important feature points based on the local maxima

$$\{R(x, y) \cap R(x, y) \geq R(u, v), \forall (u, v) \in V_x \}$$

4.3

where $T$ is a pre defined threshold value that is empirically set to be $10^6$ in our scheme to extract a desired number of corner points, and $V_{x,y}$ represents a circular neighborhood centered at $(x, y)$.

4.2 Perceptibility

Perceptibility expresses amount of distortion caused by watermark embedding. In other words, it indicates how visible the watermark is. It is measured by peak signal-to-noise ratio (PSNR) Bit error rate (BER) and Mean square error (MSE) which is mentioned in Section 3.2.2. The less the value of PSNR and more value of MSE and BER is the more perceptible the watermark is. We can see in the first row set of figures (4.2,4.3,4.6,4.7,4.10,4.11 and table (4.1,4.2,4.3,4.4) that the perceptibility grows up with increasing decreasing value of PSNR and increasing value of MSE and BER. It is obvious that block method is the most perceptible method because of the way of embedding. The second row set of the table contains probabilities of watermark detection success in non-attacked sequences as given by the detector.

4.2.1 Mean Square Error (MSE)

Mean Square Error between original video and watermarked video is calculated as follows:

$$\text{MSE} = \frac{1}{\text{size of image}} \sum_{i,j} \left[ \text{Original Image} - \text{Watermarked Image} \right]^2$$
4.2.2 Peak Signal to Noise Ratio (PSNR)

PSNR is calculated between the original and watermarked video. Larger the PSNR value, more similar is watermarked video to the original video. The video quality metric is defined in decibels as:

$$PSNR = 10 \log_{10} \left( \frac{255 \times 255}{MSE} \right)$$
4.2.3 Bit Error Rate (BER)

The performance metric is suitable for random binary sequence watermark. The parameter is defined as ratio between numbers of incorrectly decode bits and length of the binary sequence. BER indicates probability of incorrectly decoded binary patterns. It is defined as follows:

\[
\text{BER} = \frac{\text{No.of incorrectly decoded bits}}{\text{Total no.of bits}}
\]
Table 4.1 video watermarking quality parameters (9 x 12)

<table>
<thead>
<tr>
<th>Parameter for figure (4.2, 4.3, 4.4) with Watermark size (9×12) figure (4.1) and video frame Size (322×322)</th>
<th>Values after embedding of water-mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE mean square error</td>
<td>0.0020</td>
</tr>
<tr>
<td>PSNR peak signal to Noise ratio</td>
<td>72.5848</td>
</tr>
<tr>
<td>BER Bit Error Rate</td>
<td>9.0178e-004</td>
</tr>
</tbody>
</table>
4.3 APPLICATION

4.3.1 Video authentication: Popular video editing software permit today to easily tamper with video content and therefore it is not reliable anymore. Authentication techniques are consequently needed in order to ensure the authenticity of the content.
4.3.2 Video fingerprinting

To trace the source of illegal copies, a fingerprinting technique can be used. In this application, the video data owner can embed different watermarks in the copies of the data that are supplied to different customers. Fingerprinting can be compared to embedding a serial number that is related to the customer’s identity in the data.
Figure 4.6 Set-top box with WM capabilities

It enables the intellectual property owner to identify customers who have broken their license agreement by supplying the data to third parties. A consumer can receive digital services, like pay TV, by cable using a set-top box and a smart card, which he has to buy and can therefore be related to his identity. To prevent other non-paying consumers from making use of the same service, the provider encrypts the video data and this protects the service during transmission. The set top box of the consumer, who paid for the service, decrypts the data only if a valid smart card is used. Then, a watermark, representing the identity of the user, is added to the compressed video.

4.3.3 Copy protection

System checks all incoming video streams for a predefined copy-prohibit watermark. If such a watermark is found, the incoming video has already been copied before and is therefore refused by the recorder. If the copy-prohibit watermark is not found, the watermark is embedded and the
A watermarked video is stored. This means that video data stored on this recorder always contains a watermark and cannot be duplicated if the recorder is equipped with such a copy protection system.

Based on the exhaustive simulation results presented above for natural images, it can be seen that how the proposed K-harries feature-based and the Daubechies-based DWT algorithms [51] can secure the data. Especially, the proposed transform performs better for the images that consist of detailed view, bright colours, and gradients.

![Diagram of video recording process with copy protection](image)

**Figure 4.7 Video recorders with copy protection [50]**

Hence, it can be implemented by embedding the natural images or logo into each frame of video. However, the proposed technique consistently provides higher PSNR and better reconstruction quality.