Chapter 5
Hybrid Method for Watermarking

The proposed algorithm is a novel approach as compare to the approaches given till time as in this algorithm the watermarking is done on the region of interest (in this case - Face) of the image only rather than watermarking the entire image and also watermarking is done using hybridization of DCT-DWT and SVD methods.

5.1 Embedding Algorithm and Results

Here is a step-by-step explanation of the process used to embed a message behind the face part of an image:

1. **Face Detection**: Faces are identified and located within the image using algorithms such as Viola-Jones or deep learning-based detectors.
2. **Colorspace Conversion**: The RGB frame of each detected face is converted into the YCbCr colorspace.
3. **Selection of Y Frame**: The luminance component (Y frame) of the YCbCr colorspace is chosen for embedding the grayscale message.
4. Discrete wavelet transform is applied to Y frame and HL component is chosen for the embedding purpose.
5. Discrete Cosine Transform is applied to the Modified HL Component
6. **Singular Value Decomposition (SVD)**: SVD is applied to the modified Y frame to decompose it into three matrices: U, S, and V.
7. **Watermark Rescaling**: The grayscale watermark (W) intended for embedding is resized to match the dimensions of the singular component matrix S obtained from the SVD.
8. **Modification of Singular Component**: The singular component S is modified as S = S + K * W, where K is a gain factor that determines the strength of the watermark embedding.
9. **SVD Reapplication**: SVD is reapplied to the modified singular component to obtain new matrices U, S', and V.
10. **Modification of Selected Sub-band**: The modified singular component S' is used to reconstruct the altered luminance component: New_Value = $U * S' * V^T$.

11. **Inverse Colorspace Conversion**: The modified YCbCr frame is converted back to RGB colorspace.
12. **Reinsertion of Altered Face Image**: The watermarked face image, now containing the embedded watermark, is reinserted back into its original position within the image.
13. **PSNR and MSE Calculation**: The Peak Signal-to-Noise Ratio (PSNR) and Mean Square Error (MSE) are computed to assess the perceptual quality and fidelity of the watermarked image compared to the original. These metrics help evaluate how well the embedded watermark has been integrated into the image without introducing noticeable degradation.

This method ensures that the message is securely embedded behind the face part of the image while preserving the overall quality and integrity of the image content, specifically focusing on the detected faces.

(a)

(b)

Figure 5.1: Hybrid method with K=100 (a) 5 Frames of Video (b) Watermarked Frames

5.2 Extracting Algorithm and Results

Here's a step-by-step explanation of how the watermark is extracted from the face part of an image:

1. **Face Detection**: Faces are identified and located within the watermarked image using algorithms designed for face detection.
2. **Colorspace Conversion**: The RGB frame containing the detected face is converted into the YCbCr colorspace.
3. **Selection of Y Frame**: The luminance component (Y frame) of the YCbCr colorspace, corresponding to the detected face, is chosen for extracting the watermark.
4. Discrete Wavelet Transform is applied to the selected Y Frame and HL component is extracted
5. Discrete cosine Transform is applied on the extracted HL component.
6. **Singular Value Decomposition (SVD)**: SVD is applied to the extracted Y frame to decompose it into three matrices: U, S, and V.
7. **Resizing Singular Component**: The singular component (S) obtained from SVD is resized to match the size of the watermark message, resulting in $D = U * S * V^T$.
8. **Watermark Extraction**: The watermark is extracted by computing (D - S) / K, where K is a scaling factor used during the watermark embedding process.
9. **Correlation Calculation**: The correlation coefficient between the original watermark and the recovered watermark is computed. This correlation value serves as a measure of the algorithm's robustness, indicating how well the embedded watermark was preserved and recovered from the watermarked image.

This process ensures that the watermark embedded in the face part of the image can be accurately extracted, demonstrating the effectiveness and reliability of the watermarking algorithm in maintaining the integrity and security of the embedded information.

Figure 5.2: Recovered Messages

5.3 Results

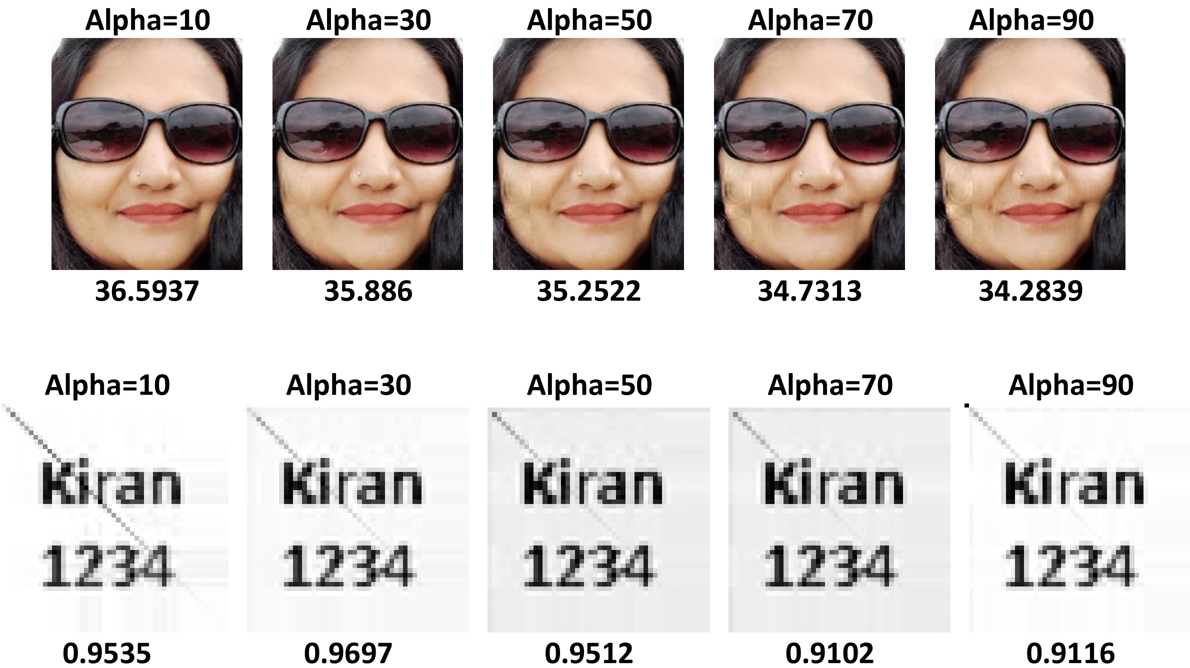


Figure 5.3: Results with Various Values of K

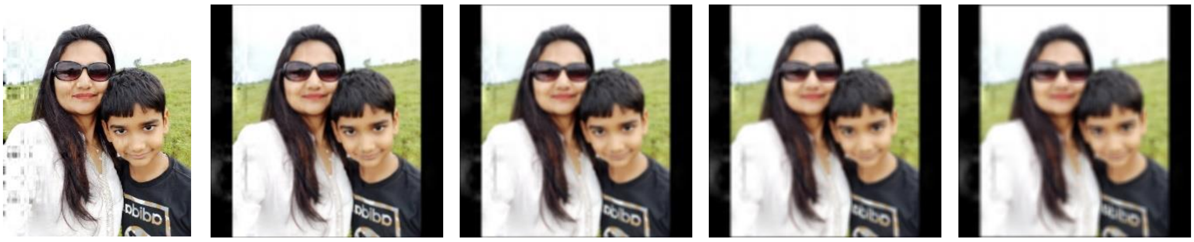
Frame No.	PSNR (db)	MSE	Correlation
1	34.0865	25.3780	0.9278
2	34.1300	25.4010	0.9269
3	34.0912	25.3767	0.9288
4	34.0765	25.3465	0.9290
5	34.1023	25.5678	0.9285

Table 5.1 5 Frames with K=100.

Alpha	PSNR (db)	MSE	Correlation
10	36.5937	14.2464	0.9535
20	36.2549	15.4026	0.9694
30	35.886	16.7681	0.9697
40	35.5506	18.1143	0.9635
50	35.2522	19.4028	0.9512
60	34.9822	20.647	0.9332
70	34.7313	21.8752	0.9102
80	34.4979	23.0828	0.9001
90	34.2839	24.2486	0.9116
100	34.0865	25.3763	0.9288

Table 5.2 Results with Various values of K

3 5 7 9 11



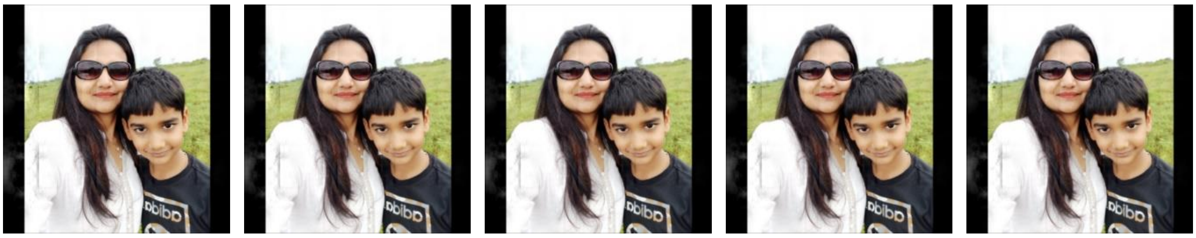
36.5937 35.886 35.2522 34.7313 34.2839

3 5 7 9 11

0.9148 0.8711 0.8311 0.7957 0.7626

(a)

1 1.5 2.5 3 3.5



35.6024 35.3429 35.2286 35.21 35.1987

1 1.5 2.5 3 3.5

0.9211 0.9174 0.9157 0.9154 0.9151

(b)

3 5 7 9 11

36.6138 35.5239 34.9623 34.5397 34.207

3 5 7 9 11

0.9261 0.8945 0.8679 0.8483 0.8328

(c)

10 20 40 9 11

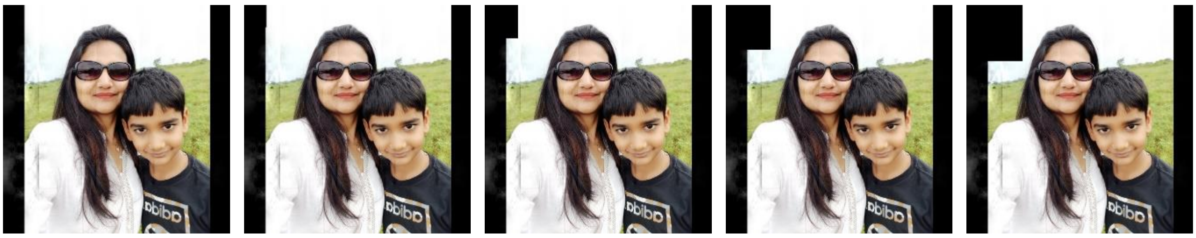
33.1388 34.1888 35.3231 36.0338 37.072

10 20 40 9 11

0.9052 0.9229 0.9345 0.9403 0.9463

(d)

25 50 75 100 125

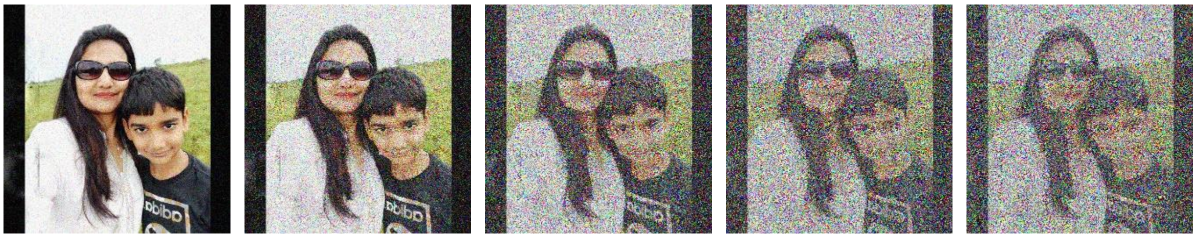


39.5572 39.5096 38.591 37.3883 36.1123

25 50 75 100 125

(e)

0.01	0.09	0.4	0.8	1



30.3834	28.5292	28.2723	28.2071	28.1969

0.01	0.09	0.4	0.8	1

0.9447	0.9046	0.9264	0.9408	0.9413

(f)

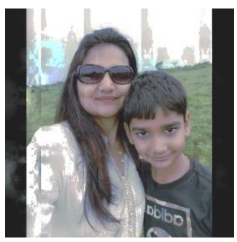
30	60	135	225	270

28.1467	27.9977	27.8397	27.6999	27.5684

30	60	135	225	270

0.9393	0.8409	0.8879	0.9637	0.982

(g)



28.5145

0.9789

(h)

Figure 5.4: Results under Various Attacks with different Intensity values (a) Average Filtering (b) Guassian LPF (c) Median Filtering (d) Compression (e) Cropping (f) Gaussian Noise (g) Rotation

5.4 Observations

The following observations were made after successfully implementing both the embedding and extraction algorithms. For these observations, a gain factor of 100 was used to evaluate perceptibility and robustness. A higher PSNR value indicates greater perceptibility, while a higher correlation value signifies stronger robustness.

1. In this method, perceptibility decreases as the gain factor increases.
2. Robustness also decreases with an increase in the gain factor.
3. Frames appear visually acceptable when the PSNR exceeds 28 dB, and the embedded message is clearly identifiable when the correlation value is above 0.50.
4. This method demonstrates complete robustness against all types of attacks.

5.5 Comparison with other methods such as Correlation, DCT, DWT, and SVD

1. At the same gain factor, this method achieves the highest perceptibility among all the methods.
2. The robustness achieved is significantly higher than Correlation, DCT, and DWT-based methods but marginally lower compared to the SVD-based method.