A New Digital Video Watermarking Using Decimated Wavelet and Principle Component Analysis in YCbCr Domain

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***Abstract*—*Digital watermarking is a technology used for security and for the copyright protection of digital media application. In this letter, we introduced "A New Digital Video Watermarking Using Decimated Wavelet and Principle Component Analysis in YCbCr domain". First, the input video stream will be divided into number of frames and then select one frame to embed the information into it. Now convert it into YCbCr color space and apply DWT followed by PCA to get the watermarked frame then replace this frame with the original frame to obtain the watermarked video. It has also tested for various attacks such asRST, cropping, compression, filtering and Gaussian noise successfully with reduced bit error. Peak signal to noise ratio (PSNR) and structural similarity index (SSIM) used to measure the quality of watermarked frame. Simulated results had shown that the proposed algorithm gives more superior results and higher imperceptibility over existing algorithm in terms of quality metrics.*

Keywords*—*Digital Watermarking, LSB, DFT, DCT, Radon Transform, YCbCr domain, DWT, PCA, PSNR and SSIM.

I. INTRODUCTION

Nowadays, digital multimedia content can be copied and stored easily and without loss in faithfulness. Hence, it is important to invent some kind of copy rights protection system. Watermarking can be considered to be a part of information hiding science called steganography [1], [2] and [3]. Steganographic systems permanently embed hidden information into cover content. So, if anybody copies the data, the hidden information will also be copied as well as.Digital watermarking has focused on still images for a long time but this trend seems to disappear nowadays. There are many algorithms which had been proposed for video watermarking. However, same as in image watermarking there are similar problems raised even in video watermarking also. Three major challenges for digital video watermarking. First, there are many non-hostile video processing, which are likely to adapt the watermark signal. Second, occurrence of rebounding to collusion is much more difficult in the circumstance of video [3]. Third, real-time is often a requirement for digital video watermarking. In recent days, the demand of copyright protection has been increased in various fields [3]. Because, preventing the digital video content from the unauthorized copying and the piracy of digital video is a challenging task. Copyright protection encloses authentication such as information of ownership and their logos in the digital media content without interrupting the perceptual quality of digital video [4]. In case of any argufy, authenticated data is extracted from the digital media and can be used as authoritative proof of prove the ownership. Watermarking is the process of embedding the secret data called a digital signature in to the digital multimedia objects such that this watermarked data can be extracted later to make an assertion about the object. Object may be an image or an audio or a video for the purpose of copyright protection. All the digital watermarking schemes must fulfill the criteria of imperceptibility as well as the robustness against all attacks for extraction or removal of watermark. From the past decades there are so many algorithms have been implemented for digital image watermarking by using discrete fourier transform (DFT) [5], least significant bit (LSB) approach [6], [7] and [8], discrete cosine transform (DCT) [9] and [10], Radon transform (RdT) [11] and [12], singular value decomposition and discrete wavelet transform (DWT) [13], [14] and [15] etc., However, all of them or failed to produce lossless extracted message without bit error rate. Also they are not suitable, when watermarked image suffers from RST attacks i.e., rotation, scaling and translation.Here in this letter, an imperceptibility and robust video watermarking algorithm

ISSN: 2349-6495(P) | 2456-1908(O)

based on Decimated Wavelet Transform (DWT) and Principal Component Analysis (PCA) has been proposed. DWT is more efficient than DFT, DCT and even other transformations. DWT is computationally efficient than other transform techniques. Due to its excellent spatio-frequency localization properties, it is very suitable to locate areas in the source video frames where the watermark data can be embedded imperceptibility. We know that even after decomposition of video frames using the wavelet transformation there exists some amount of correlation between wavelet coefficients. PCA is basicallyused to interbreed the algorithm as it has underlying property of removing the correlation among the data. i.e., wavelet coefficient and it helps in circulating the watermark bits over the decomposed subbands used for embedding thus result in stronger watermarking scheme which resists to various attacks. The watermark is embedded according to differences of original and reference video frame.

II. RELATED WORK

Frederic proposes a 2D DFT approach for digital watermarking in 1999 [5] and secure copyright protection of videos, the principle aim being to discourage outlaw copying and dispersing of copyrighted material. Here the approach is based on the 2D discrete Fourier transform (DFT) of frames of video scene, where the previous schemes were separately marks each video frame. The information to be hidden in the video can be encoded using a secret private key to ensure the confidentiality of system and also security of system and is embedded in the DFT magnitude of video frames. However, this approach does not provide much security to the host video; afterward enhanced versions of DFT have been proposed in later years.

$$F(u,v) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) * e^{\left(-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)\right)} \quad (1)$$

Where, $u = 0,1,2,\ldots.,M-1, v = 0,1,2,\ldots.,N-1$ and $j = \sqrt{-1}$

The inverse DFT (IDFT) is given by

$$f(x,y) = \sum_{u=o}^{M-1}\sum_{v=0}^{N-1} F(u,v) * e^{\left(j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)\right)} \quad (2)$$

Here, $M\ and\ N$ are the dimensions of the source frame. DFT will be very useful as the watermarking algorithm because, it helps in finding the adequate portions of the watermarking image for embedding the message, which in turns the higher imperceptibility and robustness.

2.1. Discrete Cosine Transform

DCT is one of the transformation technique used to decompose the host signal into several frequency bands, which makes a lot easier to do the watermark embedding into the middle bands, where these bands does not contains visual important portions of the host video frames. Hence the middle frequency bands have been chosen for the embedding the information into the host video. The original video frame which in motion can be converted in to spatial domain and will be divided into 8x8 blocks of pixels and the 2D DCT is applied to each block respectively. The two dimensional DCT is given by

$$C(0,0) = \frac{1}{N}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \quad (3)$$

$$C(u,v) = \frac{1}{2N^3}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) * [cos(2x+1)u\pi] * [cos(2y+1)v\pi] \quad (4)$$

Where, $u = 0,1,2,\ldots.,M-1, v = 0,1,2,\ldots.,N-1$ and $j = \sqrt{-1}$

The inverse DCT (IDCT) is given by

$$f(x,y) = \frac{1}{N}C(0,0) + \frac{1}{2N^3}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(u,v) * [cos(2x+1)u\pi] * [cos(2y+1)v\pi] \quad (5)$$

DCT have been considered by the most of algorithms in the watermarking process. Some of them added the DCT coefficient of image to the coefficients of the watermark [9] and [10] or select some of the image DCT coefficients for embedding. Other publications in the DCT domain are [16] and [17]. Authors in [17] have given the survey on various digital watermarking techniques such as LSB, DCT and DWT. They have the performance and analysis of those techniques. Recently, a DWT based algorithm has been proposed in [18]. However, all of them are suffering from lack of imperceptibility, higher hardware complexity and higher computational time. To overcome those drawbacks and to improve the security levels a new video watermarking algorithm has been proposed in this letter, which is based on DWT and PCA in YCbCr domain. The proposed algorithm has proven that it has far better than previous watermarking algorithms.

III. PROPOSED ALGORITHM

Wavelet analysis: It is a moving window technique with variable sized regions. Wavelet analysis allows the use of long time intervals where we want more precise low-frequency information, and shorter regions where we want high-frequency information.

Fig.1: Continuous wavelet transform

One major advantage of wavelets is that it has the ability of performing local analysis; hence we can analyze a localized area from a larger signal.Consider a sinusoidal signal with a small discontinuity, one so tiny as to bebarely visible. Such a signal easily could be generated in the real world,perhaps by a power fluctuation or a noisy switch.

3.1. Decimated Wavelet Transform

The DWT is more popular in signal processing applications. First we will decompose a host video into number of frames and then frames will be converted into images. Then one frame will be selected to embed the information after then DWT will be applied, and will decomposed it into four sub bands i.e., three detail and one approximation. The approximation coefficients contains lower resolution information (LL), and the detail coefficients contains the higher resolution information i.e., horizontal (HL), vertical (LH) and diagonal (HH) components. The main advantage of wavelet transform is its compatibility with the model aspect of the Human Visual System (HVS) as compared to FFT or DCT. In the proposed algorithm sub bands LL and HH from resolution level 2 of wavelet transform of the frame are chosen for embedding process. The following Fig.2 shows the functioning of decomposition and reconstruction tree. Here in this letter we supposed to use low frequency sub bands. Because, embedding the watermark in low sub bands will increase the robustness against various attacks such as RST (rotation, scaling and translation), compression, Gaussian noise and median filtering attacks while making scheme more sensitive to contrast adjustment, gamma correction and histogram equalization. Embedding the watermark in high frequency sub bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against variety of attacks.

3.2. Principle Component Analysis

It is a mathematical procedure that uses the orthogonal transformation to convert a set of observations of possible correlated variables into a set of values of uncorrelated variables called Principal Component. The number of principal component is less than or equal to the number of the original variables. Principal Component Analysis (PCA) is a method of identifying patterns in data, and expressing the data in such a way that so as to highlight their similarities and differences.PCA is a powerful tool for analyzing data and other main advantages of PCA is that once these patterns in data have been identified; the data can be compressed by reducing the number of dimensions, without much loss of information.

3.3. Watermark Embedding Algorithm

The proposed procedure of watermark embedding as shown in Fig. is described in the following.

Step1: Select and read the input video file from the database or system.

Step2: Choose number of frames from the video and select the frame which is to be used as a watermark frame. Then convert the selected RGB frame in to YCbCr components.

Step3: Now, select luminance component of chosen video frame to embed the logo image

Step4: Decompose the image into LL, LH, HL, and HH by using discrete wavelet transform (DWT) and divide the two sub bands LL into n x n non overlapping blocks D_i and calculate the mean μ, standard deviationσ^2.

$$Z = \frac{(D_i - \mu)}{\sigma^2} \qquad (1)$$

Step5: Now, select the logo image which is to be embedded into cover frame.

Step6: Apply PCA to$Z$ and calculate the principle components

$$scr = Z' * d \qquad (2)$$

Where d= vector of PC variances or Eigen values of Z

Then embed the logo in to LL with the help of eq. (1)

$$W_x'' = scr + \alpha * W_x \qquad (3)$$

Where, α = watermark embedding strength

W_x= logo image in vector format

Step8: Apply inverse PCA on the modified PCA component of the sub-band to obtain modified wavelet coefficients.

Step9: Apply inverse DWT and convert YCbCr into RGB components to produce the watermarked luminance component of the frame and the reconstruct watermarked frame.

Step10: Replace the watermarked frame with the original selected watermark frame and convert all the frames into a watermarked video.

3.4. Watermark Extraction Algorithm

Watermark extraction process as shown in Fig.4 is the inverse procedure of the watermark embedding process. The watermark extraction process as follows:

Step1: Convert the watermark (and may be attack) video in to frames and convert the RGB frames in to YCbCr components.

Step2: For each frame, choose luminance Y component and apply the DWT to decompose the Y frames in to four multi resolution subbands N x N.

Step3: Divide the subband LL into n x n non overlapping blocks$D_i$and calculate the mean μ, standard deviationσ^2.

$$Z = \frac{(D_i - \mu)}{\sigma^2} \qquad (4)$$

Step4: Apply PCA to$Z$ and calculate the principle components using eq. (2)
Where d= vector of PC variances or Eigen values of Z
Step5: Now, extract the logo by using the eq. (5)

$$W_x = W_x'' - scr/\alpha \qquad (5)$$

IV. SIMULATION RESULTS

Experimental results have been tested in MATLAB 2014a version. Fig3 shows that the watermarking videos used for the testing purpose. We had considered all the video for testing proposed embedding and extraction algorithms with the existing LSB approach. Fig4 shows that the watermarking frame, logo image, watermarked frame and extracted image with the proposed system. It shows that the watermarked frame looks same as reference frame. Simulation results showthat the proposed algorithm has given better results than the existing schemes in terms of PSNR and SSIM. We also tested with various attacks such as noise, compression, rotation, translation and filtering. For every attack we extracted watermark logo and calculated the bit error rate (BER). And the proposed algorithm works well against all the attacks that have been applied on watermarked video.In table1 we displayed the BER values and fig8 shows the statistical analysis of BER values for various attacks. Fig9 shows the quality metric between watermarked frame and reference frame, proposed PSNR has got maximum imperceptibility when compared with existing techniques. SSIM comparison has shown in fig10 for various versions of LSB with proposed algorithm.

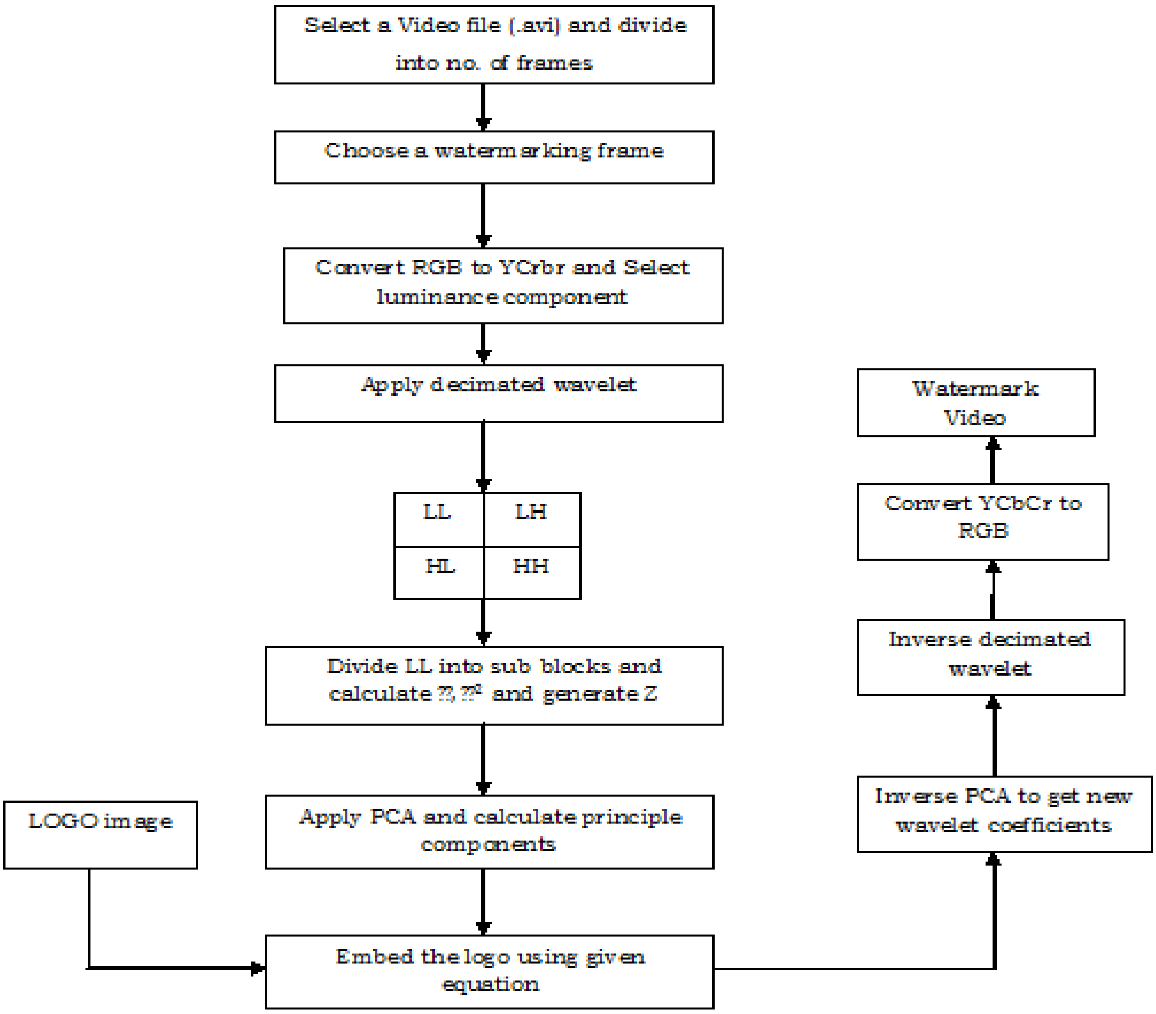

Fig.2: Watermark Embedding Algorithm

Fig.3: Watermarking videos for testing the proposed algorithm

Fig.4:Reference frame, logo image, watermarked frame and extracted watermark

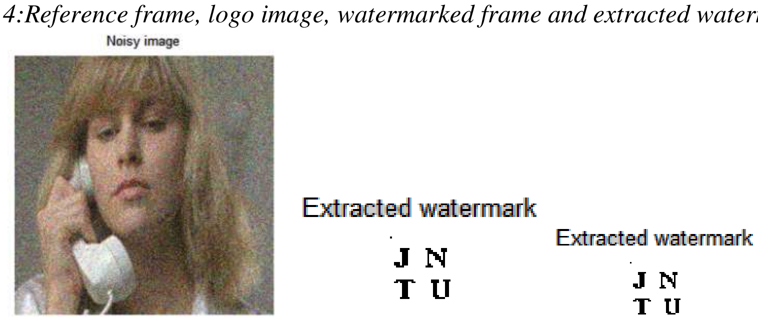

Fig. 5:Extracted watermarks after the noise and rotation attacks

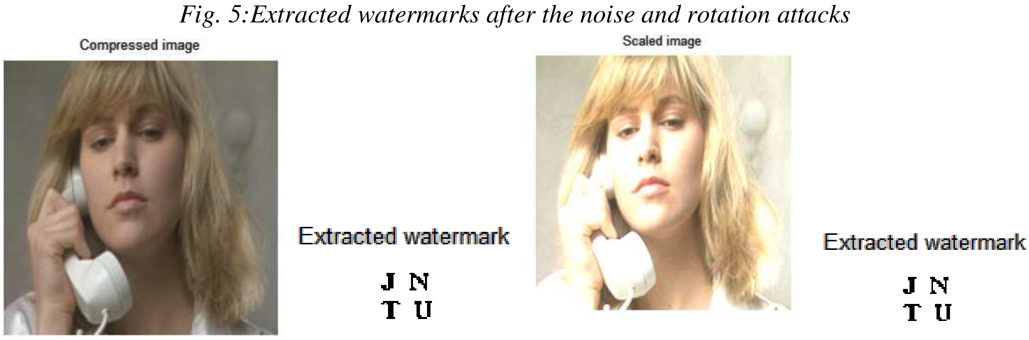

Fig. 6: Extracted watermarks after the compression and scaling attacks

Fig. 7:Extracted watermarks after the translation and filtering attacks

Tabel.1: BER values for various attacks

Type of attack	Bit Error Rate
Gaussian noise	0.00097656
Rotation	0.00097656
Compression	0.00075955
Scaling	0.00054253
Resizing	0.00054253
Median filter	0

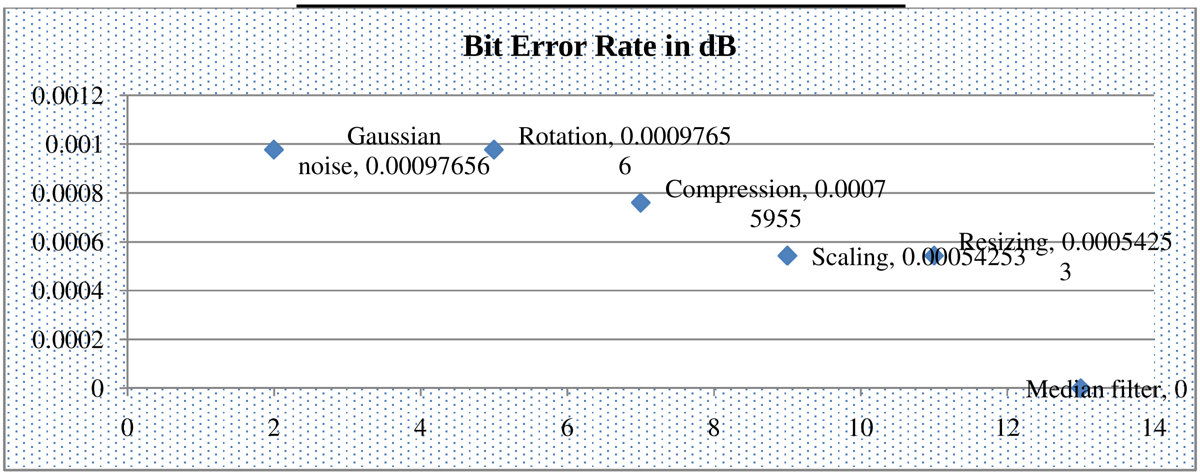

Fig.8: BER comparison for various attacks

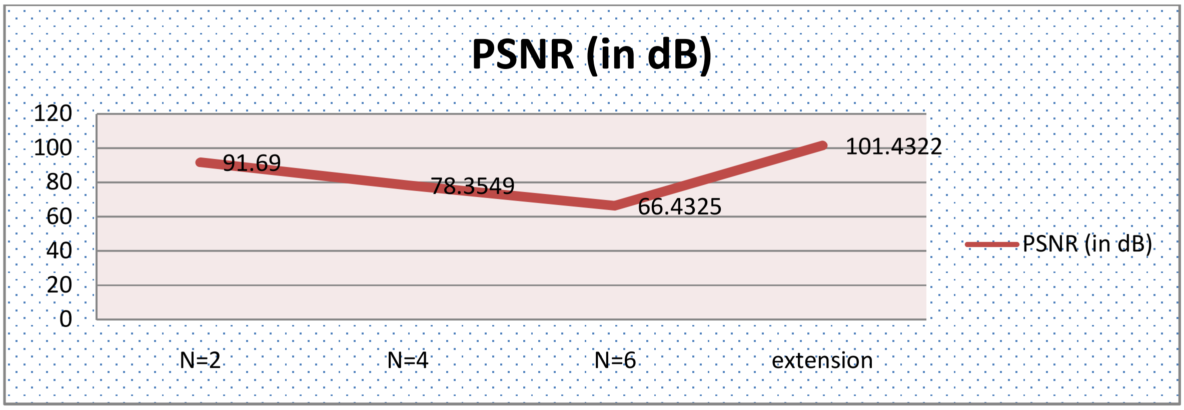

Fig.9:PSNR comparison for proposed and existing LSB approach

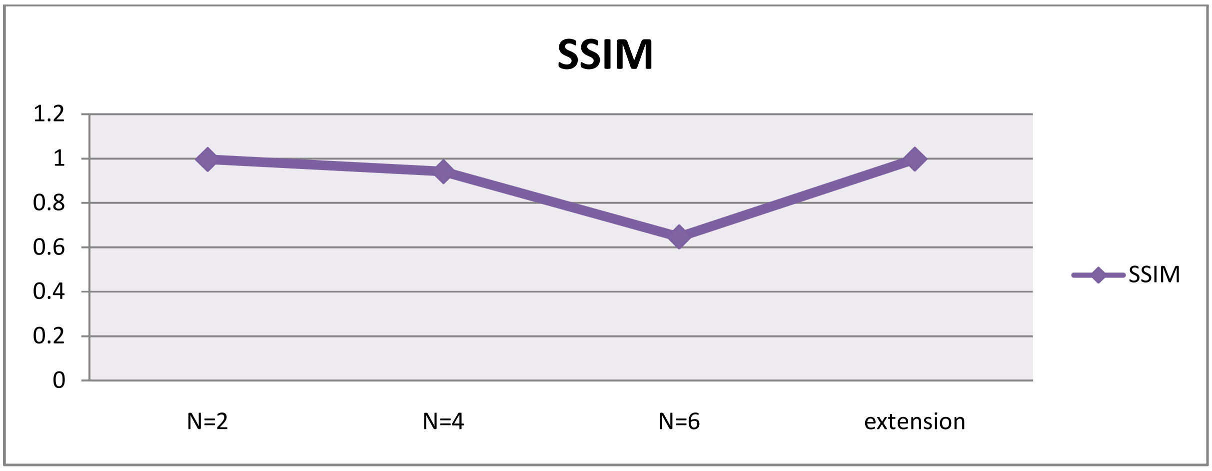

Fig.10: SSIM comparison for proposed and existing LSB approach

V. CONCLUSION

In this letter, we proposed a new digital video watermarking scheme to improve the imperceptibility and robustness of digital video watermarking algorithms. We tested various videos with several attacks such as RST, compression, filtering and Gaussian noise. For every attack, we calculated bit error rate also, also got very lesser BER. Finally, SSIM has been calculated to measure the quality of embedded message and the extracted message also calculated the quality metric PSNR for measuring the quality of watermarking frame and watermarked frame Simulation results have shown the superior performance when the watermarked image was affected with various noise attacks, compression and RST attacks.

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