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Reversible Joint Watermarking for Medical Images and Videos

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Abstract

Nowadays Digital Watermarking is widely used in the health care centers to secure the patient's records. In India, nowadays the hospitals are adapting the telemedicine technology where it is providing facility for the patients and doctors to transmit the reports and as well as to access it easily as and when it is required to do so. In order to protect the privacy, authenticity and the integrity of the Electronic Health Record (EHR), some measure has to be employed. In this regard Digital watermarking (DWM) plays a major role. Digital watermarking is implemented in mainly two domains: one at the pixel level usually called as the spatial domain and the other is at the frequency components of the information called as the frequency domain. Of the two methods, second method is most commonly adapted by most of the researchers. It includes the transforms like Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT), Discrete Wavelet Transform (DWT) and the variations of DWT viz. Lifting Wavelet Transform (LWT) and Integer Wavelet Transform (IWT). In this paper DWM for the medical scanned images and the medical video is implemented using DWT. The watermark is patient information which will be converted to quick response (QR) code using the built in function. A simple key is used at the embedding part of the DWM technique and the same key is used at the decoder side to retrieve the information which enhances the security of both medical images/videos and the patient details.

Index Terms: Discrete wavelet transform, Lifting wavelet transform, Integer Wavelet transform, Quick response code.

1. Introduction

As we have seen our country India is moving towards the world of digitization and the people are

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fond of this technology. Even the villages in India are becoming more familiar with the use of mobiles and internet. So there is a possibility of providing the health care centers with various applications like telemedicine, telemetry etc in cities and as well in villages of India. As we have aware that the patient's security is the major concern in this technology [4], the digital watermarking technology along with other security measures such as encryption may be employed by the healthcare centers all over India.

Digital watermarking is a process in which some useful information is embedded in cover information. In this work, the cover information considered is scanned image and video both of which are two dimensional in nature. The patient details or thumb impression of a patient is taken as the watermark and is converted in to QR code. This conversion is done in order to reduce the number of bits to be embedded in to the cover information so that it will not affect the original data which is very much desirable in the field of medicine to avoid unnecessary conflicts. The reason for selecting the QR code is simple that it gives more accurate results compared to other methods like barcode [8]. Along with the use of QR code, symmetric encryption technique is also employed to enhance the security [2] [3] for the data in which the same key must be used at the watermark Embedder and decoder side.

As we know that the digital watermarking may be implemented in two domains: spatial and frequency domains. The frequency domain is more frequently used by most of the researchers because of its accuracy. Nowadays DWT and its other variations like LWT and IWT are widely used by the researchers.

The Discrete Wavelet Transform (DWT) may be any wavelet where the wavelets are discretely undergo sampling and has advantages over other transforms like DCT, DFT etc. as it gives the details about both frequency and location/time [1]. Because of this reason, DWT and its other variations are substituting the other transforms.

There are different wavelets available for DWT like Haar wavelet, Daubechies wavelets, dual-tree complex wavelet transform (DCWT), non- or undecimated wavelet transform, Wavelet packet transforms etc. The Haar wavelet stores the difference and passes the sum, Daubechies wavelets to generate progressively finer discrete samplings of an implicit mother wavelet function, DCWT is shift invariant and directionally selective in two and higher dimensions. The main property of DWT is that it is time invariant but very sensitive to the alignment of signal in time. The main application of DWT is in the signal coding in order to represent the discrete signal in more redundant form probably in the data compression form. So in order to perform this function with mentioned advantages the DWT is used in the watermarking process. The DWT may be applied to both cover and watermark information if it is required.

In the medical field, the report of a patient is very much essential. If it is changed or tampered then it would lead to complications. If the size of the watermark is very much large, it would damage the important content of the scanned image or video. In order avoid such complexity; the size of the watermark should be very much small so that there is no change or very little change in the cover information.

To get the smaller size of the watermark, it is converted in to QR code [5]. The watermark information that we want to convert it into QR code will be converted in to machine readable form which is two-D in nature which may be encoded and is embedded in the cover information. At the receiver the QR code may be decoded and the embedded data may be validated. The main advantage of using QR code is [6] [7]; it has a larger data capacity i.e. 7089 digits or in other words 4296 characters which may also include a combination of punctual marks, special characters may be included in one QR code and also high fault tolerance property, even if the QR is damaged, the keys include duplications, which helps to read the data still. Because of these advantages, we may tend to choose the QR code to be used in this work.

To avoid the unauthenticated access, a secret key may be used both at the embedding and extraction side. There are various ways to use the key such as; Symmetric key i.e. using the same key both at the embedding and extraction side or asymmetric key i.e. a different key may be used. Using the symmetric key at both the sides is more effective way to provide the security. The block diagram for the implementation of the DWM embedding and extraction for medical scanning image is shown below:

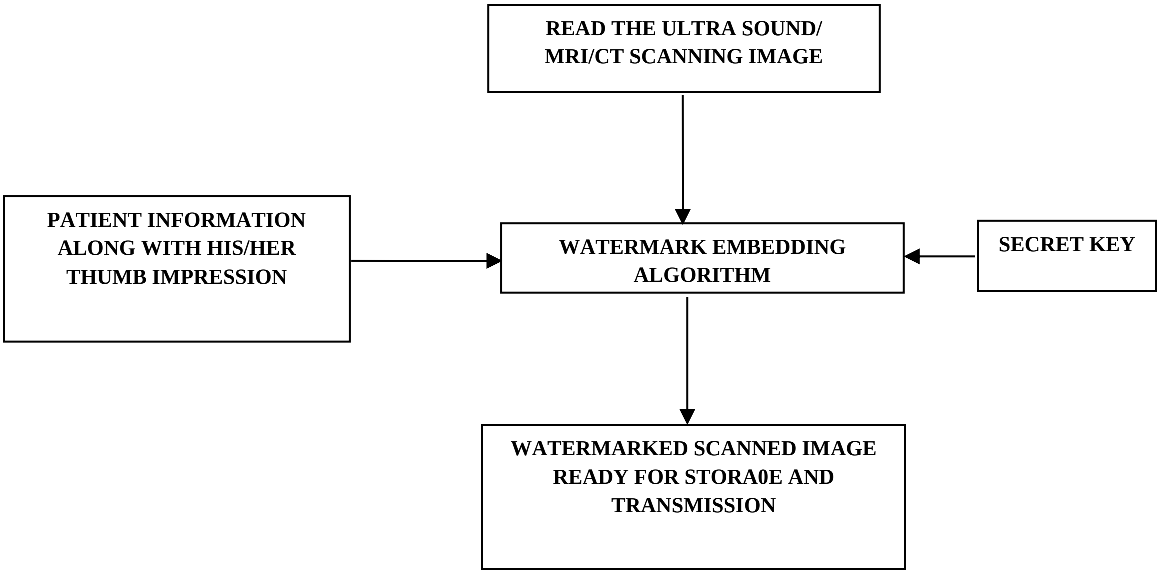


Fig.1. Block Diagram of Watermark Embedding Process

In the Fig1, we can see that the cover image to be watermarked is read from the database or directly from the scanning instrument and the watermark information is embedded in to the cover information using embedding algorithm to get the watermarked information. Along with the watermark, a secret key (which may be generated using various techniques) is also hidden in the cover information. This watermarked image may be stored in the centralized data base and if required for higher diagnosis it can be transmitted to the expertise doctors.

To perform the embedding process, the alpha blending embedding algorithm is used. Alpha Blending can be accomplished in image processing by blending each pixel from the first source image with the corresponding pixel in the second source image. According to the formula of the alpha blending the watermarked image is given by

$$WMI=K*LL3 +Q * WM3$$

Where,

WMI = low frequency component of watermarked image
LL3 = low frequency component of the original image obtained by 3-level DWT
WM3 = low frequency component of Watermark image
k, q = Scaling factors for the original image and watermark respectively.

In the above figure, the watermark extraction block diagram is shown. In this extraction process, the watermarked medical image, the original cover image and secret key are needed. Then the extraction watermark algorithm is applied in order to reconstruct the original medical image and also to extract the watermark. If any of the information is not available, it is not possible to extract the information which ensures high secureness.

To perform the extraction process, alpha blending extraction algorithm is used. According to the formula of the alpha blending the recovered image is given by

$$RW = (WMI - k * LL3)$$

Where

RW= Low frequency approximation of Recovered watermark,
LL3= Low frequency approximation of the original image
WMI= Low frequency approximation of watermarked image.

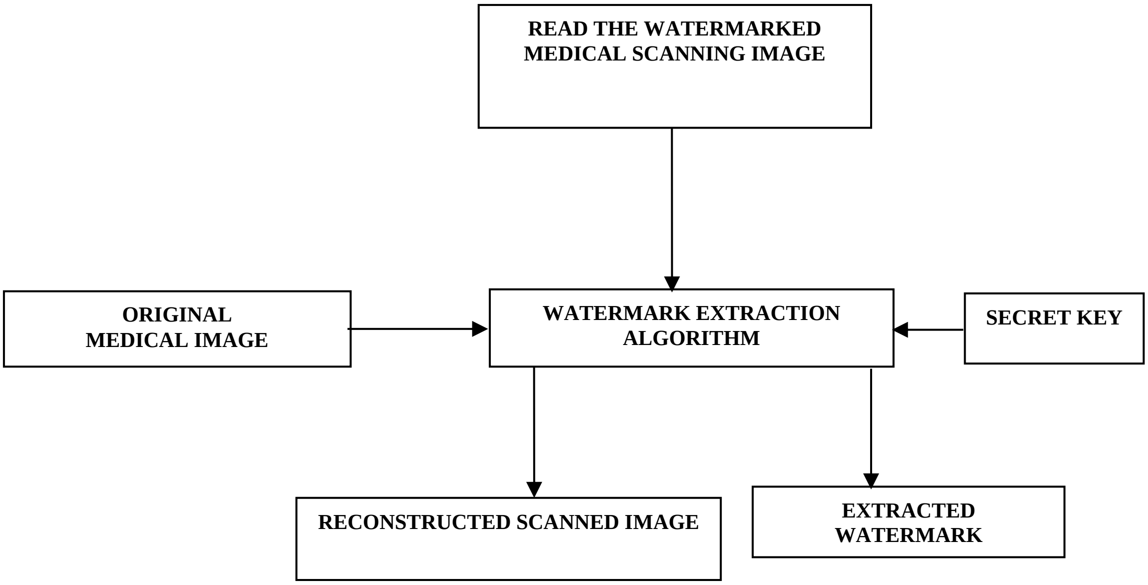


Fig.2. Block Diagram of Watermark Extraction Process

2. Implementation

Here the secured DWM with less data payload for medical scanning images and the medical video is shown. The algorithm for watermark embedding is described below:

1. Here the cover medical image which is to be watermarked is read and resized to the required size.
2. The watermark information is also read and resized to the same size as that of the cover information.
3. The 3rd level DWT is applied to both cover and watermark information.
4. Apply the alpha blending embedding algorithm.
5. During embedding process, the patient information will be added in to the cover image.
6. Apply 3rd level inverse DWT to get the watermarked image.
7. In order to enhance the security of the information, an input key is entered in which we may store frequency component details which may be used at the receiver side to extract the information/image.

The implemented process is shown in Fig3.

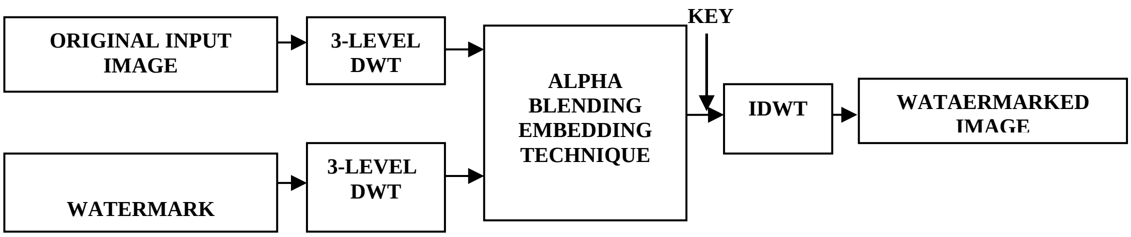


Fig.3. Proposed Watermark Embedding System using Alpha Blending Embedding Algorithm

The detailed functioning of the watermark embedding process is described below:

- In this watermarking embedding process for the medical image, an approach of hiding the watermark (patient information along with thumb impression of a patient) into the input cover image and watermarked image/encrypted image is formed.
- First the host image (original medical image) is taken as the input and DWT (Discrete Wavelet Transform) is applied to the image which decomposes an image into low frequency and high frequency components.
- Secondly the watermark image (patient information along with thumb impression of a patient) is taken as the input and converted into QR code.
- DWT (Discrete Wavelet Transform) is applied to the QR code of water mark image, which decomposes image into low frequency and high frequency components.
- The DWT is applied to the input image and the output of the DWT is LL1, HL1, LH1 and HH1 band. This is 1st-Level DWT
- The DWT is applied to the LL1 band of the 1-level DWT output and the output of the DWT is LL2, HL2, LH2 and HH2 band. This is 2-Level DWT
- The DWT is applied to the LL2 band of the 1-level DWT output and the output of the DWT is LL3, HL3, LH3 and HH3 band. This is 3-Level DWT
- The LL3 part of the watermark is embedded into the LL3 part of the input image using alpha blending embedding technique.
- The size of the input image is reduced into low size, after the third level of decomposition.
- Then IDWT is applied to combine alpha blended image with the other sub-bands and high frequency coefficients to form the watermarked image.
- After performing the embedding process, a password or else we may call it as a keyword is issued in order to prohibit the access by unauthorized persons.
- In fact the key is processed at 3-levels with help of respective frequency components of cover image and watermark image as given below and is stored in some variables which is later used in the extraction process:

k1=LL1-LL11
k2=LL2-LL22
k3=LL3-LL33

} ⟶ 1st term-→ frequency component of cover image.
2nd term-→frequency component of watermark image.

After performing the embedding process, the image may be stored and transmitted. At the receiver side or if the patient or doctor wants to access the report, they may proceed with the extraction process and check for validation. The algorithm of watermark extraction process is given below:

1. Read the watermarked medical image and the input cover image.
2. Apply 3-level DWT to both the images.
3. Apply the alpha blending extraction algorithm.
4. While this extraction process, an output key is asked.
5. If the output key entered matches with the input key, then only the 3-levels frequency components are obtained.
6. Now we apply the inverse DWT to get the extracted watermark with the help of above components obtained and also reconstruct the original medical image.

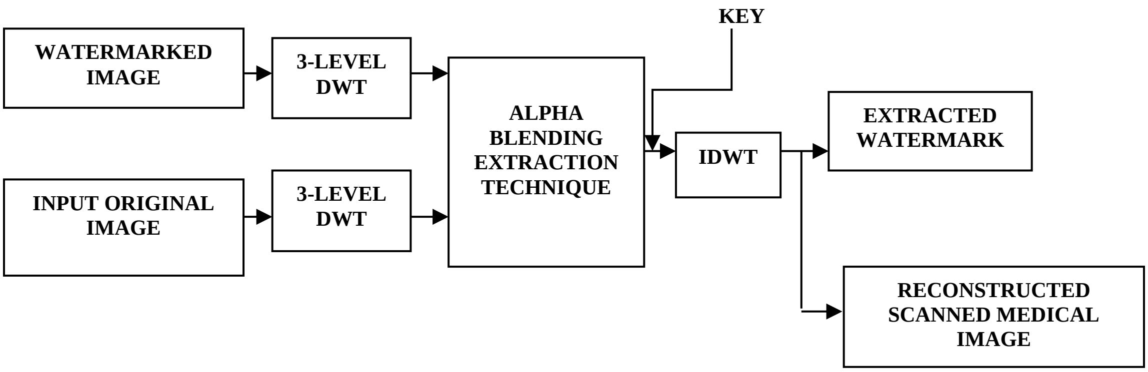


Fig.4. Proposed Watermark Extraction System using Alpha Blending Extraction Algorithm

The detailed functioning of watermark extraction process is given below:

- In this watermarking extraction process, an approach of decrypting/extracting the watermark from the watermarked image/encrypted image is given.
- First the watermarked medical image is read as the input and is converted in to QR code and 3-level DWT is applied to the image which decomposes image into low frequency and high frequency components.
- Second the original image is taken as the input and 3-level DWT is applied to the image which decomposes image into low frequency and high frequency components.
- The output of the DWT is LL, HL, LH and HH band; LL-Approximation Image, HL-Horizontal Image, LH-Vertical Image and HH-Diagonal Image.
- The LL part of the watermark is extracted from the LL part of the watermarked image using alpha blending extraction technique.
- After the above step, an output key is required.
- If the output key entered matches with the input key given at the transmitter, then only the system allows for the generation of the 3-levels frequency components of the watermark image and is generated using the following equations:

$$sec3=LL3-k3$$
$$sec2=LL2-k2$$
$$sec1=LL1-k1$$

- Then IDWT is applied to combine alpha blended image with the other sub-bands and high frequency coefficients to recover the watermark image.

In the same technique, original image is also reconstructed.

The same algorithm is also applied for the medical videos. The algorithm for performing video to frame conversion, watermarking embedding and extraction is described below:

I step: Video to Frame Conversion

- 2-D Medical videos are taken as the input, which may be in mp4, mpg, avi format.
- The input video contains the number of frames
- Read input video using video reader command which reads and stores all the properties of the video
- Initialize the video parameters
- Create empty frames
- Read the frames present in the video
- Since the calculation of DWT values needs a square matrix, frames needs to have a standard size thus resizing of frame is performed.
- Both Original Input video frames and watermarking image are resized
- After Resizing video frames will be transformed as of RGB towards individual components, Red, Green and blue evaluated by way of Channel separation.
- We can convert RGB image into gray scale image.
- For color image watermarking, DWT is performed on each individual R, G, and B components.
- DWT is performed on the Red Channel.
- DWT is performed on the Green Channel.
- DWT is performed on the Blue Channel
- For Gray scale image watermarking DWT is performed on grayscale image.

II step: Watermark Embedding

- First the host image is taken as the input and DWT is applied to the image which decomposes image into low frequency and high frequency components.
- Second the watermark image is taken as the input and converted to QR code and DWT is applied to the image which decomposes image into low frequency and high frequency components.
- The size of the input image is reduced into low size, after the third level of decomposition.
- The DWT is applied to the input image and the output of the DWT is LL1, HL1, LH1 and HH1 band. This is 1-Level DWT
- LL-Approximation Image, HL-Horizontal Image, LH-Vertical Image and HH-Diagonal Image.
- Then IDWT is applied to combine alpha blended image with the other sub-bands and high frequency coefficients to form the watermarked image.
- We can take the patient detail which is in image form as the watermark.
- The watermarked frames are converted into watermarked video by converting back the frames into video using frames to video converter.
- After the embedding process, a key is issued and used in the same way as that of images.

III step: Watermark Extraction

- For extraction process also same procedure is followed above. Instead of alpha blending embedding, alpha blending extraction is followed.

3. Results and Discussion

Performance measures are employed towards verifying the consistency as well as effectiveness regarding the method. Computation about the performance metrics is derived from three factors that contain PSNR, MSE and NCC [10] are as follows:-

Mean Square Error (MSE): Mean Square Error (MSE) is used to analyze the measures the average of the squares of the errors or deviations that is, the difference between the estimator and what is estimated.

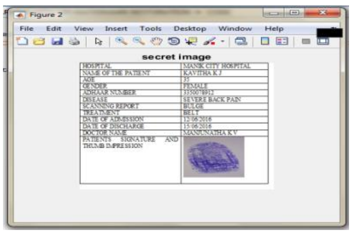
Peak Signal to Noise Ratio (PSNR): Peak Signal to Noise Ratio (PSNR) is generally used to analyze quality of image and video files in dB (decibels). PSNR calculation of two images, one original and an altered image, describes how far two images are equal.

$$\mathbf{MSE} = \sum_{i=1}^{x}\sum_{j=1}^{y}\frac{\left(\left|\mathbf{A_{ij}} - \mathbf{B_{ij}}\right|\right)^2}{\mathbf{x} * \mathbf{y}} \quad \mathbf{PSNR(dB)} = \mathbf{10} * \mathbf{log}\left(\frac{\mathbf{255^2}}{\mathbf{MSE}}\right)$$

Normalized Cross Correlation (NCC): The NCC is used to measure the similarity between the original and extracted logos, and is given by:

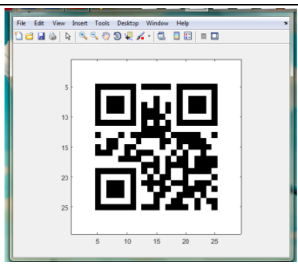
$$NCC = \frac{\sigma_{\mathrm{W},\widehat{\mathrm{W}}}}{\sigma_{\mathrm{W}}\sigma_{\widehat{\mathrm{W}}}}$$

Where **W** and **Wcap** denote the original and extracted logos, respectively; and where σ**W**, σ**Wcap**, and σ**W,** ,**Wcap** denote their sample standard deviations and covariance. NCC values near unity indicate high correlation and thus high robustness. The proposed algorithm is executed in MATLAB 2015a and the parameters are evaluated to check the robustness.



a.

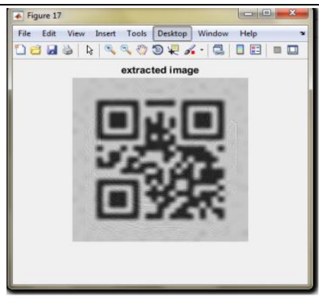
b.



c.

d.

e.



f.

Fig.5. (a) Patient detail(b) Cover Image (c)QR code of (b) (d)Watermarked Image (e) Reconstructed Image (f) Extracted Watermark.

The Fig5 shows the result of the proposed watermarking system. The below table shows the values of the parameters evaluated for the implemented invisible watermarking algorithm. The parameters evaluated for the different sizes of the cover medical image.

Table 1. Original Cover Image and the Watermarked Image When Wm is used as a QR Code

	COVER IMAGE SIZE=256×256 AND WATER MARK IMAGE SIZE=29×29				COVER IMAGE SIZE=512×512 AND WATER MARK IMAGE SIZE=29×29				COVER IMAGE SIZE=1024×1024 AND WATER MARK IMAGE SIZE=29×29			
Q	K=0.8 to 1											
	PSNR	MSE	NCC	NAE	PSNR	MSE	NCC	NAE	PSNR	MSE	NCC	NAE
0.00001 To 0.1	77.2854	0.0012	0.9078	0.0997	77.1175	0.0013	0.9942	0.0997	77.0034	0.0013	0.901	0.997

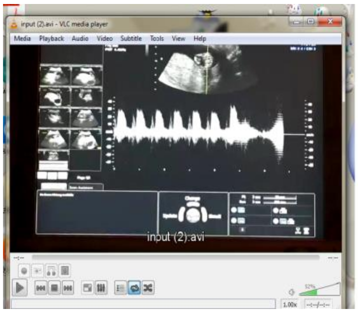
Table 2. Original QR Image and the Extracted QR Image

	COVER IMAGE SIZE=256×256 AND WATER MARK IMAGE SIZE=29×29				COVER IMAGE SIZE=512×512 AND WATER MARK IMAGE SIZE=29×29				COVER IMAGE SIZE=1024×1024 AND WATER MARK IMAGE SIZE=29×29			
Q	K=0.8 to 1											
	PSNR	MSE	NCC	NAE	PSNR	MSE	NCC	NAE	PSNR	MSE	NCC	NAE
0.00001 To 0.1	86.9327	1.31e-4	0.9997	0.0818	94.9866	2.06e-04	0.9999	0.003	100	5.4e-6	1.00	0.002

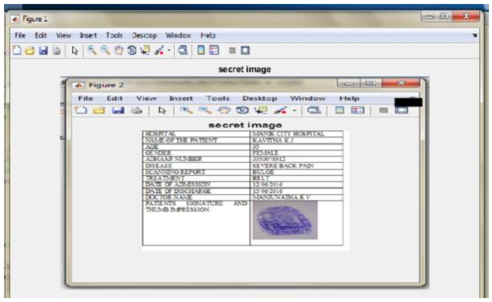
Table 3. WM Image and the Extracted WM Image

	COVER IMAGE SIZE=256×256 AND WATER MARK IMAGE SIZE=29×29				COVER IMAGE SIZE=512×512 AND WATER MARK IMAGE SIZE=29×29				COVER IMAGE SIZE=512×512 AND WATER MARK IMAGE SIZE=29×29			
Q	K=0.8 to 1											
	PSNR	MSE	NCC	NAE	PSNR	MSE	NCC	NAE	PSNR	MSE	NCC	NAE
0.00001 To 0.1	79.498	7.29e-4	0.9981	0.0327	84.015	2.579e-4	0.999	0.0185	90.28	6.059e-5	0.9997	0.0078

The results of video watermarking are as shown below:

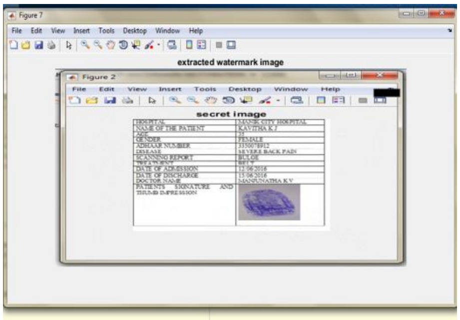


a.



b.

c.



d.

Fig.6. (a) Input Video Frame (b) Watermark (c) Watermarked Video Frame (d) Extracted Secret Image.

In this proposed system, we have embedded QR code of patient details into the medical image and medical videos. A secret key is used at the transmitter which may be a combination of alphabets, numbers and special characters. And also along with this the frequency components are stored in three-levels which enhances the security of the information. While retrieving the information back at the receiver, all this information is required without which it is not possible to perform the extraction process. We have evaluated some of the parameters to check the performance of the system. The comparison is shown between the cover image, watermarked image, QR code, extracted QR code and we can see that the proposed system gives better results. The elapsed time for performing the process is also less and is 72.9 seconds for images and 110 seconds for videos.

4. Conclusion

In this paper a joint watermarking approach based on QR code [9] is proposed for providing the security, authentication of the medical scanning images and medical videos. The algorithm is implemented is using MATLAB 2015a. The system is evaluated and we can see that the maximum PSNR obtained is more than 90 db. And also MSE, NCC and NAE values are reasonable. One of the main advantage of this proposed system is, the same algorithm is applied for images and videos and no need to develop a separate algorithm for videos. In future, we can improve the tolerance of the algorithm by developing some new encryption and QR code generation technologies.

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References

[1] A. Ai-haj, "Combining Cryptography and Digital Watermarking for Secured Transmission of Medical Images," 2016.
[2] C. Engineering and C. Engineering, "A security technique based on watermarking and encryption for MI," pp. 3–6, 2015.
[3] A. Babu, "A Reversible Crypto-Watermarking System for Secure Medical Image Transmission," pp. 1–6, 2015.
[4] C. Su, J. Huang, C. Shih, and Y. Chen, "Reversible and Embedded Watermarking of Medical Images for Telemedicine," pp. 145–150, 2015.
[5] M. S. Hassanein, "Secure Digital Documents Using Steganography and QR Code," no. November, 2014.
[6] D. Cho, "A Study on Effective Digital Watermarking Method Suitable for QR code," vol. 51, pp. 94–97, 2014.
[7] J. Waleed, H. D. Jun, S. Saadoon, and S. Hameed, "An Immune Secret QR-Code Sharing based on a Twofold Zero- Watermarking Scheme," vol. 10, no. 4, pp. 399–412, 2015.
[8] J. Chen, W. Chen, and C. Chen, "Identification Recovery Scheme using Quick Response (QR) Code and Watermarking Technique," vol. 596, no. 2, pp. 585–596, 2014.
[9] L. Laur, P. Rasti, M. Agoyi, and G. Anbarjafari, "A Robust Color Image Watermarking Scheme Using Entropy and QR Decomposition," vol. 24, no. 4, pp. 1025–1032, 2015.
[10] N. I. Yassin, N. M. Salem, and M. I. El Adawy, "Medical Video Watermarking Scheme for Electronic Patient Records," vol. 76, no. 1, pp. 12–17, 2013.

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