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# A Medical Image Watermarking Technique for Embedding EPR and Its Quality Assessment Using No-Reference Metrics

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***Abstract*****—** Digital watermarking can be used as an important tool for the security and copyright protection of digital multimedia content. The present paper explores its applications as a quality indicator of a watermarked medical image when subjected to intentional (noise, cropping, alteration) or unintentional (compression, transmission or filtering) operations. The watermark also carries EPR data along with a binary mark (used for quality assessment). The binary mark is used as a No-Reference (NR) quality metrics that blindly estimates the quality of an image without the need of original image. It is a semi-fragile watermark which degrades at around the same rate as the original image and thus gives an indication of the quality degradation of the host image at the receiving end. In the proposed method, the original image is divided into two parts- ROI and non-ROI. ROI is an area that contains diagnostically important information and must be processed without any distortion. The binary mark and EPR are embedded into the DCT domain of Non-ROI. Embedding EPR within a medical image reduces storage and transmission overheads and no additional file has to be sent along with an image. The watermark (binary mark and EPR) is extracted from non-ROI part at the receiving end and a measure of degradation of binary mark is used to estimate the quality of the original image. The performance of the proposed method is evaluated by calculating MSE and PSNR of original and extracted mark.

***Index Terms*****—** No Reference, Quality Measurement, EPR (Electronic Patient Record), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR)

## I. Introduction

Digital information management in hospitals, HIS (Hospital Information System), and its special cases of RIS (Radiology Information System), PACS (Picture Archiving and Communication System) forms the information infrastructure of modern health care [1]. On the other hand, these advances have introduced new risks for inappropriate use of medical information circulating in open networks, given the ease with which digital content can be manipulated [2]. Medical images need to be kept intact in any condition and prior to any operation, thus need to be checked for integrity and verification. It therefore becomes important to prevent unauthorized manipulation and misappropriation of such digitized images. To solve these issues, digital watermarking came as an emerging technology for medical image authentication, security, confidentiality and copyright protection [2]. But on the other hand watermarking of medical images has some hard requirements to be followed. One such hard requirement is that image should not undergo any degradation such that it affects the reading of images for diagnostic purpose [3]. The images must be kept perfectly without any loss of information, that is, the watermark should not introduce any visible distortions in the image. *For example, the typical shape of a healthy ECG signal is well known to cardiologists. Any deviation from that shape is usually considered to be a symptom of a pathological case* [4].

Medical imagery is a field where integrity and confidentiality of content is a critical issue due to the special characteristics derived from strict ethics, legislative and diagnostic implications. Medical image watermarking means embedding the patient information within the medical image. Moreover, the exchange of medical images is done through un-secure open environment like Internet which results in the following issues of concern [5]:

1. Authentication: A proof that information belongs to correct patient and is issued from the right source.

2. Integrity: Information has not been modified by un-authorized users.

3. Confidentiality: Only entitled users have access to the information.

These issues gained marginal attention due to the availability of large number of image processing software's which can easily copy or modify the images. Thus medical images can easily be copied or tampered with for illegal purposes, for example getting fake health insurance claim from some insurance company. Also tampering of medical images may cause serious results in treatments. Hospitals, insurance companies, as well as patients might want to modify the image for various reasons. *For example, micro calcification in mammography is an important diagnostic clue, and it can be wiped of intentionally for insurance purposes or added intentionally into a mammography. Similarly malignant tissues on thorax CT scan images are important clue for cancerous patients and they can also be modified for illegal purposes* [6].

With these reasons preventing medical images from forgery has become very important issue. In recent researches medical image watermarks are used to authenticate (trace the origin of an image) and/or investigate the integrity (detect whether changes have been made) of medical images [3]. They are of two types: Robust and fragile watermarks. A fragile watermarking scheme detects any manipulation made to a digital image to guarantee the content integrity while a robust scheme prevents the watermark removal unless the quality of the image is greatly reduced. For our method, the watermark has to be semi-fragile and ideally it should degrade at around the same rate as the host image.

The present work is motivated by the method proposed by Nakhaie et. All in 2011 [7], where the binary mark is generated and embedded into the DCT domain of the Non-ROI and is used as a No-Reference Quality Metric. The binary mark is obtained by taking the 8th bit plane of the third level DWT of the ROI part. This binary mark is embedded in the DCT domain of the non-ROI. But in this method, no space is left for embedding other sort of information. In the present work, binary mark generation method is altered so that EPR data can also be embedded along with the binary mark.

This paper is organized as follows: Section 2 illustrates proposed scheme including embedding and extraction procedure. Section 3 presents the results and experiments. Conclusion and future scope are given in the final section.

## II. Proposed Method

The block diagram of proposed method is shown in Fig.1.A sample MRI medical image of size 128x128 is taken as a host image. Since the embedding is done in the DCT domain by dividing image into 8x8 blocks, the input image is preprocessed by padding additional rows and columns if it is not a factor of 8. The original image is divided into two sub-images called ROI and non-ROI parts. ROI part is determined by a mask whose precise size is determined by a specialist .So we have:

$$o(i,j) + x(i,j) + y(i,j) \quad \textbf{(1)}$$

Where $o$ is the host image, $x$ is the ROI part and $y$ is the Non-ROI part. The indices $i$ and $j$ corresponds to the horizontal and vertical positions. This is illustrated in Fig. 2.

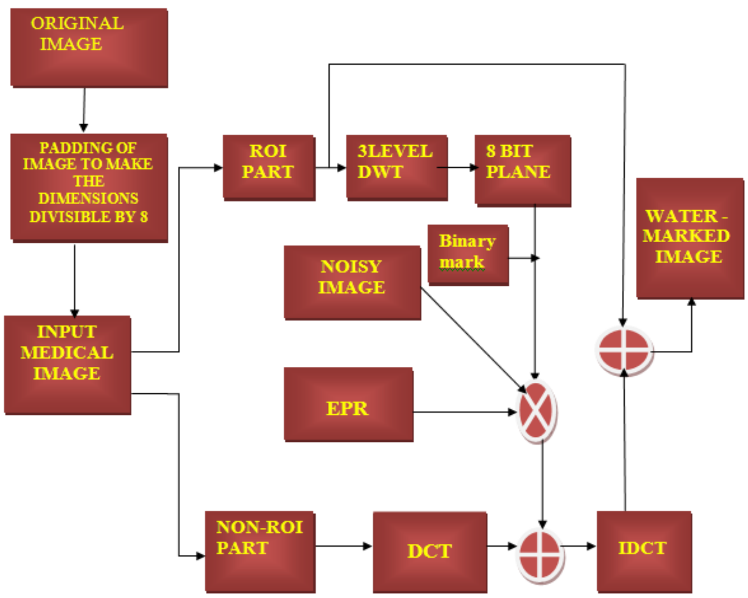



Fig 1: Block Diagram of Proposed Method

### 2.1 Dividing the Original Image into ROI and NROI parts:

The steps for separation of ROI and NROI parts are described below:

- Take an original medical image.
- If the dimensions of image are not divisible by 8, then padding of image is done using padarray () command to make the image dimensions factor of 8.This is because embedding is done in DCT domain by dividing the image into 8 x 8 blocks.

- Perform roipoly() command on it for separating ROI and NROI parts as shown in Fig. 2
- The size of ROI-I as shown in Fig. 2(c) part is 128 x128 which is same as that of size of original image and no space left for embedding other information. To solve this problem, ROI-II (as shown in Fig. 2(d)) is selected to create space embedding some other information (like EPR) in DCT domain of Non-ROI part. So, to select ROI-II for the purpose of watermark generation, following steps are followed:

1) Select an arbitrary shaped ROI, from input image.

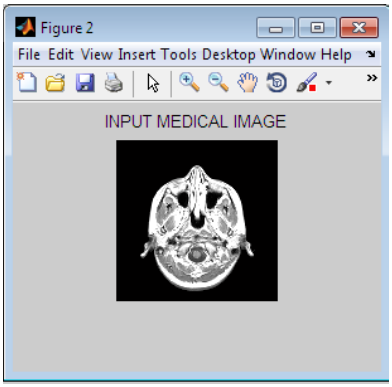
2) Find minimum and maximum coordinates of the arbitrary shaped ROI in x and y axis.

3) Determine sx= xmax - xmin and sy = ymax-ymin.

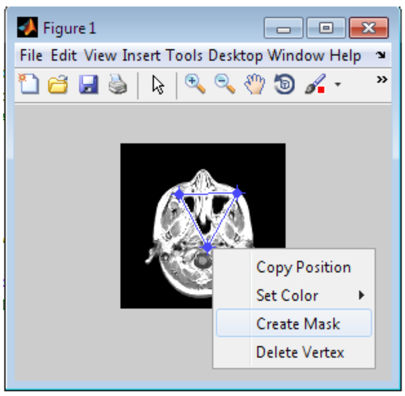
4) Generate a matrix of zeros of dimension sx and sy, sufficient enough to store the arbitrary shaped ROI information.

5) Embed the selected portion into generated matrix to obtain ROI-II image as shown in Fig. 2(d), having size 41x38 which is very small as compared to ROI-I.

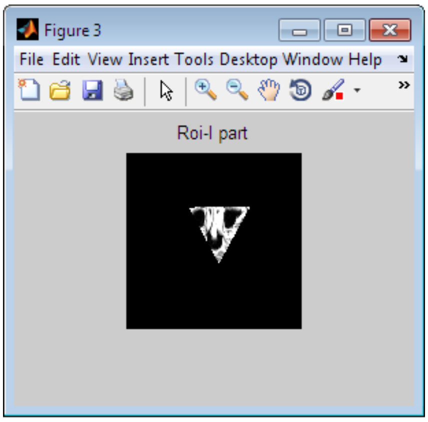
6) The binary mark is created from ROI-II and thus, sufficient space is left for embedding patient's information (EPR).



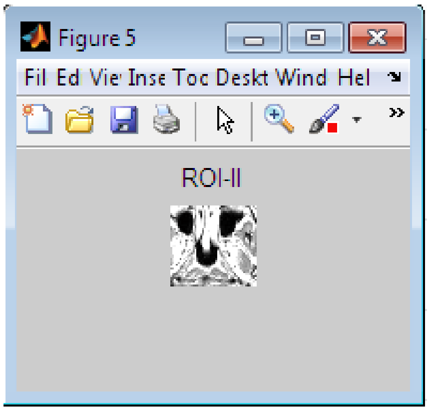

a) MRI



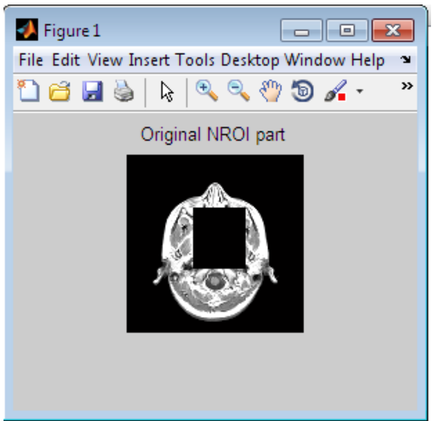

b) ROI Selecting




c) ROI-I part of size 128x128




d) ROI-I part of size 41x38




e) Non-ROI image

Fig. 2: Procedure of dividing original image to ROI and non-ROI parts

## 2.2 Binary Mark Generation

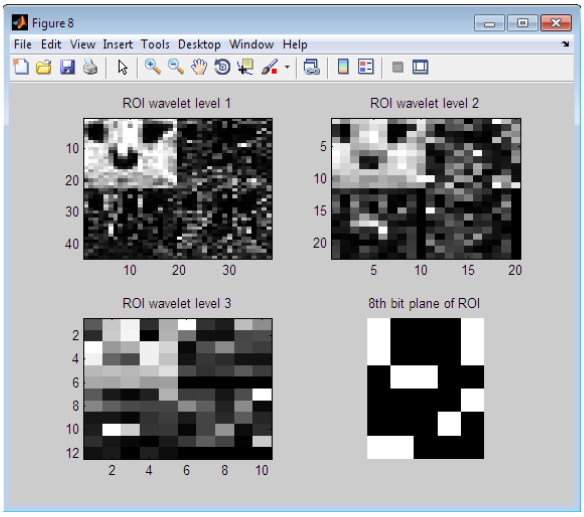
Perform 3-level discrete wavelet transformation on ROI-II image and take its 8th bit plane to make an initial binary mark called m as shown in Fig.3 (a).

**m (i , j ) =**

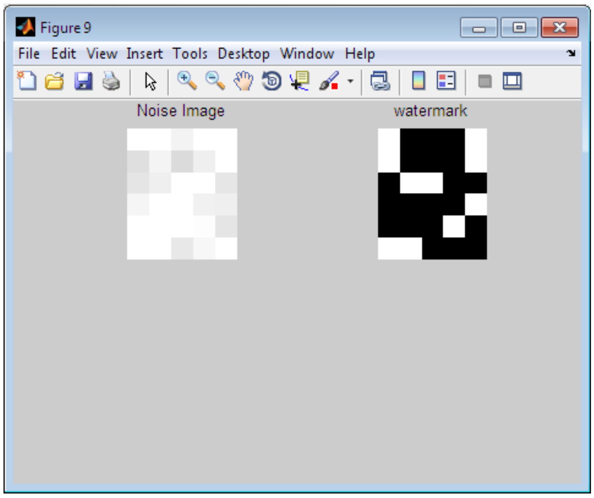
**8th bit-plane of (3-level DWT of (ROI image)) (2)**

In fact, 3-level wavelet transformation of the image is done to construct an initial mark which has a smaller size than original image. The initial mark could be any binary image because the final mark is a multiplication of initial mark and a pseudo random image. A pseudo-noise generator is used to generate a pseudo random image called p=p (i, j) with values -1 and 1, with a zero mean and Gaussian distribution. The final mark (as shown in Fig. 3(b)) is obtained by multiplying the initial mark image, m, by the PN image p using:

$$\mathbf{w(i,j)=m(i,j)*p(i,j)} \qquad \mathbf{(3)}$$




a)




b)

Fig. 3: a) Initial mark construction, b) Binary mark

### 2.3 Embedding Procedure

The embedding process is described step by step as follows:

- Embed watermark (final mark and EPR) into DCT transform of non-ROI part of image.
- EPR includes Patient_Id, Age, Gender, Doctor_ Id, Blood Pressure, Sugar Level and Recommended treatment of the patient as shown in Table 1.This EPR is embedded along with final mark in DCT domain of Non-ROI part to generate a watermarked image. The format for EPR is shown in Table 1.

Table1: Sample EPR (Electronic Patient Record)

| P_Id | Age | G | D_Id | BP | Sugar | Recommended Treatment |
|---|---|---|---|---|---|---|
| 5 char | 2 char | 1 char | 4 char | 6char | 3char | (Max storage capacity of NROI-(size of watermark+ 21*8))bits |

- To embed the watermark and EPR into the NROI part of the medical image, we have to process the image into the blocks and DCT is applied on each block. The watermark is spread over the whole image but not embedded directly.
- In this MRI image, Non-ROI part is of size: 128x128.Maximum storage capacity of Non-ROI part: [(128*128)/square of (8)] i.e. 16384/64=256 bits. Size of final mark: 6x5 i.e. 30 bits. Capacity left in NROI: 256-30= 226 bits i.e. 226/8=28 characters. So, 28 characters can be embedded in addition with final mark in the Non-ROI part .This means that there are total 256 blocks in Non-ROI part. In first 30 blocks, watermark bits are embedded into each block. After 30th DCT block, EPR is embedded in continuation of final mark.
- The watermark bits are spread into each block of DCT domain and then it is transformed back into the spatial domain.
- After that the ROI part is added into the inverse DCT of watermarked NROI part to obtain a final watermarked image.

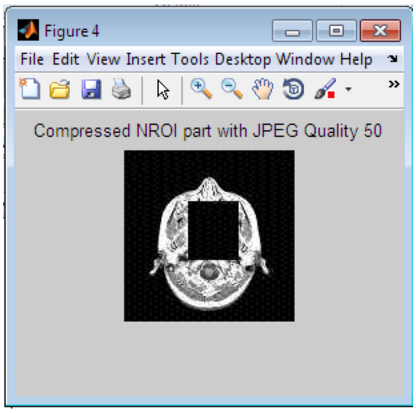
## III. Compression of watermarked NROI part using JPEG Compression Algorithm

Compress the Non-ROI part in different qualities for storage intentions or to be transmitted over communication channel for telemedicine applications while preserving an appropriate quality level. Images can be compressed by lossy or lossless compression algorithm. In case of medical image, the region of interest (ROI) must be compressed by lossless or near lossless algorithm to prevent from wrong diagnosis due to poor image quality. But Non-ROI, due to less importance can be compressed by either lossless or lossy compression algorithm. *The steps for compression of Non-ROI part with watermark embedded in it are:*

- Compress the NROI image using JPEG Compression Algorithm with different JPEG quality levels i.e. from quality 1 to 100 to construct a compressed image.
- At Quality level-10 we get a distorted image but as its quality level increases we obtain an image of good quality with invisible distortions as clear from Figure4 where an image compressed with JPEG quality 50 has invisible distortions.

Compressed Image with JPEG quality 50




Compressed Image with JPEG quality 10

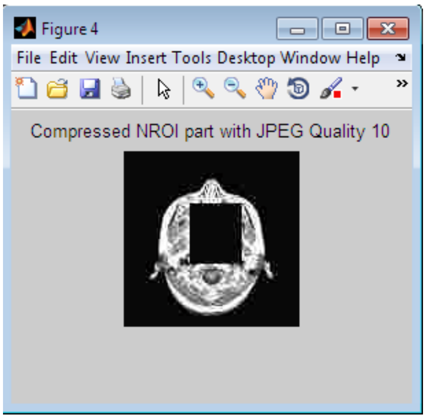



Fig. 4: Compressed NROI part with different JPEG quality

## IV. Watermark Extraction

Extraction of watermark (binary mark and EPR) from the Non-ROI part is described step by step as follows:

- Subtract ROI from received image to obtain NROI part with watermark embedded in it. The process of original watermark extraction is done from the inverse transformation of an image.
- The image is again processed in blocks and each block is transformed using DCT. The middle band coefficients are extracted and are stored as middle band sequence.
- The correlation between the middle band sequences with PN-sequences is calculated and the value with the higher correlation for watermark is selected and stored. All the blocks of the image are processed in this way.
- Final mark as shown in Fig. 5(a) and Embedded EPR are recovered from the Non-ROI part of the watermarked image as shown in Fig. 5(b).
- Then MSE and PSNR between original and extracted watermark is calculated and a measure of its degradation is used to estimate the quality of original image by presenting No-Reference Quality Metrics.
- The extracted EPR is matched with the embedded EPR; if both are same then it is clear that an image has not been distorted.

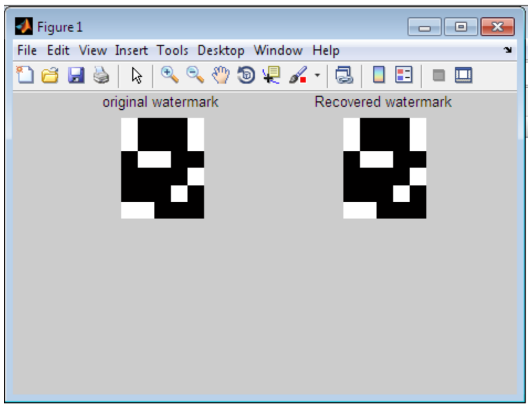



Fig. 5: a) Original and Recovered Watermark,

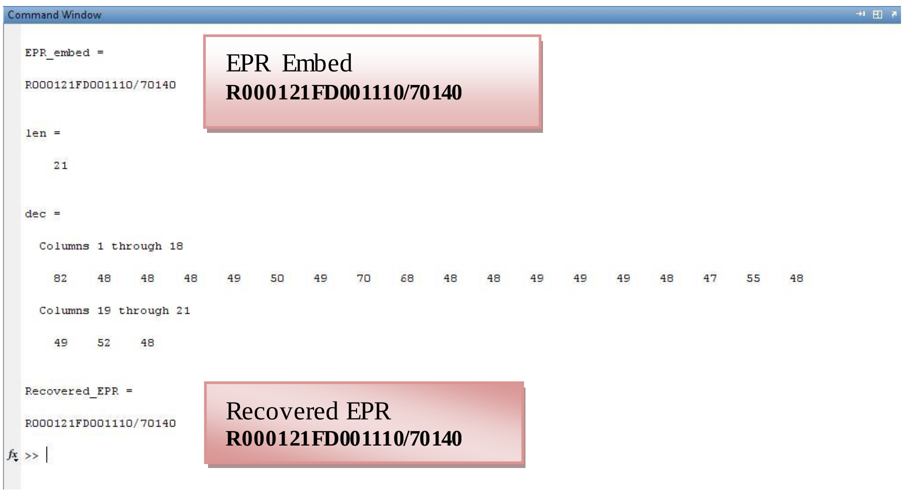



Fig. 5: b) EPR recovered from watermarked image

## V. Results

Ten medical images are taken from the database. The performance of the proposed metric is measured by performance evaluation metrics-MSE and PSNR between original and extracted mark as shown in Table 2.The results for MRI image are shown below.

Table 2: Comparison of PSNR, MSE, watermark and EPR recovered or not between Original and Recovered Watermark for image1

| JPEG quality | PSNR | MSE | Watermark Recovered | EPR Recovered |
|---|---|---|---|---|
| 10 | 15.6308 | 2.41E+03 | No | Not Exact |
| 20 | 15.6393 | 2.41E+03 | Yes | Not Exact |
| 30 | 15.6527 | 2.41E+03 | Yes | Recovered Exactly |
| 40 | 15.6628 | 2.41E+03 | Yes | Recovered Exactly |
| 50 | 15.6694 | 2.40E+03 | Yes | Recovered Exactly |
| 60 | 15.7325 | 2.40E+03 | Yes | Recovered Exactly |
| 70 | 15.7629 | 2.40E+03 | Yes | Recovered Exactly |
| 80 | 15.8314 | 2.40E+03 | Yes | Recovered Exactly |
| 90 | 15.8329 | 2.40E+03 | Yes | Recovered Exactly |
| 100 | 15.9325 | 2.40E+03 | Yes | Recovered Exactly |

Results show that PSNR of original and extracted mark increases with an increase in JPEG Quality and MSE decreases with an increase in JPEG Quality. It means that watermark degrades with degradation of whole image and is used as a No-Reference Quality Metric which blindly estimates the quality of an image. At JPEG quality level 10 and 20, Electronic Patient Record (EPR) is not recovered exactly. But from Quality level 30 to 100, we recovered the EPR exactly as embedded in NROI part of the image which proves the authenticity of an image.

MSE and PSNR of the extracted mark are a good approximation of degradation of whole image which is done by JPEG compression algorithm at different quality levels-1 to 100.

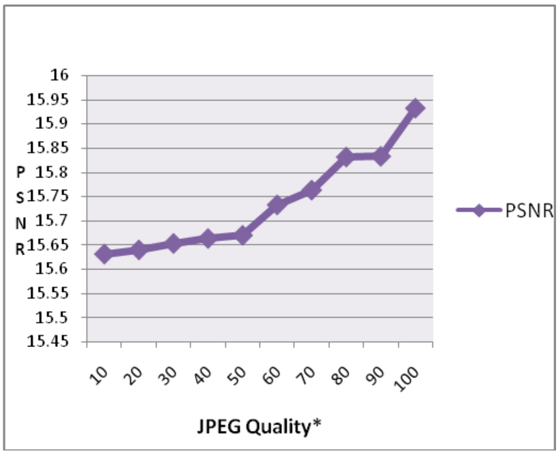



Fig. 6: PSNR between Original and Recovered Watermark for image1

Fig.6 shows that PSNR increases with an increase in JPEG quality level. Thus there is positive correlation between PSNR and JPEG quality. The less the amount of errors caused by processing, compression or transmission, the smaller MSE is. On the other hand, the more degraded the image, the higher MSE is as shown in Figure 7.Therefore, the measure given by MSE can be used as an estimation of the degradation of the original image.

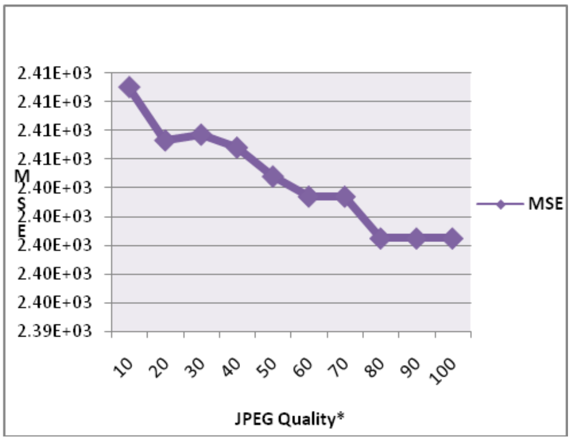



Fig 7: MSE between Original and Recovered Watermark

## VI. Conclusion

The main idea of this paper is presenting a watermarking method using discrete wavelet transform based on ROI processing which is appropriate for No Reference quality measurement. In this method, watermark which is embedded into the DCT domain of Non-ROI part of an image has got two parts – a binary mark and EPR data. The binary mark is a semi- fragile in nature and therefore when medical image is subjected to intentional or unintentional operations, the mark degrades at around the same rate with degradation of host image. Thus it can be helpful in judging the quality level of any medical image. The Non-ROI of the image was subjected to JPEG compression at different quality levels and the degradation of the extracted binary mark is analyzed using performance evaluation metrics- PSNR and MSE. The PSNR has positive correlation with JPEG quality. Thus performance metrics shows a good approximation of degradation of whole image. In the proposed work, an attempt is also made to embed EPR along with the binary mark. The EPR is recovered exactly when the image is stored at JPEG quality 30 or more. The EPR provides authentication and confidentiality of the patient data. Also, embedding EPR within the image saves storage space and reduces bandwidth requirements while transmission.

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