COMPRESSION IN IMAGE RECOVERY WATERMARKING USING PNG (PORTABLE NETWORK GRAPHIC)

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ABSTRACT

Medical image is a very important material in medical world. A medical image is able to control and judge a life of human. Therefore the messages that keep inside the medical image must be protect well to avoid tragedy. Watermarking is a process that back up and protect the information of the in the medical image. An image is divided into two parts ROI (Region of Interest) which is an area that holding important process and RONI (Region of Non Interest) which is the area that is black in color in the medical image. In the process of watermark, all the information is compressed to reduce the size for storing purpose. Compression method plays a role in watermark process. Once the capacity of storage is limited, the smaller the size the information, the more information can be store. Lossless compression method is the first choice for the research due to same quality of the image will be produce after compressed. The type of lossless compression method will be tested and the better compression method which is holding the lowest value of compression ratio will be chose. TALLOR (Tamper Localization and Lossless Recovery) is use in the research. The important information in ROI will be compressed and embed in RONI. After the process of embedding is end, the watermarked image is tested with the PSNR (peak signal-to-noise ratio) to calculate the similarity of the image before and after watermarked. A high value of PSNR value is preferred which is in the range of 35.0 dB to 55.dB.

ABSTRAK

Imej perubatan adalah satu bahan yang sangat penting dalam dunia perubatan. Satu imej perubatan dapat mengawal dan menilai kehidupan manusia. Oleh itu mesej yang menyimpan di dalam imej perubatan mesti dilindungi baik untuk mengelakkan tragedi. Penanda air adalah satu proses yang membaiki dan melindungi maklumat dalam imej perubatan. Imej dibahagikan kepada dua bahagian ROI (Region of Interest) yang merupakan kawasan yang mengadakan proses yang penting dan RONI (Region of Non Interest) yang merupakan kawasan yang berwarna hitam dalam imej perubatan. Dalam proses penanda air, semua maklumat yang dimampatkan untuk mengurangkan saiz untuk menyimpan tujuan. Kaedah pemampatan memainkan peranan dalam proses penanda air. Apabila ruang penyimpanan terhad, saiz maklumat yang menjadi kecil membernakan maklumat yang lebih untuk menyimpan dalam RONI. Kaedah pemampatan 'Lossless' adalah pilihan pertama untuk penyelidikan kerana kualiti imej yang sama dengan imej sebenarnya akan dihasilkan selepas mampat. Pelbagai jenis kaedah mampatan 'Lossless' akan diuji dan kaedah pemampatan yang terbaik yang memegang nilai terendah nisbah mampatan akan dipilih. TALLOR (Tamper Localization and Lossless Recovery) adalah digunakan dalam penyelidikan. Maklumat yang penting dalam ROI akan dimampatkan dan menerapkan dalam RONI. Selepas proses menerapkan berakhir, imej yang dijalankan process tanda air akan diuji dengan PSNR (peak signal-to-noise ratio) untuk mengira persamaan imej sebelum dan selepas process tanda air. Nilai PSNR yang baik adalah berada dalam lingkungan 35.0 dB ke 55.dB.

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ROI: Region of interest

RONI: Region of non-interest

TALLOR: Tamper Localization and Lossless Recovery

PSNR: Peak signal-to-noise ratio

CHAPTER 1

INTRODUCTION

1.1 DIGITAL IMAGE AND ITS LIMITATIONS

With the appearance of hand phone, digital image can be easily created by everyone and with the appearance of internet, everyone can upload and download image from internet. By using the image editing software, every type of image can be easily edited by everyone. Therefore many images is being embezzle for commercial use and creating rumor that affected the image owner.

Medical imaging is a technique and process used to create images of the human body for clinical purposes or medical science. Medical image is use by a doctor to check the body of the patient. It is important for a patient to know more details about their body current health. Normally hospital will not keep two medical images as a backup therefore if someone intends to edit or tamper it. The original information will be loss. If the doctor using the wrong information in the operation, the body health for the certain patient is imperil.

For security, a method that use for protect the image is use which is watermarking. This method can prevent the modification of the image and have ability to recover the tampered image.

1.2 DIGITAL WATERMARKING

Digital watermarking is a kind of method that uses data to embed in a picture or audio. The purpose for this method is to protect the data and also to identify ownership of the copyright. Watermarking is a process to embed or hide some information into a specific picture or audio data. There are two type of water marking which is visible and invisible. Visible watermarking embeds a symbol, word or logo that known as a visible material into a data to show copyright such as a company logo is edited in a picture. Invisible watermarking hides some information in a data that is impossible to view it with naked-eye such as medical picture and money. Invisible water marking is closely related to the field of steganography which the information is hidden and can be retrieved later. Steganography is the art and science of hiding information by embedding messages within other, seemingly harmless messages. Steganography works by replacing bits of useless or unused data in regular computer files (such as graphics, sound, text, HTML, or even floppy disks) with bits of different, invisible information. This hidden information can be plain text, cipher text, or even images.

Since a digital copy of data is the same as the original, digital watermarking is a passive protection tool. It just marks data, but does not degrade it nor controls access to the data. A complete watermarking can store the data, detect for tampered and recover it to the original data that contain 99% similarity.

1.3 COMPRESSION METHOD

In the world of computer science and information, data compression is a very useful method to reduce the bit-rate of a data (image, video, file, etc) from the original data to store. Data compression is useful because it can help people to save data storage and reduce the usage of resource. But once the data is compressed, it needed decompressed to be run again. Compression method is categorized into lossy and lossless.

Lossy data compression is a data encoding that reduce the quality of the data in the compression process, by the word it can be known as losing some of the data. The aim of the lossy compression is to minimize the amount of data to be saved and handled. Lossy compression is very common to use in multimedia data. Medical image is very important to deliver data or message to patient and doctor therefore watermarking in lossy compression is not an ideal choice. This is because all information in the medical image very important, it must be precise and complete.

Figure 1: Example of the lossy compression.

Lossless data compression is a type of data compression that can reconstruct the compressed data with the exactly original data. It is different with the lossy compression method because it can remain the original quality of the data. For example, ZIP file format is one of the lossless data compression. The aim of the lossless data compression is to remain the original quality of the data, it is normally use for the important data such as medical image, executable programs, text documents, and source code. Some image file

formats, like PNG or GIF, using lossless compression. Lossless compression is required for text and data files, such as bank records and text articles. Therefore it is important to use this method in the medical image watermarking which can produce and protect the original data in the medical image.

1.4 MEDICAL IMAGE WATERMARKING

Medical image watermarking is a kind of marker covertly embedded in a medical image to protect the original data and avoid the image from tampering. Modification of medical image is prohibited therefore watermarking method is apply on the medical image for protection of real data.

Watermarking that uses lossy compression method is to insert the watermark in the least significant bits (LSBs) of the image pixel that change the original pixel value of the image. Another issue with this method is the quality that using this method is slightly lower than the original medical image because this method provides approximate recovery.

Another new method of watermarking is using the lossless compression method which can recover the edited medical image for a better result that is approximate 100% same as the original medical image. The technique is to embed the watermarking into the least significant bits of the image. Since the last binary bits are the least significant bits, its modification will not perceived by human eyes. This technique is not as robust as transform domain techniques and rarely survives various attacks (S.C. Liew, Jasni M. Z. ,2010). A medical image is divided into two region which are ROI (Region of Interest) and RONI (Region of Non Interest). Once the ROI is defined, watermark is embedded in the RONI (Region of Non Interest). When the ROI is modify or destroy, the watermark in RONI can be retrieved and recover the ROI. Another method would be using the whole image for watermarking where imperceptible modification of the pixels is done (S.C. Liew, Jasni M. Z. ,2010). One of the problem with this method is the ROI has its limitation which is the area for protection is not large enough. Further research on this method will be carried out to ensure that larger ROI can be protected.

1.5 RESEARCH AIM:

The aim of this research is to improve the area for implementations of tamper localization and recovery watermarking schemes for medical images with compression method.

1.6 RESEARCH OBJECTIVES:

There are two research objectives:

i) To develop image recovery watermarking scheme using compression method

ii) To test watermarking scheme on ultrasound images

1.7 RESEARCH OUTCOMES

i) The development of image recovery watermarking scheme using compression method

ii) The testing of watermarking scheme on ultrasound images

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter introduces watermarking in details. It consists of 6 sections 2.2 that explain about general image watermarking. Section 2.3 that about compression in image watermarking. Section 2.4 about the Region and Interest and Region of NON-Interest and section 2.5 about watermarking in medical image. Section 2.6 is compression ratio and section 2.7 is watermarked medical image quality test.

2.2 GENERAL IMAGE WATERMARKING

Watermarking is a process to keep or hide some important information into a data such as picture, video and audio. It provides copyright protection to data (image) to declare rightful ownership. There are four essential factors to determine the quality of watermarking which are robustness, imperceptibility, capacity and blind watermarking Robust is a measure of immunity of watermark against attempts to image modification and manipulation like compression, filtering, rotation, scaling, collision attacks, resizing, cropping. Imperceptibility means quality of host image should not be destroyed by presence

of watermark. Capacity includes techniques that make it possible to embed majority of information. Blind Watermarking: is the extraction of watermark from watermarked image without original image is preferred because sometimes it's impossible to avail original image (B.L. Gunjal, 2010).

There is classification of the watermarking technique such as the type of domain, the visibility of watermark, and the ability of the watermark to resist attack and watermark detection and extraction.

2.2.1 DOMAIN

There are two type of domain that can explain how the watermark is embedded which is spatial domain and transform domain. Spatial domain is a watermarking technique that embed watermark in the LSB (Least Significant Bits) of the RONI. AS changing 1 unit of greyscale medical image is hard to realize by a human eye. Another type is transform domain that embed watermark into the transform coefficients of the cover image. (S.C. Liew, J.M. Zain, 2010).

2.2.2 VISIBILITY OF WATERMARK

There are two type of watermark which is visible and invisible. The information that can be seen by human eye is known as visible such as a company logo is embedded in a company product image. Invisible information that hides in the image such as medical image is another type of visibility that human cannot see it directly by eye and it is needed to retrieve out by certain algorithm. (B.L. Gunjal, 2010).

2.2.3 ABILITY OF WATERMARK RESIST ATTACK

Fragile watermark embedded in an image is destroyed when modification is done on the watermarked image which may indicate that the integrity of the image had been compromised. It may not able to distinguish between malicious attacks and incidental manipulations like JPEG lossy compression (Piva et al., 2005). Semi-fragile watermarks can survive certain degree of legitimate manipulation such as compression and cropping. (S.C. Liew, 2011)

2.2.4 WATERMARK DETECTION AND EXTRACTION

There are two types of watermark detection and extraction which are blind watermarking and non-blind watermarking. Blind watermarking is the data can be extract without the presence of the original data while non-blind watermarking requires that original image to exist for detection and extraction whereas blind techniques do not require original image. (B.L. Gunjal, 2010).

2.3 MEDICAL IMAGE WATERMARKING

Transmission of medical image through internet and mobile needed special security and protection because critical judgment is done on the information provided by medical images. Exchange of medical image between different hospital at different places (as shown in the figure below) is a common activity now a day (B. L. Gunjal, S. N. Mali, 2012). M. B. Kulkarni and R. T. Patil (2012) stated that the exchange of medical images through insecure network like Internet provides the possibility of changes in medical image

therefore reversible watermarking scheme in medical image for tamper detection and recovery is important.

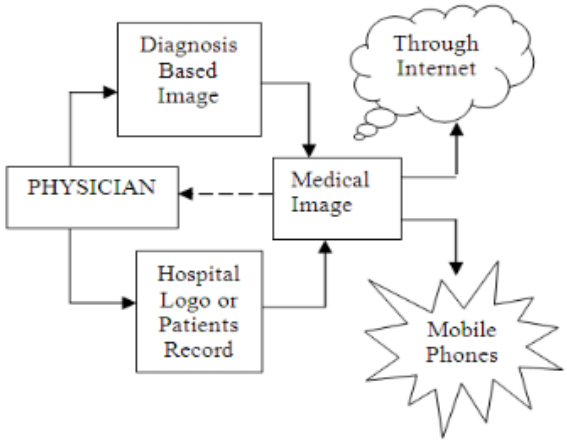

Figure 2: Transmission of medical images from physician of remote hospital to specialist through internet and mobile phone.

Medical image is divided into two parts which are ROI and RONI. The useful information is embedded in the RONI part since the RONI part does not contains any important information. The spatial domain technique (LSBs) is used for reversible watermarking as the removed information is restored in other part of the image. When tamper is detected the data is retrieve from the RONI part and recover the medical image to its original state. (M. B. Kulkarni, R. T. Patil, 2012).

2.4 COMPRESSION IN IMAGE WATERMARKING

Compression is a method to reduce the bit-rate of a data from original data for storing purpose. Lossless compression is one of the compression method that can reconstruct the exacted data back to the original data. This method is suitable for medical image because every details part in the medical image is importance in the process of

diagnosis. (Shih and Wu, 2005). There are many type of lossless compression such as RLE, lossless JPEG, Huffman Coding and Arithmetic coding.

Run-length encoding (RLE) is a simple lossless data compression algorithm. It replaces the sequences of the same data values by a count number and a single value. For example, RRRRRRLLLLLEEEEEERRRRRLLLLLEEE , if we apply RLE on the line of word, it interprets as 6R5L6E5R5L3E which mean six R, five L, six E, five R, five L, three E. The run-length code represents the original 30 characters in only 12. The actual format used for the storage of images is generally binary rather than ASCII characters like this, but the principle remains the same. RLE has a very simple algorithm as compare to other compression techniques but RLE will only work best if it is being applied to images that have large number of identical successive bits such as bitmap files.

Joint Photographic Experts Group (JPEG) standard is commonly used for lossy compression for digital images. The degree of compression can be adjusted, allowing a selectable tradeoff between storage size and image quality. JPEG typically achieves 10:1 compression with little perceptible loss in image quality. A JPEG file can be created by specifying the degree of compression needed. The highest image quality has the largest file size and vice versa. JPEG has an option to allow lossless compression. JPEG2000 standard which is a wavelet based was developed in year 2000 to replace the original DCT based JPEG standard. The aim of JPEG 2000 is not only improving compression performance over JPEG but also improving features such as scalability and editability.JPEG 2000 has advantages over the original standard such as compression performance.

Huffman Coding is technique used to compress files for transmission. This method is proposed by Dr. David A. Huffman in 1952 for construction of minimum redundancy codes. It applicable to many forms of data transmission for example text files. Huffman coding is a form of statistical coding. Arithmetic coding is another compression technique that is different with Huffman Coding. It is more complex but more powerful than Huffman Coding in terms of compression ratio.

Compression method is applied to image watermarking. The usage of JPEG by encoding ROI part of medical image and embed into RONI part in gray-scale image. (S.C. Liew, J.M. Zain, 2010). Patient's data. Hash message of ROI, ROI pixel. LSB of border pixel is compressed using Huffman coding in grey-scale image watermarking process. (Osamah M., B.E. Khoo, 2010). Arithmetic coding is use to compress the location map to facilitate the extraction of the watermark. (Weng et al. , 2007).

2.5 ROI AND RONI

The medical picture is divided into two part ROI (Region of Interest) and RONI (Region of Non Interest). ROI is the part that contains important information therefore watermark is usually being embedded in the RONI part as this region does not contribute in the process of diagnosis. The ROI and RONI part needed to be defined before the process of watermark embedding start.

2.6 COMPRESSION RATIO

The rate of Compression method is tested by compression ratio which is defined as.

Compression Ratio = Compressed Data/ Uncompressed Data

The compressed data represent the bits after the data compressed while the uncompressed data represent the bits before the data compressed. The value of compression ratio is nearer to zero value show that the compression method is good.

2.7 WATERMARKED MEDICAL IMAGE QUALITY TEST

Quality of watermarked image can be tested by PSNR (peak signal-to-noise ratio). It is measured in decibels (dB). First of all, the similarity of the image before and after watermarked is measure by fidelity. High fidelity means that the reconstructed image is quite similar to its original image and the other way round. The invisible watermark shows a high fidelity while the visible watermark shows a low fidelity. One way to quantify distortion is the mean-square error. This is defined as:

$$MSE = \frac{1}{n}\sum_{i}^{n}(I_i' - I_i)^2$$

I represent the original image while *I'* represent the watermarked image. MSE is the average term by term difference between the original and watermarked image. The problem with mean-square error is that it depends strongly on the image intensity scaling and while PSNR rectifies this problem by scaling the mean-square error according to the image range (Smitha and Navas, 2007). PSNR is defined as below:

$$PSNR(dB) = 10\ log_{10}\frac{\max I^2}{MSE}$$

Max *I* represent the peak value of the original image. Assume that both image before and after watermarked are identical, value of MSE is equal to 0 hence the value of PSNR is equal to infinity. The high value of PSNR can prove that the image is high fidelity. Human unable to observer the minor different from the image before and after watermarked. (S.C. Liew, 2011)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter is explains about what step and procedure is carry on during the research, hardware and software used and Gantt chart for the research. Section 3.2 is explains about the research methodology used in this chapter. The explanation included Tamper Localization and Lossless Recovery (TALLOR) and compression. All the hardware and software used is listed in section 3.3. Section 3.4 is showing Gantt chart during the research.

3.2 RESEARCH METHODOLOGY

3.2.1 Type of Compression Method

The research is about the compression method that use in the watermarking process which is tamper localization and recovery watermarking schemes for medical images. There are two types of compression method which are lossy and lossless compression method. Medical image is an important image that can provide useful information to medical staff. Every procedure during operation must be precise therefore lossless compression method is chosen in the watermarking process due to lossless compression

method can recover the compressed information approximately 100% same as the original copy. With this, the information is protected and safe to use.

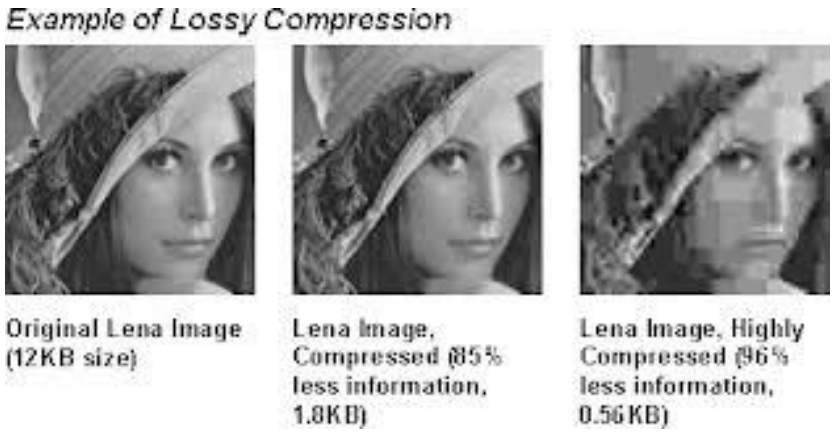

Figure 3.1: Example of lossy compression

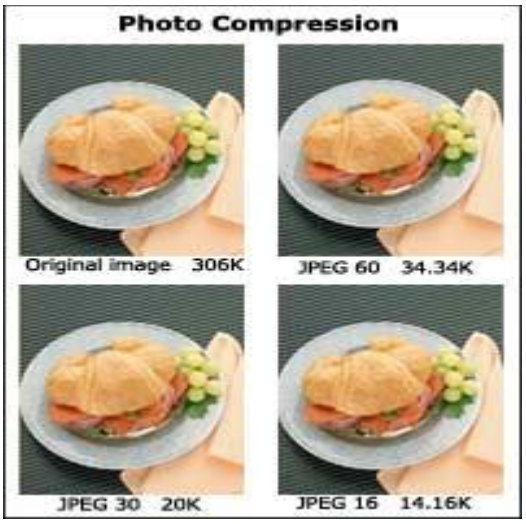

Figure 3.2: Example of lossless compression

3.2.2 Medical Image

Greyscale medical image is chosen for the research. Medical image is divided into two parts, ROI (Region of Interest) and RONI (Region of Non Interest). ROI is the region that provides important and useful information while RONI is region that does not provide any message or information for medical staff. Therefore, the information of ROI is compressed and hides in RONI which is black in color. All the size of greyscale medical image is fixed which is 600 x 480 pixels therefore the area for RONI is also fixed. With the same and fixed area, we can use compression method to store more information therefore larger part of the ROI region is protected.

Figure 3.3: Example of the ultrasound image

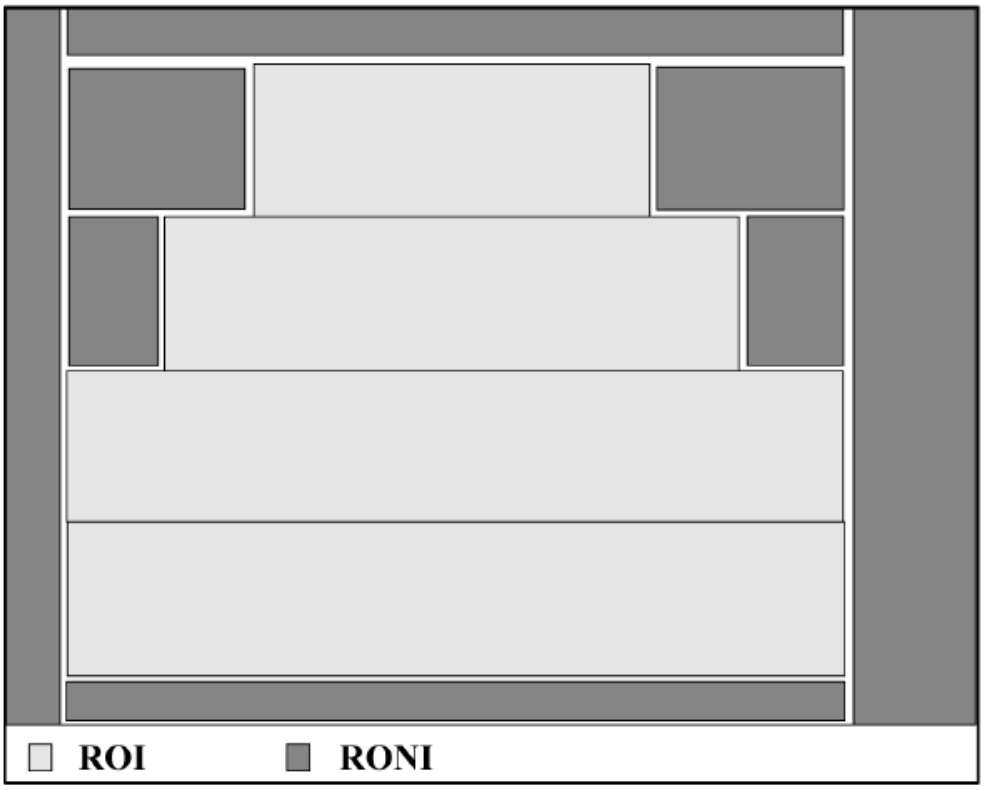

Figure 3.4: Area of ROI and RONI

3.2.3 Compression Method

There are many type of lossless compression method, for example Huffman coding, arithmetic coding , RLE, JPEG and LZW. All of this compression method can compress and reconstructed the exact original data from a compressed data. They are using different algorithm for same purpose which is reduces the size and remains the quality of the data. The smaller the size the more information can be store. For example in medical image, the RONI part is fixed therefore the size for compressed ROI is main problem, the smaller the size of ROI the more information can be store at RONI. Therefore the choice of compression method is the main key to maximize the area of ROI cover. This will be clearly show by compression ratio.

Compression Ratio = Compressed Data/ Uncompressed Data

The value of compression ratio is smaller (closer to zero), the better the compression method. For example, the compression ratio for compression method X and Y is 0.4 and 0.8 respectively, X consider as better compression method (assume the image quality is same).

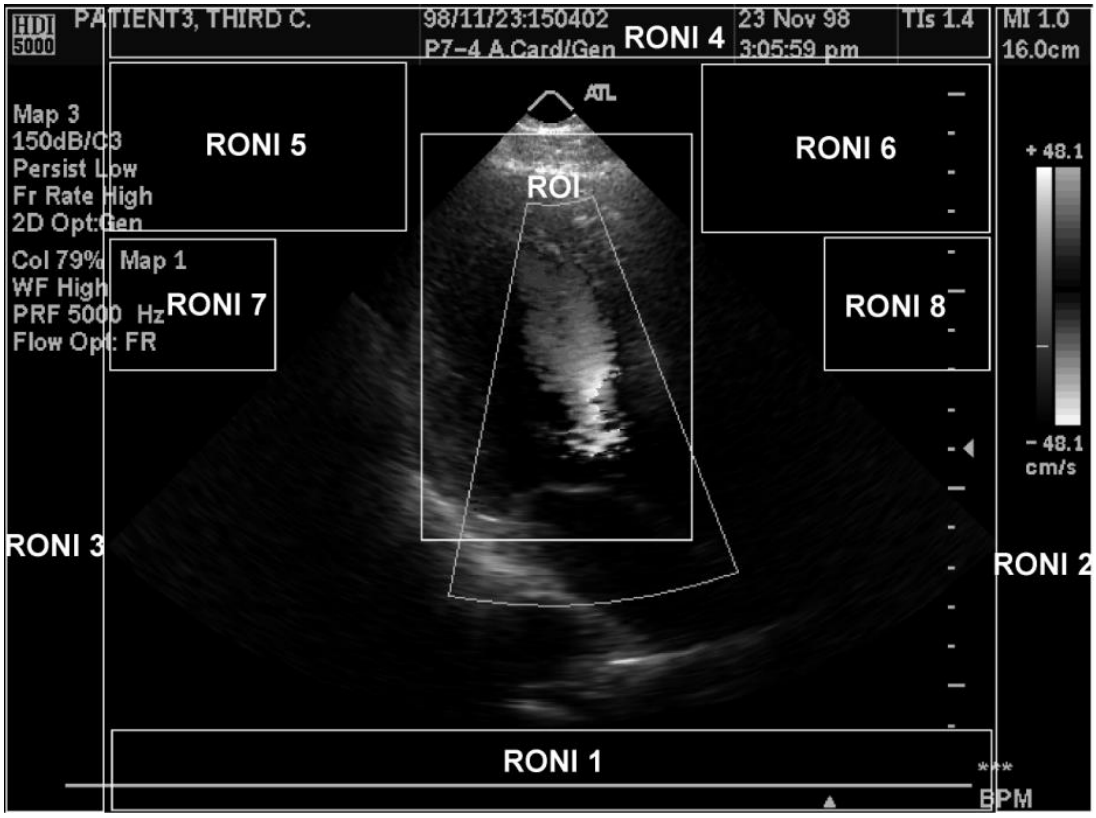

Figure 3.5: Ultrasound image that divided into ROI and RONI

Figure 3.3 and 3.5 clearly show that the total area of RONI is larger than total area of ROI. For embed the ROI region into RONI region all the pixel that represent the ROI region need to be store. The RONI region is larger than ROI region, but only the LSB and second LBS of the pixel is used for storing purpose. Therefore, the ROI region to be store and protect is limited. For example, there are 30000 pixels for RONI region but only 2 bits can use for store information so 60000 bits is free to use. If ROI region pixel is 100 x 100 pixels (80000 bits), the bits of RONI region is not enough for ROI region to hide information therefore compression method is needed to reduce the size of ROI region.

3.2.4 Tamper Localization and Lossless Recovery (TALLOR)

The way to fulfill the requirement is to compress the ROI region into a compressed file and embedded in the RONI. SHA-256 is used to hash the compressed file before it is being embedded in the RONI. The hash value can be used to authenticate the compressed file and other more secure hash function may be use. The hexadecimal hash value will be embedded in the RONI together with the compressed file.

In the tamper localization process, the compressed ROI region is retrieved and hashed again with the hash function that use in embedding process (Hash B). The hash value before embedding known as hash A. Hash A and B is compared, if a positive result is shown means that the RONI region had not been tampered. The retrieved ROI compressed file from RONI region is decompressed and form pixel values in block. The current pixel values of ROI (ROI A) are compared with the pixel value that retrieved from the decompressed ROI file (ROI B). The exact tampered pixel will be localized if any difference is found between ROI A and ROI B. Tampered pixel will be replaced by the original pixel (from ROI B) according to their position.

3.2.5 Testing

Figure 3.6: Example of medical image with highlighted ROI part

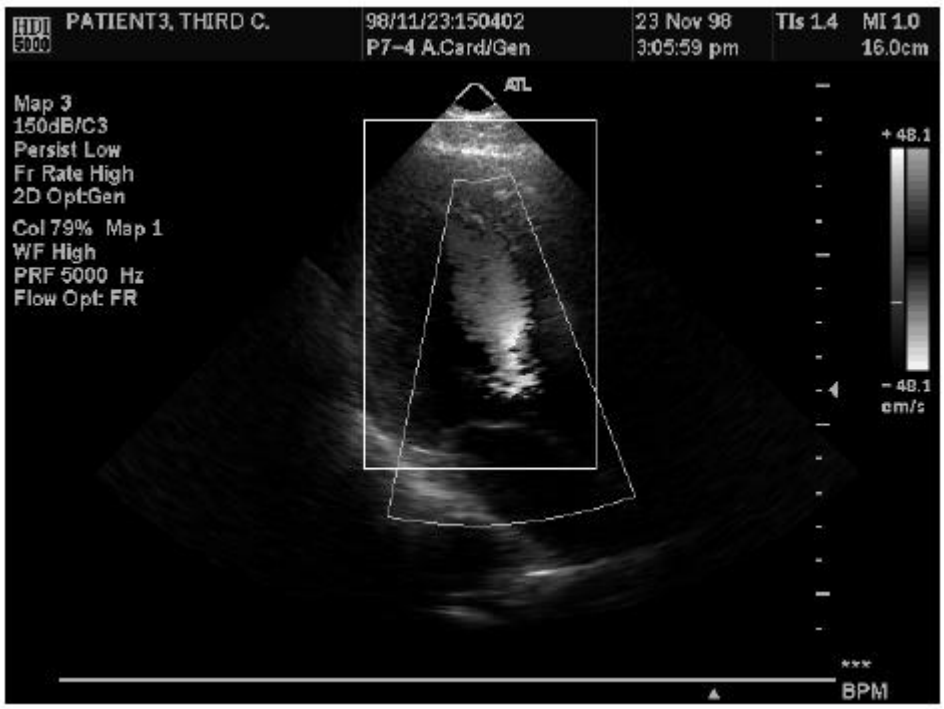

Figure 3.7: Example of medical image with highlighted ROI part

The same area of ROI and RONI region is use carry out the experiment with different compression method by using TALLOR process. All total 8 rectangle regions as shown in figure 3.5 is fixed with is 143,400 pixels while the ROI are is fixed by using 160 x 240 pixels. The bits of RONI region that ready for embed is 286,800 bits while ROI region is 307200 bits.

Before embedding the ROI region is compressed to a smaller compressed file and compression ratio is calculate. After embedding, the quality of the watermarked image is test with PSNR (peak signal-to-noise ratio). High PSNR value means that the watermarked image is more similar to the original image. A value from range between 30dB to 50dB is preferred and can assume as a nice quality of watermarked image.

3.2.6 Expected result

Different compression method will use for testing and a compression method with low compression ratio value which can produce a high PSNR value will be choose. Therefore the outcome of the research will be a watermarking process by using compression method.

3.3 HARDWARE AND SOFTWARE

3.3.1 Hardware

Hardware is one of the important tools in develop a research. With the help of hardware the research can be carry out more efficiency.

Table 3.1: Hardware and function

Hardware	Function
Laptop with internet service	Develop the research Prepare the research report Search for information through website
Printer	Print research report, log book
USB Device	Save the data as a backup storage and transfer data from computer to computer

3.3.2 Software

Software specification is also one important tool use to develop this research.

Table 3.2: Software and purpose

Software	**Purpose**
Microsoft Word 2010	Prepare documentation
Microsoft Power Point 2010	Prepare slide presentation
Microsoft Project 2010	Prepare Gantt Chart
Matlab R2008b	Coding for watermarking
Image J	Use to display the image and result

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter is about research result and discussion. It consists of 6 sections 4.2 that show embedding process and Section 2.3 that show the retrieving process in early stage. Section 2.4 is about the compression method. Result for TALLOR is explained in section 2.5 and section 2.6 is about the result for ROI enlargement.

4.2 EMBEDDING PROCESS

In the embedding process, I have tried a simple algorithm to save the bits into RONI. 7^{th} and 8^{th} bits are chosen for the testing purpose. This is easier to proof whether the bits (data) is successful embed into the ultrasound image. In the testing process, bits number '1' is embedded in 7^{th} bit and 8^{th} bit. 2 bits in a pixel is use for embed in RONI, therefore 1 pixel of ROI is needed 4 pixel of RONI for embed purpose (1 pixel contains 8 bits). 4 pixel of RONI is combined to form a block therefore the embedding process is executed block by block.

Example code for embedding process:

```
block(r,c)=bitset(block(r,c),7,1);

block(r,c)=bitset(block(r,c),8,1);
```

The result show as below, an obvious white dot is show above the alphabet ‘S’ in the ultrasound image. This can proof that my test us successful and the bits will save on 1st bit and 2nd bits in the real project to avoid human to see or read the data by naked eye.

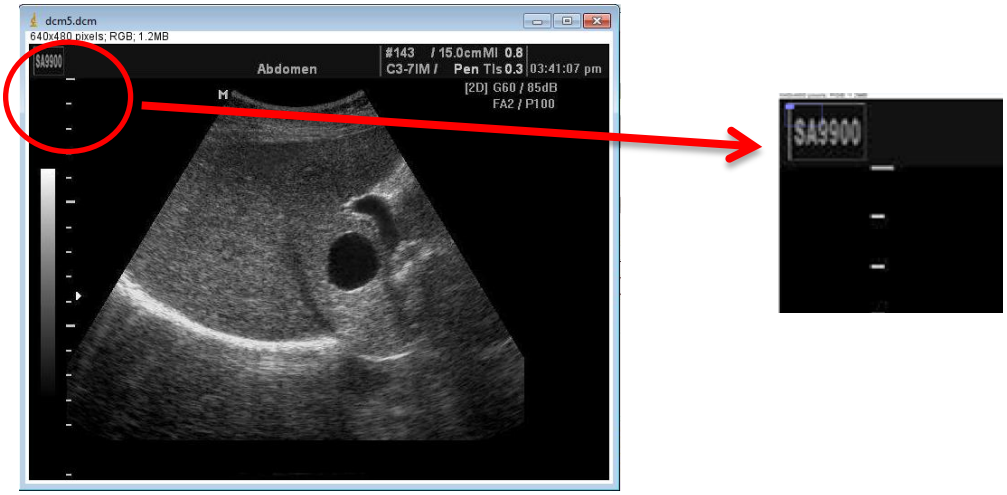

Figure 4.1: Ultrasound image before embedding process

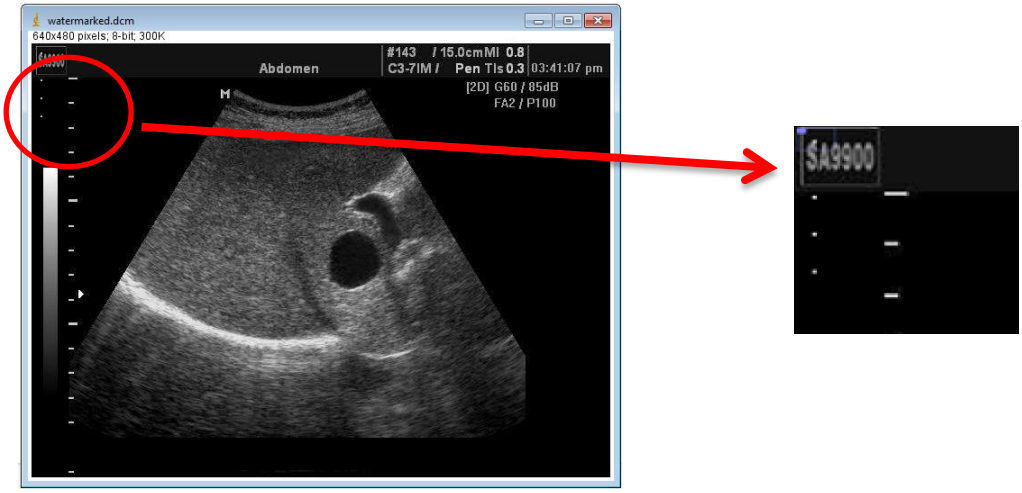

Figure 4.2: Ultrasound image after embedding process

4.3 RETRIEVING PROCESS

In the retrieve process, I have modified the actual coding to show the result follow by the embedding process just now. Example code for retrieve process :

```
retrievebits=bitget(block(r,c),7);
retrieveblock=[retrieveblock retrievebits];
retrievebits=bitget(block(r,c),8);
retrieveblock=[retrieveblock retrievebits];
```

Below is the result that the matlab command window show, the retrieve block is retrieve the block according to the block that I embed in the previous process

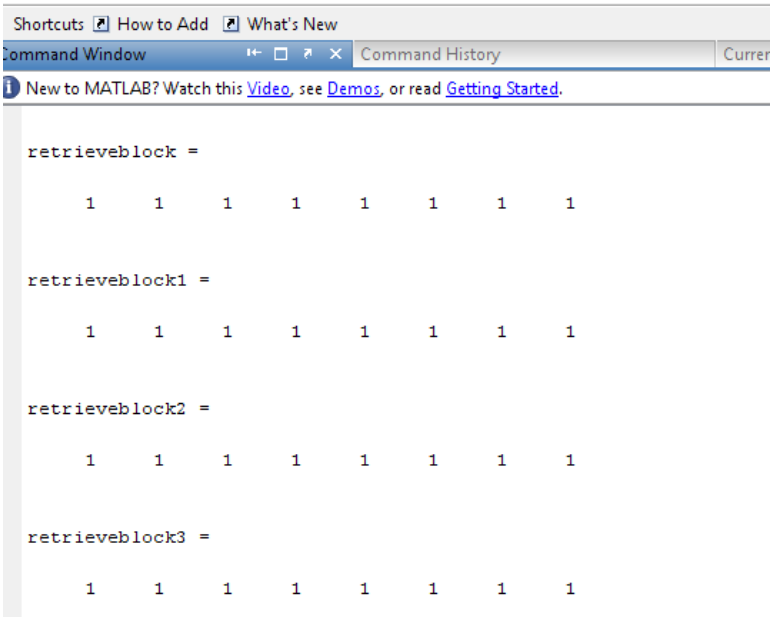

Figure 4.3: Output data of retrieving process

4.4 COMPRESSION

Compression method also include in the watermarking process which are Portable Network Graphics (PNG), Graphics Interchange Format (GIF) and Joint Photographic Experts Group (JPEG). All of the compression methods produce different result and output during and after the process. Some of the compression method is built in in matlab software therefore different parameter is chosen for different compression method. Another compression method is from external source, after modification the compression is implemented into the watermark coding and tested.

At the early stage, coding is tested manually, try and error since all the coding is not completely created. The table shows the result by using different compression method using a same photo. All of the compression method show positive result (compression ratio lower than 1).

Table 4.1: Result for image compression by using different compression method

Compression	Type	Input (pixels)	Output (length of pixels)	Compression ratio
Portable Network Graphics (PNG)	Lossless	307200	63697	0.2073
Graphics Interchange Format (GIF)	Lossless	307200	90284	0.2939
Joint Photographic Experts Group (JPEG)	Lossless	307200	91866	0.2990
PNG and JPEG	Lossy	307200	Compress(143737) decompress(20829)	0.0678

According to table 4.1, there are different outputs generated by different compression method. Compression ratio is the main output that can identify the strength of the compression method. From the data above, PNG compression method show the lowest compression ratio among the lossless compression method therefore PNG is the best compression method among the lossless compression method. On the other way, Lossy compression method can show a lower compression ratio compare to lossless compression method but the main disadvantage that using lossy compression method is the some of the data is loss therefore not 100% of data is remain after compress. The high quality of lossy compression method is chosen for research therefore there is hard to differentiate the changes of the compressed image with the original image by human eye.

Watermarking process (Embedding and Retrieving bits from image) and compression method is tested separately therefore the last step is to combine them together to process an ultrasound image to get the output (watermarked image) and calculate the result with PSNR and also the recovered image (to test whether the bits that save in the watermarked image can successfully retrieve).

The original and watermarked images for each compression method are shown and compare for the figure below.

Original Image

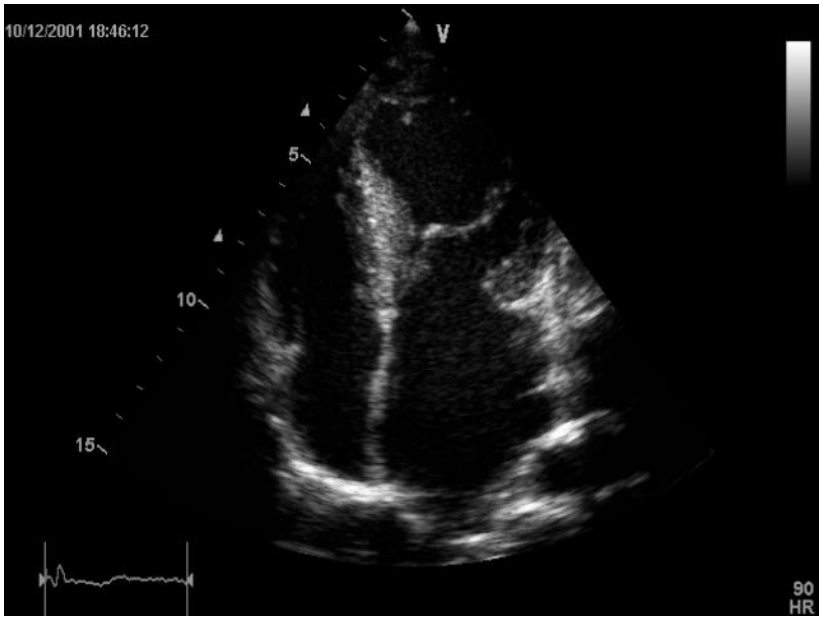

Figure 4.4: Original ultrasound image

GIF compression (Lossless)

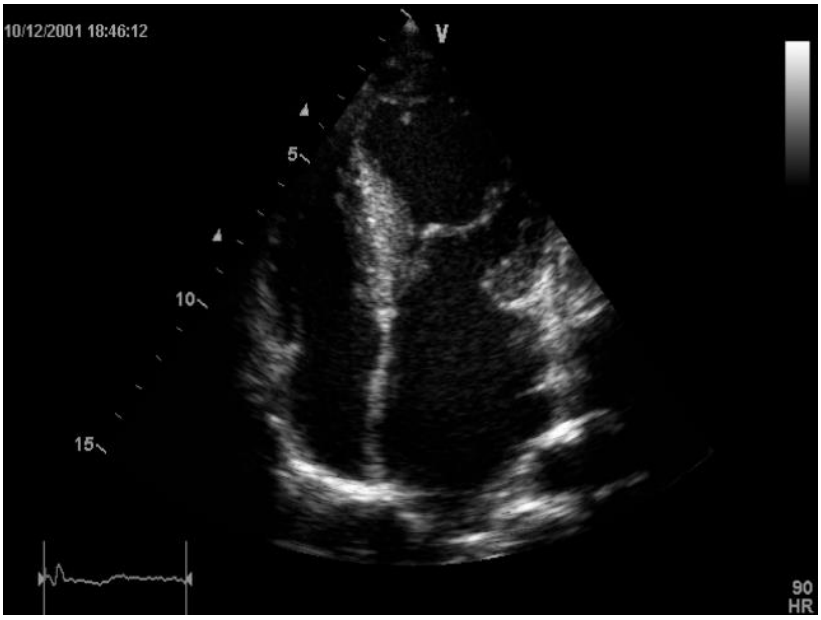

Figure 4.5: Ultrasound image compressed by GIF compression method

PNG compression (Lossless)

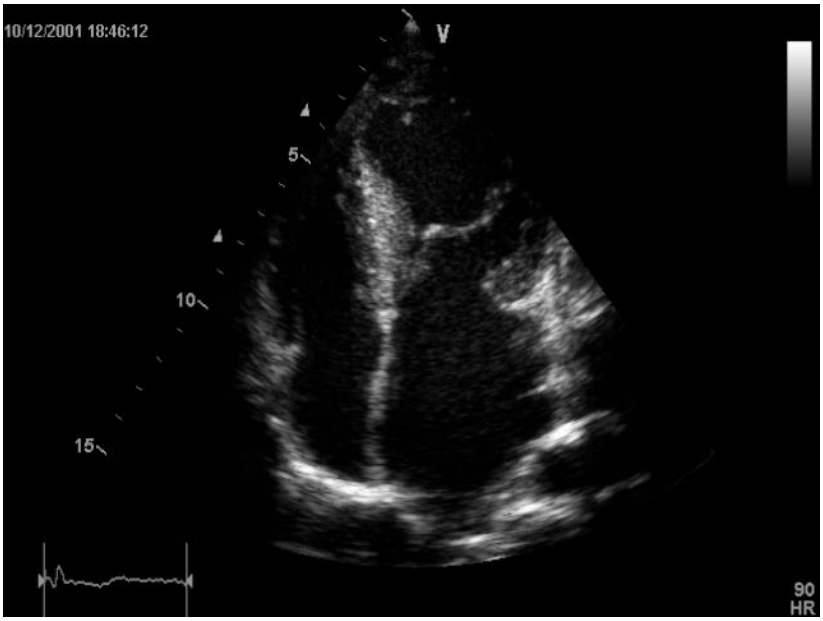

Figure 4.6: Ultrasound image compressed by PNG compression method

JPEG (Lossless)

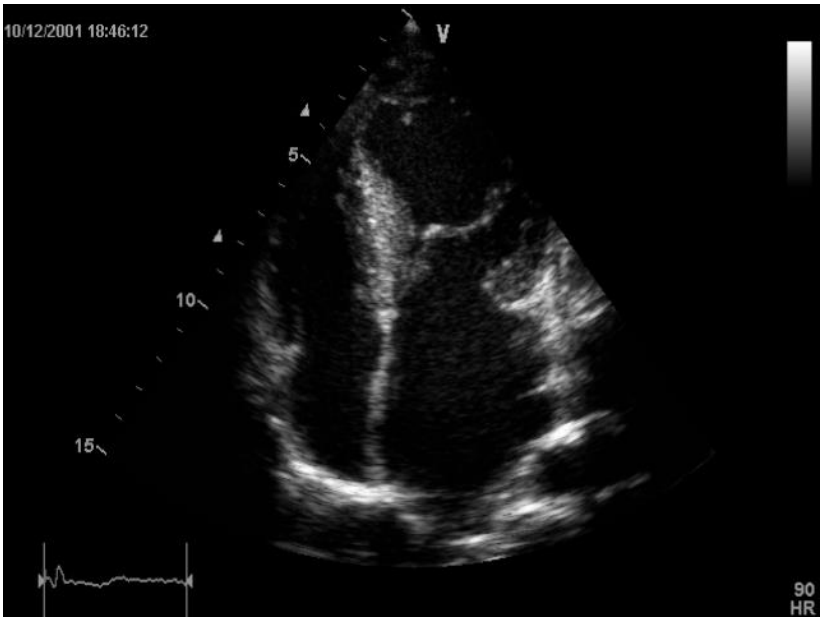

Figure 4.7: Ultrasound image compressed by JPEG compression method

Combination of png and lossy jpg (Lossy)

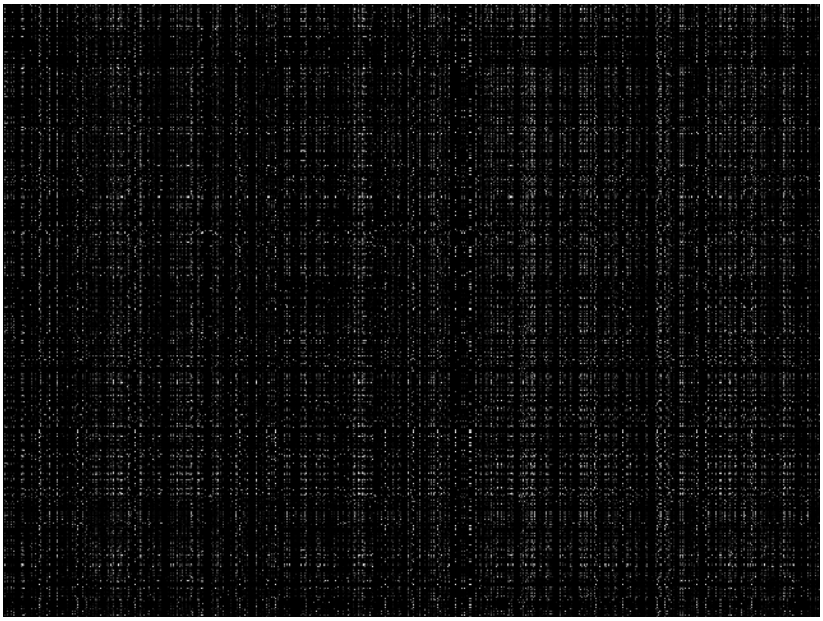

Figure 4.8: Ultrasound image compressed by PNG compression method

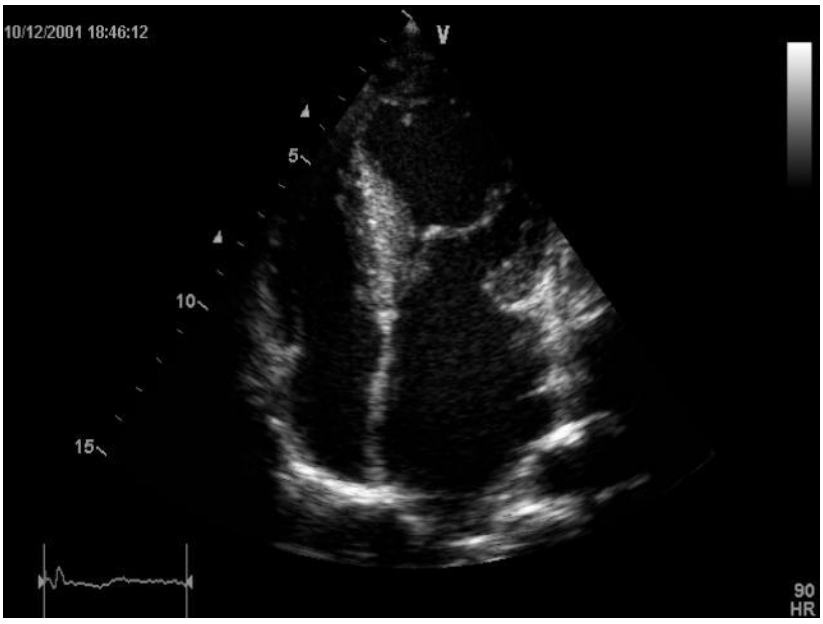

Figure 4.9: Ultrasound image decompressed by lossy JPEG compression method

Zoom in Comparison (using ImageJ)

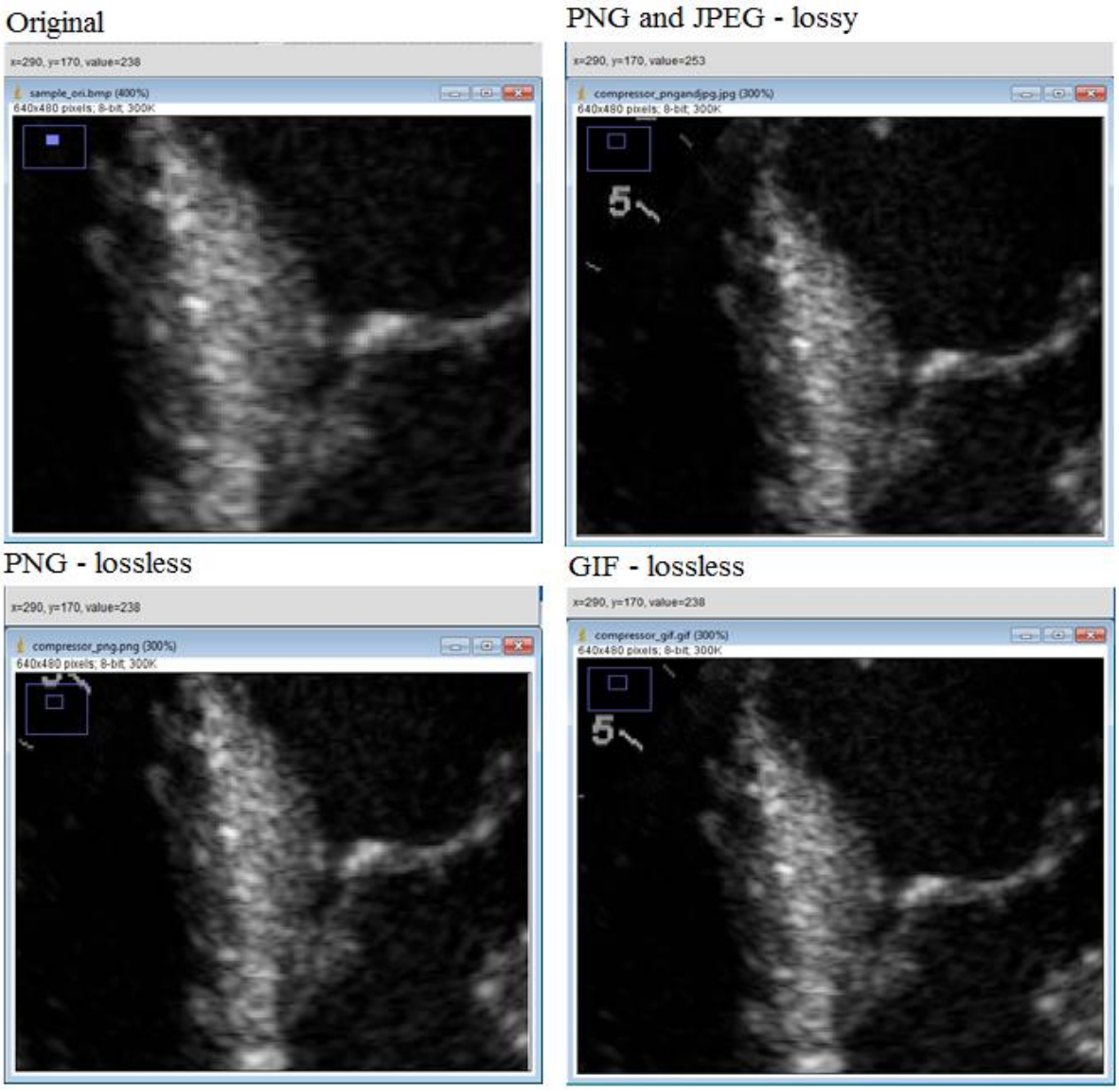

Figure 4.10: Comparison of pixel value show by four ultrasound images

Coordinate (290,170) is chosen for pixel value comparison, Image above show that the lossless compression method can produce image that show the same pixel value as original image (238) while lossy compression method show the slightly different pixel value compare to the original image which is 253.

4.5 TAMPER LOCALIZATION AND RECOVERY (TALLOR)

4.5.1 ROI and RONI

Table 4.2: Size of RONI

RONI	Size	Pixels/bits
1	518x48	24864/198912
2	56x474	26544/212352
3	58x474	27492/219936
4	518x30	15540/124320
5	174x100	17400/139200
6	170x100	17000/136000
7	98x80	7840/62720
8	120x56	6720/53760
Total		143400/1147200

The ROI size is 160 x 240 pixels which are 38400 pixels or 307200 bits.

In the watermarking process, there are only 2 bits per pixel of RONI is used for embedding purpose therefore there are only 286800 bits.

143400 pixels x 2 = 286800 bits

Or

1147200 bits / 4 = 286800 bits

It is not enough for a 160 x 240 pixels ROI to embed into RONI. Below is the calculation of bits for embedding purpose.

3072000 bits – 286800 bits = 20400 bits

There are 20400 bits is not embedded into RONI therefore compression method is needed to reduce the bits of ROI.

4.5.2 Embedding Process

The coordinate (x-axis and y-axis) for region of interest (ROI) and Region of non-interest (RONI) is adjusted and fixed. Different compression method is tested and the result is noted. First of all, in embedding process the coordinate of the image for ROI and RONI is fixed for the image, ROI is take out for compression purpose. After compression, the image will be save under a specific image format such as .png , .gif and .jpg known as 'testing'. The pixels of the image are saved in the RONI and a new watermarked image is produced as an output. All the compression is using the same ultrasound image and same size of ROI which is 38400 pixels or 307200 bits. The compression ratio and PSNR value is calculated as the table below.

Table 4.3: Result for different compression method in embedding process for sample 1

Compression method	Type	Length of embed block	Compression Ratio	PSNR (dB)
Portable Network Graphics (PNG)	Lossless	20579 pixels or 164632 bits	0.5359	48.4578
Graphics Interchange Format (GIF)	Lossless	30486 pixels or 243888 bits	0.7939	47.9297
Joint Photographic Experts Group (JPEG)	Lossless	22620 pixels or 180960 bits	0.5891	47.9882
Png and jpeg	Lossy	6130 pixels or 49040 bits	0.1596	54.1426

Embedding process is repeated by using sample 2 and sample 3 to make sure the embedding in watermarking is work for all type of ultrasound image. Same size of ROI (38400 pixels) but different ultrasound images is used.

Table 4.4: Result for different compression method in embedding process for sample 2

Compression method	Type	Length of embed block	Compression Ratio	PSNR (dB)
Portable Network Graphics (PNG)	Lossless	20835 pixels or 166680 bits	0.5426	48.6303
Graphics Interchange Format (GIF)	Lossless	33873 pixels or 270984 bits	0.8821	47.3417
Joint Photographic Experts Group (JPEG)	Lossless	21885 pixels or 175080 bits	0.5699	48.3420
Png and jpeg	Lossy	7072 pixels or 56576 bits	0.1842	53.4586

Table 4.5: Result for different compression method in embedding process for sample 3

Compression method	Type	Length of embed block	Compression Ratio	PSNR (dB)
Portable Network Graphics (PNG)	Lossless	18944 pixels or 151552 bits	0.4933	49.7423
Graphics Interchange Format (GIF)	Lossless	31542 pixels or 252336 bits	0.8214	48.1186
Joint Photographic Experts Group (JPEG)	Lossless	20842 pixels or 166736 bits	0.5428	49.6302
Png and jpeg	Lossy	5938 pixels or 47504 bits	0.1546	55.0445

According to the result, PNG compression method show the best result among the lossless compression methods in three samples. PNG produce the lowest compression ratio which is 0.5359, 0.5426 and 0.4933 for sample 1, sample 2 and sample 3 respectively among the lossless image compressor that compressed the original ultrasound image with high quality. The GIF compression method show the highest compression ratio, in other word, the larger length of pixel value is ready to embed therefore smaller part of ROI is protected. The compression ratio for GIF compression method is 0.7939, 0.8821and 0.8214 for sample 1, sample 2 and sample 3 respectively. The lower the compression ratio (nearer to zero) the better the compression method therefore PNG compression method can assume as the best compression method among lossless compression method in this research. On the other hand, high quality lossy compression method is an extra compression method that covered in this research. Lossy compression method composed by png and lossy jpeg compression method show the best result among all the compression method. This is because in the process of lossy compression, the image is compressed and pixel is modified simultaneously so not 100% of data is remains.

The result shows the PNG compression method have the highest PSNR value which is 48.4578 dB, 48.6303 dB and 49.7423 dB when compare with the original ultrasound image for sample 1, sample 2 and sample 3 respectively among the lossless compression method. The GIF shows the lowest value of PSNR which is 47.9297 dB, 47.3417 dB and 48.1186 dB in order from sample 1 to sample 3. The higher the PSNR value the better the compression method. This is because when two different images is compared, when the PSNR value is infinity means that both of the image are same. Lossy compression method is use in this research, compare to lossless compression method, lossy compression method produce a higher PSNR value. This is because the less pixel of image is embedded into the RONI therefore most of the pixel of the original image is remain the same. As conclusion, high value of PSNR is produce (greater than 40dB) that can assume that the different of the watermarked image is unable to observe by human eye easily without using any software or hardware tools. Output image for each compression will show from figure 4.11 to figure 4.31.

Image Result

Sample 1

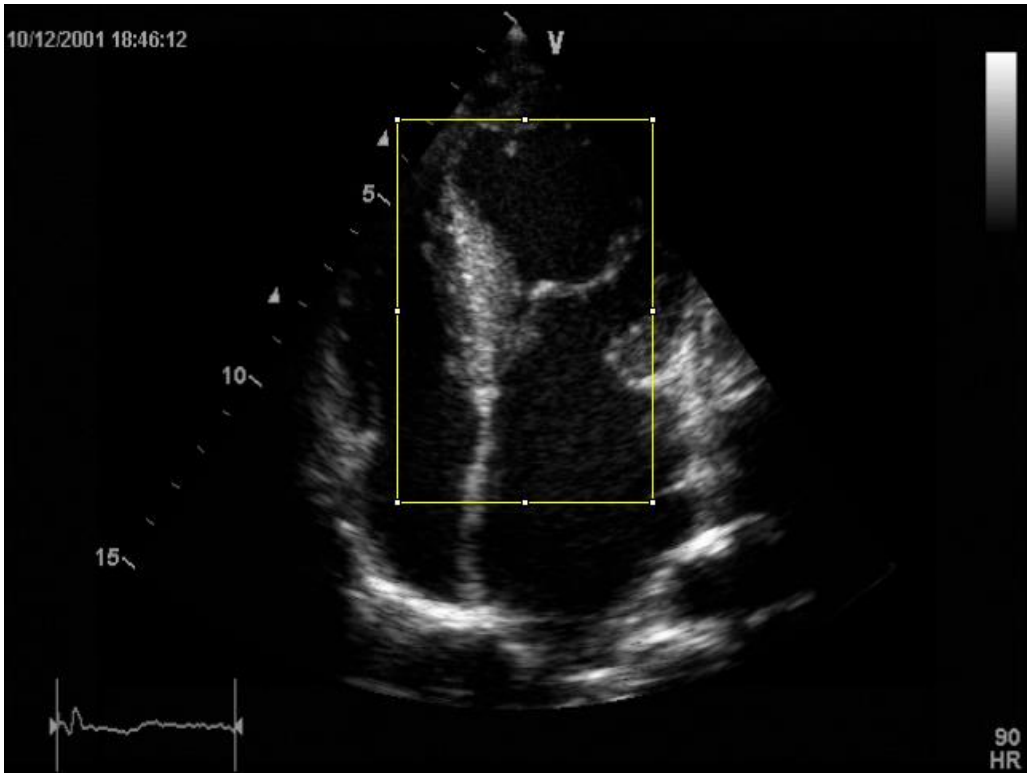

Figure 4.11: Original ultrasound images with highlighted ROI region for sample 1

PNG compression method

Figure 4.12: Compressed ROI region

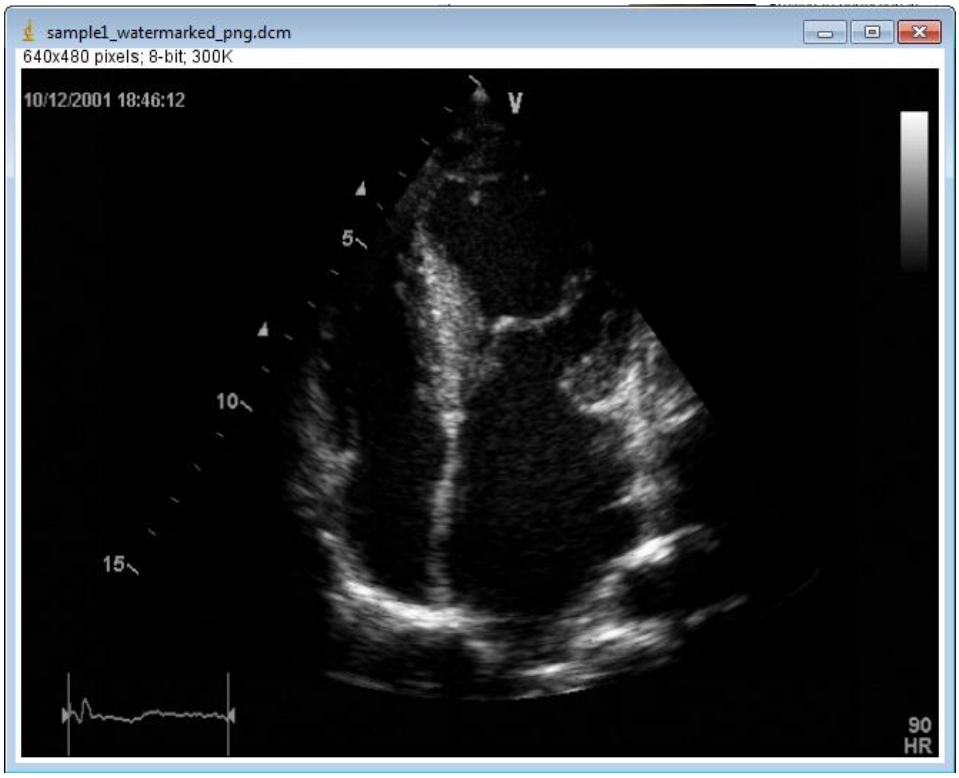

Figure 4.13: Watermarked image, PSNR= 48.4578

GIF compression method

Figure 4.14: Compressed ROI region

Figure 4.15: Watermarked image

PNG and JPEG compression method

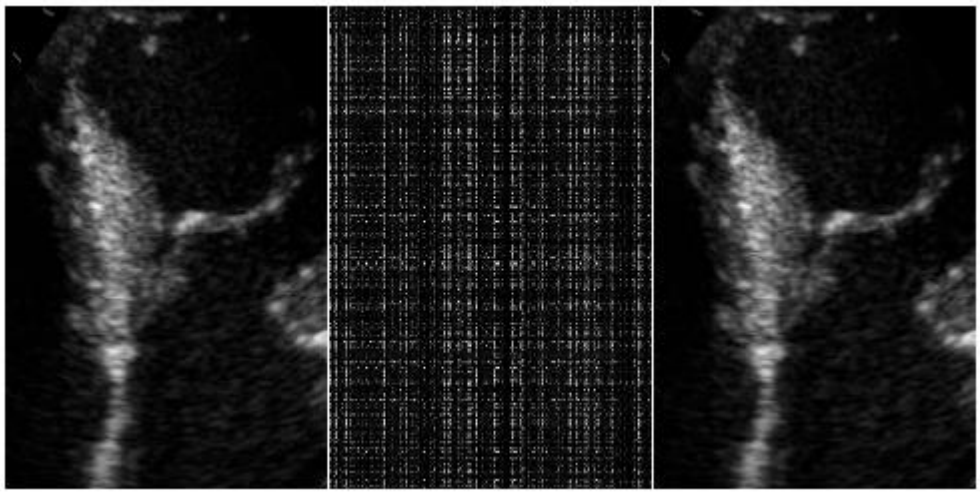

Figure 4.16: Retrieved ROI, Compressed ROI region and Decompressed ROI

(from left to right)

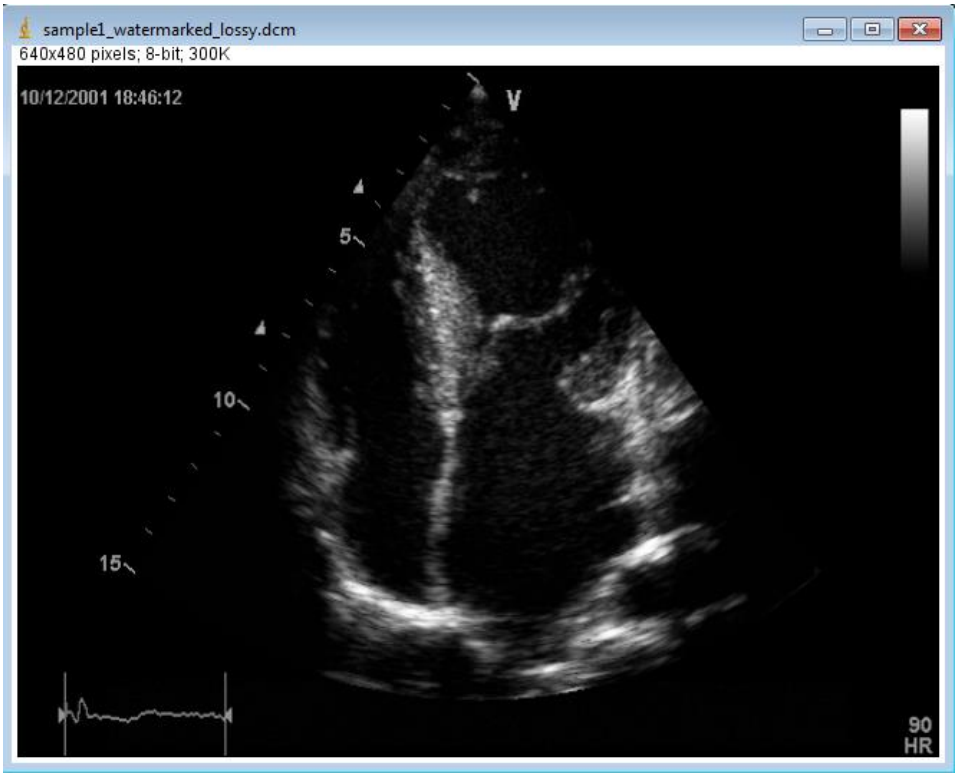

Figure 4.17: Watermarked image

Sample 2

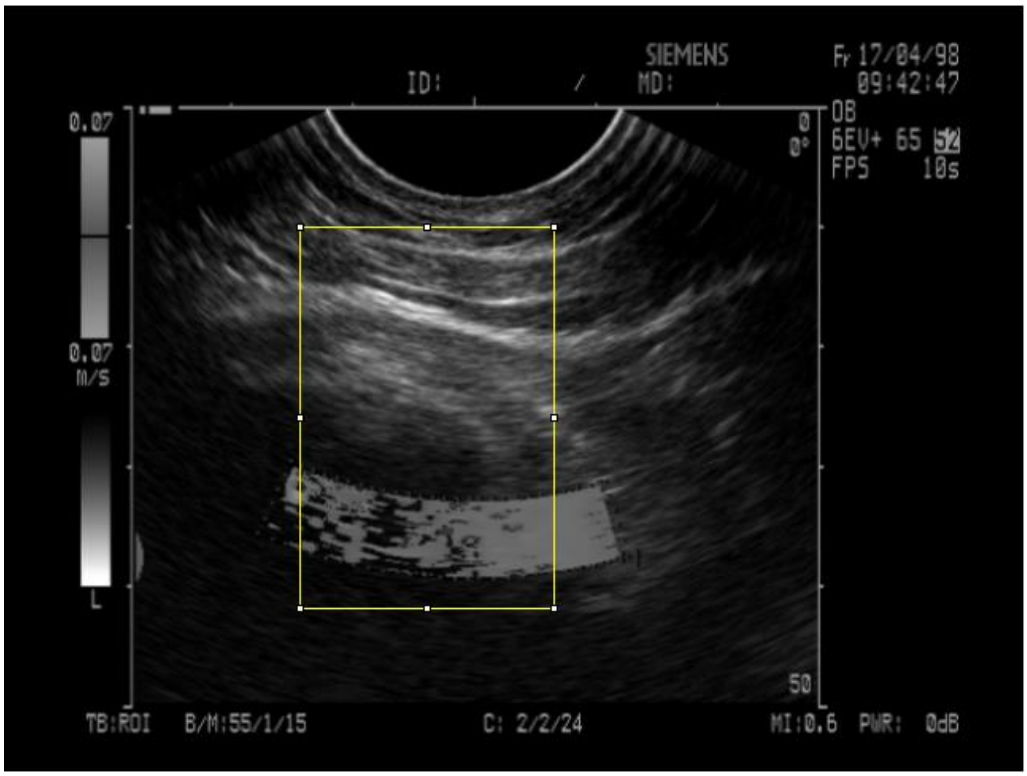

Figure 4.18: Original ultrasound image with highlighted ROI region for sample 2

PNG compression method

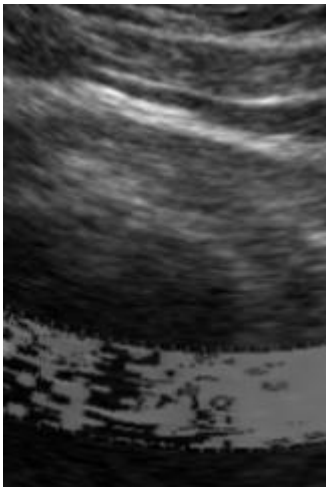

Figure 4.19: Compressed ROI region

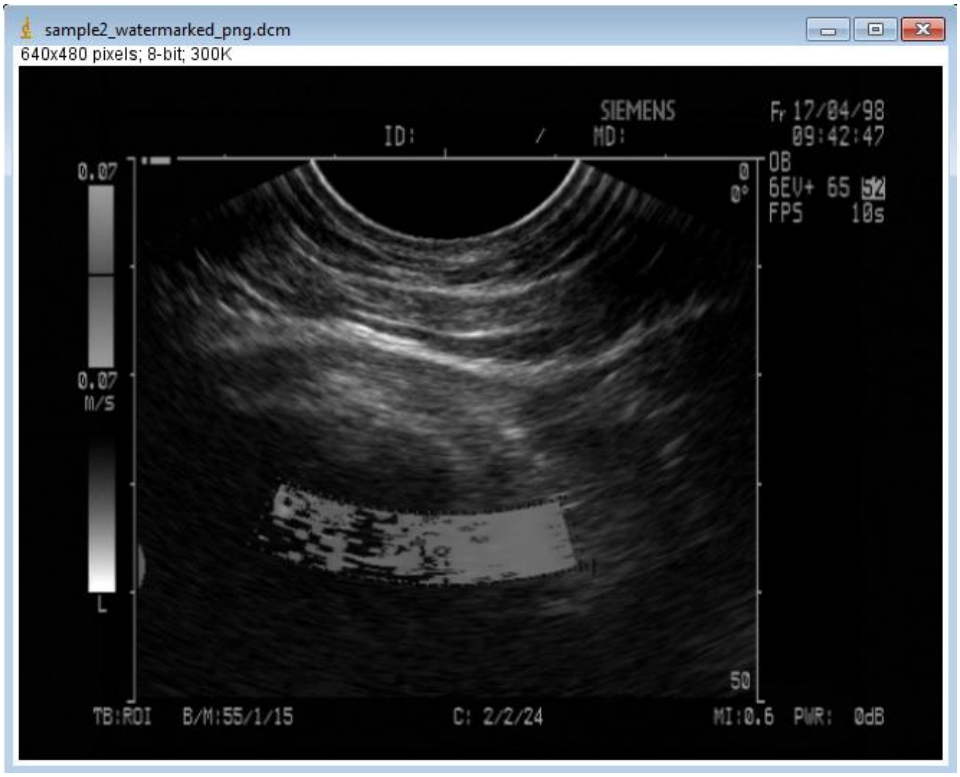

Figure 4.20: Watermarked image, PSNR= 48.4578

GIF compression method

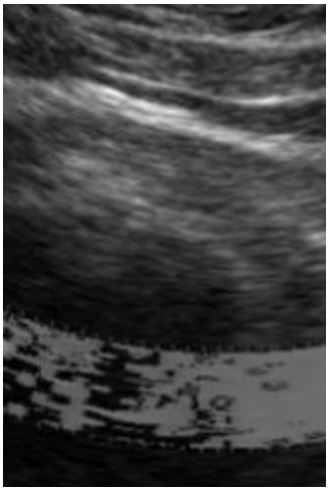

Figure 4.21: Compressed ROI region

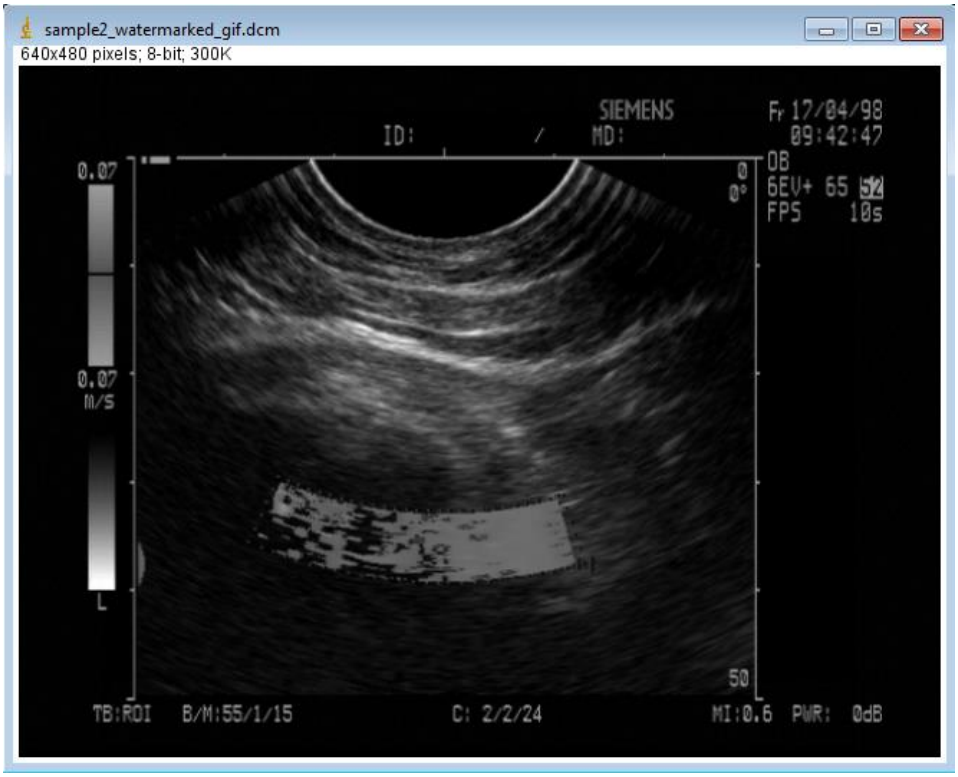

Figure 4.22: Watermarked image

PNG and JPEG compression method

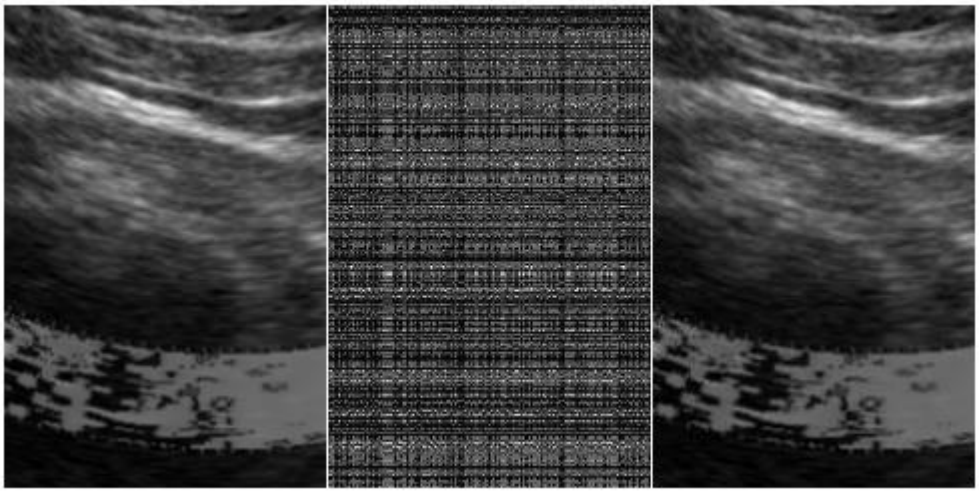

Figure 4.23: Retrieved ROI, Compressed ROI region and Decompressed ROI

(from left to right)

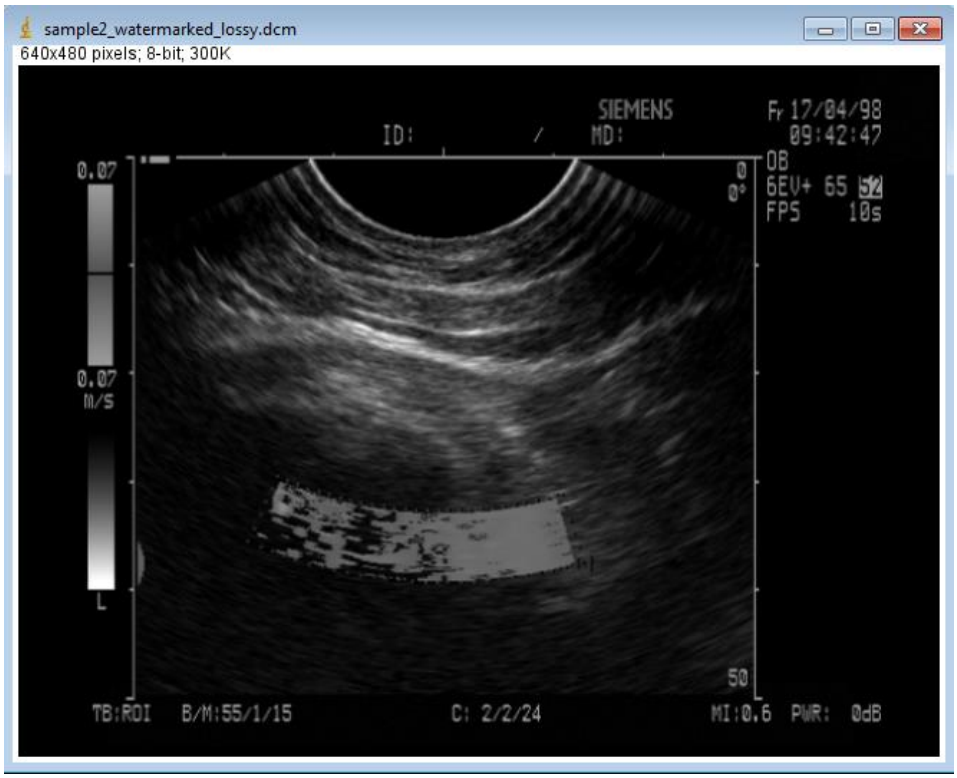

Figure 4.24: Watermarked image

Sample 3

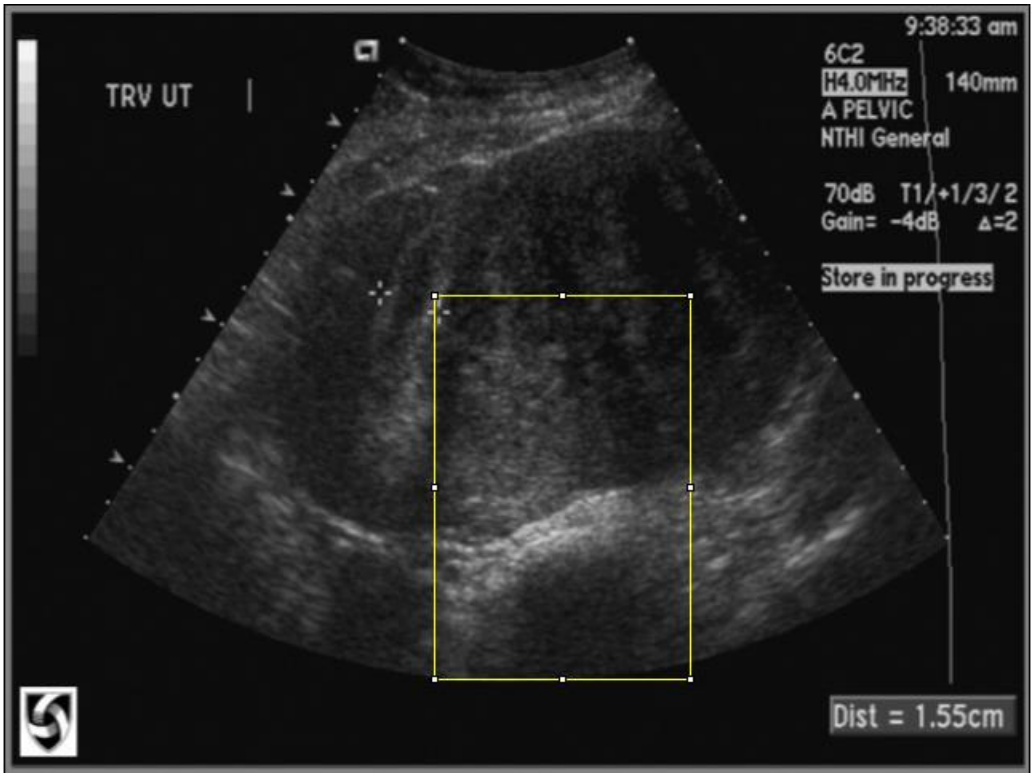

Figure 4.25: Original ultrasound image with highlighted ROI region for sample 3

PNG compression method

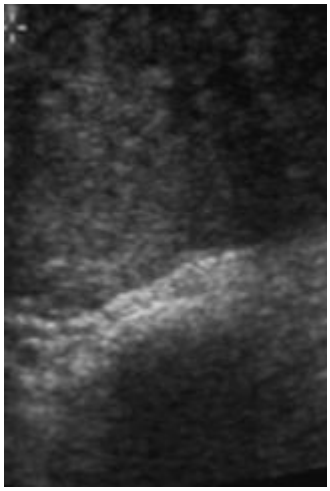

Figure 4.26: Compressed ROI region

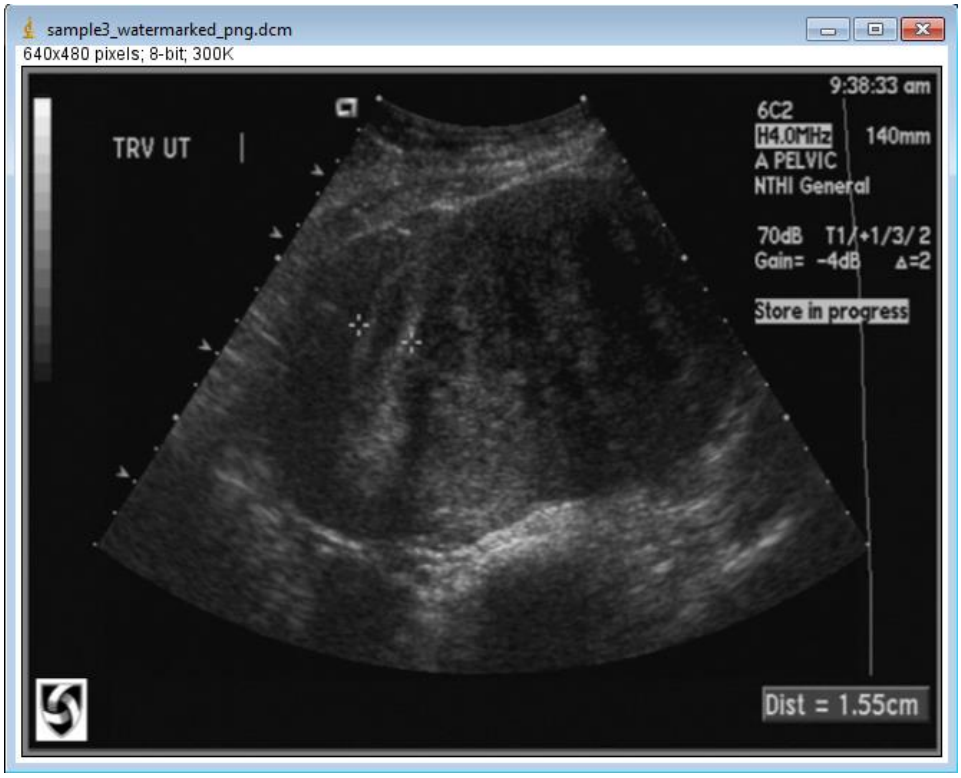

Figure 4.27: Watermarked image

GIF compression method

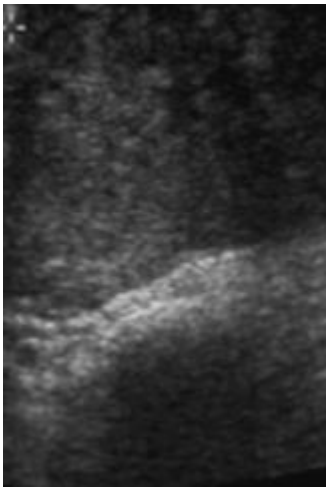

Figure 4.28: Compressed ROI region

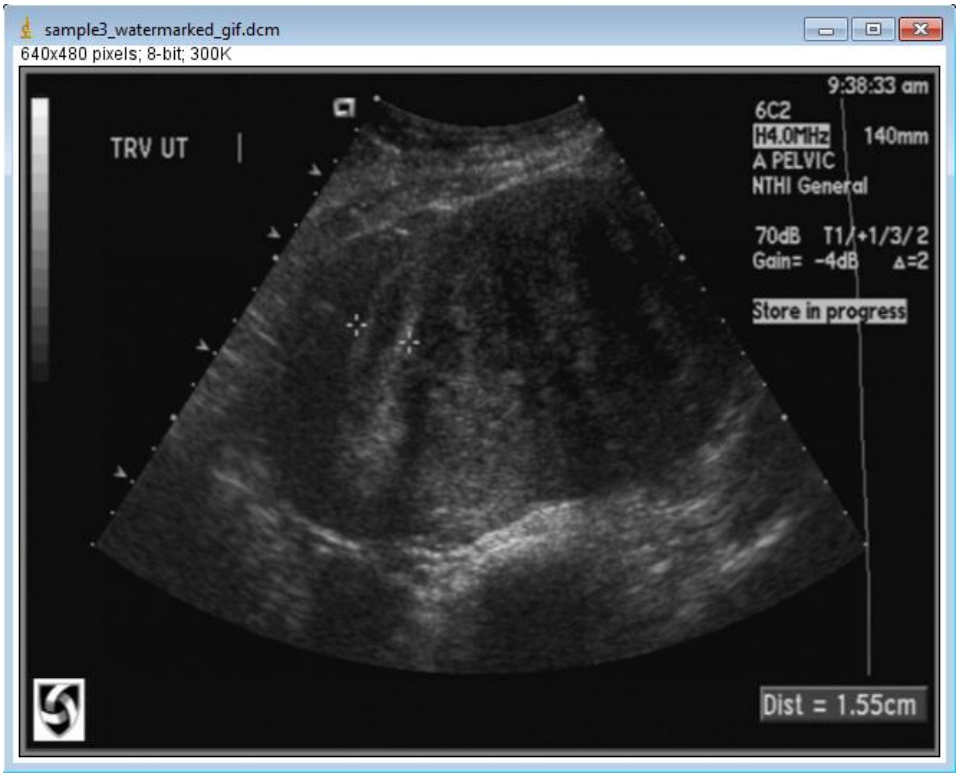

Figure 4.29: Watermarked image.

PNG and JPEG compression method

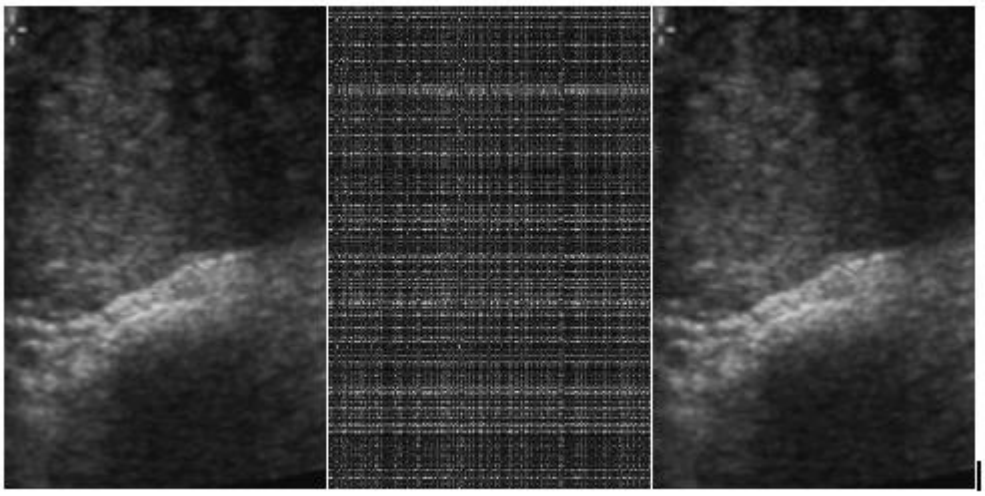

Figure 4.30: Retrieved ROI, Compressed ROI region and Decompressed ROI (from left to right)

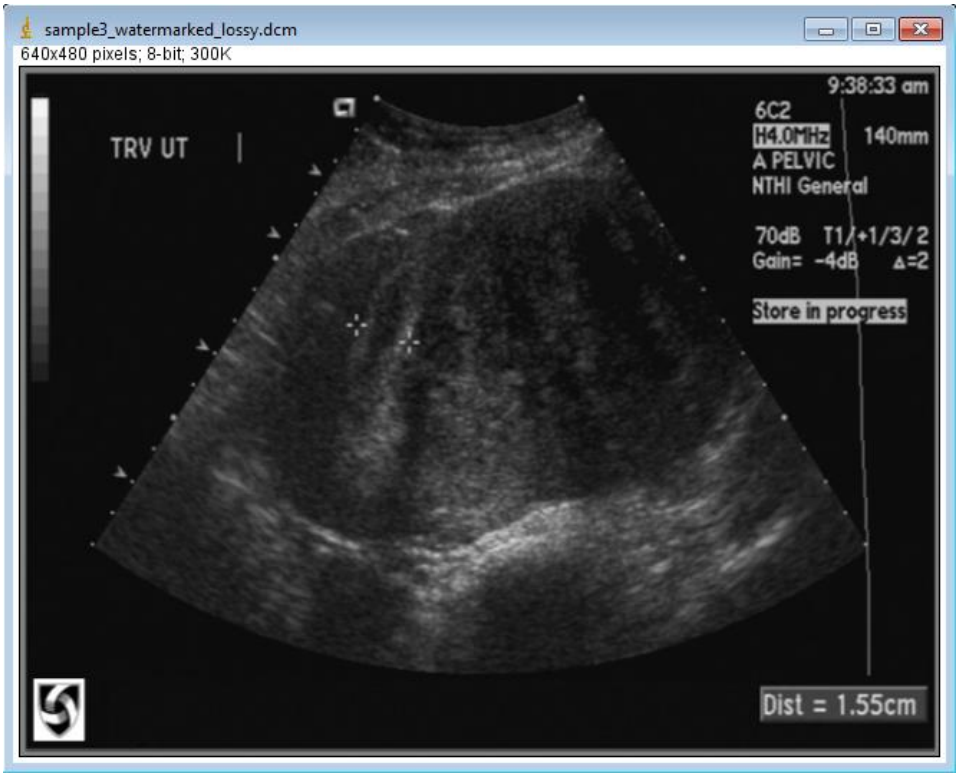

Figure 4.31: Watermarked image

4.5.3 Retrieving Process

In the retrieve process, the watermarked image is tamper by using software (ImageJ). The input for the watermarking coding is tampered image. The tampered image will check by the TALLOR authenticate code, if the result is positive (tampered) the image recover process is start. First of all, the coding will retrieve the embedded pixel from image and save it as 'temp' according to the format (.png, .gif and .jpg). After that, the image 'temp' pixel will recover the tampered ROI. Result table is formed.

Table 4.6: Result for different compression method in retrieving process for sample 1

Compression method	Length of retrieve block	PSNR with original image (dB)
Portable Network Graphics (PNG)	20579 pixels or 164632 bits	48.4574
Graphics Interchange Format (GIF)	30486 pixels or 243888 bits	47.9297
Joint Photographic Experts Group (JPEG)	22620 pixels or 180960 bits	47.9882
PNG and JPEG	6130 pixels or 49040 bits	47.4748

Retrieving process is repeated by using sample 2 and sample 3 to make sure the retrieving process in watermarking is work for all type of ultrasound image.

Table 4.7: Result for different compression method in retrieving process for sample 2

Compression method	Length of retrieve block	PSNR with original image (dB)
Portable Network Graphics (PNG)	20835 pixels or 166680 bits	48.6303
Graphics Interchange Format (GIF)	33873 pixels or 270984 bits	47.3417
Joint Photographic Experts Group (JPEG)	21885 pixels or 175080 bits	48.3420
PNG and JPEG	7072 pixels or 56576 bits	47.5398

Table 4.8: Result for different compression method in retrieving process for sample 3

Compression method	Length of retrieve block	PSNR with original image (dB)
Portable Network Graphics (PNG)	18944 pixels or 151552 bits	49.7436
Graphics Interchange Format (GIF)	31542 pixels or 252336 bits	48.1186
Joint Photographic Experts Group (JPEG)	20842 pixels or 166736 bits	49.6302
PNG and JPEG	5938 pixels or 47504 bits	49.9143

Comparison of data between table 4.3 and table 4.6, table 4.4 and table 4.7 and table 4.5 and table 4.8 show that the length of embed (table 4.3, 4.4, 4.5) and length of retrieve (table 4.6, 4.7, 4.8) are same for specific compression method in sample 1, 2 and 3. Thus, same data of data that embedded in RONI is retrieve completely and perfectly therefore a result table is generated. The PSNR value is produce by the comparison of the recovered image and the original ultrasound image. In the result table, PSNR value of PNG compression method is 48.4574 dB, 48.6303 dB and 49.7436 dB respectively. GIF compression method show the lowest PSNR value which is 47.9297 dB, 47.3417 dB and 48.1186 dB for sample 1,2 and 3 respectively. For lossy compression method, the PSNR value is not consistent that means this compression method is not stable for watermarking process. The PSNR value for lossy compression method is 47.4748 dB (lowest in sample 1), 47.5398 dB (moderate in sample 2) and 49.9143 dB (highest in sample 3) therefore it is not suitable to use in watermarking schemes.

Output image for each compression will show from figure 4.32 to figure 4.67.

Image Result

Sample 1

PNG compression method

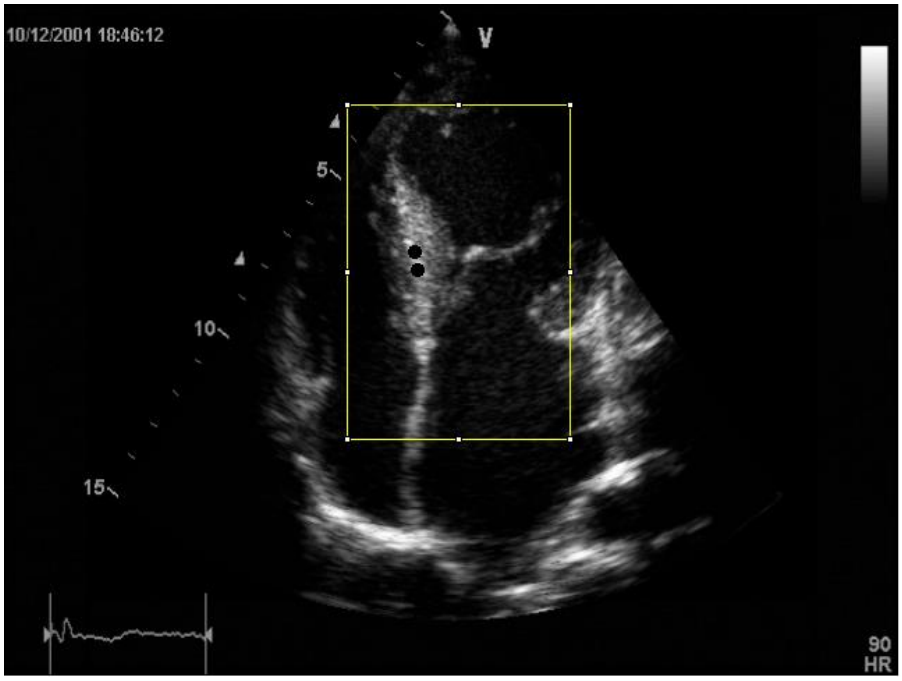

Figure 4.32: Tampered watermarked image with ROI (yellow rectangle)

Figure 4.33: Zoom in image of ROI

Figure 4.34: Retrieved compressed ROI region

Figure 4.35: Recovered image, PSNR= 48.4574dB

GIF compression method

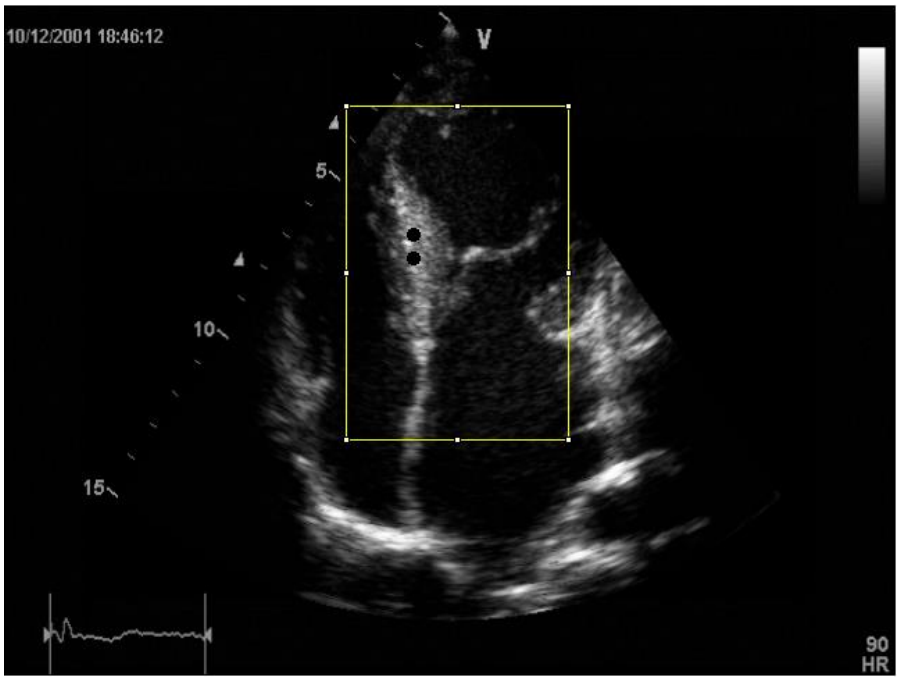

Figure 4.36: Tampered watermarked image with ROI (yellow rectangle)

Figure 4.37: Zoom in image of ROI

Figure 4.38: Retrieved compressed ROI region

Figure 4.39: Recovered image, PSNR= 47.9297dB

PNG and JPEG compression method

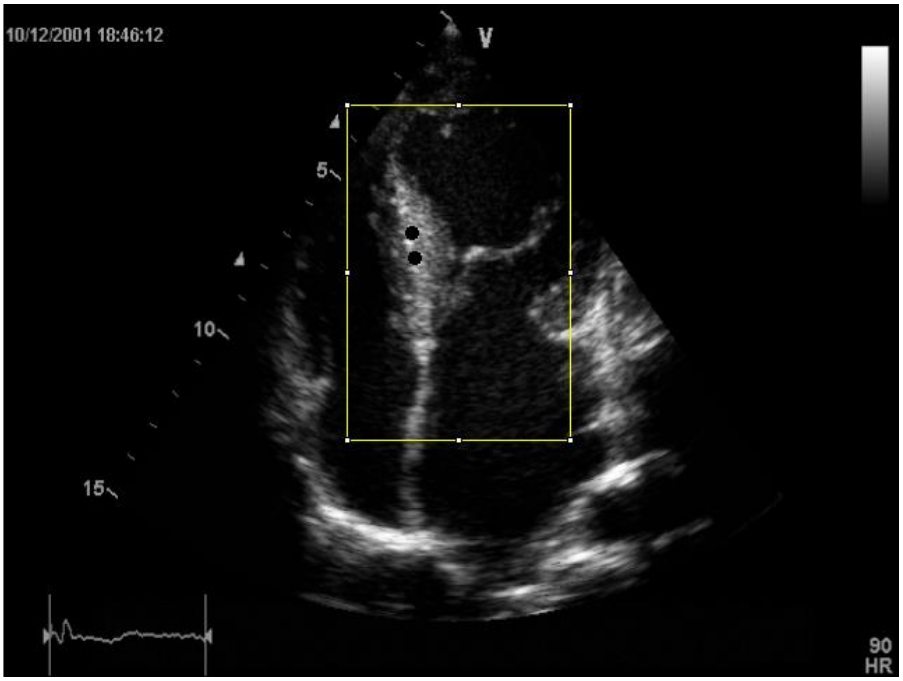

Figure 4.40: Tampered watermarked image with ROI (yellow rectangle)

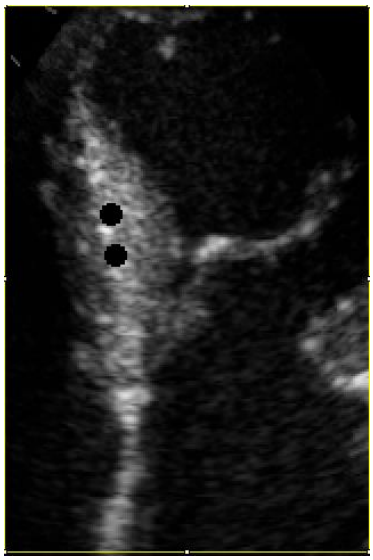

Figure 4.41: Zoom in image of ROI

Figure 4.42: Retrieved compressed ROI region

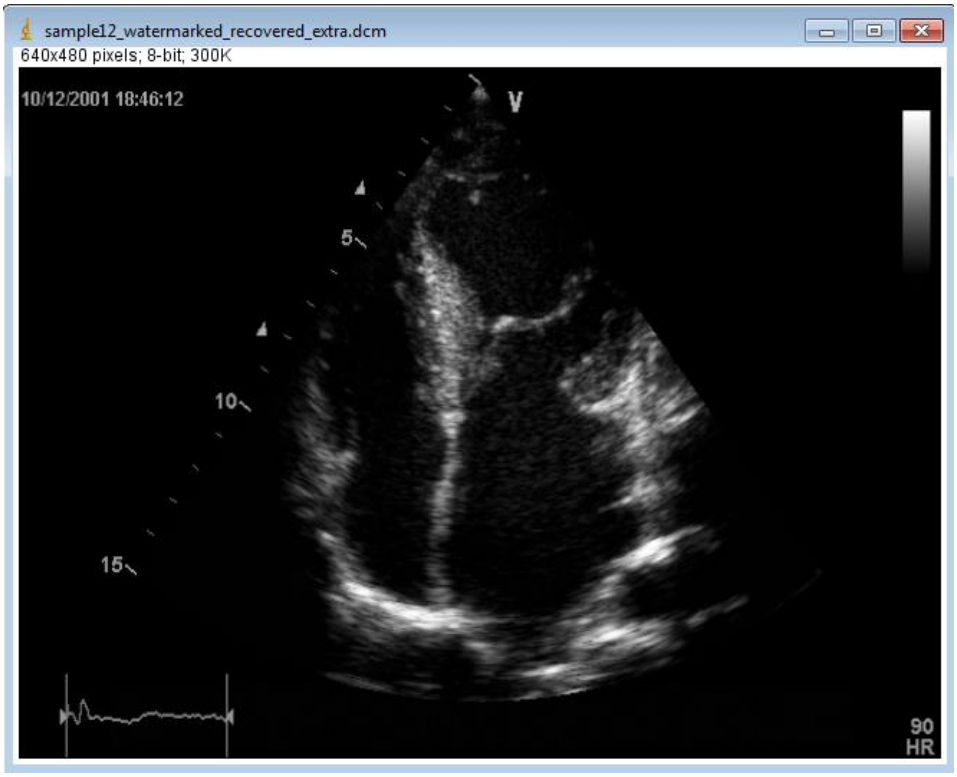

Figure 4.43: Recovered image, PSNR= 47.4748dB

Sample 2

PNG compression method

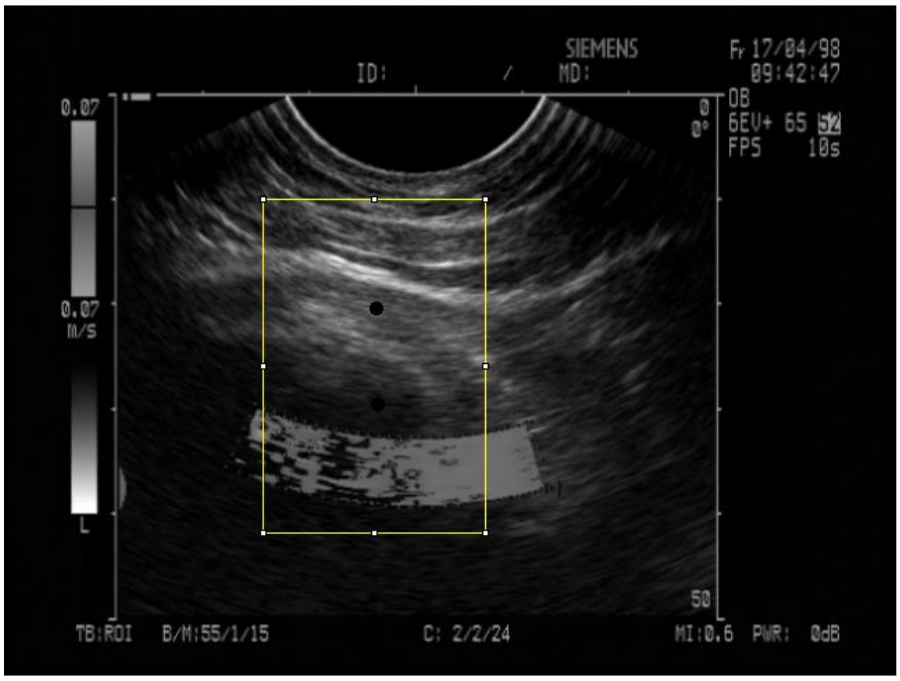

Figure 4.44: Tampered watermarked image with ROI (yellow rectangle)

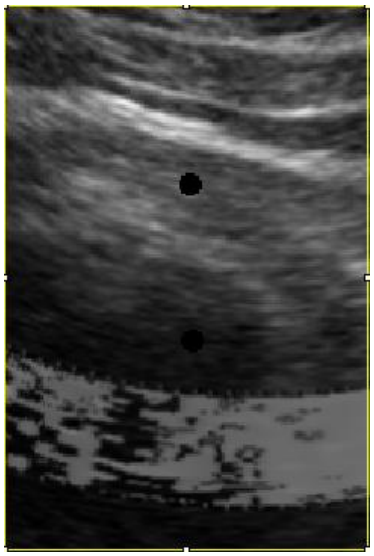

Figure 4.45: Zoom in image of ROI

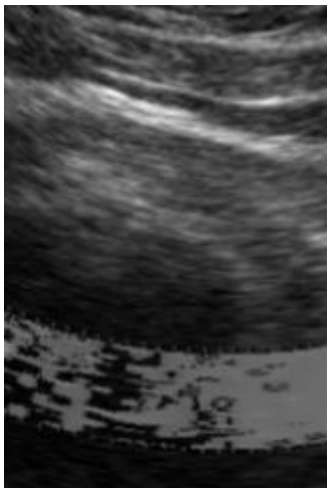

Figure 4.46: Retrieved compressed ROI region

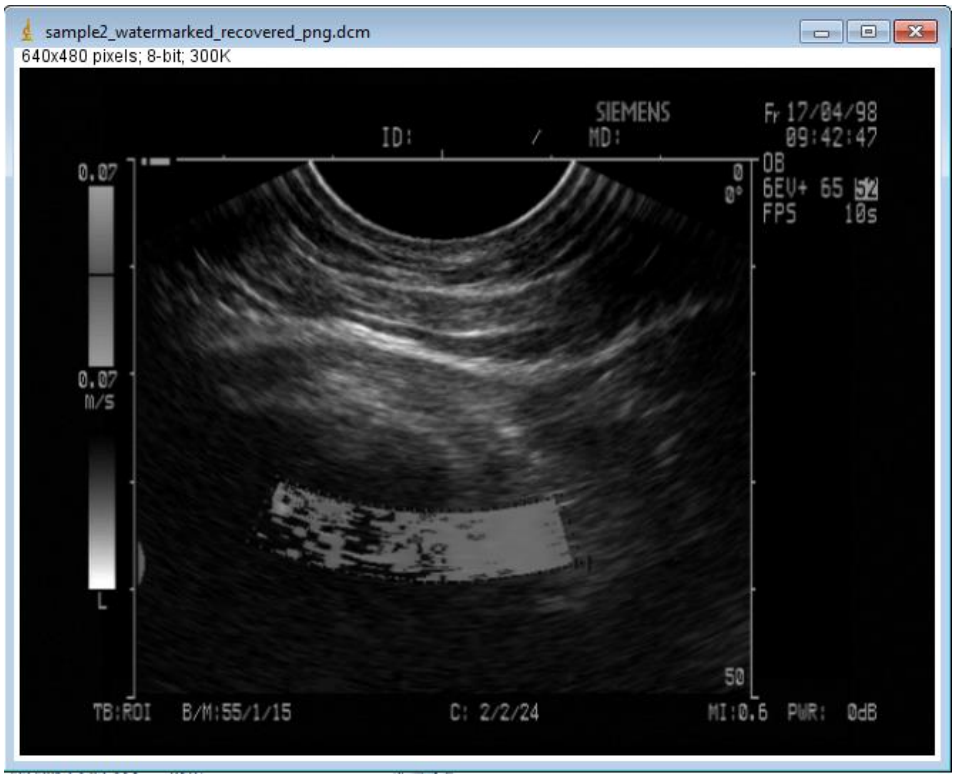

Figure 4.47: Recovered image, PSNR= 48.6303dB

GIF compression method

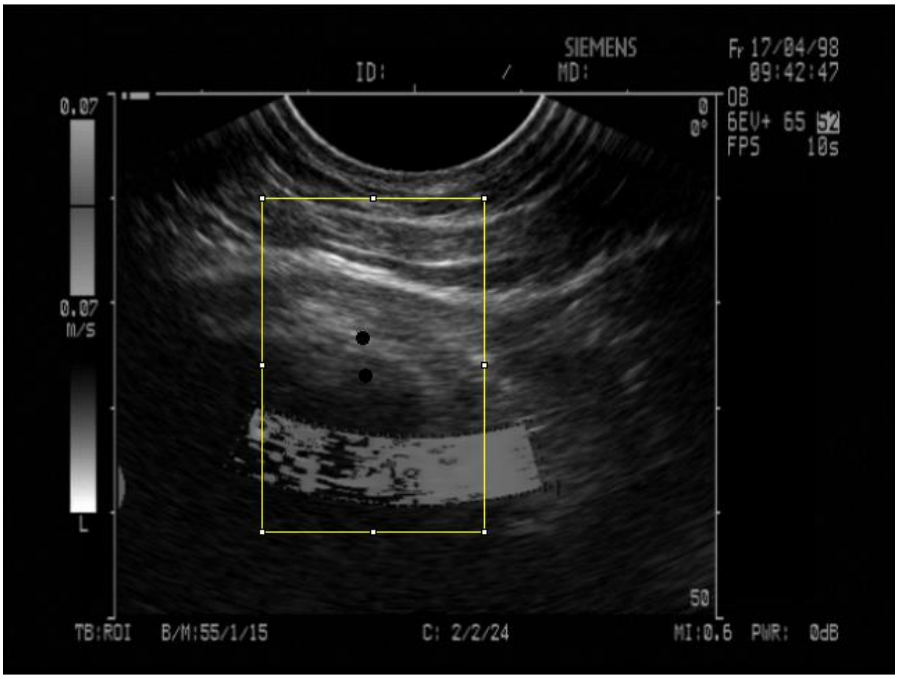

Figure 4.48: Tampered watermarked image with ROI (yellow rectangle)

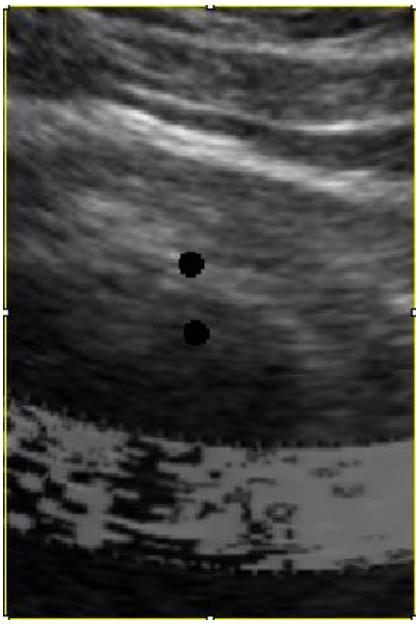

Figure 4.49: Zoom in image of ROI

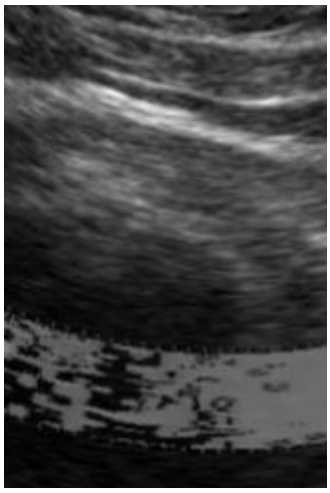

Figure 4.50: Retrieved compressed ROI region

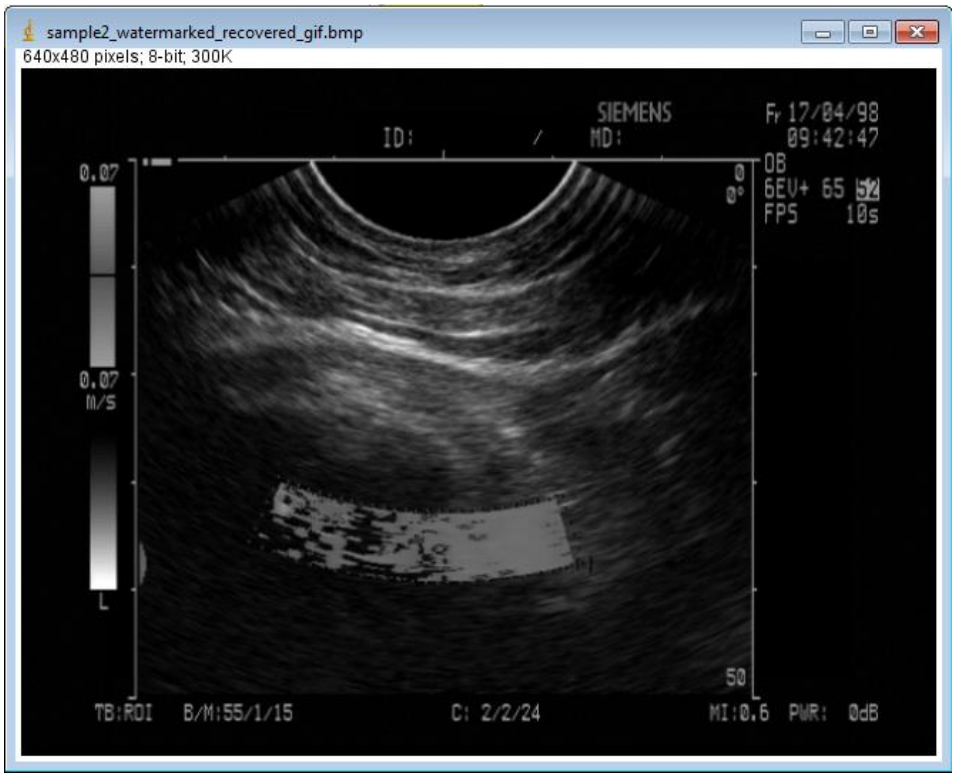

Figure 4.51: Recovered image, PSNR= 47.3417dB

PNG and JPEG compression method

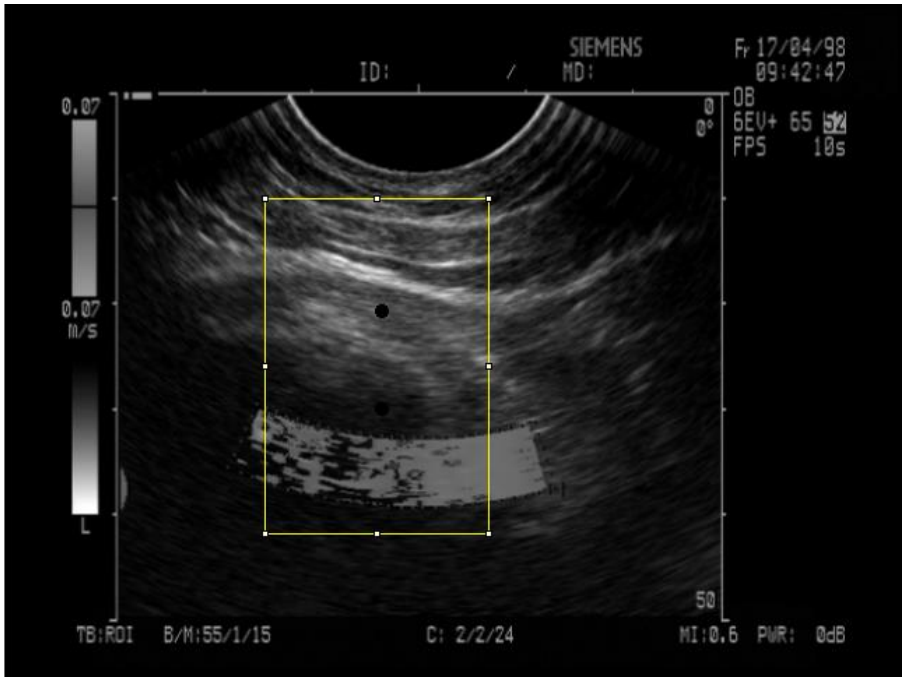

Figure 4.52: Tampered watermarked image with ROI (yellow rectangle)

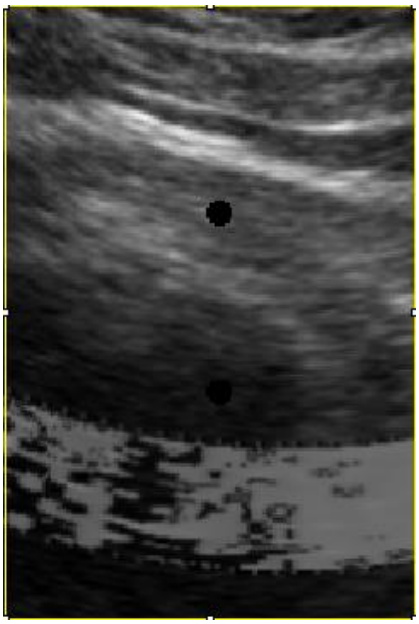

Figure 4.53: Zoom in image of ROI

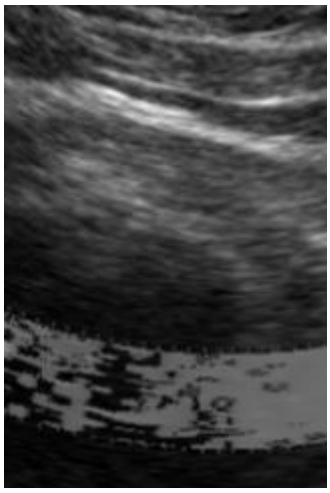

Figure 4.54: Retrieved compressed ROI region

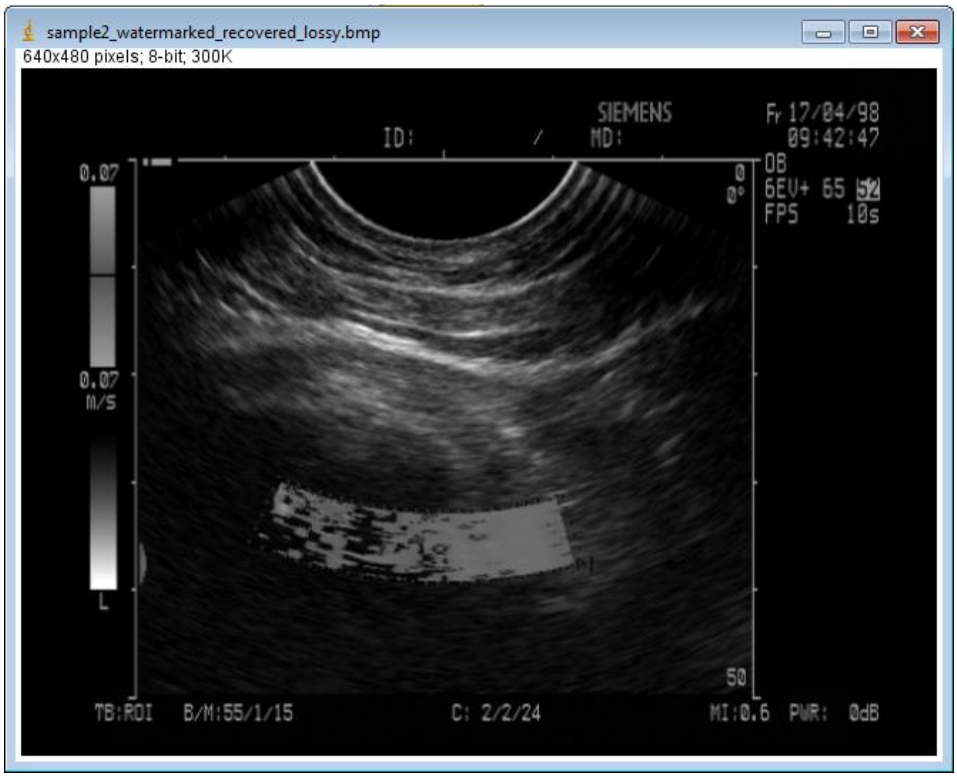

Figure 4.55: Recovered image, PSNR= 47.5398dB

Sample 3

PNG compression method

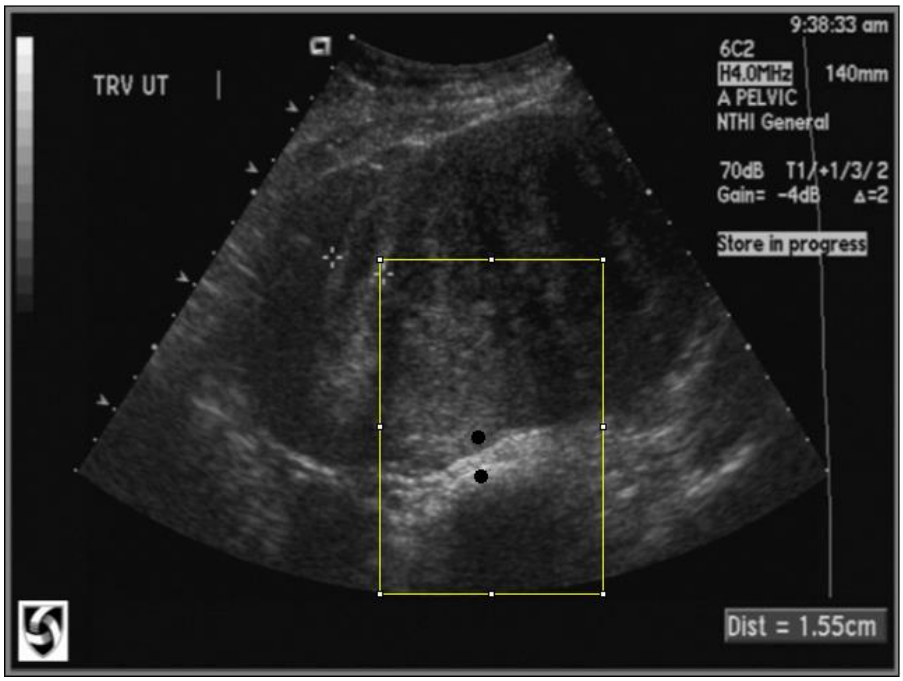

Figure 4.56: Tampered watermarked image with ROI (yellow rectangle)

Figure 4.57: Zoom in image of ROI

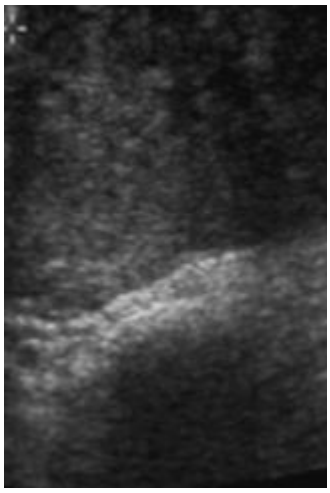

Figure 4.58: Retrieved compressed ROI region

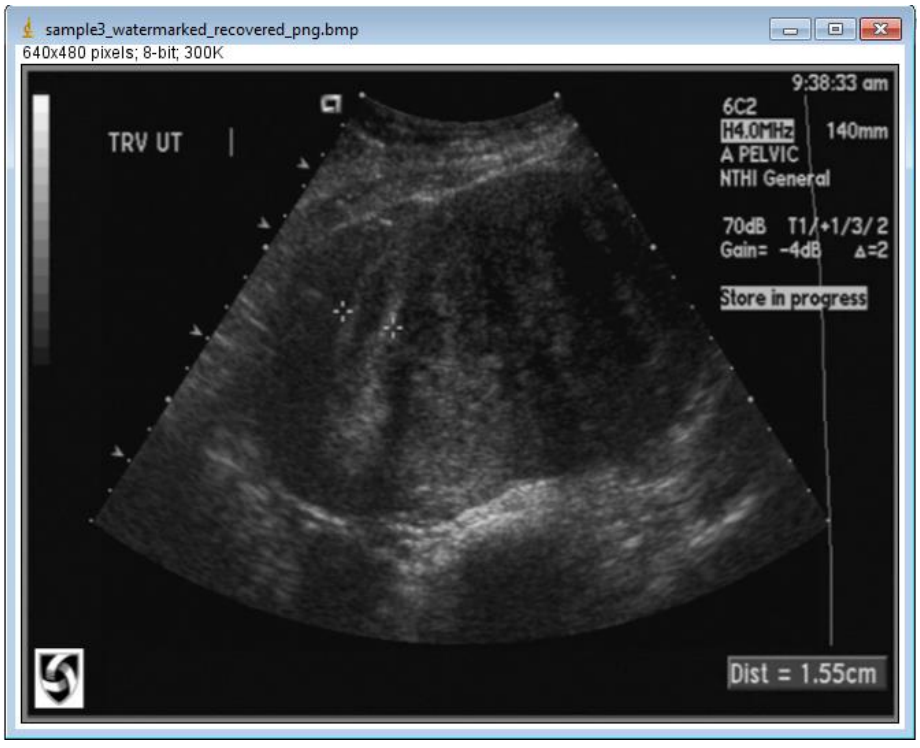

Figure 4.59: Recovered image, PSNR= 49.7436dB

GIF compression method

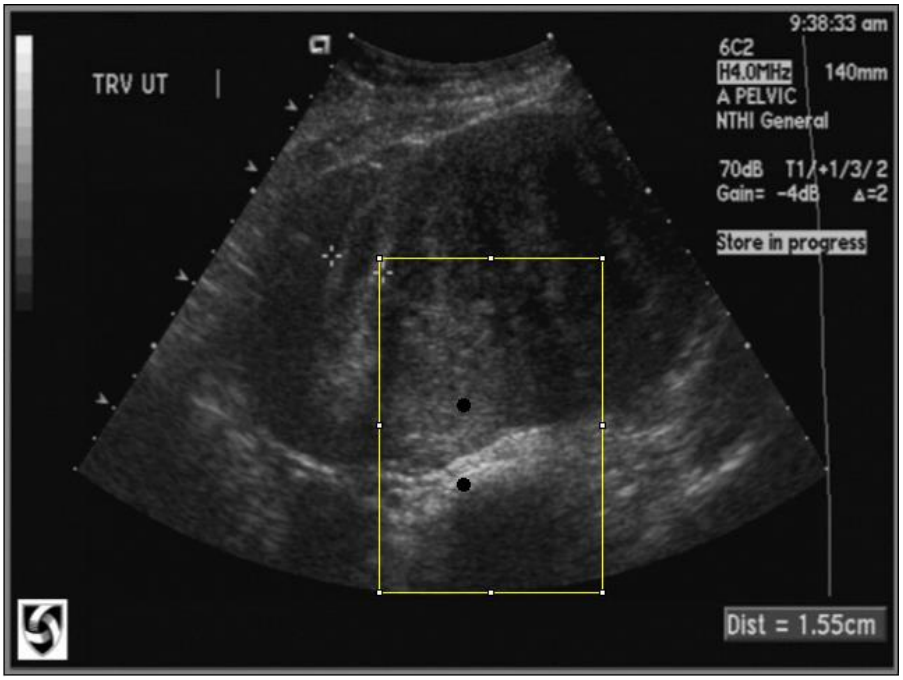

Figure 4.60: Tampered watermarked image with ROI (yellow rectangle)

Figure 4.61: zoom in image of ROI

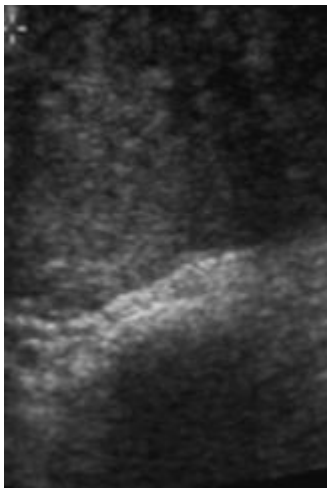

Figure 4.62: Retrieved compressed ROI region

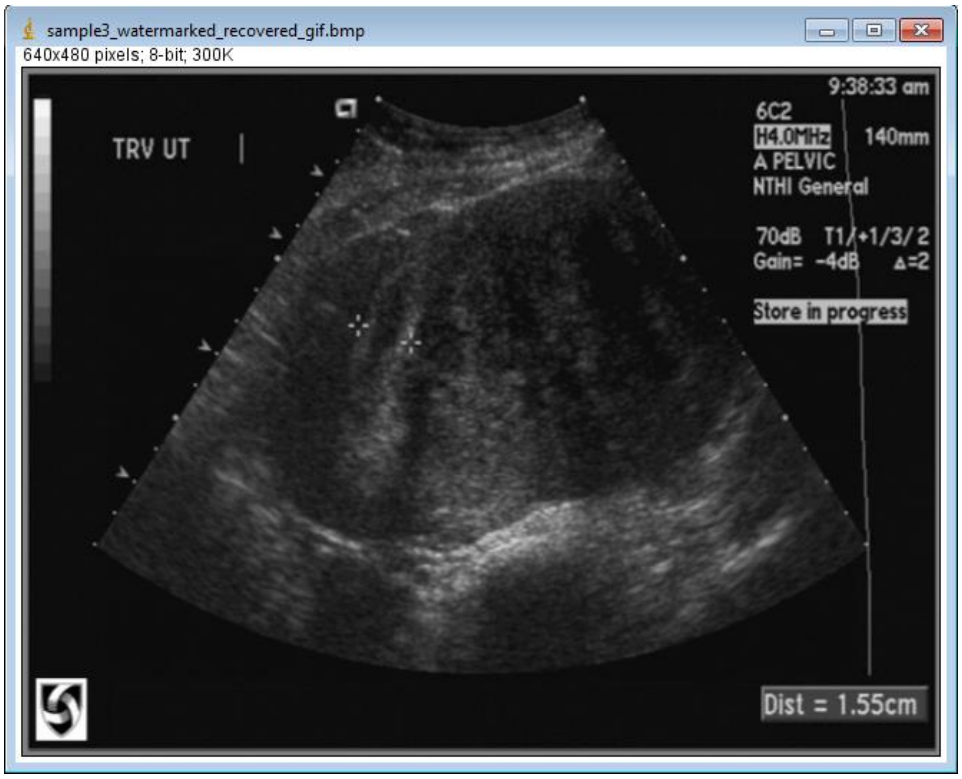

Figure 4.63: Recovered image, PSNR= 48.1186dB

PNG and JPEG compression method

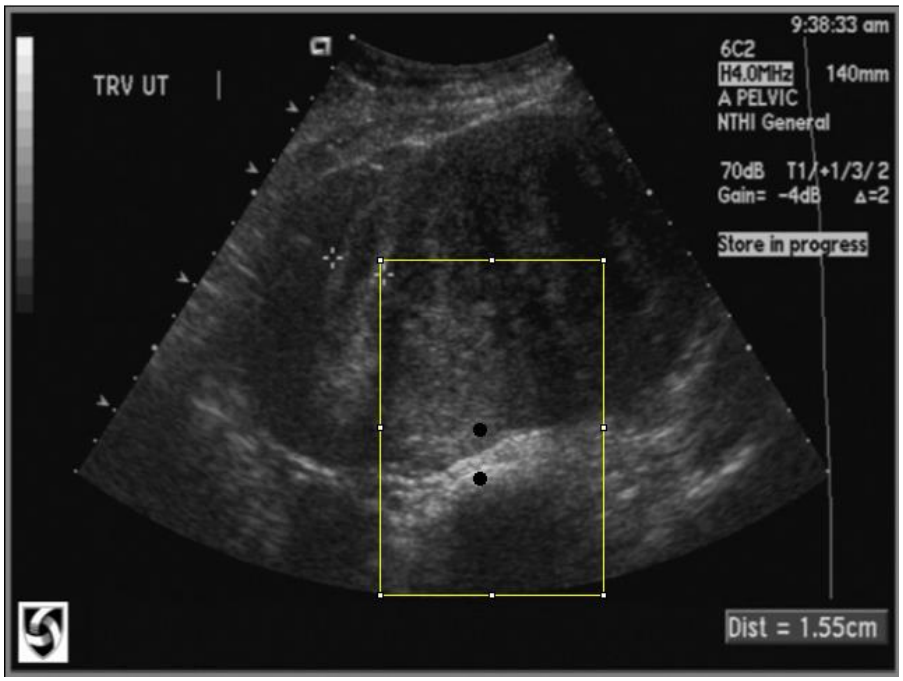

Figure 4.64: Tampered watermarked image with ROI (yellow rectangle)

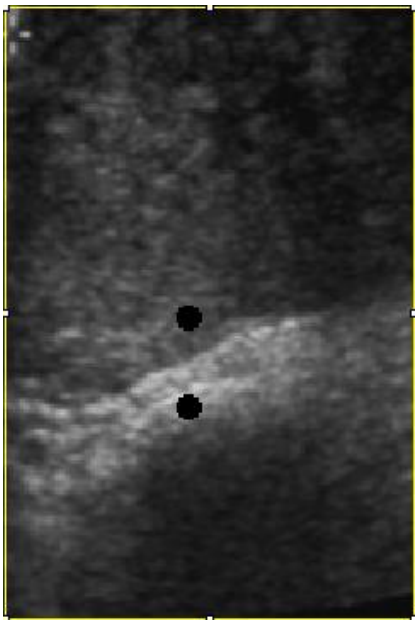

Figure 4.65: Zoom in image of ROI

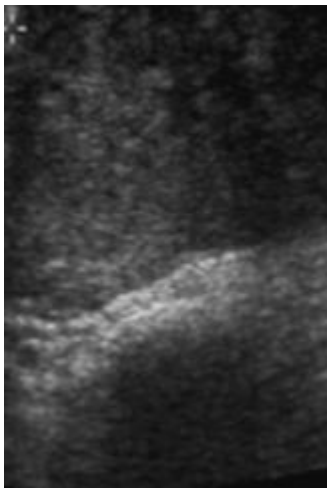

Figure 4.66: Retrieved compressed ROI region

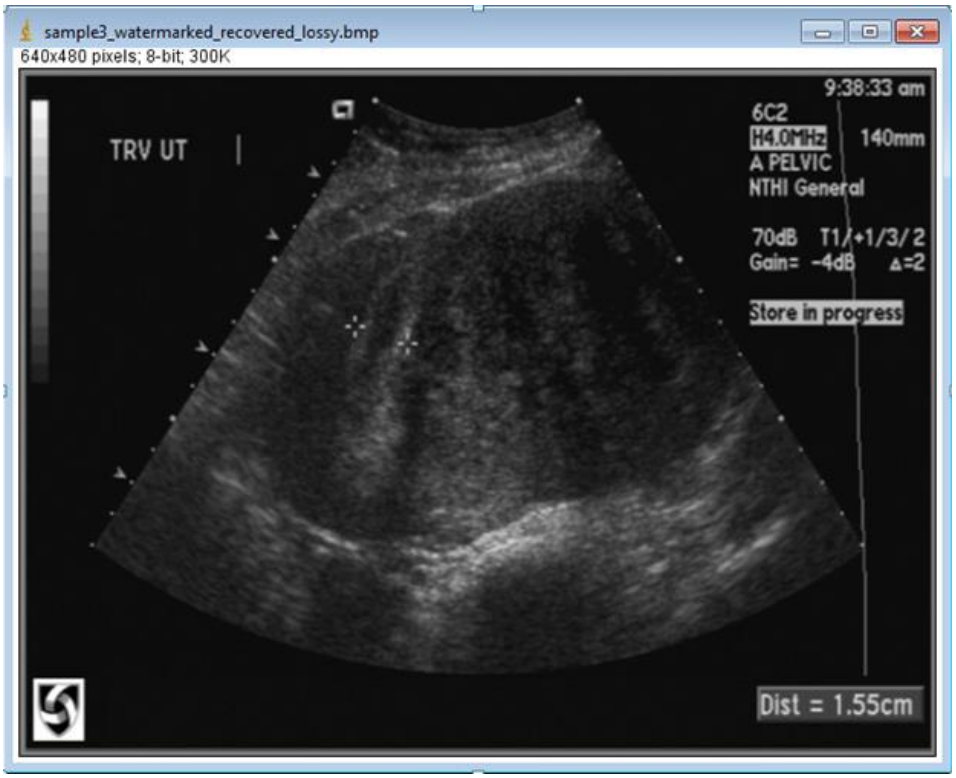

Figure 4.67: Recovered image, PSNR= 49.9143dB

4.5.3 Selection of Compression method

According to the result of section 4.5.1 and section 4.5.2, PNG compression method is the most suitable compressor in this research therefore, PNG compression method is chosen and use for testing in ROI enlargement process.

Table 4.9: Result for PNG compression method in embedding process

Ultrasound image	Length of embed block	Compression Ratio	PSNR (dB)
Sample 1	20579 pixels or 164632 bits	0.5359	48.4578
Sample 2	20835 pixels or 166680 bits	0.5426	48.6303
Sample 3	18944 pixels or 151552 bits	0.4933	49.7423

Table 4.10: Result for PNG compression method in retrieving process

Ultrasound image	Length of retrieve block	PSNR with original image (dB)
Sample 1	20579 pixels or 164632 bits	48.4574
Sample 2	20835 pixels or 166680 bits	48.6303
Sample 3	18944 pixels or 151552 bits	49.7436

4.6 ROI ENLARGEMENT

The aim for this research is to increase the ROI region in watermarking schemes using compression method, in other word is to increase the protection area. Compression method PNG is chosen for the ROI enlargement process.

Table 4.11: Output record from embedding process for ROI enlargement using PNG compression method

Ultrasound image	Length of Original block	Length of embed block	Compression Ratio	PSNR (dB)
Sample1	56000 pixels or 448000 bits	29250 pixels or 234000 bits	0.5223	46.9625
Sample2	53568 pixels or 428544 bits	28239 pixels or 225912 bits	0.5272	47.2426
Sample3	53928 pixels or 431424 bits	26276 pixels or 210208 bits	0.4872	48.3345

In the previous experiment, ROI is fixed (38400 pixels) to use for each sample in watermarking process. From the table above, a larger part of ROI is present, 56000 pixels, 53568 pixels and 53928 pixels for sample 1, sample 2 and sample 3 respectively. Length of embed block is 29250 pixels, 28239 pixels and 26276 pixels for sample 1, sample 2 and sample 3 respectively. All of the images show a good result for Compression ratio and PSNR calculation. The compression ratio for sample 1 is 0.5223, sample 2 is 0.5272 and sample 3 is 0.4872. The PSNR value (dB) is 46.9625 for sample 1, 47.2426 for sample 2 and 48.3345 for sample 3. Results above prove that the embedding process is success.

Table 4.12: Output record from retrieving process for ROI enlargement using PNG compression method

Ultrasound image	Length of retrieve block (pixels)	PSNR with original image (dB)
Sample1	29250 pixels or 234000 bits	46.9625
Sample2	28239 pixels or 225912 bits	47.2426
Sample3	26276 pixels or 210208 bits	47.9882

The length of retrieve block is 29250 pixels, 28239 pixels and 26276 pixels for sample 1, sample 2 and sample 3 respectively. The PSNR value (dB) for sample 1, sample 2 and sample 3 is 46.9625, 47.2426 and 47.9882 respectively. Comparison between the length of retrieve block in table 8 and length of embed block in table 7 is carried out. The same pixel value from same sample show that the embed data and retrieve data is same therefore it is qualified to use in recovery process.

Sample 1

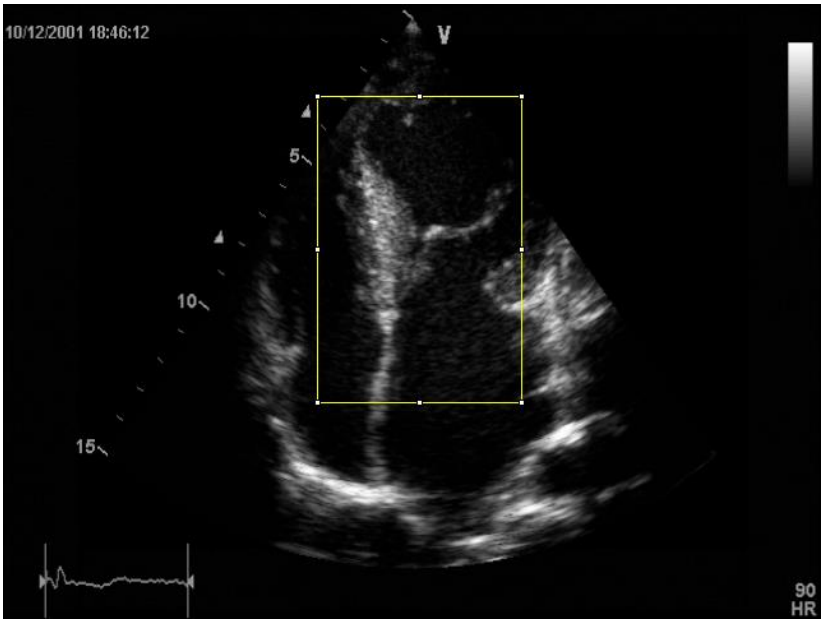

Figure 4.68: Ultrasound image with highlighted ROI before the enlargement process

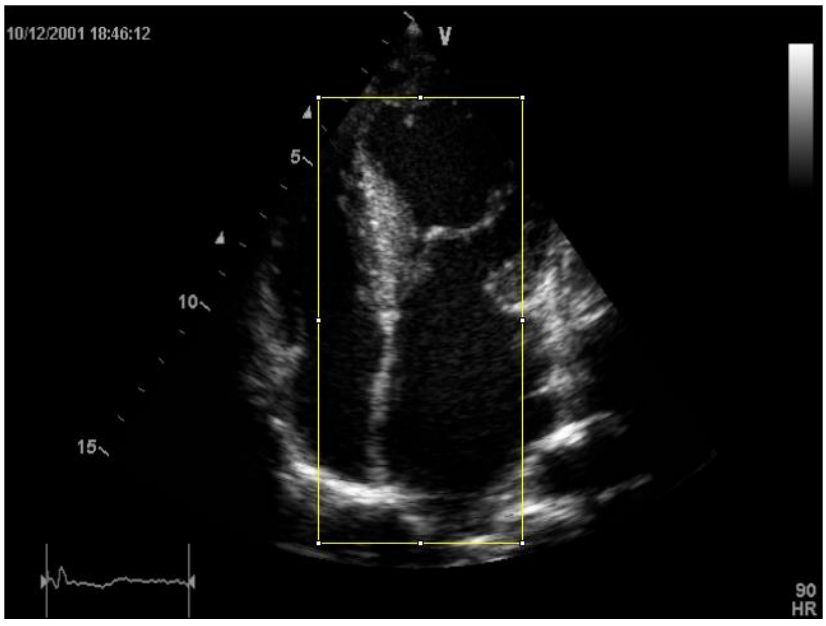

Figure 4.69: Ultrasound image with highlighted ROI after the enlargement process

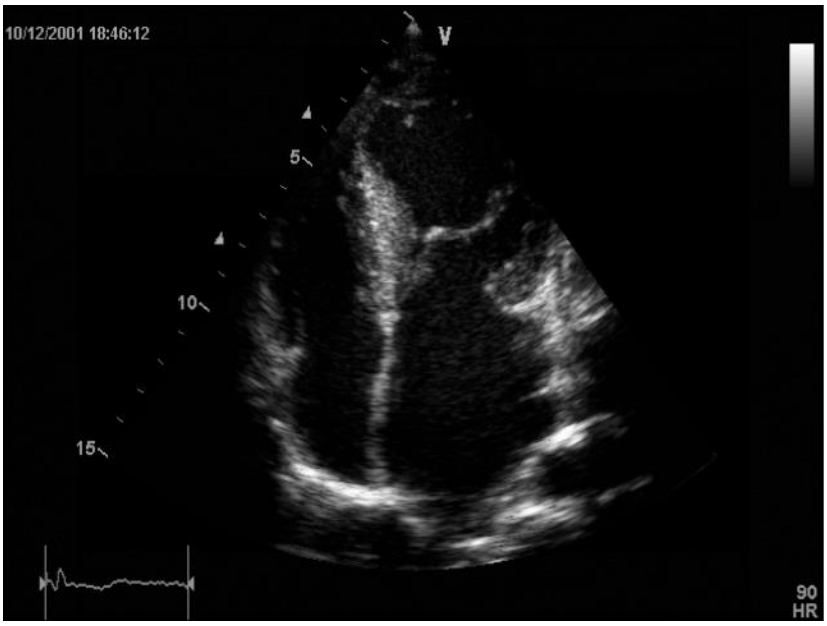

Figure 4.70: Watermarked image, PSNR= 46.9625dB

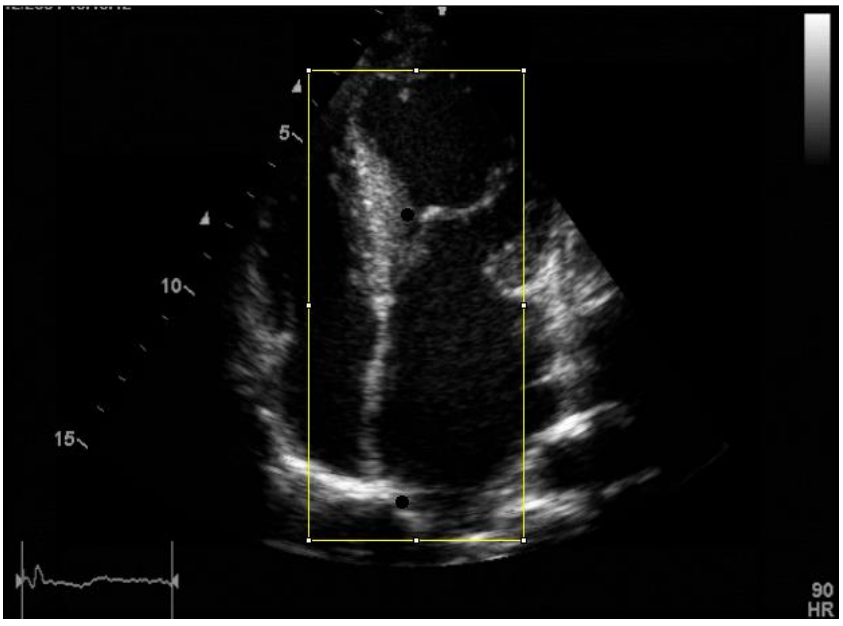

Figure 4.71: Tampered image

Figure 4.72: Zoom in ROI image

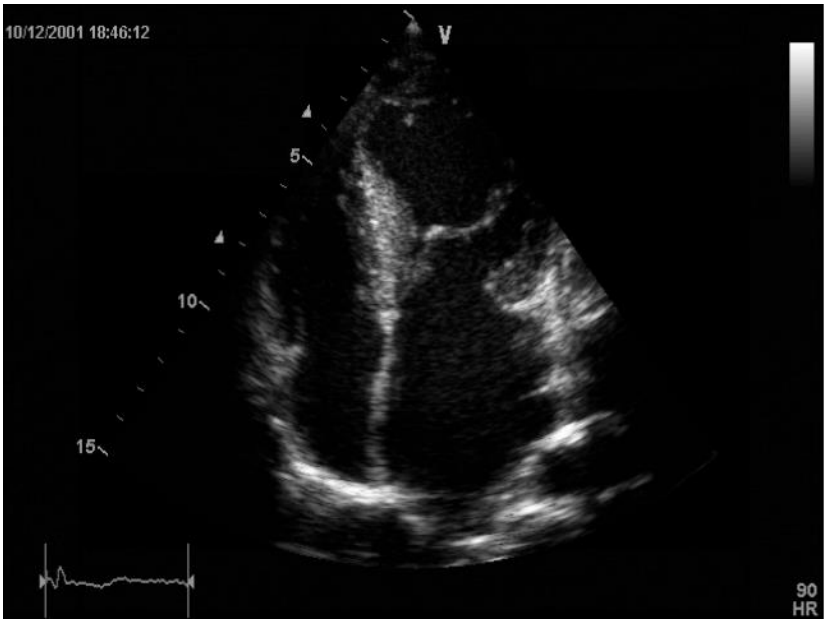

Figure 4.73: Recovered image, PSNR= 46.9625dB

Sample 2

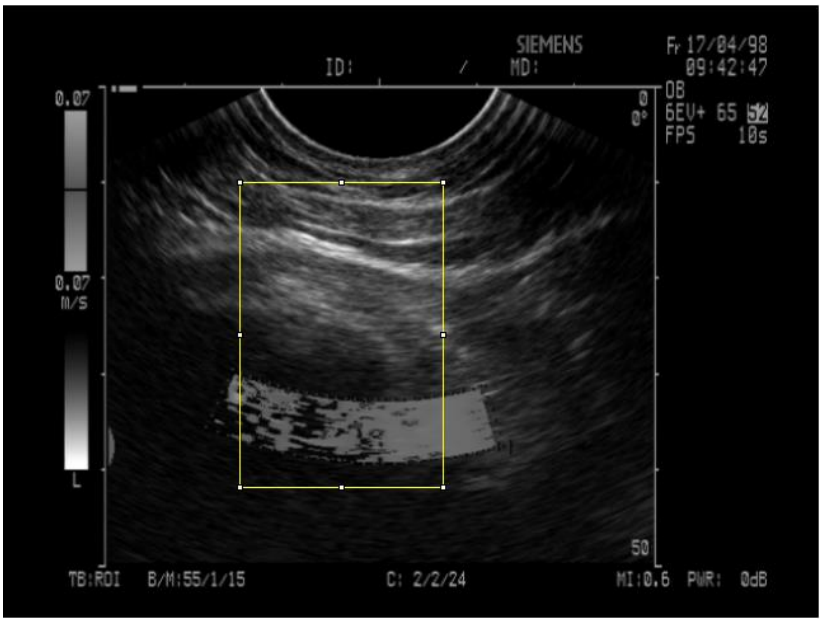

Figure 4.74: Ultrasound image with highlighted ROI before the enlargement process

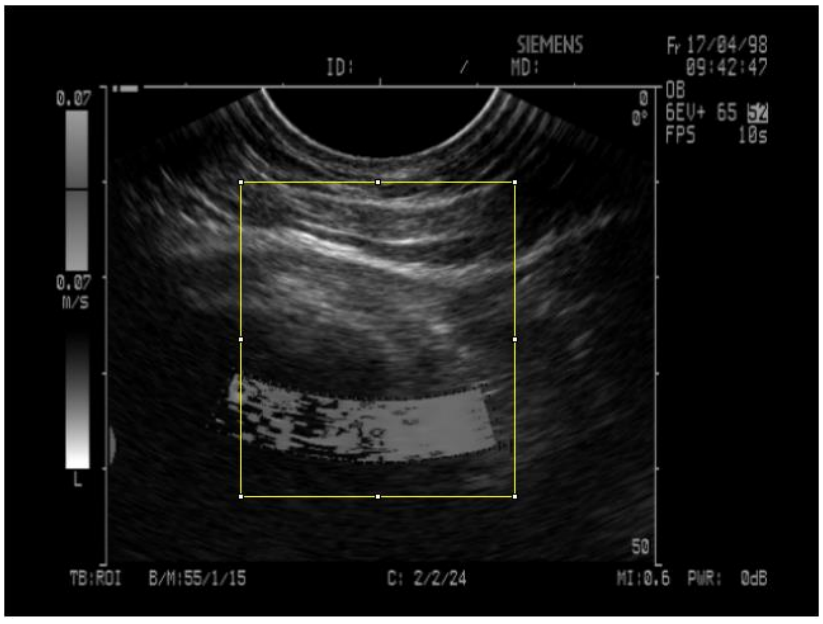

Figure 4.75: Ultrasound image with highlighted ROI after the enlargement process

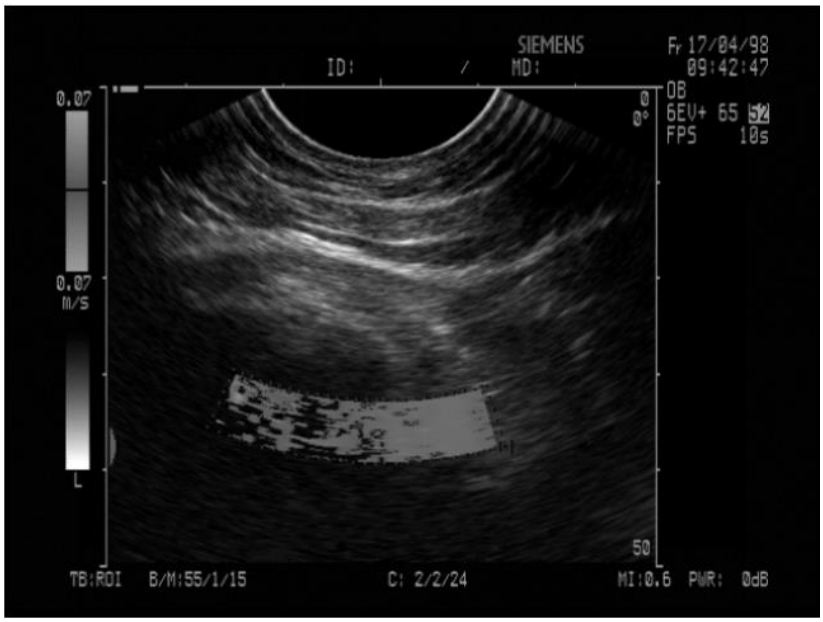

Figure 4.76: Watermarked image, PSNR= 47.2426dB

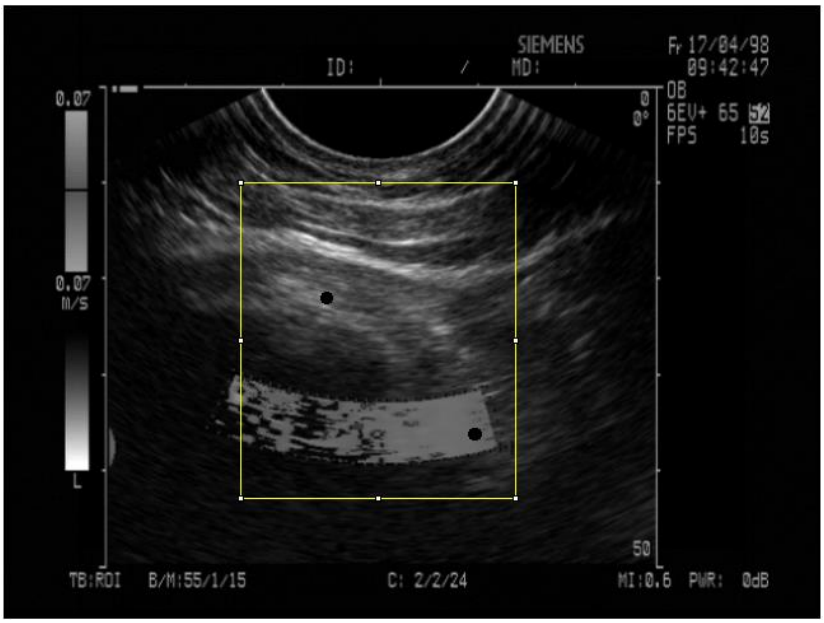

Figure 4.77: Tampered image

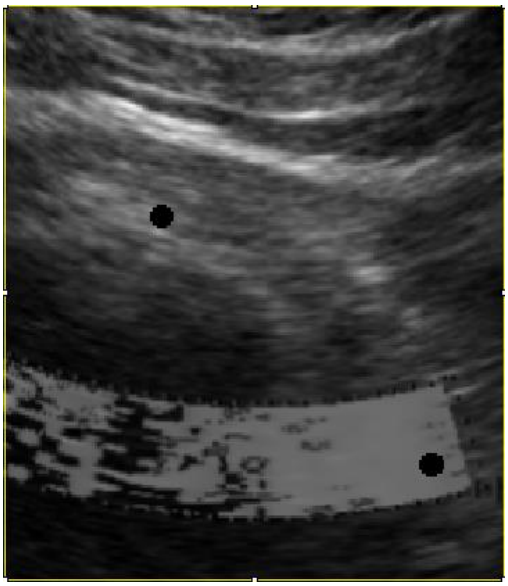

Figure 4.78: Zoom in ROI image

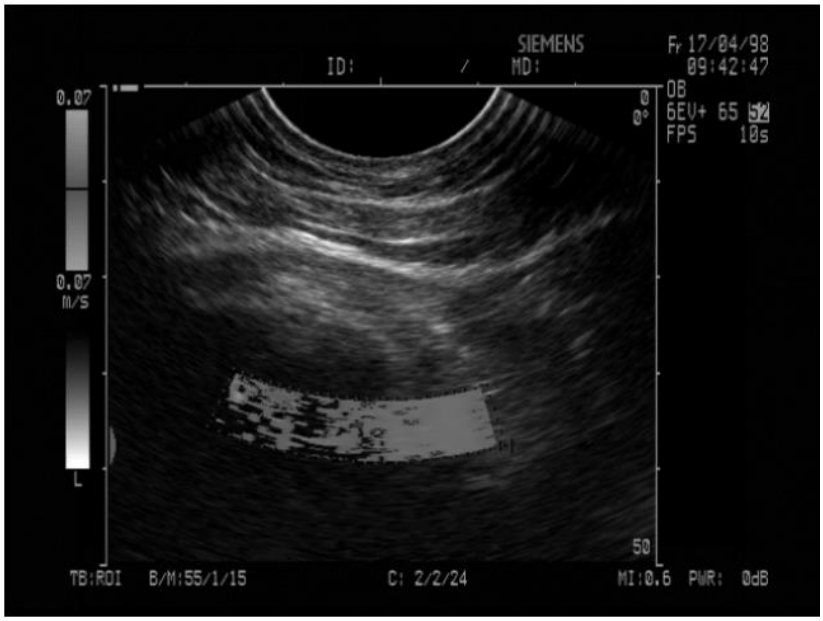

Figure 4.79: Recovered image, PSNR= 47.2426dB

Sample 3

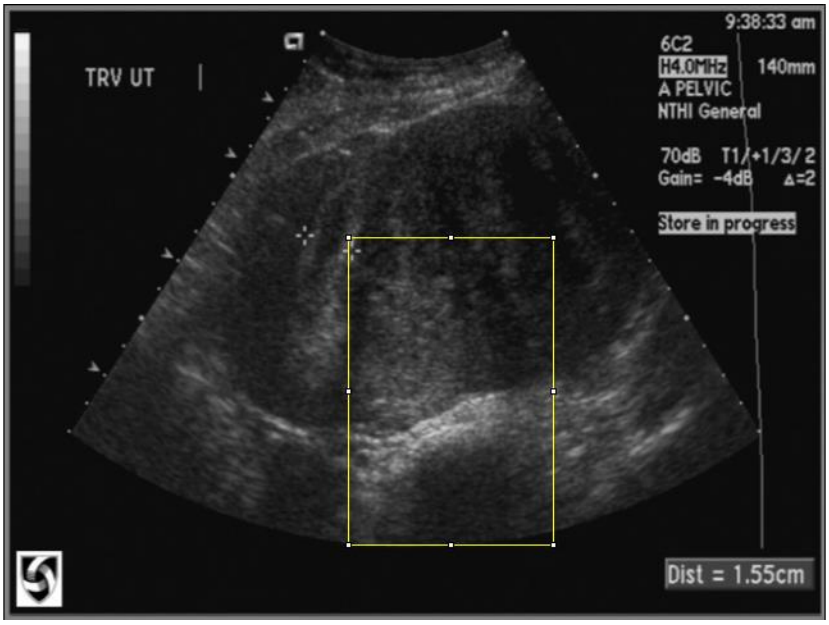

Figure 4.80: Ultrasound image with highlighted ROI before the enlargement process

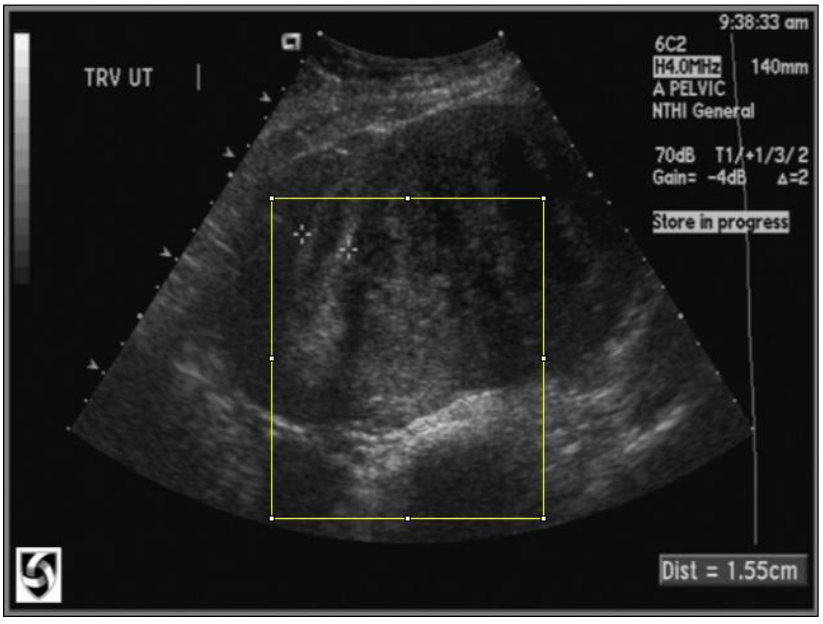

Figure 4.81: Ultrasound image with highlighted ROI after the enlargement process

Figure 4.82: Watermarked image, PSNR= 48.3345dB

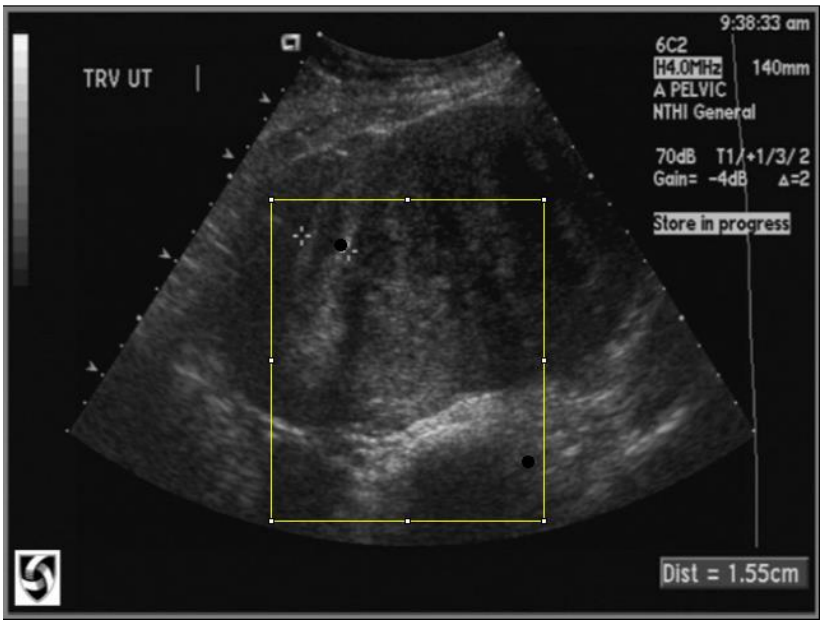

Figure 4.83: Tampered image

Figure 4.84: Zoom in ROI image

Figure 4.85: Recovered image, PSNR= 47.9882dB

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

This chapter involved section 5.2 is list out the contributions and limitations of the thesis for my research. In the section 5.3 depicts of the future work according to the result of this thesis. Finally, the section 5.4 is about synopsis the chapter.

5.2 CONTRIBUTIONS AND LIMITATIONS

A TALLOR (Tamper Localization and Lossless Recovery) watermarking scheme using PNG compression method is proposed. ROI region is successfully compressed and embedded into the RONI region. In the retrieving process, the ROI region is successfully retrieve and recover if there is any tamper occurs. By using this compression method, the area of ROI is increased therefore larger part of ROI is protected. The ROI region that recover is approximately 100% same as the original ROI therefore it is safe to use by any medical staff. For limitations, although the area of ROI is improved but not the whole ultrasound image is protected. Besides, there is no exist software or system that can let the medical staff who without programming experience to use on it. Thus, a future work is needed to improve the weakness.

5.3 FUTURE WORK

For the further improvements will be made according to the result from this thesis. The below are the some of the probable future works:

Another new and better compression will be found or develop to increase the limited ROI protection area to whole ultrasound image protection therefore whole ultrasound image will be protected.

A system about TALLOR watermarking scheme will be created therefore medical staff can process the ultrasound image easily.

5.4 SUMMARY

In this chapter, the summary of the research are contributions and limitations of the research. The result from this research to listed out some of the probable for future work. First of all, the objectives for this research are to involve compression of image in ultrasound image watermarking. Four type of compression method is tested successfully, for lossless, there are PNG, GIF and JPEG compression method while for lossy, there is JPEG compression method. All of the image compression method execute their function completely without any error and produce a positive result in compression ratio (value less than 1). Retrieving process to retrieve the bits from the RONI and tamper detection make sure that the compressed image is in the right format therefore output of recovered ultrasound image is produced. Besides, aim for my research is to increase the area of protection (ROI) for an ultrasound image using compression method. In this research, different compression method is tested to find out the best image compression method in my research. Both lossless and lossy compression method is chosen for testing and the best is PNG compression method. PSNR value and compression ratio is calculated for each compression method for comparison and find out the most suitable to use in the TALLOR watermarking scheme. According to the outcome, the aim and objectives that mentioned in chapter 1 was achieved.

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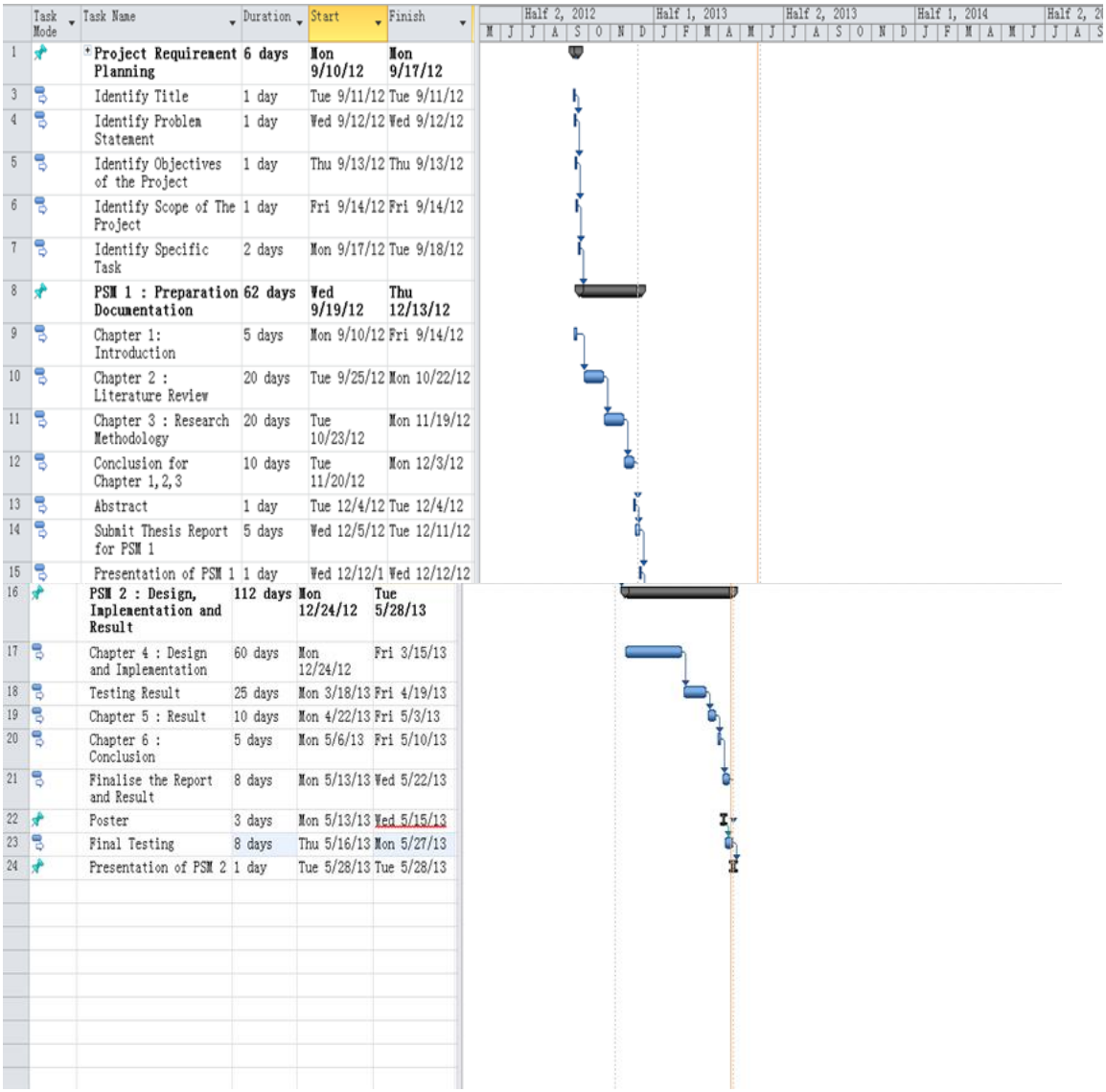
APPENDIX

Gantt chart



	Task Mode	Task Name	Duration	Start	Finish
1		**Project Requirement Planning**	**6 days**	**Mon 9/10/12**	**Mon 9/17/12**
3		Identify Title	1 day	Tue 9/11/12	Tue 9/11/12
4		Identify Problem Statement	1 day	Wed 9/12/12	Wed 9/12/12
5		Identify Objectives of the Project	1 day	Thu 9/13/12	Thu 9/13/12
6		Identify Scope of The Project	1 day	Fri 9/14/12	Fri 9/14/12
7		Identify Specific Task	2 days	Mon 9/17/12	Tue 9/18/12
8		**PSM 1 : Preparation Documentation**	**62 days**	**Wed 9/19/12**	**Thu 12/13/12**
9		Chapter 1: Introduction	5 days	Mon 9/10/12	Fri 9/14/12
10		Chapter 2 : Literature Review	20 days	Tue 9/25/12	Mon 10/22/12
11		Chapter 3 : Research Methodology	20 days	Tue 10/23/12	Mon 11/19/12
12		Conclusion for Chapter 1,2,3	10 days	Tue 11/20/12	Mon 12/3/12
13		Abstract	1 day	Tue 12/4/12	Tue 12/4/12
14		Submit Thesis Report for PSM 1	5 days	Wed 12/5/12	Tue 12/11/12
15		Presentation of PSM 1	1 day	Wed 12/12/1	Wed 12/12/12
16		**PSM 2 : Design, Implementation and Result**	**112 days**	**Mon 12/24/12**	**Tue 5/28/13**
17		Chapter 4 : Design and Implementation	60 days	Mon 12/24/12	Fri 3/15/13
18		Testing Result	25 days	Mon 3/18/13	Fri 4/19/13
19		Chapter 5 : Result	10 days	Mon 4/22/13	Fri 5/3/13
20		Chapter 6 : Conclusion	5 days	Mon 5/6/13	Fri 5/10/13
21		Finalise the Report and Result	8 days	Mon 5/13/13	Wed 5/22/13
22		Poster	3 days	Mon 5/13/13	Wed 5/15/13
23		Final Testing	8 days	Thu 5/16/13	Mon 5/27/13
24		Presentation of PSM 2	1 day	Tue 5/28/13	Tue 5/28/13