Tamper Detection and Recovery of Medical Image Watermarking using Modified LSB and Huffman Compression

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Abstract*— Medical image is an object which can help doctors to diagnose the patient. However, due to the rapid development of technology nowadays, mostly there are several parties that did some manipulation towards the medical image by using this technology. It can be harm for the patient. One of the concrete solutions to protect the authenticity of an image from the manipulation is by applying a watermarking. By inserting the watermark, the process to detecting the location of a manipulated medical image can be done by this system. Hence, the manipulated medical image can also be recovered until it similar with the original image by inserting a feature extraction such as the average intensity of the image blocks. This paper will discuss a scheme of reversible watermark using a modified LSB and Huffman compression to detecting and recovering the manipulated medical image. The testing results shows that this system is capable to detect the attack with an accuracy of up to 100% and can do the recovery with an accuracy of recovery rate up to 98% for some attacks.

***Keywords*— tamper detection; image recover; watermarking; modified LSB; Huffman**

I. INTRODUCTION

Digital image has a lot of uses in life, one of them is in the field of medic. Medical image is a representation of digital image which is vulnerable. Medical image used as an object that useful to help in diagnose the patient. Some medical tools can be used to get this medical image. Ultrasound image or Ultrasonography (USG) is one of a medical tool that can capture the image representation of human organs.

To an accurate medical image, the authenticity of the medical image that produced can be very important because it will impact the outcome of disease diagnosis. However, its not easy to keep the authenticity of this medical image because the effort to manipulating the medical image can be done in many ways, one of them is with the help of software. In addition, beside the image manipulation duplication and recognition of copyright also commonly happen. This is because there is no copyright in digital image. Of course it may cause an error in diagnosing the patients and it will certainly very harmful. By that, the manipulation effort which has been done towards a certain medical image must be detected so the authenticity can be kept. Besides being able to detect any manipulation activities towards the medical image, it also needs to recover the medical images that has been manipulated so it similar with the original image in order to enhance the accuracy of the patient diagnosis.

To protect the medical images, the method of digital image watermarking was performed. Digital image watermarking is a technique of insertion of certain information in the image in the digital image. This inserted information is called as watermark. That watermark can be text, image, audio, or even video[3].

To protect the image authenticity, the detection of manipulation and recovery towards the manipulated image is important to be applied. There are several studies that have been done before in this field of detection and recovery of the medical image manipulation, such as the one that been done by Zain[1] which uses modified LSB watermarking method based on the block. This method stores the average intensity of the image pixel blocks used to reconstruct the manipulated image. Then Liew[3] proposed a design of a reversible watermarking scheme based on the method from Zain. Liew divides the image into the ROI (Reign of Interest) and RONI (Reign of Non-Interest). The original LSB of the whole image pixels will be captured and compressed by Huffman compression before the watermarking is applied. The LSB from the compression results will be stored in the RONI image. This original LSB can be restored so the watermark can be reversible. In this paper, we proposed a watermarking scheme for detection and recovery of manipulation in the medical image based on the method from Zain[1] and Liew[3].

II. WATERMARKING SCHEME

A. Image Preparation

The medical images used are a grayscale ultrasound image with the size of 640x480 pixels and the format is bitmap with a color depth of 8bit. The images used are obtained from www.ultrasound-images.com. The division of ROI and RONI are firstly done so that the medical images have clear boundaries. ROI is the region used to process diagnose of a patient and RONI is the region which not being used. The division of ROI-RONI visualized as follows.

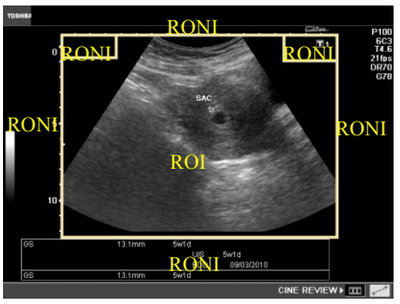

Figure 1. ROI and RONI Location

From the division of ROI-RONI region above, ROI region will be divided into blocks of 6x6 pixels. These blocks will be used as the place to insert the watermark information which previously we made the mapping block scheme first so that the insertion will be more orderly process. The mapping block scheme was illustrated as A→B→C→D→…→A, where A-C was a block of 6x6 that made before. The purpose of the mapping illustration above is recovery information from the block B which placed in block C, and so on. A mapping scheme has done is similar with the one that Zain[1] used which is based on the following formula:

$$\vec{B} = [(k \times B) mod N_b] + 1 \quad (1)$$

where $\vec{B}$, B, $k \in [1,N_b]$, k is a prime number, and N_b is the total number of blocks in ROI.

B. Watermark Insertion in ROI

ROI is divided into blocks of 6x6pixels, and each block is divided into 4 pieces of sub-blocks of 3x3 pixels. Then the number of block recovery for each blocks are found by using equation (1). K primes number used during the extraction should be the same as the insertion.

The average intensity values of each block are calculated (Avg_B) and the average intensity value for each sub-block are calculated (Avg_Bs). Then the watermark authentication v and p, also recovery watermark for each sub-block will be increased. The value of watermark v and p are calculated by the following equation:

$$v = \begin{cases} 0, & if\ Avg\_Bs > Avg\_B \\ 1, & otherwise \end{cases} \quad (2)$$

The watermark p (parity bit) is generated as:

$$p = \begin{cases} 1, & if\ Avg\_Bs\ is\ odd \\ 0, & otherwise \end{cases} \quad (3)$$

As for the value of recovery watermark is information of the sub-blocks average (Avg_Bs) from sub-blocks target. The watermark insertion scheme v, p, and r are as follows [4] :

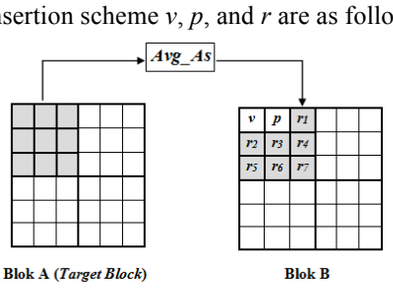

Figure 2. Insertion in ROI Block

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In the Figure 3, we provide a of flowchart the watermark insertion scheme.

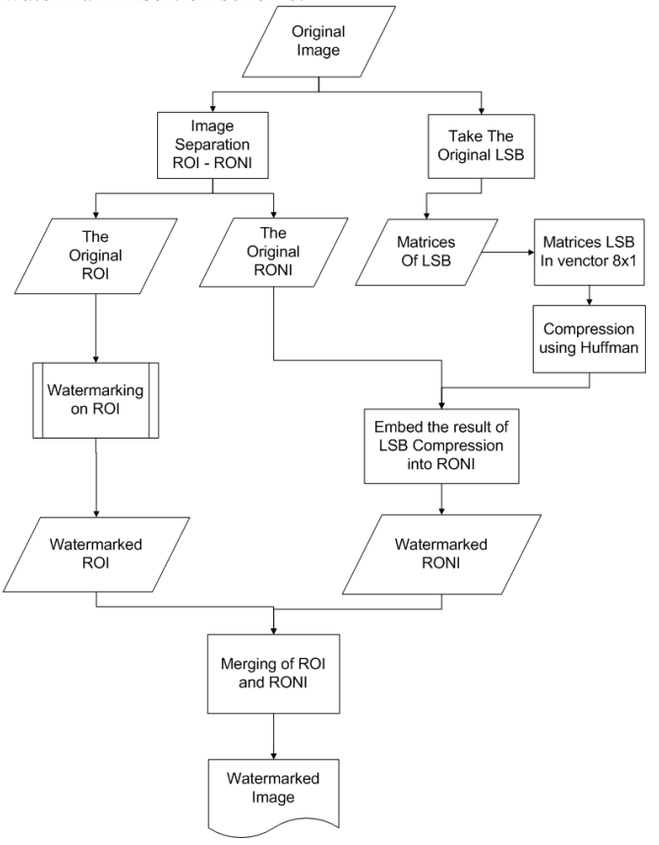


Figure 3. Block Diagram of the Image Watermarking

C. Original Image LSB Insertion in RONI

The original LSB captured from each ROI pixels will be compressed by Huffman and stored in RONI region. Original LSB captured is a binary matrix with the size of 640x480. These matrices are encoded into decimal per 8 bit of capturing the LSB.

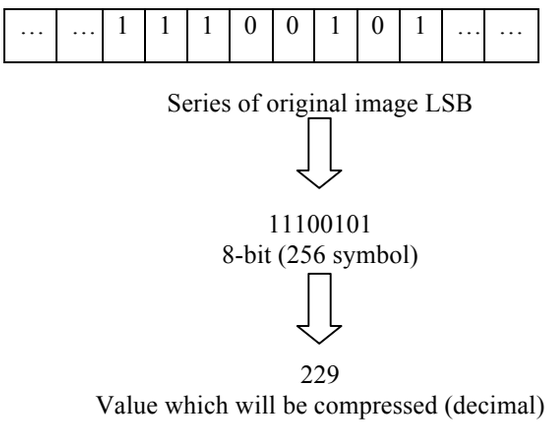


Figure 4.Calculation LSB block values

These LSB block values are compressed using Huffman compression method and produce a compressed LSB

and Huffman dictionary. Since the capturing of this original LSB using a series of 8-bit, so the content of the encoding in the Huffman dictionary will be 28=256. A compressed LSB using Huffman will be inserting in the RONI region as twice of LSB's bit.

Based on the test performed, the entire LSB from the Huffman compression is not enough to be inserted at 1 bit of RONI LSB. Therefore, the 2 bits LSB on RONI is used to enlarge the storage.

D. Manipulation Detection and Recovery

Firstly, the division of ROI and RONI were applied to the suspect image. It also the same with watermarking process, ROI is divided into blocks of 6x6 pixel and each block divided into 4 sub-blocks of 3x3 pixels. The detection process was done by checking the value of watermark v and p from a certain sub-block. Then a set LSB sub-block as 0 and calculate Avg_Bs and Avg_B to get v' and p' as shows in equation (2) and (3). If v=v' and p=p' for each sub-blocks, those blocks are a valid blocks. However, if one of v' and p' were not the same with v and p, then those blocks are detected as tampered block.

If the detection process is done, the next process is to do recovery towards the manipulation. Blocks which detected as tampered block will be recovered by taking 7 bits recovery (watermark) from each recovery block which has relation with each tampered block. Then the last is to set a value of 7 bits MSB for each sub-blocks on tampered block with 7 bits recovery r, meanwhile for the eighth bit will be set as 0.

E. Returning the Original Image LSB

The process of returning the original LSB on the image has done so that the watermark system which has been made is expected to become reversible. The original LSB stored in RONI will be returned after the detection and recovery of image process are done. The original LSB will be returned to each pixel even though there is no manipulation process has been applied to that certain pixel, if there is no manipulation process has been applied towards that certain pixel which its original LSB will be returned, so we hope the image's LSB can be returned to its original value as before the watermarking has been applied. Huffman's compressed bits which restored in RONI will be decompressed, and then its original LSB will be rebuild based on those decompression values.

It is possible there will be error in RONI region because both LSB are not restored while its original LSB were captured. However, all the pixels can be returned to its origins in ROI region.

III. TESTING RESULTS

A. Quality of Watermarked Image

The testing towards medical images had been done for 10 testing images. For this watermarking scheme produces watermarked images with PSNR of 47 dB up to 48.6 dB. Meanwhile the error rate is around 34.5% up to 46.3%. This result shows that watermarked images have a high quality for its difference with the original image cannot be recognized.

(a) (b)

Figure 5. Comparison of Original Image and Watermarked Image. (a) Original Image (b)Watermarked Image with PSNR 47.6789 dB

B. Watermark Extraction

This testing has purposes to know the image quality which produced by watermark extraction. Watermark will be extracted by returning all its original LSB which are restored in RONI. This process produces extracted image with PSNR around 54.2-56.4 db. It shows that there are several parts which cannot be returned in RONI region. It happens because there are 2 bits for each pixel which used to store the whole original image LSB in RONI region, so that there is are 2nd RONI LSB which cannot be returned to its original forms. Therefore, it will be better if we use a compression method that can compress 1 bit original image LSB and insert it to RONI region, so there will be no part in RONI region which is damage. The numbers compression comparison using Huffman compression method and Run Length Encoding (RLE) can be seen as follow.

TABLE 1. COMPARISON OF COMPRESSION METHOD

Compression Method	Bit after compressed	Ratiocompression
None	307200	1
RLE, RC threshold=15	404115	1.31548
RLE, RC threshold=7	379604	1.23569
RLE block 2x2, RC threshold=7	280749	0.91390
RLE block 3x3, RC threshold=7	232500	0.75684
Huffman block 2x2 (16 symbol)	209774	0.68286
Huffman block 4x1 (16 symbol)	166039	0.54049
Huffman block 8x1 (256 symbol)	134428	0.43759

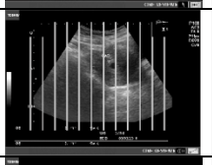
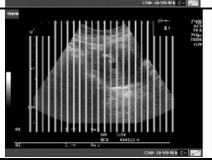
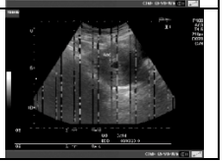
There is no damage in ROI region itself, ROI is similar with original images. Therefore, this watermarking system called as fully reversible for ROI image region.

C. *Manipulation Detection and Recovery*

The attacks which have been done to testing this process was block modifications attacks, sharpening contrast, and increasing the brightness. Block modifications attacks can be detected with an accuracy of up to 100%. Meanwhile for others attacks also can be detected with an accuracy of up to 99%. For the block modifications attacks on manipulated images, the recovery rate is up to 98%. And for the rest of attacks, the recovery rate is around 4.5%-60.5%. Recovery cannot be done perfectly (100%) due to the limitation of watermark storage blocks which stored in ROI. In this paper, two ROI regions are used. Upper ROI and lower ROI. This turn the watermark information storage region to be very limited, and the cause for performing a huge manipulation towards one of ROI region is the manipulated blocks of mapping blocks will also be damage. If it happens, then recovery process will not produce a perfect result.

From the attacks, it can be conclude that the bigger region of block manipulation, it will be followed by the worse recovery quality and it can be seen from the recovery rate. One of the visualization examples of manipulated image with the block size of 5%, 20%, and 40% and its recovery can be seen as follow.

TABLE 2. DETECTION AND MANIPULATION OF BLOCK MODIFICATIONS ATTACKS RESULT

Attacks Percentage	Visualizationblock attacks	Recovery results
5%		
20%		
40%		

IV. CONCLUSIONS

This watermarking scheme shows a good detection performance. Meanwhile, for the process of performance recovery shows by the block manipulation attacks. This watermarking system is fully reversible for the part of ROI image. We provide the testing results as follows. The watermark system is capable to detect the attack with an accuracy of up to 100% and can do the recovery with an accuracy of recovery rate up to 98% for some attacks.

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