# MEDICAL IMAGE: ROI AND RONI DEFINITION USING FUZZY LOGIC

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## ABSTRACT

This thesis discusses on the edge detection in fuzzy logic before medical image watermarking. Normally most of the researcher defined the ROI and RONI in the medical image manually. This research will be proposed that the ROI and RONI in the medical image can be defined automatically by using fuzzy logic. There are rules of inference in the FIS which will affect the relationship between the different variables of a fuzzy system input variable and fuzzy output. The images will be used to process are ultrasound, magnetic resonance imaging, computed tomography etc. Firstly, the area of interest (ROI) of the particular ultrasound image will be determined using fuzzy logic. 2×2 pixel window is used to determine whether the pixel is black, white or an edge. Then, we definitely know that which is the ROI and RONI in the ultrasound image by determining the edge using FIS. Thus, this will help doctor on determining the ROI which could be faster than doctor determined it one by one. Computational system should implement widely due to the increasing of medical image. After that, it will proceed with embed the watermark on the RONI by using least significant bit (LSB) technique or other techniques so that it can help in preserve imperceptibility of the watermarked image.

# ABSTRAK

Tesis ini membincangkan tentang pengesanan pinggir imej perubatan dengan logik kabur sebelum Watermarking. Biasanya kebanyakan penyelidik ditakrifkan ROI dan RONI dalam imej perubatan secara manual. Kajian ini akan dicadangkan bahawa ROI dan RONI dalam imej perubatan boleh ditakrifkan secara automatik dengan menggunakan logik kabur. Terdapat peraturan inferens dalam FIS yang akan menjejaskan hubungan antara pemboleh ubah yang berbeza yang kabur pembolehubah input dan output sistem kabur. Imej-imej yang akan digunakan untuk proses adalah ultrasound, MRI, tomografi berkomputer dan lain-lain. Pertama, kawasan berkepentingan (ROI) imej ultrasound yang tertentu akan ditentukan dengan menggunakan logik kabur. 2×2 tetingkap piksel digunakan untuk menentukan sama ada piksel yang berwarna hitam, putih atau kelebihan. Kemudian, kita pasti tahu bahawa yang merupakan ROI dan RONI dalam imej ultrasound itu dengan menentukan bahagian tepi atau pinggir dengan menggunakan FIS. Oleh itu, ini akan membantu doktor untuk menentukan ROI yang boleh menjadi lebih cepat daripada doktor menentukan ia satu persatu. Sistem pengkomputeran perlu melaksanakan secara meluas kerana peningkatan imej perubatan. Selepas itu, ia akan meneruskan embed tera air pada Roni dengan menggunakan teknik-kurangnya penting bit (LSB) atau teknik lain supaya ia boleh membantu dalam memelihara imperceptibility imej tera air.

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| | |
|---|---|
| RONI | : Region of non-interest |
| ROI | : Region of interest |
| LSB | : Least Significant Bit |
| HVS | : Human Visual System |
| MRI | : Magnetic Resonance Imaging |
| CT | : Computed Tomography |
| FL | : Fuzzy Logic |
| PSNR | : Peak Signal-to-Noise ratio |
| DCT | : Discrete Cosine Transform |
| FIS | : Fuzzy Inference System |
| DICOM | : Digital Imaging and Communication in Medicine |

# CHAPTER 1

# INTRODUCTION

This chapter describes briefly about medical image ROI and RONI definition using a fuzzy inference system in fuzzy logic (FL). Introduction, problem statement, objectives and scope of this thesis describe in this chapter.

## 1.1 INTRODUCTION

Edge detection is very useful in computer vision and pattern recognition field for image analysis. In a modern health care, medical image plays an important role in field of medical science and clinic purpose. Unfortunately, people can modify the medical image easily with existing image processing tools nowadays. Those medical images also can be called as diagnostic images are obtained by computerized radiography, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound etc. It is embedded into the original multimedia data, where it remains detectable as long as the perceptible quality of the content is at an acceptable level. Watermarking proposed to enhance medical image data security, content verification and fidelity. Anyway, the process of before watermarking also consider as an important part. To help doctor to define the ROI (Region of interest) of medical image, the method of computational use on detecting edges using fuzzy logic is proposed here. FL provides a means for encapsulating the means subjective decision- making process in an algorithm suitable for computer implementation. Thus, the particular image is used FL algorithms to find out the RONI (Region of non-interest). A RONI of a medical image is an area which does not including important information. Thus, the ROI must be stored without any distortion. The next step is to embed data in noisy portions by finding the noisy pixels of the image. FL is a conception to computing based on "degrees of truth." FL introduces partial truth values in between true and false. Fuzzy set (Simple Fuzzy Variables) have values in the range of [0, 1]. Fuzzy rule base (a set of conditional (IF-THEN) fuzzy propositions) is the main functioning tool behind making fuzzy inference. Instead of these, the principle behind FL is straight forward and its implementation in software is relatively easy. After found the RONI, then there are many ways of watermarking like may find noisy pixels of the image to embed data in that noisy portion to save the border size. The least significant bit (LSB) is used to store the text data which needed to embed in the pixels (J. M. Zain, 2004). FL is applied to retain imperceptibility of the image had been watermarked. Thus, data hiding techniques is used for concealing or hiding patient information with medical images.

## 1.2 PROBLEM STATEMENT

Doctors normally defined the ROI and RONI of medical images manually. However, the problem is there are more than thousands of medical images produced per day in a hospital. So doctors would be needed to spend time to analyze on all the medical images. Therefore, the increase use of computational models enables doctors to ease some of their jobs. In between, it is hard for us humans to recognize things in nature especially in those image colors. For example, the image looks like black color from our visual eye, but that is grey color after use some software or computational models to view and prove it. Due to the advanced of technology in communication and computer network, the use of computational models should increase as well. Thus, doctors can reduce their jobs on determining the ROI of medical image with the use of computational models, especially for the ultrasound images. Ultrasound imaging is a powerful diagnostic technique with the advantages of strong real-time, low price, convenience, high security over other medical imaging methods. Unfortunately, ultrasound is the inherent presence of speckle noise which would degrade the image quality and increase the difficulty for the observer to diagnose. Thus, it is essential preserve edges for interpretation and diagnosis of ultrasound images. Besides ultrasound images, other medical images will be used as well. FL algorithm is used to find the RONI and then the next step embed the data into suitable portions. Most of the researchers defined the ROI and RONI of medical image manually regarding to their own or from expert knowledge. Thus, from this research can define the ROI and RONI automatically through FL.

## 1.3 OBJECTIVES

This thesis's objectives are:

a) To investigate the usage of fuzzy logic in image processing
b) To use fuzzy logic for ROI and RONI definition in medical images
c) To test and compare edge detection using fuzzy logic with other edge detection methods.

## 1.4 SCOPE

FL based pixel window scanning algorithm will be proposed to find the edge through a fuzzy inference system (FIS) in the grayscale image. There are several rules based to be defined in FIS. Those rules based are used to determine whether the related pixel is the black, white or edge. This process can be done before we proceed with watermarking. Watermarking is defined as the invisible embedding or insertion of a message in a host document, an image, for example. Anand et al., proposed to insert an encrypted version of the electronic patient record in the LSB (Least Significant Bit) of the gray-scale levels of a medical image (Anand, 1998). Scope of this project is to help doctor in determining the important parts on medical image and after that the watermarking process will be protect information from unauthorized access, use, disclosure, disruption, modification, perusal, inspection, recording or destruction. The bit field in medical image representing the image (non-destructive) defines the ROI, to be left intact and regions of insertion.

## 1.5 THESIS ORGANIZATION

This thesis contains of five (5) chapters.

Chapter 1 is discussing about background and introduction of research.
Chapter 2 will mainly focus on literature review of the research.
Chapter 3 study the methodology of the research.
Chapter 4 show the results and discussion of the research.
Chapter 5 is summarizing the future work and conclusion of this research.

# CHAPTER 2

# LITERATURE REVIEW

This chapter briefly describes the review on research related with watermarking using fuzzy logic. This chapter will discuss of components in DICOM, methods of edge detection, region of interest, general watermarking scheme, describes the classification of watermarking by domain, region of interest, introduces the concept of medical image watermarking, use of computational techniques, fuzzy inference system, introduces watermarking scheme and previous works.

## 2.1 DICOM IMAGE PROCESSING

DICOM is Digital Imaging and Communication in Medicine. It is a software integration standard that is used in Medical Imaging. A DICOM file has a .dcm extension. X-Rays, ultrasounds, CT (Computed Tomography), and MRI support DICOM and use it extensively in all modern medical imaging systems. Their file contains more than just images. The feature of its file consists of the data header, called as metadata and it also consists of DICOM image data set (G. Coatrieux, 2000). There are images consists related information like image type, study, modality, matrix dimensions, patient's name and number of stored bits in the header. For the image data follow the header and contain 3D information of the geometry. Its standard allows the communication between equipment from differences modalities and vendors make easy on the managing of digital images. Its protocol is used to exchange information mainly on DICOM image between all medical imaging applications that are connected to the hospital network.

## 2.2 METHODS OF EDGE DETECTION

There are many methods for edge detection, but most of them can be grouped into two categories, search-based and zero-crossing based as below (Siddhartha Bhattacharyya, 2013).

- Search based
  - Firstly, it will compute a measure of edge strength to detect edges.
  - Measure edge strength using first order-derivative expression such as the gradient magnitude.
  - Then, usually the gradient direction will be used as a computed estimate of local orientation of edge on searching for local directional maxima of the gradient magnitude.

- Zero-crossing based
  - In order to detect edge, it will search for zero crossings in a second-order derivative expression computed from the image, usually the zero-crossings of the Laplacian or the zero-crossings of a non-linear differential expression (Siddhartha Bhattacharyya, 2013).
  - As a pre-processing step to edge detection, a smoothing stage, typically Gaussian smoothing, is almost always applied (see also noise reduction).
  - Example: Laplacian detector

In a nut shell, many edge detections are depended on the computations of image gradients. The difference between them is the use on types of filters for computing gradient estimates in x and y directions.

### 2.2.1 SOBEL EDGE DETECTION

Sobel edge detection is a classic first-order edge detection operator that finds contrast, performs a 2D spatial gradient measurement on an image and emphasizes regions of high spatial frequency that correspond to edges. It is usually used to find the approximate absolute gradient magnitude in an input grayscale image at each point. Not only is the gradient of image for each position calculated, but also their direction. It is based on convolving the image with a small, separable, and integer valued filter. This operator will have a pair of 3×3 convolution kernels. Convolution kernel is considered as a small matrix useful on techniques in image processing like edge detection, sharpening, blurring and so on. The convolution kernels of this detector are given as below.

**Table 2.1:** Convolution Kernels (Mx and My) of Sobel Edge Detection

| | | |
|---|---|---|
| 1 | 2 | 1 |
| 0 | 0 | 0 |
| -1 | -2 | -1 |

Mx

| | | |
|---|---|---|
| 1 | 2 | 1 |
| 0 | 0 | 0 |
| -1 | -2 | -1 |

My

### 2.2.2 CANNY EDGE DETECTION

Canny edge detection is the most widely used in computer image processing. It optimizes the product of signal-to-noise ratio and localization. It can detect edges with noise suppressed at the same time. It begins by smoothing an image by convolving it with a Gaussian of a given sigma value. Derivatives in both x and y directions are computed based on the smoothed image. These in turn are used to compute the gradient magnitude of the image.

### 2.2.3 LAPLACIAN EDGE DETECTION

Laplacian filter is one of the derivative filters used to find rapid changes on the areas of edge in images. Normally it will smooth the image due to the reasons derivative filters are very sensitive to noise. It takes the second derivative of the image. The LoG will give the value of zero where the image is basically uniform. The LoG will give a positive response on the darker side and a negative response on the lighter side wherever a change occurs on the pixel value. If there is at a sharp edge between two regions, the response will be zero away from the edge, positive just to one side, negative just to the other side or zero at the same point in between on the edge itself. The resulting output is rather noisy if we filter the original image with a simple Laplacian which is a LoG filter with a very narrow Gaussian. Sharpen the edges also causing the increases of noise. On the other hand, using a larger Gaussian will reduce the noise, but reducing of sharping effects will be occurred. The convolution mask of this detector is given below.

**Table 2.2:** Convolution Masks for Laplacian Edge Detection

| | | |
|---|---|---|
| 0 | -1 | 0 |
| -1 | 4 | -1 |
| 0 | -1 | 0 |

## 2.3 REGION OF INTEREST (ROI)

ROI is an important area to be considered while watermarking medical images. It is an area that contains diagnostically important information and must be processed without any distortion in medical images. In contrast, region of non-interest (RONI) is an area that did not contain diagnostically important information in a medical image. Thus, mostly people will embed the watermark in the RONI to maintain the originality of the ROI. To extract the watermark, then the process will become reverse, which is the ROI is used for watermark embedding so that the original information is restored.

## 2.4 GENERAL WATERMARKING SCHEME

Watermarking is the process of adding or embedding a visible watermark into some cover data for the purpose of identification of the original source or owner of the multimedia data. Embed the information and a decoder for detection (ABDULLAH, 2009) to produce the result which shows in Figure 2.1. Function E which is the encoder used to embed the watermark, W inside original image $I$ (Chuin, 2011) as shown in Eq. (2.1).

$$E(I, W) = I\text{w} \tag{2.1}$$

Thus, $I$w (the watermarked image) is the output of the process. The decoder, D is extracts or detects the watermark, W from the original image (Chuin, 2011). The equation is as shown in Eq. (2.2).

$$D(I, I\text{W}) = W \tag{2.2}$$

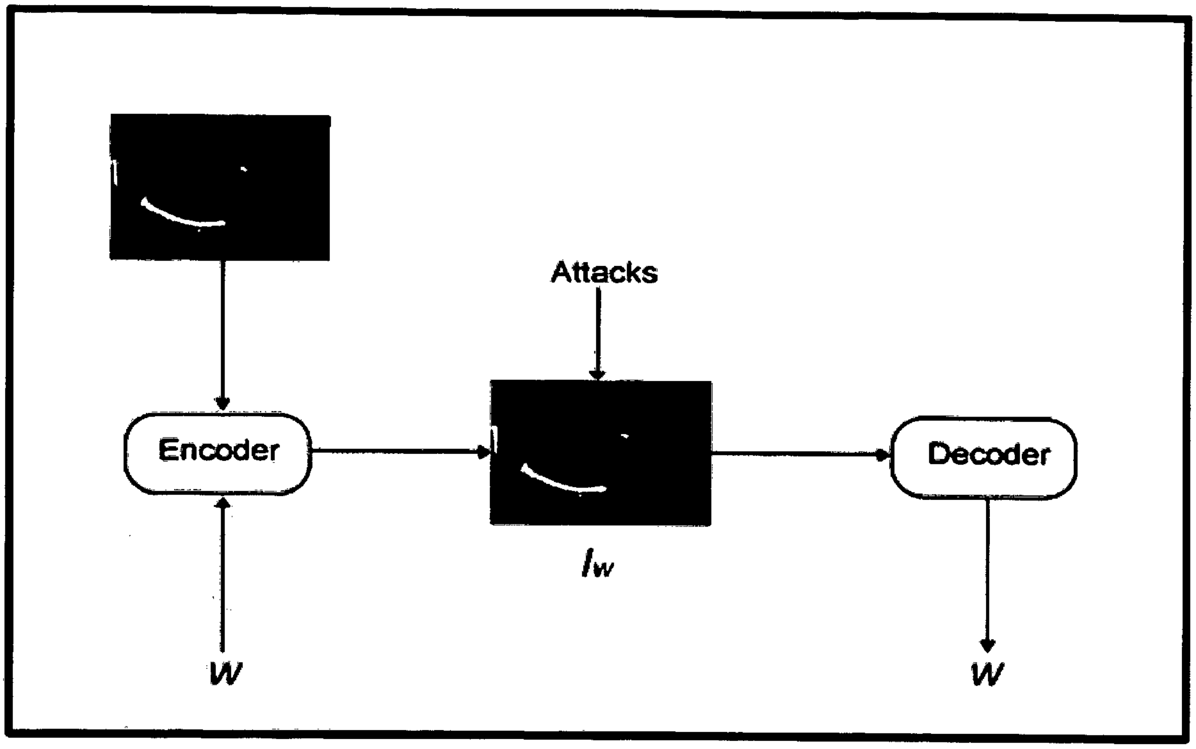


**Figure 2.1:** Image Watermarking Scheme

## 2.5 TYPES OF DOMAIN

There are two famous approaches to watermarking which are spatial domain watermarking and transform domain watermarking that are mostly used where the watermark is embedded.

### 2.5.1 SPATIAL DOMAIN WATERMARKING

It is easy to implement and does not require original image for watermark detection. In addition, it embeds the watermarking into the least significant bits of the image. Its modification will not perceive by human eyes because the last binary bits is the least significant bits (Chuin, 2011). Unfortunately, it often fails under signal processing attacks such as compression and filtering. Besides, due to the watermark is directly applied in the pixel values, and it will cause the fidelity of the original image data can be severely degraded. In addition, it is less robust compared to transform domain techniques.

### 2.5.2 TRANSFORM DOMAIN WATERMARKING

By modifying the coefficients of global or block transform, watermark embedded in the transform domain example like DCT (Discrete Cosine Transform), DWT (Discrete Wavelet Transform) and DFT (Discrete Fourier Transform) (Chuin, 2011). Generally, frequency domain watermarking provides more protection under most of the signal- processing attacks. It is not practical for a huge image database because the existing frequency domain watermark algorithm requires the original image for comparison in the watermark retrieval process. In addition, the necessity of progressive transmission property in existing spatial domain and frequency domain watermarking algorithms limit their Internet applications. The advantage of using the transform domain watermarking is that user have more control over the watermark insertion areas that are basically the ROI to insert the watermark. The reason is more than one coefficients against every pixel value in transform domain watermarking. Furthermore, it is more robust compared to spatial domain watermarking.

## 2.6 USE OF COMPUTATIONAL INTELLIGENCE TECHNIQUES

Computational intelligence is the study of adaptive mechanisms to enable intelligent behavior in complex, uncertain and changing environments. In the previous reviewed work, there is several uses of computational intelligence techniques such as genetic algorithm, neural network and fuzzy logic. These techniques are optimally used to select the locations where the watermark needs to be inserted. Besides, FL and other methods also can be used in edge detection.

### 2.6.1 GENETIC ALGORITHM

GA (Genetic algorithm) is basically employed to choose the best embedding positions in the image watermarking (Saliza Ramly, 2011). GA is more focused on the requirement of watermark capacity. GA is often used to expand watermark capacity. In addition, GA also used to find the best strengths of watermark to maintain the quality of the image. This computational technique mostly tended to work by using JPEG image. Many of the researchers have been done this in transform domain. Selection, crossover and mutation are their important process on edge detection.

### 2.6.2 NEURAL NETWORK

The works involved NN (Neural network) mainly focus on the robustness. There are several types of NN usually used in watermarking. For example, Radial Basic Function (RBF), Back-propagation Neural Network (BPNN), Hopfield and full counter-propagation Neural Network (FCNN). DCT is one of the work in NN which applied in the transform domain. For example, they embed the watermark by using the highest changeable threshold values of DCT coefficients, which are determined by the perceptual features of the original image. Most of the researchers used JPED image as the original image and binary image as the watermark info (Saliza Ramly, 2011). Normally image edge detection in this method will be firstly classification of pixel and determine on which part of a segment or not by the value of pixel is (S.Lakshmi, 2010). After that, edge detection process will be proceeded through all pixels between different homogeneous areas and see which part is edge.