



## Comparison of Thresholding Methods in Image Processing for Uterus Ultrasound Images

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### Abstract

Image processing is one of the abilities of Artificial Intelligent that can help defining different types of images. Currently, in the medical field, experts are needed to define the location and size of tumors. Occasionally, these experts might make human errors, and as a result, the images from image processing must be used as Decision Support Systems (DSS) for the experts. Moreover, the DSS that were produced from the image processing in the current study will be used to help the experts to identify tumors with more precision and accuracy. In this study, 20 images from ultrasound that have low contrast were used. There are six different alternatives that can be used in image processing, to define the location of tumors, by using images from ultrasound: the ISODATA method, Li entropy, Minimum cross-entropy, Otsu's method, the Triangle method, and Yen entropy. Thereby, these six methods were compared to find the best method. In each method, there are different ways, to find the threshold and present the image qualities, that are different from those of the original image. The ISODATA method, Li entropy, and Otsu's method showed bright colors and have high contrast on the boundaries. The Triangle method and Yen entropy tend to cover overestimated edges, and transformed bright colors into black, which can prevent the locating of tumors. Minimum cross-entropy transformed most colors into white. In summary, it was found that Otsu's method and the ISODATA method are the best options, for increasing the contrast in images, which make it easier to clarify tumors)

**Keywords:** *Image processing, Threshold, Decision Support Systems, Medical field*

### 1. Introduction

Artificial Intelligence (AI) is a type of technology, that can learn and think like humans. AI has statistical memory that imports data by using machine learning, and it includes deep learning that can use complex logic. Nowadays, AI is becoming more widespread in many different fields such as business, education, and industries.

At present, experts are needed to analyze ultrasound images, to define the location and size of tumors, which takes time. However, sometimes the data is needed within a short time, such as when doctors need the data as soon as possible, in order to perform an operation, but they must wait for the experts to analyze the images. Furthermore, experts can make human errors, which can lead to the providing of the misdiagnosed treatment for patients.

Ultrasound is the use of ultrasound waves that is capable of imaging superficial structures and organs, for example liver and kidney. However, ultrasound images contain an excessive amount of noise and low contrast and also provide grayscale images, which can lead to incorrect analysis in identifying the location and indicating the size of tumors. Therefore, image processing must be used to improve image quality. Data Support Systems (DSS) can be created from this image processing to help experts with analyzing ultrasound images, and therefore, DSS can increase accuracy and precision in analysis.

A total of six thresholding methods were used: the ISODATA method, Li entropy, Minimum cross-entropy, Otsu's method, the Triangle method, and Yen entropy, to conduct the image processing with ultrasonic images. Our review of previous research studies indicated that these six methods are very popular for use in image processing, especially to classify the image data.

El-Zaart, A. (2008) studied the ISODATA (Iterative Self-Organizing Data Analysis Technique) method with gamma distribution, which was new method in image processing. This method converts thresholding values into histograms, and combines them with gamma distribution as an unsupervised classification algorithm. Bangare et al. (2015) studied Otsu's method, which gave promising results by automatically performing clustering-based image thresholding. It was recommended as the most simple and standard approach for automatic threshold selection. Moreover, it has few limitations and can be applied to



different problems. Al-Ajlan and El-Zaart (2009) studied the minimum cross-entropy thresholding method based on gamma distribution, instead of Gaussian distribution, which classifies images into more than two classes of pixels and is more general than the Pal method, because gamma distribution can be used for both symmetric and non-symmetric histograms. Gopinathan and Deepa (2015) studied the Triangle method, which can calculate such various kinds of images as computed tomography (CT-scan), magnetic resonance imaging (MRI), synthetic aperture radar (SAR) and ultrasound imaging. In their study, it was found that the Triangle method was better for CT-Scan images and SAR images. Sezgin and Sankur (2004) compared the combined performance measures of 40 different image thresholding methods. They applied these methods to degraded images with noise and blur. Finally, they found that the clustering-based method of Kittler and Illingworth including the entropy-based methods of Kapur, Sahoo, and Wong and Sahoo, Wilkins, and Yeager were best for NDT images.

The aim of this current study is to find the methods, that use thresholding to separate different grayscale colors in ultrasound images, with the objective of producing the DSS for use by experts. Furthermore, we would like to find the suitable thresholding methods that can be used for ultrasonic images in order to indicate the location and sizes of tumors in the uterus.

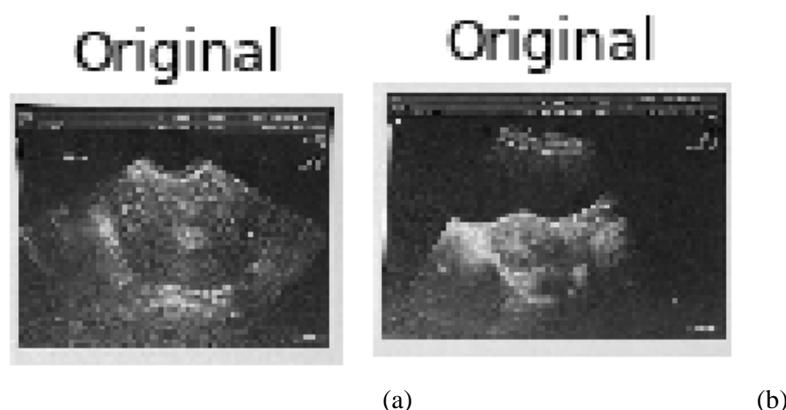
## 2. Objectives

The aims of this research study are as follows:

- 1) To study image processing.
- 2) To study the algorithm of various thresholding methods.
- 3) To compare the performance of thresholding methods which are used for ultrasonic images.

## 3. Materials and Methods

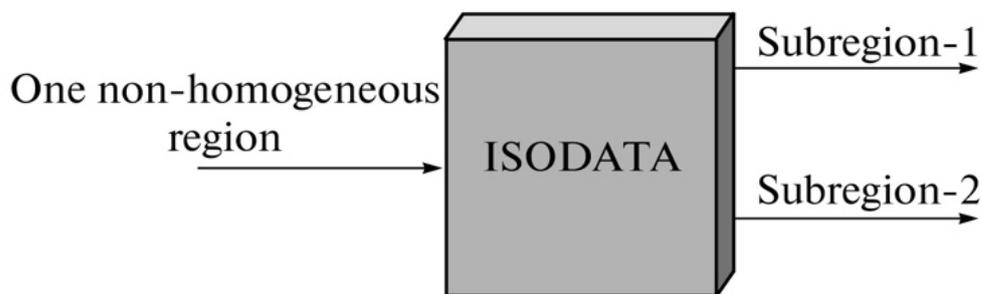
A set of 20 uterus ultrasound images was obtained from Saint Louis Hospital in Bangkok. There was a limitation because the data is considered to be personal information. From the images that were obtained, there are 10 images of a normal uterus and 10 images of an abnormal uterus that have tumors. Therefore, the data were separated into two types of cases: normal uterus and abnormal uterus, the example images of which are shown in Figure 1.



**Figure 1** (a) normal uterus ultrasound image and (b) abnormal uterus ultrasound image



The ISODATA (Iterative Self-Organizing Data Analysis Technique) method separates non-homogeneous classes into two sub-classes, as shown in Figure 2. In this method, there are three steps. The first step is the sampling of the initial threshold value. Next, each pixel is divided to the nearest class. Nevertheless, a specific formula is employed to find the mean in Gaussian distribution, so finding the mean in another distribution, will be inaccurate and the formula is not involved with the nature of distribution. Therefore, estimation of the threshold is not accurate. Lastly, Gaussian distribution is used to find the mean  $\mu_1$  and  $\mu_2$ , and then, the second and third steps are repeated, until there is a small change between iterations. The steps of the ISODATA image processing are shown in Figure 3.



**Figure 2** Separation of non-homogeneous classes by the ISODATA method

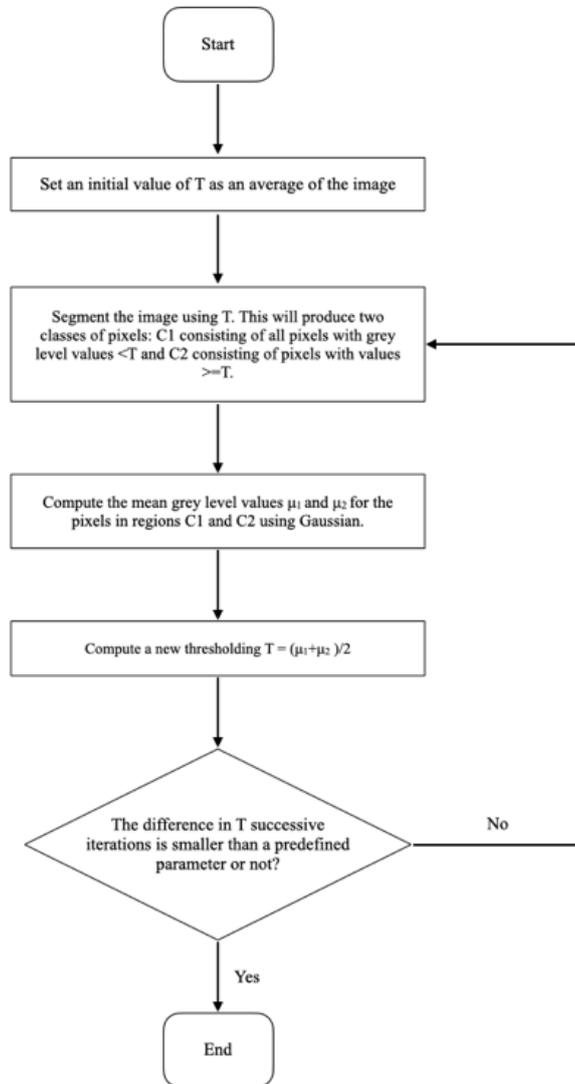
Otsu's method is used to automatically binarize level decisions, based on the type of distribution. It estimates a measure of spread in pixel level, and finds all possible threshold values. Its aim is to find the threshold value, where the sum of foreground and background spreads is at its minimum by classifying the image into two classes: foreground and background. Then, it minimizes the weighted within the class variance values between the two classes, and calculates an optimal threshold value.

**Li entropy** minimizes Kullback-Leibler distance with the condition, that the observed and reconstructed images, have identical average intensity, in their two classes: foreground and background.

$$D(q,p) = \sum_{i=0}^n q(g_i) \log \frac{q(g_i)}{p(g_i)} \quad (1)$$

Where

$q(g_i)$	is the distribution of the observed image
$p(g_i)$	is the distribution of the reconstructed image
$D(q,p)$	is the Kullback-Leibler distance



**Figure 3** Flow chart of the ISODATA algorithm



**Yen entropy** divides images into two classes, foreground and background. Consequently, the maximization of the two classes is found in order to optimize the fit threshold. Furthermore, we decided to sum the signal value of the two classes, by the following equation:

$$TC = C_b(T) + C_f(T) \quad (2)$$

$$TC(T) = -\log \left\{ \sum_{g=0}^T \left[ \frac{p(g)}{P(g)} \right]^2 \right\} - \log \left\{ \sum_{g=T+1}^G \left[ \frac{p(g)}{1-P(g)} \right]^2 \right\} \quad (3)$$

Where  $C_b$  is the background class entropy  
 $C_f$  is the foreground class entropy  
 $TC(T)$  is the total class entropy

**The Triangle method** calculates the line from a minimum to a maximum peak (mode) histogram between frequency and pixel value. Furthermore, there are issues in this method that result from a lack of information and the mode being on the end of the histogram. Therefore, this method is modified by extending it to find which side of the max peak the data goes the furthest, and searching for the threshold within that largest range.

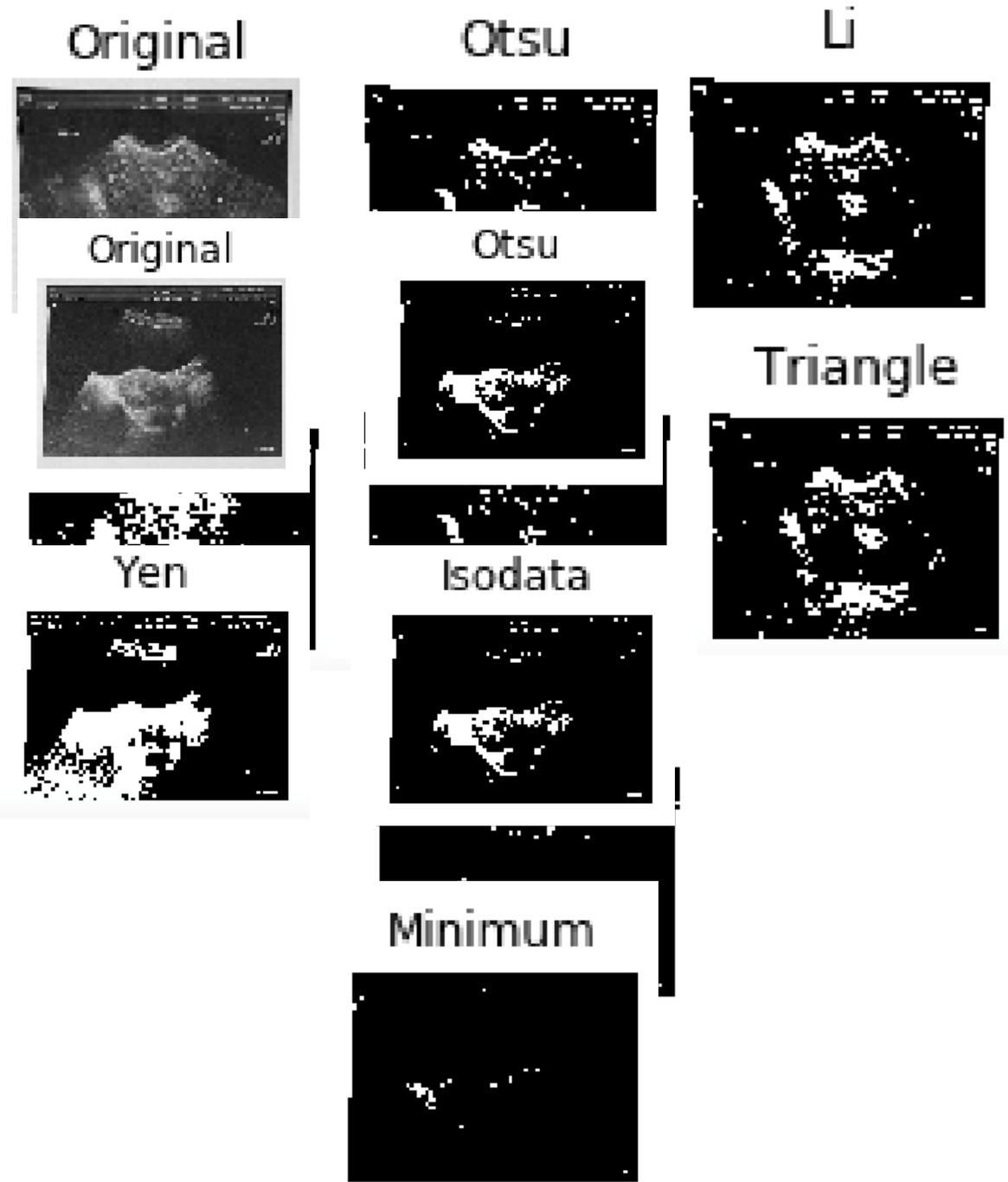
**Minimum cross-entropy** is a thresholding method, that is based on Gaussian distribution. This method chooses the threshold, that minimizes the cross entropy between the segmented image and the original image.

#### 4. Results and Discussion

In this study, six methods of image processing were compared: the ISODATA method, Li entropy, Minimum cross-entropy, Otsu's method, the Triangle method, and Yen entropy, in order to find the optimal method that is suitable for use in the medical field. The data were separated into two cases, which were normal and abnormal uterus ultrasound images. In the ultrasound images, there are bright and dark colors, in which bright color refers to tissue and the dark color refers to fluid, because ultrasound waves cannot go through tissue. Therefore, ultrasound waves are reflected back, and shown as a bright color, whereas they can pass through fluid, so the image is shown as a dark color.

There was a major error in the minimum cross-entropy method, because it uses the minimum thresholding value. Therefore, this method had errors in segmentation, that made the threshold have more dark pixels. The original image was compared with the light pixels, and as a result, it was concluded that the method that gave the nearest result to the original, is the most suitable method.

In the normal uterus case, as shown in Figure 4, it was found that the ISODATA method, Otsu's method, and Li entropy, can segment bright and dark colors clearly. Yen entropy was overestimating in the detection of tissue. The ISODATA method, Otsu's method, Li entropy, and Yen entropy use the closest thresholding values. Minimum cross-entropy underestimated in the detection of tissue, as it minimizes the cross entropy between the segmented image and the original image. Thus, it was concluded that the ISODATA method, Otsu's method, and Li entropy are the best methods, for normal uterus ultrasound images.



**Figure 4** Results of normal uterus ultrasound images, after applying different thresholding methods

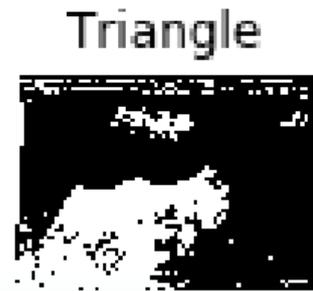
In the abnormal uterus case, as shown in Figure 5, it was found that the ISODATA method and Otsu's method can segment the edges of a tumor clearly. Yen entropy, the Triangle method and Li entropy



overestimated in the detection of tumors. The ISODATA method, Otsu's method, Li entropy, and Yen entropy use the closest thresholding values. Minimum cross-entropy underestimated in the detection of tissue as it minimizes the cross entropy, between the segmented image and the original image. Thus, it was concluded A set of 20 uterus ultrasound images.



**Figure 5** Results of abnormal uterus ultrasound images, after applying different thresholding methods





## 5. Conclusion

The purpose of this study is to use Artificial Intelligence to create decision support systems (DSS) for experts in image processing. In this study, ultrasound images were used because they have significant amounts of noise. Thereby, this DSS will enhance the accuracy and precision, in indicating the location and size of tumors, and decrease the noise in ultrasound images. Furthermore, it can help to decrease human error and reduce the amount of time required.

The six alternatives of image processing: the ISODATA method, Li entropy, Minimum cross-entropy, Otsu's method, the Triangle method, and Yen entropy were chosen and compared in order to find the optimal methods. Each method converts the image into a grayscale image and computes the thresholding value. The different methods have various ways, to calculate and choose the thresholding value, so they provide different results.

From the findings of this study, it was determined that the ISODATA method, Otsu's method, and Li entropy are fit for processing normal uterus ultrasound images, and the ISODATA thresholding method and Otsu thresholding method are fit for processing abnormal uterus images. The other methods have overestimating, or underestimating that leads to incorrect results. Therefore, the ISODATA (Iterative Self-Organizing Data Analysis Technique) method, and Otsu's method are the best methods which are suitable for both types of cases.

## 6. Acknowledgements

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## 7. References

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