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Enhancement of Image Segmentation osing Automatic Histogram Thresholding

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Abstract— This study is focused on histogram thresholding methods automatically. In computer vision, Image segmentation is an initial and vital step in a series of processes aimed at overall image understanding. In other words Segmentation refers to the process of partitioning a digital image into the multiple segments (set of pixels as known as super pixels). Two very simple image segmentation techniques that are based on the gray level histogram of an image are Thresholding and Clustering. Thresholding method is widely used for image segmentation approach. It is useful in discriminating foreground from the background.

By selecting an adequate threshold value T, or automatically computing threshold value T, the gray level image can be converted in to binary image. Several methods are there to find the threshold automatically for image segmentation. Some of the methods like Otsu, Kapur, Triangle, Iterative and also manually threshold is calculated for different type of images like X-ray computed tomography (CT-Scan), magnetic resonance imaging (MRI), synthetic aperture radar (SAR), Ultrasound image were explained and the results are presented to show the validity of the methods.

Keywords-*Segmentation, Histogram Thresholding, Methods in Histogram Thresholding.*

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I. INTRODUCTION

Threshold is one of the widely methods used for image segmentation. It is useful in discriminating foreground from the background. By selecting an adequate threshold value T, the gray level image can be converted to binary image. The binary image should contain all of the essential information about the position and shape of the objects of interest (foreground). The advantage of obtaining first a binary image is that it reduces the complexity of the data and simplifies the process of recognition and classification. The most common way to convert a gray-level image to a binary image is to select a single threshold value (T). Then all the gray level values below this T will be classified as black (0), and those above T will be white (1). The segmentation problem becomes one of selecting the proper value for the threshold T. A frequent method used to select T is by analyzing the histograms of the type of images that want to be segmented. The ideal case is when the histogram presents only two dominant modes and a clear valley (bimodal). In this case the value of T is selected as the valley point between the two modes. In real applications histograms are more complex, with many peaks and not clear valleys, and it is not always easy to select the value of T.[1][3]

THRESHOLD TECHNIQUES

Threshold technique is one of the important techniques in image segmentation. This technique can be expressed as:

$$T=T[x, y, p(x, y), f(x, y] \qquad (1)$$

where: T is the threshold value.

x, y are the coordinates of the threshold value point.
p(x,y) ,f(x,y) are points the gray level image pixels.[4][19]
Threshold image g(x,y) can be defined as:

$$g(x,y)= \begin{cases} 1 & if \quad f(x,y) > T \\ 0 & if \quad f(x,y) \le T \end{cases} \qquad (2)$$

This paper is organized as five sections, section II explains about existing work, section III is about proposed work, section IV gives the experimental results and conclusion has been drawn in section V.

II EXISTING METHODOLOGY

Many researchers have discussed more about threshold techniques. P.Daniel Ratna Raju, G.Neelima was proposed histogram thresholding in order to help the segmentation step in what was found to be robust way regardless of the segmentation approach used semi atomic algorithm for histogram thresholding were discussed. Examples using different histogram thresholding Methods were shown.[2] BülentSankur, Mehmet Sezgin had conducted an exhaustive survey of image thresholding methods with a view to categorize them, express them under a uniform notation, indicate their differences or similarities, and finally as a basis for performance comparison. They had been categorized into six groups according to the information they are exploiting, such as: Histogram shape-based methods, clustering-based methods, entropy-based methods, object attribute-based methods, spatial methods and local methods. [3]

Ciaran O Conaire was proposed surveys a number of dynamic thresholding methods for object and event detection. The benefits and drawbacks of each method are discussed, along with some experiments on real and synthetic data that illustrate the performance of each method and highlight the relevant

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issues involved in choosing the appropriate implementation of a dynamic thresholding algorithm.[4]

Salem Saleh Al-amri, N.V. Kalyankar and Khamitkar S.D had made attempts to undertake the study of segmentation image techniques by using five threshold methods as Mean method, P-tile method, Histogram Dependent Technique (HDT), Edge Maximization Technique (EMT) and visual Technique and they are compared with one another so as to choose the best technique for threshold segmentation techniques image. These techniques applied on three satellite images to choose base guesses for threshold segmentation image.[7] Ruey-Ming Chao, Hsien-Chu Wu, Zi-Chun Chen was proposed a method to automatically determine how many thresholds should be set and what the best range of each threshold is for different images. It finds the segmentation threshold by observing the change of the variance values and the mean values of each threshold range in the image histogram. The proposed method needs simple calculation, so that it has less time complexity.[8]

Ch. HimaBindu, and K. Satya Prasad was proposed otsu method which is a popular non-parametric method in medical image segmentation. Traditional Otsu method for medical image segmentation is time–consuming computation and became an obstacle in real time application systems. This paper describes a way of medical image segmentation using optimized Otsu method based on improved thresholding algorithm[10].

III PROPOSED METHODOLOGY

The work analyses the knowledge about different thresholding methods automatically from different types of images like Computerized Tomography (Ct) Scan, Magnetic Resonance imaging, ultrasound and Synthetic Aperture Radar images, etc.,.

Although many methods are available for automatic threshold, some methods are best suited for some particular type of images like triangle threshold method are best suited for CT-Scan images and others are best suited for other images and so on. The dissertation discusses automatic histogram threshold techniques on different input image and the results of threshold values are calculated for the output images obtained from all the threshold methods.

A Comparative study is made on the performance of the various automatic histogram threshold techniques like Otsu, Kapur, Triangle, Iterative, and also manually threshold value is calculated for different image types. The images corresponding to the best threshold value are shown.

A. Otsu Thresholding

Otsu's method is used to automatically perform clustering-based image thresholding, the reduction of a graylevel image to a binary image. [2]

The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal.[13]

METHOD DESCRIPTION

In Otsu's method we exhaustively search for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

$$\sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t)$$

Weights ω_i - probabilities of the two classes separated by a threshold t

σ_i^2 -variances of these classes.

Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance.

$$\sigma_b^2(t) = \sigma^2 - \sigma_w^2(t) = \omega_1(t)\omega_2(t)\left[\mu_1(t) - \mu_2(t)\right]^2$$

which is expressed in terms of class probabilities ω_i and class means μ_i.

The class probability $\omega_1(t)$ is computed from the histogram as t:

$$\omega_1(t) = \Sigma_0^t p(i)$$

while the class mean $\mu_1(t)$ is:

$$\mu_1(t) = \left[\Sigma_0^t p(i)\, x(i)\right] / \omega_1$$

where $x(i)$ is the value at the center of the ith histogram bin. Similarly,compute $\omega_2(t)$ and μ_2 on the right-hand side of the histogram for bins greater than t.[1][3]

B. Kapur Thresholding

The Kapur [4] method selects a threshold to divide the histogram into two probability distributions, one representing the object/event and one representing the background noise. The threshold, *T*, is chosen such that the sum of the entropies of these probability distributions is maximised. Entropy is a measure of information and the entropy of a distribution *p*(*x*) is given by: [3]

$$e = -\int p(x)\log p(x)\,dx$$

When a histogram is normalised so that, $\sum^{N}_{i=1} h_i = 1$,it can be thought of as a probability distribution. If we write

$$E_j = -\sum_{i=1}^{j} h_i \log h_i$$

the Kapur method chooses T so as to maximise the sum of the two-class entropies, E. We set T to the value of bin j that maximizes

$$E = \frac{E_j}{A_j} + \log A_j + \frac{E_N - E_j}{A_N - A_j} + \log(A_N - A_j)$$

C. *Triangle Thresholding*

The triangle algorithm, a geometric method, cannot tell whether the data is skewed to one side or another, but assumes a maximum peak (mode) near one end of the histogram and searches towards the other end. This causes a problem in the absence of information of the type of image to be processed, or when the maximum is not near one of the histogram extremes (resulting in two possible threshold regions between that max and the extremes). Here the algorithm was extended to find on which side of the max peak the data goes the furthest and searches for the threshold within that largest range.[4]

The triangle method is a line is constructed between the maximum of the histogram at b on the gray level axis and the lowest (or highest depending on context) value a on the gray level axis where the histogram is significantly larger than 0. The distance l normal to the line and between the line and the histogram is computed for all values from a to b. The level where the distance between the histogram and the line is maximal is the threshold value (level). This technique is particularly effective when the object pixels produce a weak peak in the histogram. [5]

D. *Iterative Threshold*

1. Initial guess of body – e.g. background is four corners
2. Compute mean background and mean object at step t

$$\mu^t_B = \frac{\sum_{(i,j)\in background} g(i,j)}{\#\text{background pixels}} \qquad \mu^t_O = \frac{\sum_{(i,j)\in object} g(i,j)}{\#object\ \text{pixels}}$$

3. Set

$$T^{t+1} = \frac{\mu^t_B + \mu^t_O}{2}$$

4. If $T^{t+1} = T^t$ halt otherwise go to #2.

PROCEDURE

1. Get an initial threshold thresh from the command line if specified or Compute the average gray value of image and use it as an initial threshold .(thresh)
2. Consider the two image regions R1 and R2 that are determined by thresh. (i.e. pixels above thresh and pixels below thresh) Compute the average gray values (avg1, avg2) for R1 and R2. Note that the number of pixels in R1 or R2 may be zero.
3. Compute a new threshold using: thresh = (avg1 + avg2)/2
4. Repeat 2-4 until avg1 and avg2 do not change between successive iterations
5. Apply the threshold to the image (values above thresh set to 255 otherwise 0)

IV RESULTS AND COMPARISON

RESULTS FOR IMAGE TYPES WITH DIFFERENT THRESHOLD METHODS

Table4.1. Table showing the results of image types with different threshold methods.

IMAGE TYPE	OTSU	KAPUR	TRIANGLE	ITERATIVE	CUSTOM
CT SCAN	81	145	49	82	137
MRI	63	148	78	65	208
ULTRASOUND	55	135	48	57	67
SAR	133	71	88	131	84

Figure 4.2: Graph for image types with different threshold methods

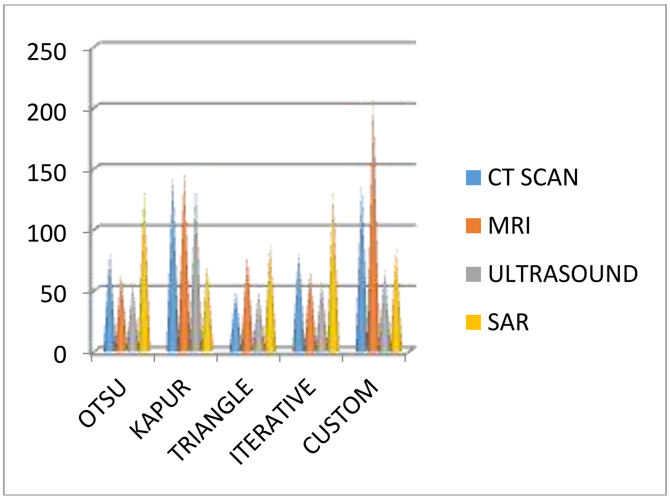
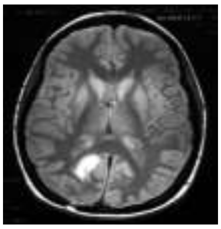
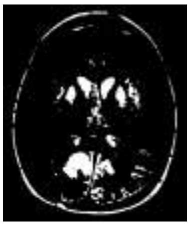
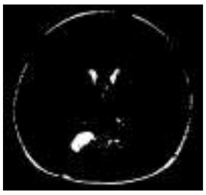


Fig4.3: TEST ON CT-SCAN IMAGE

(A)ORIGINAL IMAGE 	**(B)OTSU METHOD** 	**(C)KAPUR METHOD** 
(D)TRIANGLE METHOD 	**(E)ITERATIVE METHOD** 	**(F)CUSTOM METHOD** 

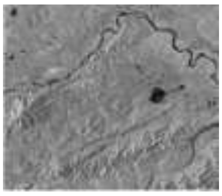
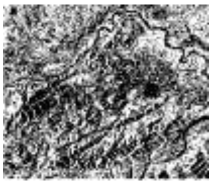
Here we infer that Triangle threshold method is better for CT-Scan image than other threshold methods.

Fig4.4: TEST ON MRI IMAGE

(A)ORIGINAL IMAGE 	**(B)OTSU METHOD** 	**(C)KAPUR METHOD** 
(D)TRIANGLE METHOD 	**(E)ITERATIVE METHOD** 	**(F)CUSTOM METHOD** 

Here we infer that Kapur threshold method is better for MRI image than other threshold methods.

Fig4.5: TEST ON SAR IMAGE

(A)ORIGINAL IMAGE 	**(B)OTSU METHOD** 	**(C)KAPUR METHOD** 
(D)TRIANGLE METHOD 	**(E)ITERATIVE METHOD** 	**(F)CUSTOM METHOD** 

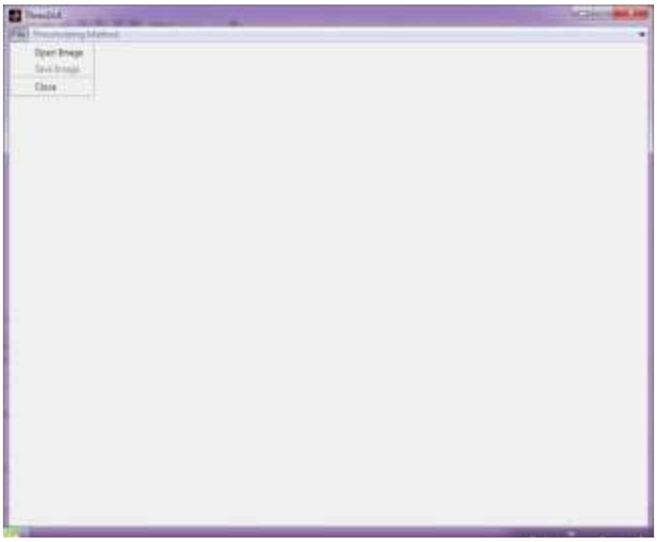
Here we infer that Triangle threshold method is better for SAR image than other threshold methods.

Fig4.6: TEST ON ULTRASOUND IMAGE

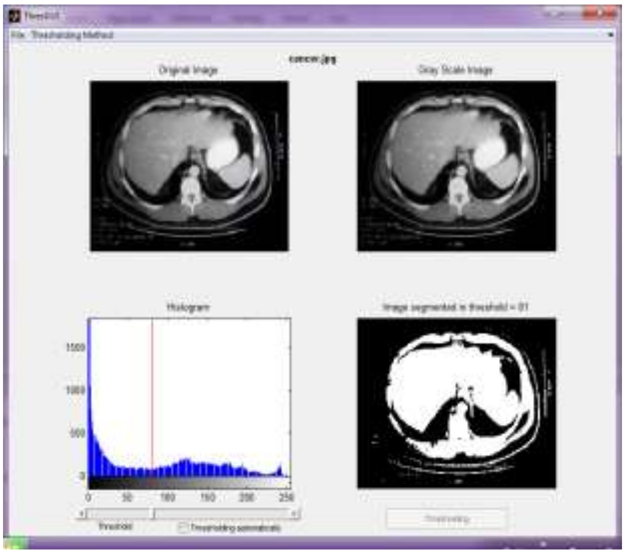
(A)ORIGINAL IMAGE 	**(B)OTSU METHOD** 	**(C)KAPUR METHOD** 
(D)TRIANGLE METHOD 	**(E)ITERATIVE METHOD** 	**(F)CUSTOM METHOD** 

Here we infer that Iterative threshold method is better for Ultrasound image than other threshold methods.

SCREENSHOTS:

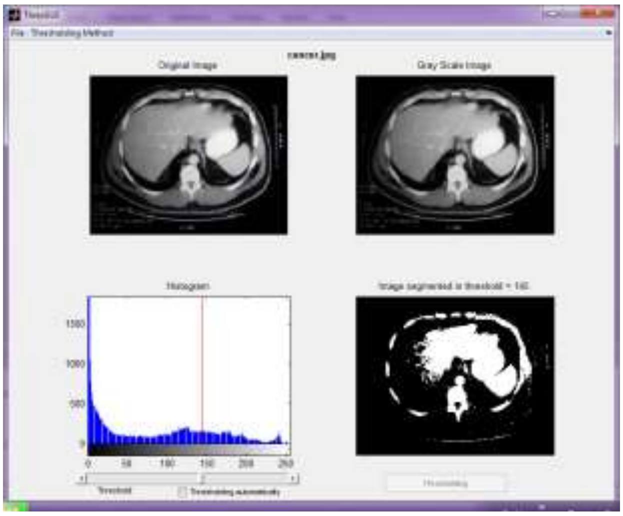


OPEN AN IMAGE:

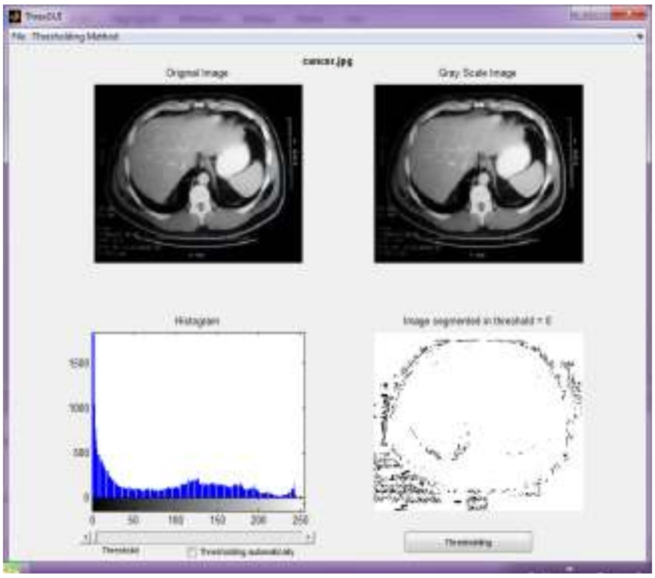


KAPUR METHOD ON CT SCAN IMAGE

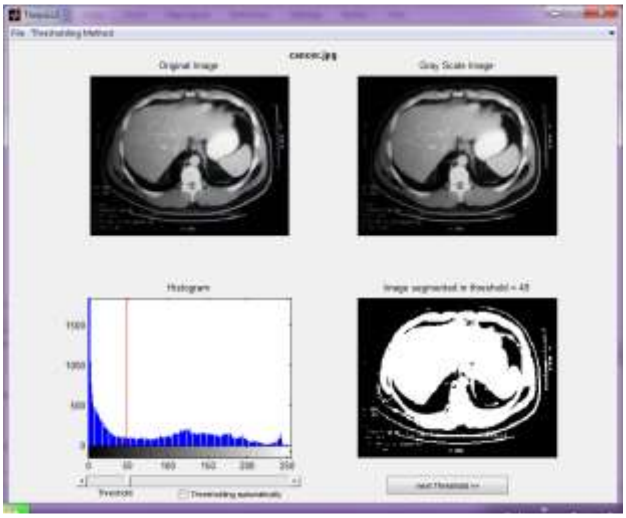
TEST ON CT SCAN IMAGE



TRIANGLE METHOD ON CT SCAN IMAGE



OTSU METHOD ON CT SCAN IMAGE



ITERATIVE METHOD ON CT SCAN IMAGE

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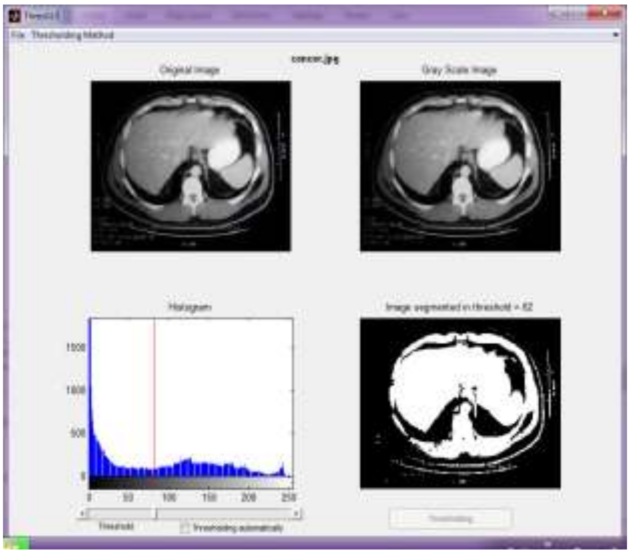
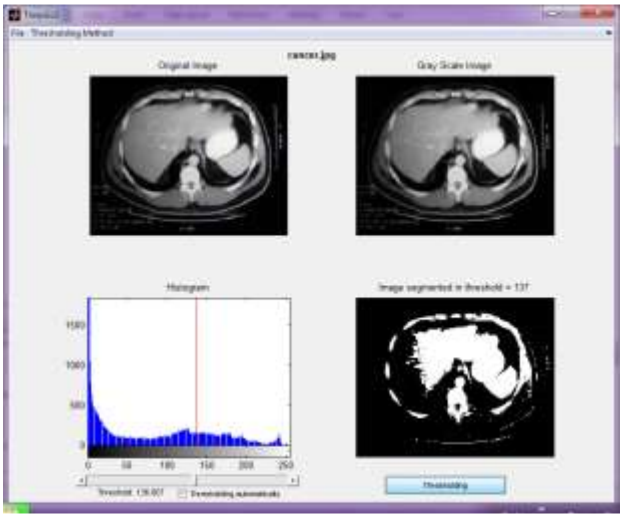
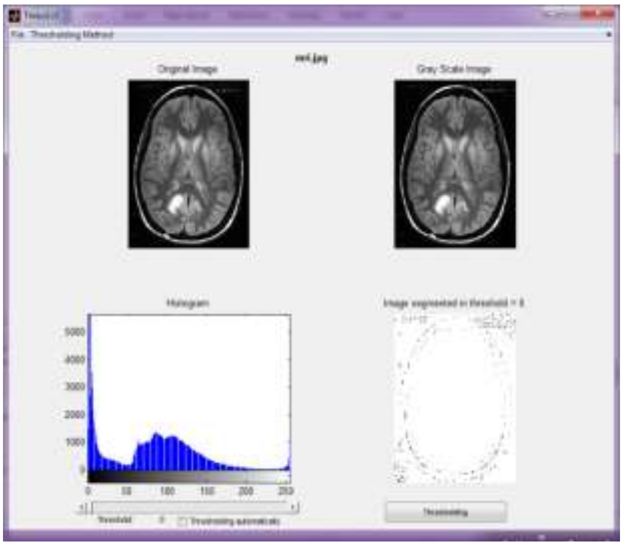


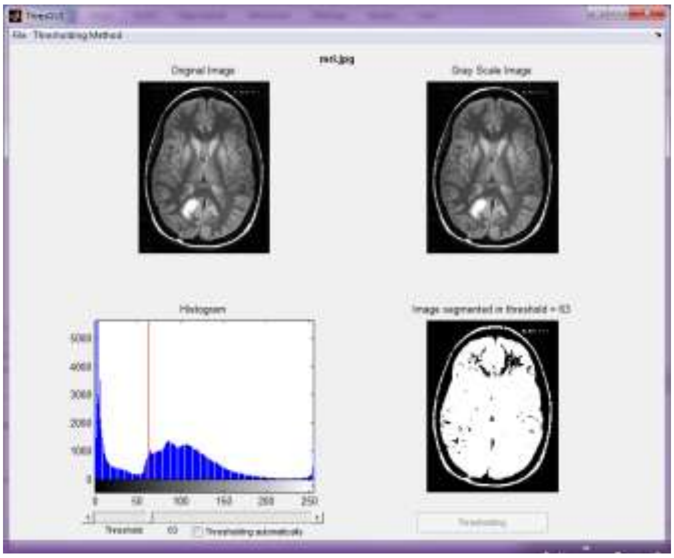
CUSTOM METHOD ON CT SCAN IMAGE



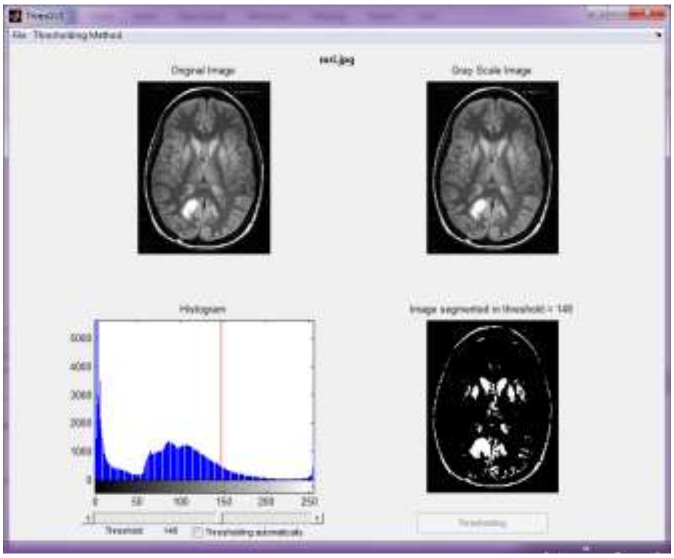
TEST ON MRI IMAGE



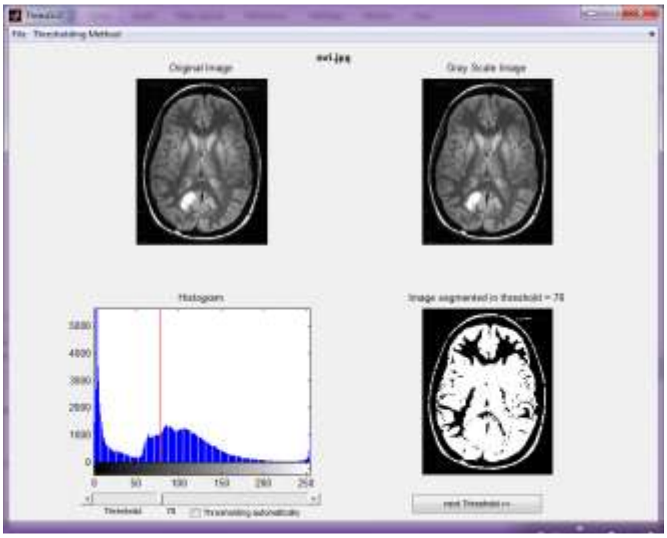
OTSU METHOD ON MRI IMAGE



KAPUR METHOD ON MRI IMAGE



TRIANGLE METHOD ON MRI IMAGE



ITERATIVE METHOD ON MRI IMAGE

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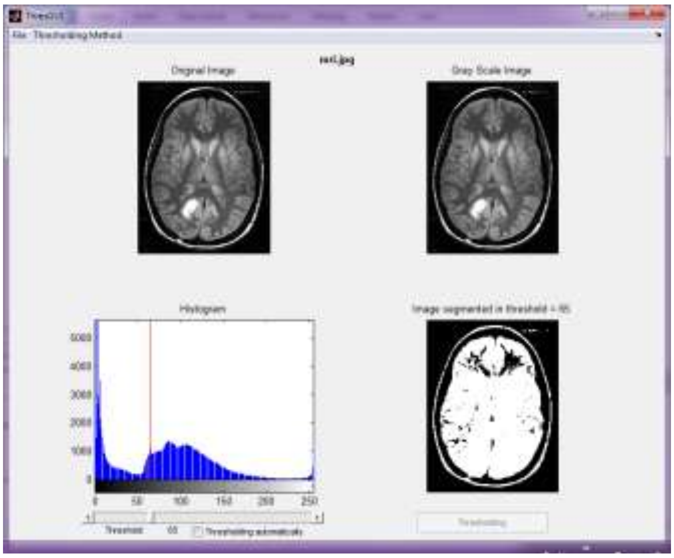
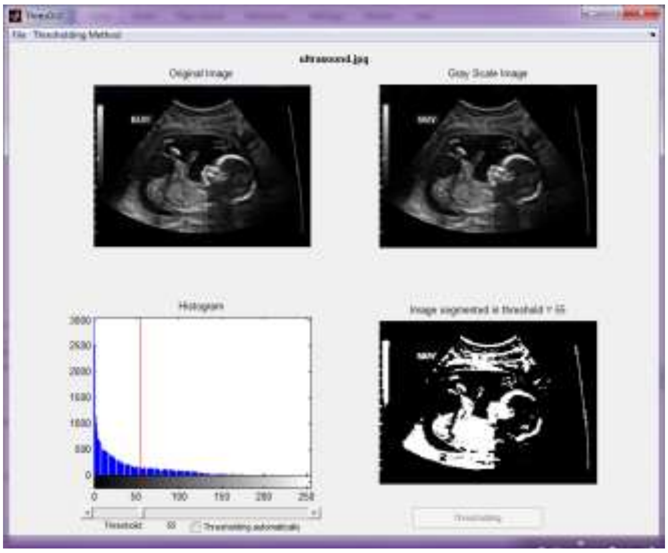
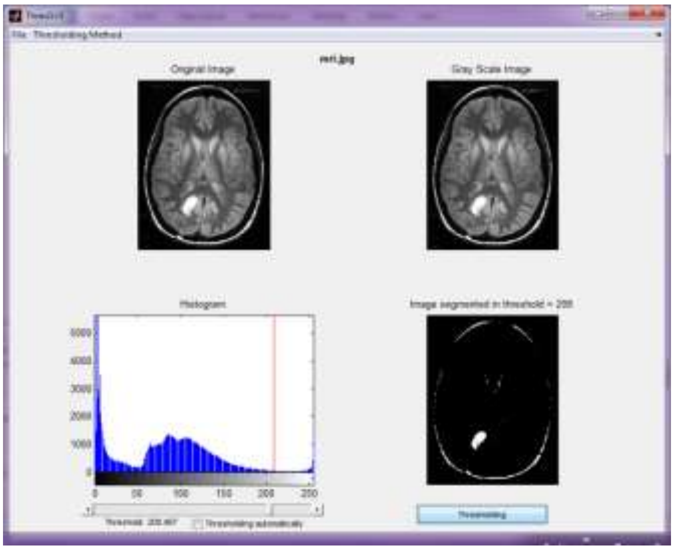


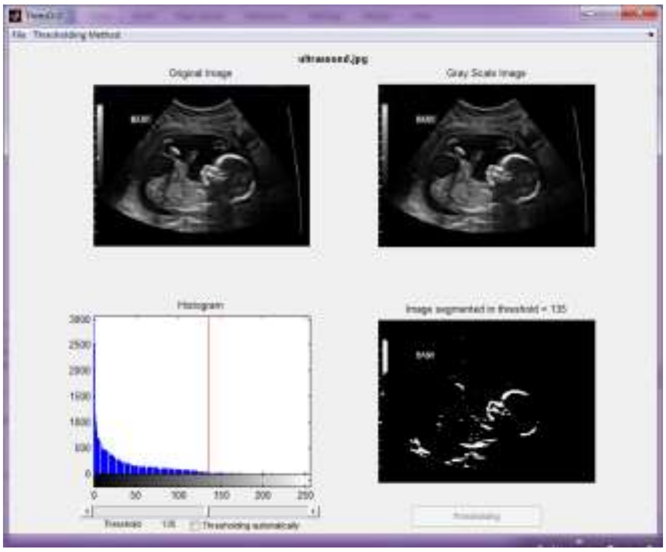
CUSTOM METHOD ON MRI IMAGE



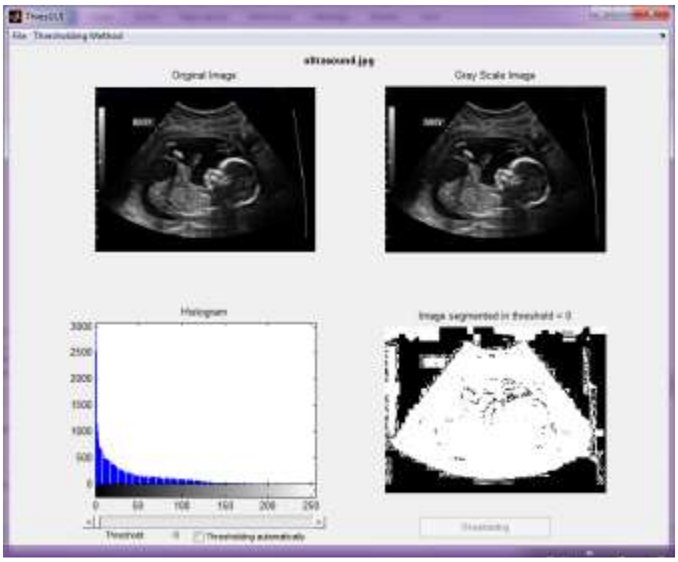
KAPUR METHOD ON ULTRASOUND IMAGE



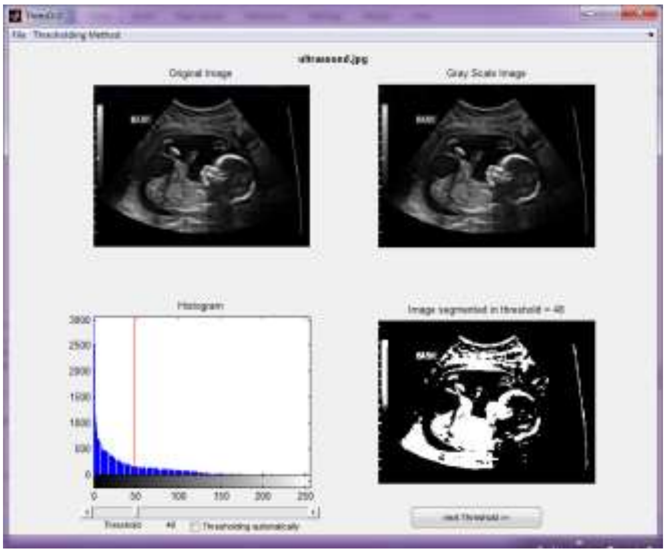
TEST ON ULTRASOUND IMAGE



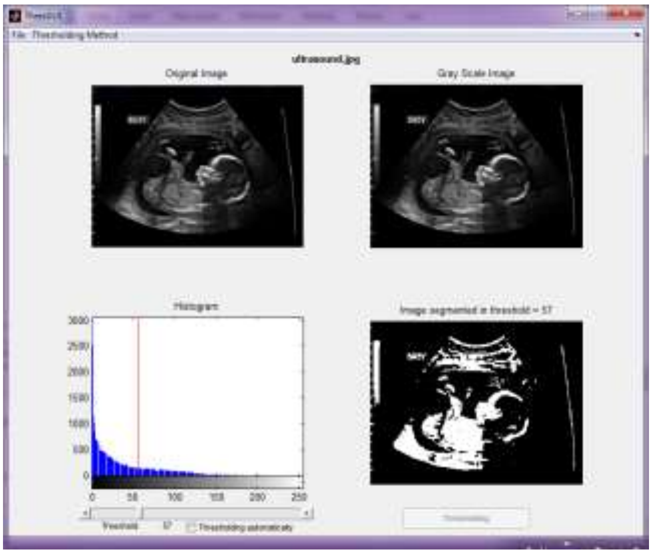
TRIANGLE METHOD ON ULTRASOUND IMAGE



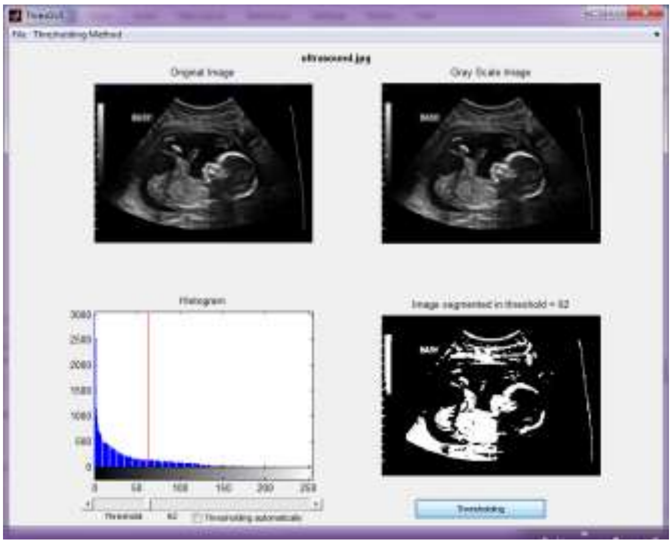
OTSU METHOD ON ULTRASOUND IMAGE



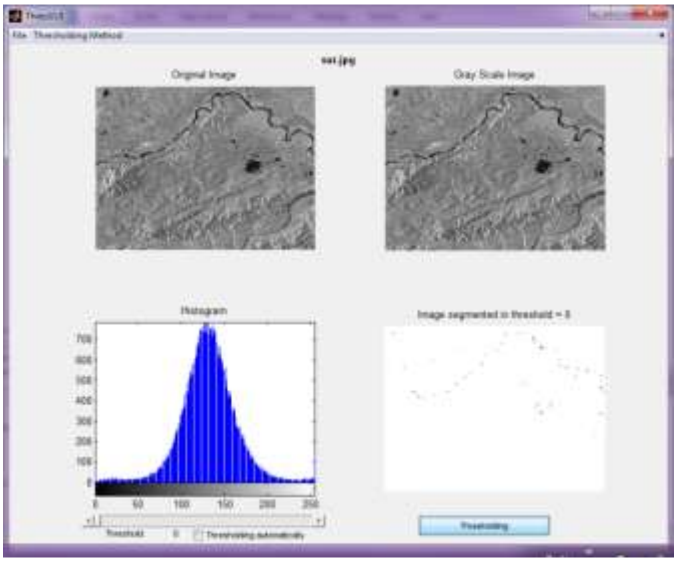
ITERATIVE METHOD ON ULTRASOUND IMAGE



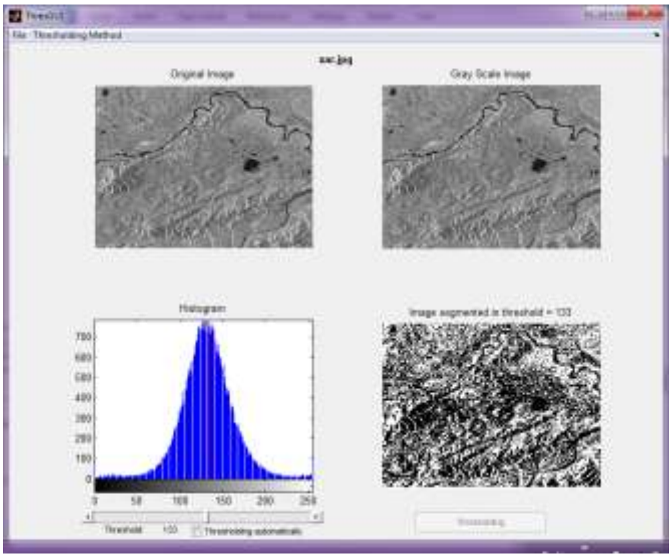
CUSTOM METHOD ON ULTRASOUND IMAGE



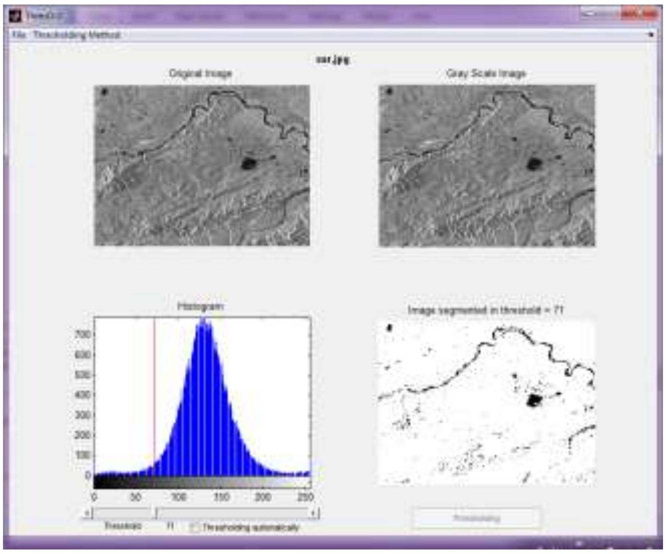
TEST ON SAR IMAGE



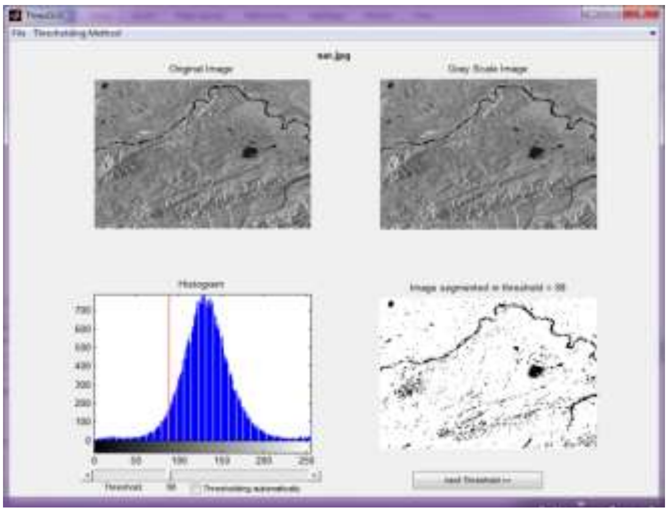
OTSU METHOD ON SAR IMAGE



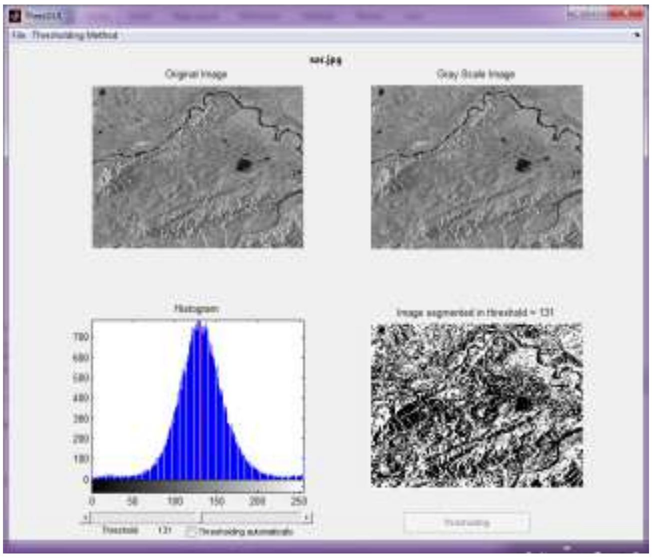
KAPUR METHOD ON SAR IMAGE



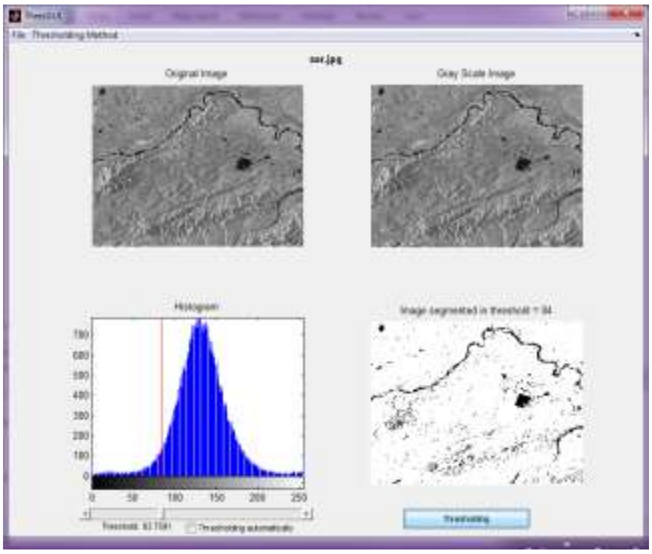
TRIANGLE METHOD ON SAR IMAGE



ITERATIVE METHOD ON SAR IMAGE



CUSTOM METHOD ON SAR IMAGE



SAVE AN IMAGE

V CONCLUSION

From our experiments, we see that our methods could achieve the image segmentation purpose. For some type of images like Computerized Tomography (Ct) Scan, Magnetic Resonance imaging, ultrasound and Synthetic Aperture Radar images are applied different kinds of automatic thresholds methods inside, the result is quite good, and this method could also performs well on natural and landscape images.

When we test our algorithm on the some natural images with the same similarity measurement, we found the result become worse. And the main reason is that the pixel value variance is really large in the region, which means pixels in the same region may have small similarities and are segmented into different groups.

The different kinds of automatic thresholds methods are applied on some type of images and found that it was successfully identified the meaning of the image. Triangle threshold method is better for CT-Scan image and SAR image, Kapur threshold method is better for MRI image and Iterative threshold method is better for Ultrasound image and also we can able to calculate the threshold manually to see the better result of the image.

In Future work could include some of the automatic threshold methods which will apply with the different type of images.

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