Comparison of The Local and Global Thresholding Methods in Image Segmentation

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Abstract— The image segmentation is the basic step in the image processing involved in the processing of medical images. Image segmentation is an essential but critical component in low level vision image analysis and, pattern recognition. It is one of the most difficult and challenging tasks in image processing which determines the quality of the final result of the image analysis[1]. This paper presents an approach to segment the medical images obtained from the mammograms It extracts the texture from the given image. Various image segmentation algorithms are discussed.

Index Terms— Segmentation; Mammogram; Thresholding; Histogram.

I. INTRODUCTION

Breast cancer has been one of the major causes of death among women since the last decades and it has become an emergency for the healthcare systems of industrialized countries. This disease became a commonest cancer among women. If the cancer can be detected early, the options of treatment and the chances of total recovery will increase [2]. Mammography is the main test used for screening and early diagnosis. Early detection performed on X-ray mammography is the key to improve breast cancer prognosis. In order to increase radiologists diagnostic performance, several computer-aided diagnosis (CAD) schemes have been developed to improve the detection of primary signatures of this disease: masses and micro calcifications. Masses are space-occupying lesions, described by their shapes, margins, and denseness properties. A benign neoplasm is smoothly marginated, whereas a malignancy is characterized by an indistinct border that becomes more speculated with time. Because of the slight differences in X-ray attenuation between masses and benign glandular tissue, they appear with low contrast and often very blurred. Micro calcifications are tiny deposits of calcium that appear as small bright spots in the mammogram [2].
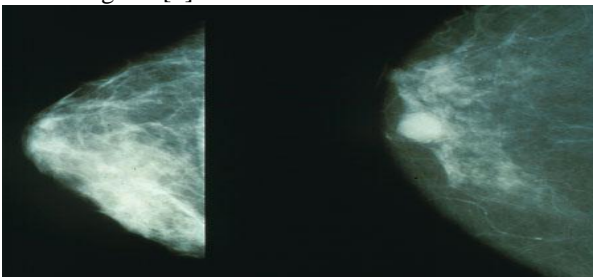

Figure 1: Image depicting breast cancer

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Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics[1]. Image segmentation is the process of dividing an image into different regions such that each region is homogeneous. The main objective behind the segmentation of the medical image is to separate the tumor from the background[1]. This enables the concentration of the image towards the tumor, separating the important information from the background. This significant part which contains the information is also referred to as the Region of Interest or is abbreviated as ROI.[4]

Segmentation of images holds an important position in the area of image processing. It becomes more important while typically dealing with medical images where pre-surgery and post surgery decisions are required for the purpose of initiating and speeding up the recovery process [5].

Image Segmentation is a data and model based process used in computer vision for partitioning a digital image into multiple segments for further easier analysis[3]. It is an essential and usually an initial task in image analysis that is used to distinguish various objects in an image. Characteristics can be for example computed properties such as color, texture, grey level, depth, intensity or motion. The methods that are used for extracting and representing the information from an image are called segmentation techniques[3].

Image Segmentation applications include:
• Image Compression
• Image editing
• Machine vision (e.g. path planning for mobile robots)
• Medical Imaging
• Computer driven facial and fingerprint recognition.

II. IMAGE SEGMENTATION ALGORITHMS

As per the dictionary meaning of the word 'segmentation' is to divide something into parts that are loosely connected. Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics[1]. Typical computer vision applications usually require an image segmentation-preprocessing algorithm as a first procedure. At the output of this stage, each object of the image, represented by a set of pixels, is isolated from the rest of the scene. The purpose of this step is that objects and background are separated into nonoverlapping sets[4]. The different Image segmentation algorithms are Clustering, Histogram thresholding , Region Based Techniques (Split-and-merge techniques, Region growing Techniques) Edge Detection

Technique, to name a few[1].

A. Histogram Thresholding

Histogram thresholding is one of the widely used techniques for monochrome image segmentation. It assumes that the images are composed of regions with different gray level ranges. The histogram of the image can be separated into a number of peaks, each corresponding to one region and there exists a threshold value corresponding to valley between the two adjacent peaks[6].

Histograms are constructed by splitting the range of the data into equal-sized classes. Then for each class, the number of points from the data set that fall into each class is counted. Suppose that the gray-level histogram corresponds to an image f (x, y) composed of light objects on the dark background, in such a way that object and background pixels have gray levels grouped into two dominant modes[7]. One obvious way to extract the objects from the background is to select a threshold 'T' that separates these modes. Then any point (x, y) for which f (x, y)> T is called an object point, otherwise, the point is called a background point[7]. A major weakness of this segmentation mode is that: it generates only two classes. Therefore, this method fails to deal with multichannel images. This features create the possibility for corrupting the histogram of the image. For overcoming this problem various versions of thresholding technique have been introduced that segments medical images by using the information based on local intensities and connectivity [8].

a) Bimodal Histogram:
If two dominant modes characterize the image histogram, it is called a bimodal histogram. Only one threshold is enough for partitioning the image[1].

b) Multimodal Histogram
If for example an image is composed of two types of dark objects on a light background, three or more dominant modes characterize the image histogram. In such a case the histogram has to be partitioned by multiple thresholds[1].

B. Local and global Thresholding

Thresholding may be viewed as an operation that involves tests against a function T of the form:

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

Where f(x,y) is the gray level , and p(x,y) is some local property.
Simple thresholding schemes compare each pixels gray level with a single global threshold. This is referred to as Global Thresholding.
If T depends on both f(x,y) and p(x,y) then this is referred to a Local Thresholding.

Basic Global Thresholding includes[1]:
1) Select an initial estimate for T
2) Segment the image using T. This will produce two groups of pixels. G1 consisting of all pixels with gray level values >T and G2 consisting of pixels with values ≤T.

3) Compute the average gray level values mean1 and mean2 for the pixels in regions G1 and G2.
4) Compute a new threshold value

$$T= (1/2) (mean1 +mean2)$$

5) Repeat steps 2 through 4 until difference in T in successive iterations is smaller than a predefined parameter T0.

The major problem with thresholding is that we consider only the intensity, not any relationships between the pixels. There is no guarantee that the pixels identified by the thresholding process are contiguous. We can easily include extraneous pixels that aren't part of the desired region, and we can just as easily miss isolated pixels within the region (especially near the boundaries of the region). These effects get worse as the noise gets worse, simply because it's more likely that a pixels intensity doesn't represent the normal intensity in the region. When we use thresholding, we typically have to play with it, sometimes losing too much of the region and sometimes getting too many extraneous background pixels.

Another problem with global thresholding is that changes in illumination across the scene may cause some parts to be brighter (in the light) and some parts darker (in shadow) in ways that have nothing to do with the objects in the image. We can deal, at least in part, with such uneven illumination by determining thresholds locally. That is, instead of having a single global threshold, we allow the threshold itself to smoothly vary across the image.

The problem is how to design a relevant filter. In a monochrome image, edge is defined as a discontinuity in the gray level, and can be only detected when there is a difference of the brightness between two regions. There exist complex edge detectors that are also applied on color images.
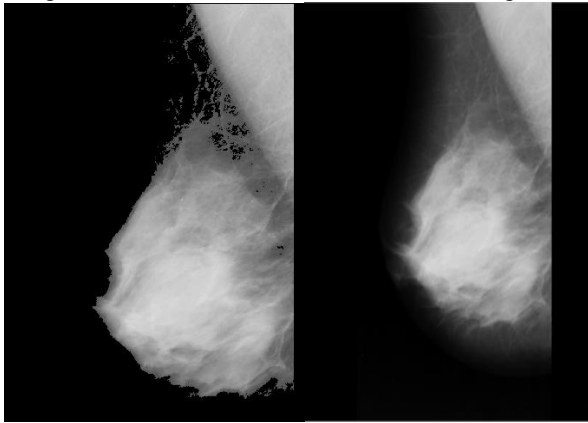
OTSU's Technique
Based on a very simple idea, which is to find the threshold that minimizes the weighted within-class variance[10].

This turns out to be the same as maximizing the between-class variance operating directly on the gray level histogram, so it's fast once the histogram is computed. Also the histogram and the image are bimodal. There is no use of spatial coherence, or any other notion of object structure. Stationary statistics are assumed although it can be modified to be locally adaptive.The algorithm for the explained OTSU's technique[9] is:-

```
T=0.5*(double(min(f(:)))+double(max(f(:))));
   Done=false;
   While ~done
   G=f>=T;
   Tnext=0.5*(mean(f(g))+mean(f(~g)));
   Done=abs(T-Tnext)<0.5;
   T=Tnext;
   End
```

This paper has proposed a method of applying global threshold and local threshold obtained from OTSU's algorithm on a Benign and Malignant Breast cancer effected

image. The results for the same are shown in figure 2.

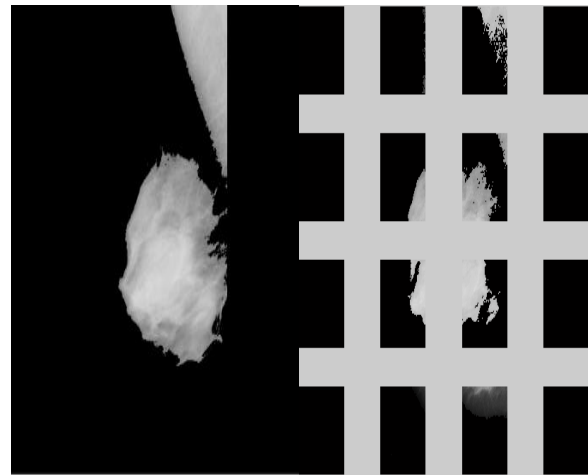**Figure 2.** a) Original image   b) Globally Thresholded Image

Local thresholding in this paper is carried out by cropping the original image into 16 equal parts. Once the cropping is done, OTSU's algorithm is applied on all the cropped parts individually, resulting in a distinct threshold for every cropped portion. This results in the original image getting segmented with the help of locally generated threshold. The result for the same is shown in figure 3.

MAX OF MEAN

Another technique to segment a using adaptive threshold is by taking the result of maximum of the mean value[11]. Mean of any image in MATLAB finds the mean of all the row vectors and returns them in the form of a row vector. The threshold is then obtained by finding the maximum mean from the row vector. This method surprisingly gives decent results for Benign and Malignant image. The result of using this function on the Benign image is shown in figure 4a. The max of mean technique can be implemented locally, by cropping the original image into equal parts, also. The result for the same is shown in figure 4b.
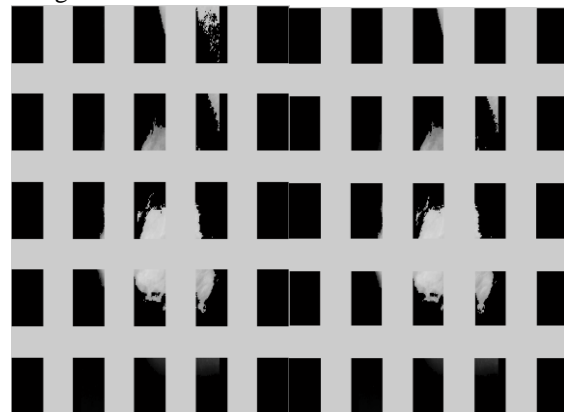

Figure 3. a) Original image   b) Locally Thresholded image

Figure 4. a) Globally Thresholded image   b) Locally threholded image

The advantage of cropping an image is that a different threshold can be applied for every cropped portion (Local thresholding) and the unwanted or extra part, if any, can be removed from the image. The pectoral muscles can be removed by using various statistical properties of an image as limits. This paper shows the removal of pectoral muscles by using the properties standard deviation and median as limits. To obtain satisfactory results the numbers of cropped portions are increased from 16 to 25. The result for the same are shown in figure 5.

Figure 5: a)Locally thresholded image with pectoral muscle   b) Without pectoral muscle

C. Using Max Mean For Malignant Image

The result of using this function on the Malignant image is shown in figure 5.
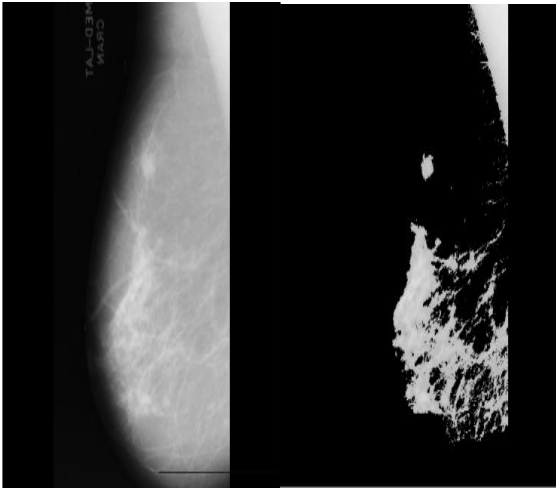
Figure 6.a) Original image   b) Globally Thresholded Image

To obtain satisfactory results when the numbers of cropped portions are increased from 16 to 25, the result are as shown in figure 7.
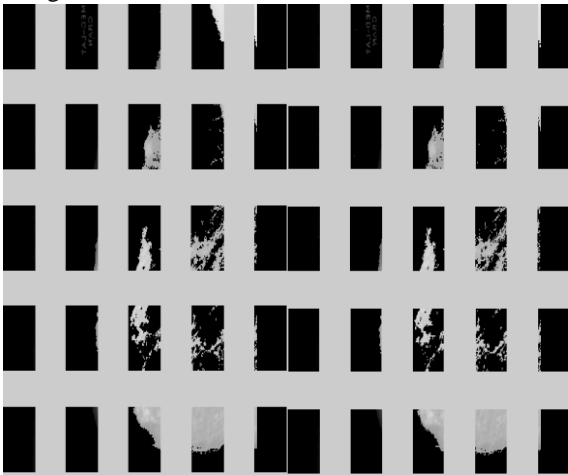

Figure 7:

   a)Locally thresholded   b) Without pectoral
image with pectoral muscle   muscle

III. IMPLEMENTATION

The above discussed algorithms are implemented using MATLAB R2010. The input image was an ultrasound image in the pgm format obtained from MIAS database.
Out of the various algorithms, the results were obtained using the local and global thresholding methods using Max of Mean and the Otsu's algorithm.

IV. CONCLUSION

The image segmentation is a relevant technique in image processing. Numerous and varied methods exist for many applications. It is believed that there are two key factors which allow for the use of a segmentation algorithm in a larger object detection system: correctness and stability.

The algorithms were although different for the images obtained for benign and malignant tumor images. Accordingly the local and global thresholding methods were applied and the results were obtained.

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