FIBRO-ADENOMA EDGE DETECTION AND MEASURE BY IMAGE PROCESSING TECHNIQUES*

BY

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ABSTRACT

The occurrence of fibroadenoma in females (premenopausal stage) is a major cause of benign breast lumps. This can lead to breast cancer if not consulted and treated by a specialist [1]. Reproductive hormones cause fibroadenomas. These are painless lumps in the breast having a well-defined shape. Precise diagnosis of fibroadenoma is done by acquiring cytological samples of the breast using techniques like core biopsy or fine-needle aspiration. But these techniques are time-consuming methods. It can also be located visually by using different combinations of medical imaging techniques such as ultrasound, mammography, MRI, etc. Medical imaging techniques lack the precision in identifying fibroadenoma. But incorporating it with image processing techniques like watershed segmentation, intensity slicing, thresholding, etc. can certainly yield promising results. This project attempts to incorporate various image processing techniques over breast ultrasound to distinguish fibroadenoma from other segments and marking the lump.

KEYWORDS

Fibroadenoma, Ultrasonography, Watershed segmentation, Region of Interest, Thresholding.

1. INTRODUCTION

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The most common benign tumor of the female breast is Fibroadenoma. Bumps and lumps found in the breast are majorly due to the presence of fibroadenoma. These benign tumors arise from advanced connective fibrous tissues. The smallest instances include lobules and ductules, although most traditional fibroadenomas develop in the stroma surrounding the mammary glandular system's tiny branches. Lobules (milk-producing glands) and ducts (tubes that transfer milk to the nipple) make up the breasts (tubes that carry the milk to the nipple). Surrounding these are glandular, fibrous, and fatty tissues. The fibroadenomas arise out of the terminal ductal lobular units, and it's the same place from where breast cancer too arises[2]. The glandular tissue and ducts expand over the lobule to form a firm lump. It is probably aroused due to a lot of unopposed estrogens [3]. As breasts are a growing organ in young women so there is the presence of a lot of unopposed estrogen in their breasts. Fibroadenoma usually represents simple, movable, painless, smooth, well-defined lumps that can be present in one or both breasts also they can be single or multiple in numbers[4.pdf]. In the second and third decades of life, fibroadenoma occurs most often in women and usually measures a few centimetres [4]. The tumors usually develop solid oval masses of 3 cm or less around the nipple, with their long axis orientated radially. These tumors, particularly develop during pregnancy. They sometimes shrink during menopause. It is also possible for fibroadenoma to resolve by themselves. They typically occur between the ages of 10 and 40 in women [5]. Within the teenage and young adult population, it is the most common breast mass. Their peak occurrence varies from 25 to 40 years [6]. After which the frequency decreases. Macroscopic analysis of a typical fibroadenoma reveals a well-defined, fleshy mass comprised of homogenous, whorled, gray-white tissue containing pinpoint yellow flecks, which can enhance your risk of breast cancer[7]. The following research is based on a breast ultrasonography image of a patient having fibroadenoma.

2. ULTRSONOGRAPHY

Ultrasonography uses high-frequency sound (ultrasound) waves to create images of internal body organs, tendons, and tissues. It aims to find the source of defect or disease. A transducer is a device that converts electrical current into sound waves and transmits them to the tissues and generates an ultrasound image also known as a Sonogram. Probes are used to generate ultrasound waves which are passes to the organs and tissues of the body. The ultrasound pulses echo off the tissues which are again received by the probe and presented on screen as a sonogram. Ultrasound imaging is a technology that uses high-frequency sound waves (greater than 20,000Hz) to observe internal parts of the body. Ultrasound images can show internal organ activity as well as blood flowing via blood arteries because they are captured in real-time. Unlike X-ray imaging, ultrasound imaging does not expose you to ionizing radiation [8]. Ultrasonography is used to assess breast defects discovered by mammography. The best way to tell the difference between dense masses (an example) and less dense masses (an example) is to use cysts and improved solid tissue density [8]. Ultrasound uses sound waves rather than radiation to detect lesion size and form, as well as whether the lesion is solid or fluid[9, 10].

– Ultrasound may also be used to aid in the guidance of a biopsy (tissue sampling).

– Ultrasound has good contrast resolution (for example, it's easy to tell the difference between normal tissue and a cyst), but poor spatial resolution.

Sound energy is a vibratory disturbance that travels through a substrate in the form of a wave. Sound travels well across air, solids, and liquids. Ultrasound waves are waves with a frequency greater than 20,000 Hz (20 kHz) [11]. A transducer sends sound waves and captures the echoing waves in an ultrasound examination. The transducer sends short pulses of inaudible, high-frequency sound waves into the body when it is pushed against the skin. The sensitive receiver in the transducer records minute changes in pitch and direction when sound waves bounce off interior organs, fluids, and tissues.

3. Techniques Used

Watershed Segmentation

Watershed segmentation is a region-based method having its own mathematical morphological origin. It is based on a classical algorithm used for the segmentation of objects from an image. The philosophy behind this kind of segmentation is: - "You start filling every isolated valley (local minima) with different colored water (labels). As the water rises, depending on the peaks (gradients) nearby, water from different valleys, obviously with different colors will start to merge. To avoid that, you build barriers in the locations where water merges. You continue the work of filling water and building barriers until all the peaks are underwater and Then the barriers you created to give you the segmentation result "[12, 13]. The image is visualized in 3 dimensions that are 1 intensity values and 2 spatial coordinates. This is done by considering the image as a topographic landscape having ridges and valleys present in it. Elevation levels of these valleys are defined based on the gray level values of each pixel. High intensity presents peaks and low intensity shows the presence of valleys. The brightness of each point here describes its height and helps the algorithm to find the lines from the top of the ridges. It decomposes the image completely and assigns each pixel as a region or valleys based on their gray intensity values.

Decomposition of the image into regions becomes the base of merging it at their watershed locations by flooding it with water or colored water[14]. Therefore, Watershed segmentation is an algorithm used for the extraction of objects ranging from small to big sizes from an image. This was not possible before with the help of traditional methods which caused the neglect of small pieces of information. With watershed segmentation, the parts of the body in their image are highlighted. Further, a layer of color was added over the segmented image to provide a greater enhancement and enhanced small parts visibility.

Top-Hat transformation

The top-hat transform is a method of transforming for extracting small information and elements from pictures. The top hat transform produces an image that contains all of the objects or components in an input image that is smaller and lighter than the structural element. Function extraction, context equalization, and image enhancement are all activities that top-hat transform is used for [15]. The white top-hat transform is the difference between the input image and its opening by some structuring factor, the black top-hat transform is defined as the difference between the closing and input images. [16]. It is useful for determining the difference between its closure by a structural element and an input image. The black transform creates an image that contains all of the little elements or components in an input image that are darker than their surroundings and smaller than the structuring element. The image returned by the black top-hat contains the "objects" or "elements" that:

- Are "smaller" than the structuring part
- And their surroundings are darker.

The structuring factor b can be used to keep track of the scale, or width, of the top-hat transform's extracted parts. The greater the latter, the more elements can be removed [16]. Both top-hat transformations are images in which all pixels have non-negative values. The bottom-hat transform of f (also known as the black top-hat transform) is given by:

$$T_b(f) = f \cdot b - f$$

Where ‘. ‘is the closing operation.

Histogram Equalization

Histogram equalization is a technique used for changing the contrast of a picture by changing the histogram's intensity distribution of an image. The factors required to apply histogram equalization to the image are PMF(Probability Mass Function) to determine the occurrence of the pixel intensity and CDF (Cumulative Distribution Function) to uniformly distribute the pixel intensity by calculating the sum of previous value to the current pixel intensity. The goal of this strategy is to give the image's cumulative probability function a linear pattern. This strategy also helps in improving the contrast of the image.

The cdf is calculated as follows:

cdf(x)= ∑k=−∞x P(k)

The approach works well in pictures of both bright and dark backgrounds and foregrounds. The procedure, in particular, will result in better detail in over-or under-exposed pictures and sharper views of bone structure in x-ray images.

Thresholding

Thresholding is a technique used for image segmentation in which the pixels of an image are altered based on their intensity values to make the image easier to analyze. It means the binarization process of a grayscale image is performed over here. It's performed to help image processing by separating "object" or foreground pixels from background pixels [13, 17]. A threshold value is set before performing the technique over an image.

The pixels intensity value is the most common image property to the threshold:

Here x and y ranges are based on the rows and columns of the original image. So g(x,y) becomes the new binarized image, and f(x,y) becomes the original image values.

- $g(x,y) = 0$ if $f(x,y) > T$ and
- $g(x,y) = 1$ if $f(x,y) < T$, where T is the threshold.

A range of grey levels related to region 1 can be described using two thresholds,

- $T1 < f(x,y) < T2$, and $g(x,y) = 0$ if $f(x,y) < T1$ OR $f(x,y) > T2$, and
- $g(x,y) = 1$ if $T1 <f(x,y) <T2$.

Threshold value used here is: - x(i,j)>=72 && x(i,j)<=94

Bit-plane Slicing

Bit plane slicing is an image processing technique that represents the image into multiple bit planes ranging from 0(also known as LSB) to 7(also known as MSB). This shows the user a variation in intensity levels of the image in each bitplane and any irregularities associated with it can be identified [18, 19].

In this project, we have taken an ultrasonography image of fibroadenoma and sliced it into 8 planes ranging from bit 00000000 to bit 11111111 [20].

Region of interest and bwboundaries

Based on the visual perception the area of fibroadenoma is selected by using the cursor. That can further be used as an input for different masks and further processes. Functions like bwboundaries and bwarea are used to calculate the area marked freehand by the user. This helps to get a bunch of outputs with a specific area of presence of fibroadenoma

4. Results and Discussion

Figure 2 shows watershed is a transition that a grayscale image defines. The watershed is a classic segmentation procedure that is used to distinguish various items in a picture. The watershed algorithm treats pixel values starting from user-defined markers as a local topography (elevation) (elevation). Watershed segmentation is an area-focused technique that uses image morphology [21].

Figure 3 shows the histogram equalization of the fibroadenoma and the difference in intensity between the original image and the processed image. On comparing Figure 1 and Figure 3 it is observed that there is a significant difference in the contrast of the image and the fibroadenoma is quite visible in Figure 4. Figure 4 and 5 show the effect of histogram equalization on the image intensity-wise, the uneven intensities of the original image are now in a state of uniformity throughout the processed one yielding the desired result.

When comparing the bit planes of the fibroadenoma in Figure 6 it is observed that the output of the 6th-bit plane and as well as the 7th-bit plane (MSB) shows a promising output compared to the others. The shape of fibroadenoma is quite visible in the 6th-bit plane and is easily distinguishable.

Figure 7 shows the output of the fibroadenoma using the blacktop hat transform. The area around the fibroadenoma is highlighted and the boundaries surrounding the lump are visible yielding a promising result. These techniques and their outputs will be highly useful by the user to mark the area of fibroadenoma which will be needful in the last 'Region of Interest' technique.

Figure 8 shows a formed binarized image of the original input image. In the output image, it can be seen that the area with fibroadenoma is easily distinguishable and the ends of the fibroadenoma can be marked from the particular output. Providing users with the proper shape of the fibroadenoma that can be used further in many more techniques.

Based on the outputs from all different previously used techniques the shape of fibroadenoma was marked by the user. A similar shape was tagged into the image of this technique as an input shown in Figure 9. Figure 10 shows the selected region becomes a mask and complete detail of the fibroadenoma of the breast can be seen. As well as the area and the number of pixels occupied by the fibroadenoma are shown in a dialog box as shown in Figure 11. The cropped output of the fibroadenoma with edges again helps the user to understand the fibroadenoma and possibilities of harmfulness.

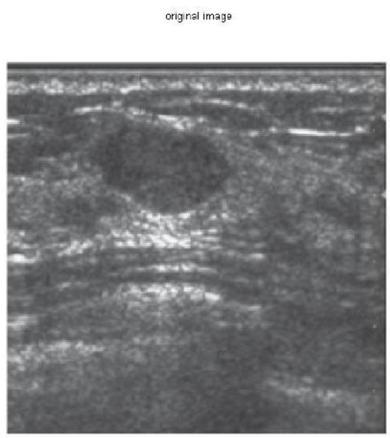

Figure 1: - Input Breast ultrasound image

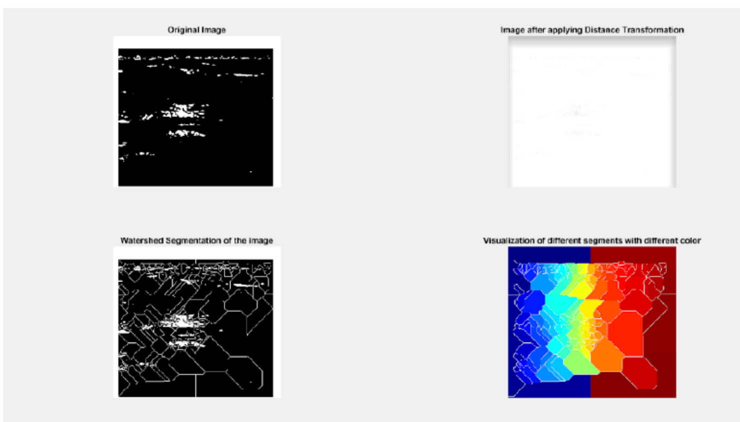

Figure 2: - Watershed Segmentation of Breast ultrasound image

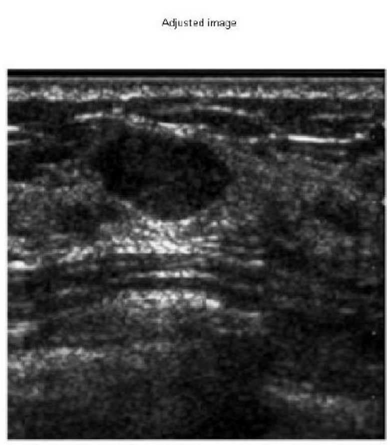

Figure 3: - Histogram Equalization of Ultrasound image

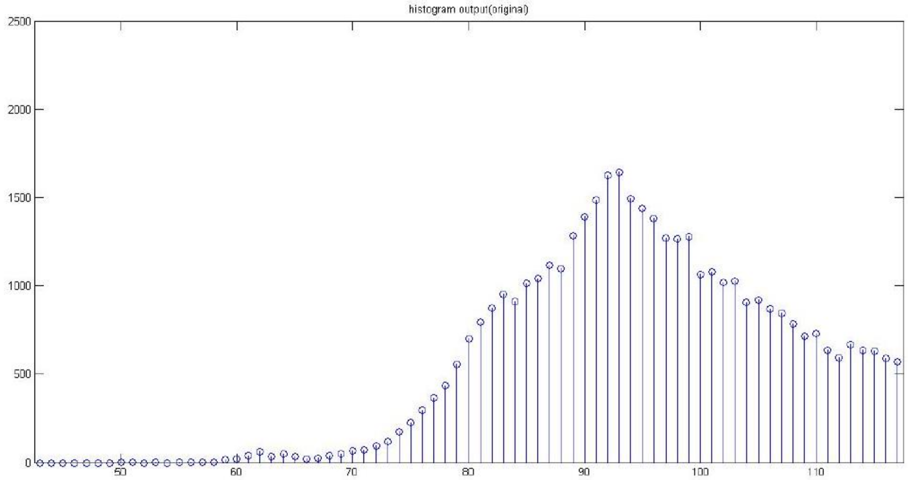

Figure 4: - Histogram Plot of original Image

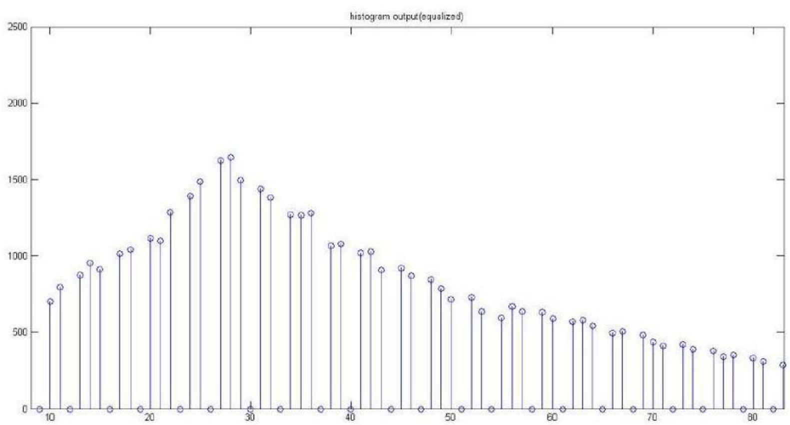

Figure 5: - Equalized histogram plot of original image

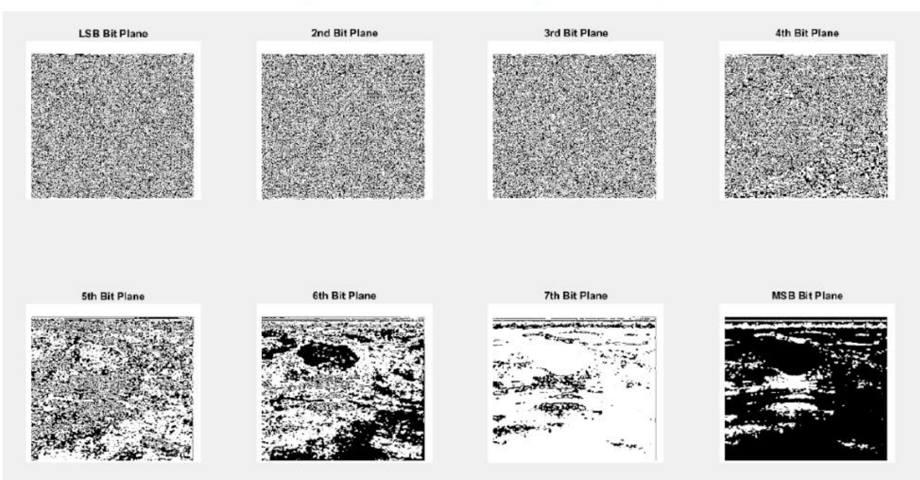

Figure 6: - Bit-plane slicing of Figure 1

Figure 7: - Top-hat transform of Figure 1

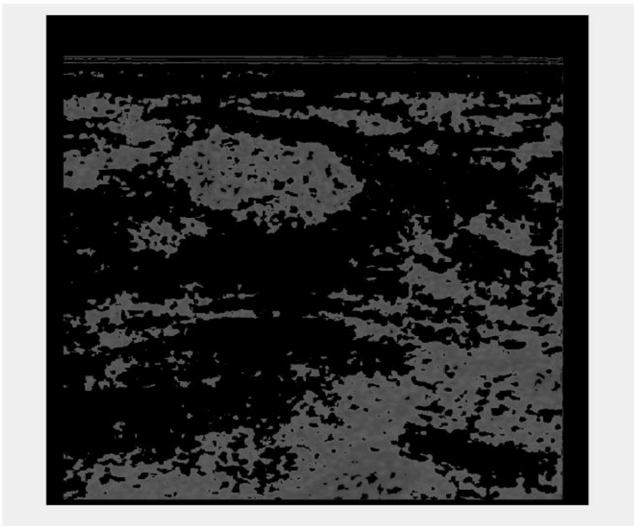

Figure 8: - Thresholding of Figure 1

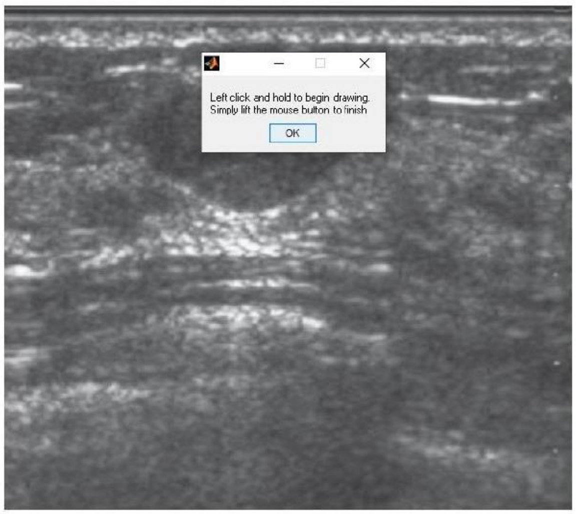

Figure 9: - Freehand selection on Input image

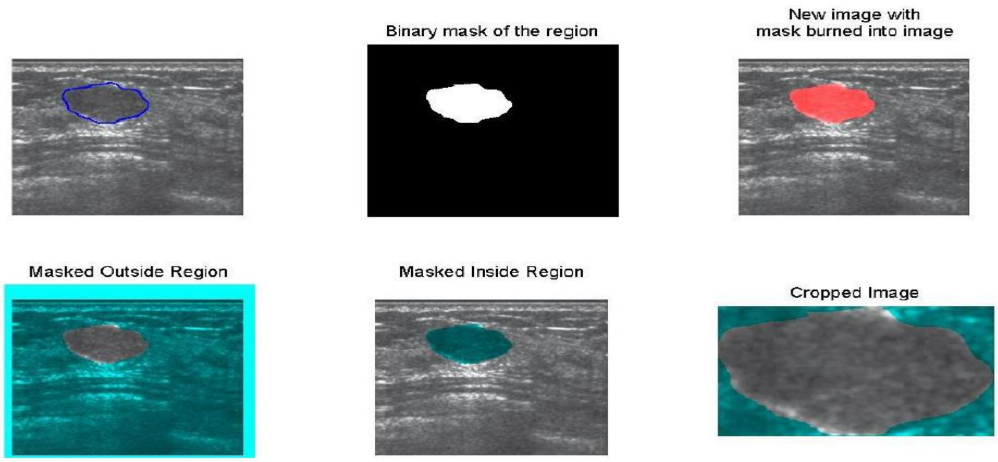

Figure 10: - Mask Generation of cursor marked area

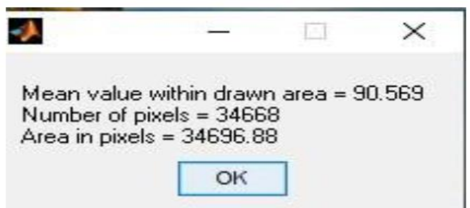

Figure 11: - Output with calculated area of Fibroadenoma

5. Conclusion

The Fibroadenoma of the breast which was procured using ultrasonography had been subjected to multiple image processing techniques to enhance the original output and improve the overall quality of the image by highlighting the boundaries surrounding the fibroadenoma, adjusting the contrast, and calculating the area around the lump. These details give the user vital information in context to the progression of the lump which reduces the time required for detection through any other invasive method such as biopsy.

6. References

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