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Characterization of Breast Fibroadenoma in U/S Images Using Image Texture Analysis Techniques

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Abstract: ***A new approach to texture characterization from breast ultrasound scan is presented. This study was aimed to use the texture analysis and classification methods to characterize the breast Fibroadenoma, cyst and normal breast regions in U/S images using image processing program (IDL, interactive data language). An analytical case control study of Breast US images of 130 adult subjects with Fibroadenoma, cyst and normal images that in which used as entry data. Tiff format was created as IDL variables and then using 3x3 window the image was scanned and based on the image histogram the selected feature also called FOS was calculated using this window. Linear discriminant analysis was used for the tissue classification. The study found that the Fibroadenoma texture reveal a different underlying pattern compared to the cyst and normal breast tissues with classification sensitivity and specificity 100% and 92.5% respectively for fibroadenoma, and the combination of the texture features throughout the different U/S image phases provide the highest predictive overall accuracy of 95% using linear discriminant analysis technique.***

Keywords: Fibroadenoma, Breast Ultrasound, Breast Cyst, Tumor.

1. Introduction

The breast is a modified sweat gland that is composed of 15 to 20 lobes that are not well delineated from each other that overlap, and that vary greatly in size and distribution. Each lobe consists of parenchymal elements (lobar duct, smaller branch ducts, and lobules) and supporting stromal tissues (compact interlobular stromal fibrous tissue, loose periductal and intralobular stromal fibrous tissue, and fat). The functional unit of the breast is the terminal ductolobular unit (TDLU), which consists of a lobule and its extralobular terminal duct. Each lobule consists of the intralobular segment of the terminal duct, ductules, and loose intralobular stromal fibrous tissue. TDLUs are important because they are the site of origin of most breast pathology and of aberrations of normal development and involution (ANDIs). Most breast carcinomas are thought to arise in the terminal duct near the junction of the intralobular and extralobular segments. Lobar ducts give rise to much less pathology than do TDLUs—mainly large duct papillomas and the duct ectasia–periductal mastitis complex. However, most invasive ductal carcinomas have ductal carcinoma in situ components that can use the ductal system as conduits for growth into other parts of the breast. Each segmental duct has several rows of TDLUs arising from it. Anterior TDLUs tend to have long extralobular terminal ducts, whereas posterior TDLUs tend to have shorter extralobular terminal ducts. Some TDLUs lie at the distal end of the ductal system and are horizontally oriented. Anterior TDLUs are more numerous than posterior and terminal TDLUs, and over time, the posterior TDLUs tend to regress, leaving a progressively larger percentage of anterior TDLUs. Because anterior TDLUs greatly outnumber posterior TDLUs, most breast pathology that arises from TDLUs occurs in the superficial half of the mammary zone, just deep to the anterior mammary fascia. Rumack et.al (2011).

The vast majority of the lesions that occur in the breast are benign. Much concern is given to malignant lesions of the breast because breast cancer is the most common malignancy in women in Western countries, Caleffi, et.al (2001). The term "benign breast diseases" enompasses a heterogeneous group of lesions that may present a wide range of symptoms or may be detected as incidental microscopic findings. Vecchia and Parazzini, (1985). Fibrocystic changes (FCCs) constitute the most frequent benign disorder of the breast. Such changes generally affect premenopausal women between 20 and 50 years of age. Although many other names have been used to describe this entity over the years, (including fibrocystic disease, cystic mastopathy, chronic cystic disease, mazoplasia, Re's disease), the term "fibrocystic changes" is now prefrred, bec ause this process is observed clinically in up to 50% and histologically in 90% of women (Kinoshita, 2002). FCCs may be multifocal and bilateral. The most common presenting symptoms are breast pain and tender nodularities in breasts. Cysts are fluid-filled, round or ovoid structures that are found in as many as one third of women between 35 and 50 years old. Although most are subclinical "microcysts," in about 20%– 25% of cases, palpable (gross) cystic change, which generally presents as a simple cyst, is encountered (Houssami, 2005). Cysts cannot reliably be distinguished from solid masses by clinical breast examination or mammography; in these cases, ultrasonography and fine needle aspiration (FNA) cytology, which are highly accurate, are used. (Houssami, 2005).

Characterization of Fibroadenoma simply presented in fig. (1) Below:

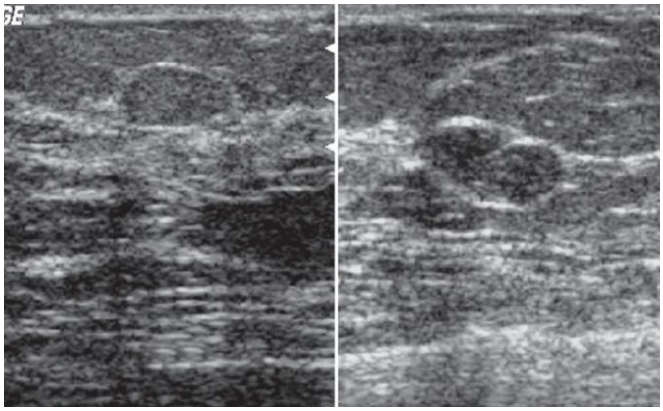

Figure 1: Fibroadenoma. (Left), Classic shape of benign fibroadenomas is elliptical. Such lesions are wider than tall and completely encompassed by a thin, echogenic capsule. (Right), Second most common shape of benign Fibroadenoma is gently lobulated. Classic lobulated Fibroadenoma have three or fewer lobulations, are wider than tall, and are completely encompassed by a thin, echogenic capsule. Rumack et.al (2011).

There are three roles for sonography in breast imaging: (1) primary screening; (2) secondary screening (following mammography); and (3) diagnosis. Sonography currently does not have a proven role in primary breast cancer screening, but the use of sonography in secondary screening (after mammography, as an ancillary study), especially in women with dense breast tissue on mammography, has expanded since the last edition and continues to be investigated.

The normal anatomic structures of the breast span a spectrum of echogenicities, from midlevel gray to intensely hyperechoic. Hyperechoic normal structures include compact interlobular stromal fibrous tissue, anterior and posterior mammary fasciae, Cooper's ligaments, and skin. Duct walls, when visible, also appear hyperechoic. Normal structures that have midlevel echogenicity (isoechoic) include fat, epithelial tissues in ducts and lobules, and loose, intralobular and periductal, stromal fibrous tissue. Water density tissue on mammography corresponds to a variety of different normal tissues that can be shown sonographically. Dense interlobular stromal fibrous tissue, loose periductal or intralobular stromal fibrous tissue, and epithelial elements in ducts and lobules all appear to be of equal density mammographically.

2. Material and Method

A 130 patient with age range from 16-80 year were underwent successful breast ultrasound examination with Siemens ultrasound machines with high frequency linear 10 MHz probe is typically used to scan the breast, in which the main indication were Fibroadenoma and cyst where the other pathological problem was not a focus of this study. Normal study was carried as control group in order to compare the normal texture relative to cyst and Fibroadenoma texture. This study was conducted in the period from January 2014 to September 2016 in Saad specialist hospital. K.S.A.
The breast had been assessed into radial or anti/radial plane. Using a warm gel, examine the breast in a pattern in both transverse and para-sagital plane. Overlap each scanning movement to ensure the whole breast is covered. The transducer is placed with the left margin on the nipple. The right margin is then pivoted about the nipple rotating in a clockwise direction. The right edge is moved onto the nipple and the left edge becomes the mobile part of the transducer. Then the image were extracted and grouped for three different classes; all images had a size of 512×512 pixels with 8-bit gray levels and were represented in DICOM format. Then tiff format was created in order to be used as IDL variable, 6 features from FOS which are mean; variance; skewness; kurtosis; energy; and entropy are computed from the intensity function of the image and were calculated for each ROI through all images using 3x3 window size and the data prepared for SW-LD analysis. And the result showed that:

3. Results

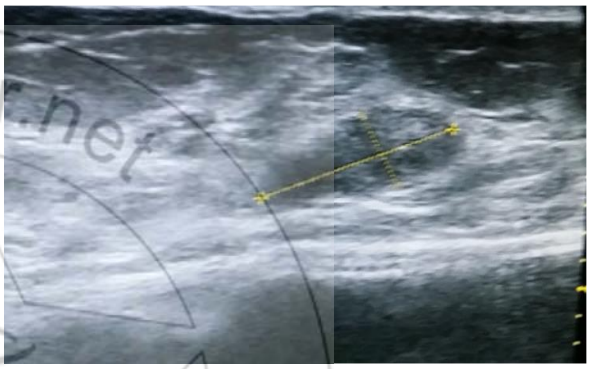

Figure 2: Original ultrasound images for breast fibroadenoma

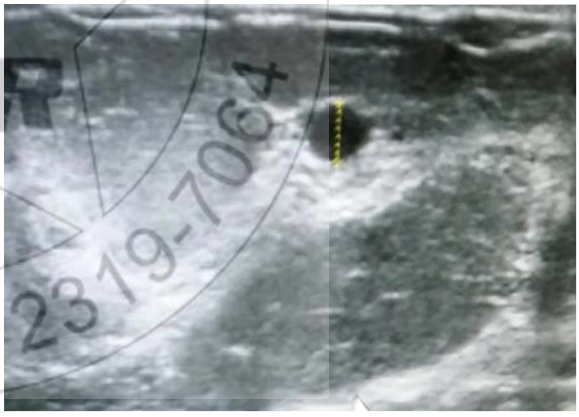

Figure 3: Orignal image of breast cyst in U/S.

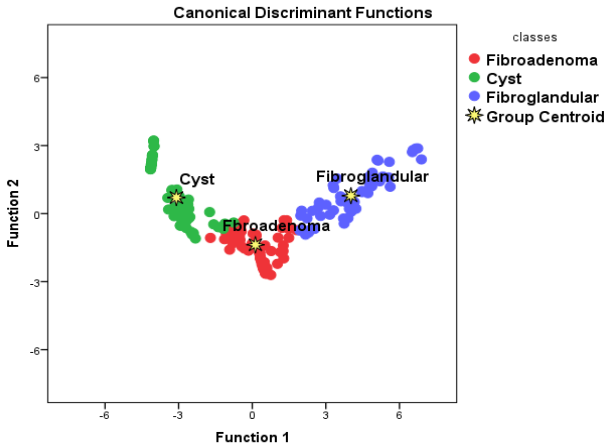

Figure 4: Scatter plot generated using discriminate analysis

function for three classes represents: Fibroadenoma, cyst and normal fibroglandular tissue.

Table 1: Showed the classification accuracy of the Fibroadenoma using linear discriminant analysis:

Classes		Predicted Group Membership			Total
		Fibro-adenoma	Cyst	Fibro-glandular	
Original	Fibro-adenoma	**100.0**	0.0	0.0	100.0%
	Cyst	7.2	**92.8**	0.0	100.0%
	Fibro-glandular	7.8	0.0	**92.2**	100.0%

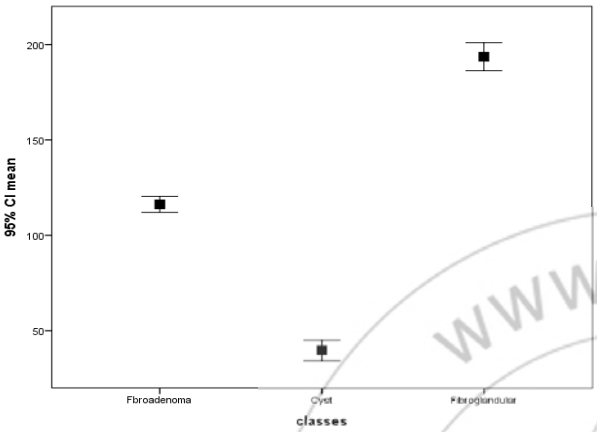

Figure 5: Classification based on mean feature for breast US.

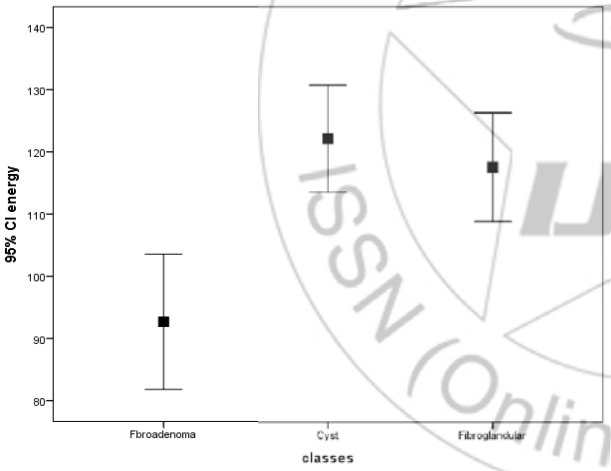

Figure 6: Classification based on entropy feature for breast US.

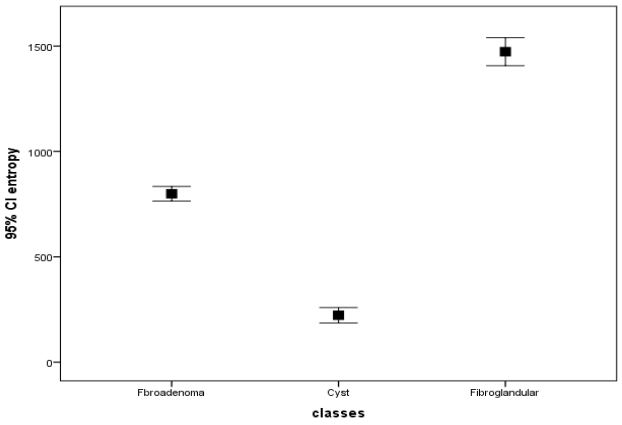

Figure 7: Classification based on mean feature for breast US.

4. Discussion

Firstly the classification was aimed to extract these feature from the image based on the normal image histogram where the primary image (figure 1.) was converted into tiff format as an input image for IDL image processing program, then a window of 3x3 was created in order to scan the image then the feature were extracted for three different images of US containing three classes which are Fibroadenoma, breast cyst and relative to the normal fibroglandular tissue and the feature were include; mean; variance; coarseness; skewness; kurtosis; energy; and entropy. All these feature were calculated for all images and then the data were ready for discrimination which was performed using step-wise technique in order to select the most significant feature that can be used to classify the Fibroadenoma in US images which give best demonstration during the scan for three selected classes and the result showed that: Table (1). Linear discreaminant function and the overall classification accuracy equal to 95% and 100%, 92.8% and 92.2% classification sensitivity for Fibroadenoma, cyst and fibroglandular tissue respectively with classification specificity of 92.5% were computed from gray level histogram and the results are represented that there is a well concentration of features around the class centers which give a remarkable difference among the three classes especially between the cyst and normal breast tissues in the mean of gray level feature as in Figure (4) however, No clear difference in the energy was seen between the cyst and fibroglandular tissue while both are clearly separated from the Fibroadenoma in which indicate that the Fibroadenoma can be differ from these classes because of different texture in US as in figure (5). Among all phases of ultrasound scan the Fibroadenoma reveal different texture for entropy and mean while having low texture feature for energy feature.

Linear discriminate analysis were used to classify the Fibroadenoma, and breast tissue, so the features of the classified regions of the whole images (as raw data) were classified furthers. The result of the classification showed that the Fibroadenoma were classified well from the normal breast tissues even though it has characteristics similar to surrounding tissue, and the texture reveal a different underlying pattern compared to the breast and cyst with classification sensitivity 100%, and the combination of the texture features throughout the different US image phases provides the highest predictive overall accuracy of 95% using linear discriminant analysis. Images with the same slice location were analyzed simultaneously using both US and texture correlation. In this way the texture evolution during the propagation of the sound-wave was taken into account. The method was applied to recognizing normal breast and its two main pathology understudy. Experiments with various sets of texture parameters and two classification methods showed that a simultaneous analysis of texture parameters derived from three subsequent acquisition moments considerably improved the classification accuracy). Also the lesion was examined and the image was tested using 3x3 matrix size (window) based on the intensity profile of the scanned image and this performed in order to differentiate the pathology under study from the normal tissue because of

similarity that may note in component of these classes. Finally, excellent discrimination between Fibroadenoma, cyst and normal fibroglandular tissue can be established on the basis as few as three optimal feature among the 18 texture characteristics tested. This serves as a second method to perform more characterization of such tumor.

5. Conclusion

This study conclude that Fibroadenoma, cyst of the breast and other breast tissue in US images for simplicity can be diagnosed and classify by using the following simple equation after extracting the associated features using a window of 3×3 pixel from the region of interest; the biggest classification score assume the tissue type :

Fibroadenoma = (mean*1.62) + (energy*0.03) + (entropy*-0.175) - 26.834
Breast cyst = (mean*1.02) + (energy*0.064) + (entropy*-0.119) – 12.062
Fibroglandular normal tissue = (mean*0.913) + (energy*0.06) + (entropy*-0.065)- 45.086

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