REGISTRATION AND DETECTION ALGORITHMS FOR BILATERAL ASYMMETRY IN DIGITAL MAMMOGRAM IMAGES - A SURVEY

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ABSTRACT

Among the women population, the most dreadful disease identified in a survey, is breast cancer. Digital Mammography is a screening technique used to detect this dreadful disease. Among the four main symptoms of breast cancer, bilateral asymmetry is one of the main abnormalities that must be detected at an early stage. Many algorithms indicate the presence of this symptom from the suspicious regions of digital mammogram images. This paper presents a survey on the detection algorithms used for bilateral asymmetry.

Keywords *:* Breast Cancer, Digital Mammograms, Bilateral Asymmetry, Registration Algorithms, Detection Algorithms.

I. INTRODUCTION

Breast cancer seems to be the most common cause of mortality in women population. Digital mammography is the best computer aided detection method to identify breast abnormalities at an early stage. The early detection may increase the survival rate and chances of a patient's recovery from the disease. Four main symptoms are identified to occur in women with breast cancer. They are masses, calcification, bilateral asymmetry and architectural distortion. From a survey it is concluded that cancer mortality rates among women has been reduced by 32-70%. Among the four symptoms, bilateral asymmetry seems to have the most serious effects on the patient.

Bilateral asymmetry is defined as abnormal asymmetry between left and right breast of a woman. The asymmetry is identified in the breast parenchymal tissues between corresponding region of left and right breasts. A common asymmetry is found with the presence of fibro glandular tissue in one breast as large column compared to the corresponding area in the other breast. Asymmetric breast tissues are non-cancerous, but abnormal asymmetry may lead to the development of mass which in turn leads to cancer. So the factor of asymmetry must be considered as a serious concern in a woman's risk profile.

Breast imaging and reporting and data system of American College of Radiology (ACR) [1] identified two types of bilateral asymmetry, that is global asymmetry and focal asymmetry. In a situation where a large volume of fibro glandular tissue is identified in one breast compared to the respective area in other breast, the asymmetry is distinguished as global asymmetry. When an asymmetry is found on circumscribed area of breast, it is called focal asymmetry. This type of asymmetry lacks borders and found to be the presence of healthy fibro glandular tissues surrounded by fatty tissues.

Breast tissues with asymmetry are normally benign but it may later develop as a mass which in turn leads to cancer. The diagnosis done by radiologists is by

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comparison of left and right mammogram images for visual abnormalities that may indicate the presence of breast lesion. This diagnosis may not be always accurate. It is susceptible to errors and so, computer aided detection methods were devised. Computer aided techniques help in the detection and classification of the features of mammogram images, offering goof results. These results help the radiologists in decision making between follow up and biopsy.

This paper presents a survey of algorithms used in the processing of images for the detection of bilateral asymmetry. Section 2 presents some of the registration and alignment methods of left and right breasts. Section 3 provides the details of the existing methods and algorithms for detecting bilateral asymmetry. Section 4 concludes and provides the final remarks on work undergone in bilateral asymmetry detection.

II. REGISTRATION AND ALIGNMENT

Before detecting asymmetry in images, the images of left and right breast acquired from Digital mammogram images must be aligned. This process of alignment assures that the accurate points of left and right breasts are only compared for asymmetry.

Many researchers concentrate on the alignment and registration process of a pair of mammograms as a preprocessing step. In some cases registration is not necessary [2]. Image registration is done normally for use in temporal analysis of mammogram images.

Registration if done for mammograms may contain two groups

a) Methods that use features such as curves and points to match the images.

b) Methods that use gray level values of images.

Registration process is also divided into categories such as rigid and non-rigid techniques. While using rigid techniques, images are aligned using methods like scaling and translation. In non-rigid methods a non-linear transformation method is used and the images can be adjusted for warping. While working on detecting bilateral asymmetry, more concentration is to be given on the natural asymmetry of breasts, non-occurrence of variant points to compare between left and right breasts and distortion sufficient enough to occur during imaging process. This process of registration or alignment ensures that only correct corresponding points of left and right breasts are compared for asymmetry.

Lau and Bischof [3] aligned breast region using three control points around the boundary. The first point is the nipple point and the other two points are the corner points between breast boundary and the chest wall. In this work four steps were involved in the alignment of left and right breasts.

1. Rotate an image to an angle so that it matches with the orientation of the other image
2. Both the breast images are aligned corresponding to a particular point
3. Transform the images to left or right so that their angles remain the same.
4. Make ny other adjustment in size and shape to match the differences between them.

According to Yin et. al., [4] breast boundary and nipple points are taken as parameter to align the 2 breasts. The first co-ordinate, connectivity point, was used to identify the breast border. The second parameter, which was the nipple point position, was calculated based on the thick parenchymal opacity area and thicker skin line

around the nipple position. Registration of images was done using least-square methods.

Mendez et al., [5] established techniques which referenced nipple and breast border for aligning the breasts. The offset co-ordinates of nipples of both images were calculated and rotated accordingly for alignment. The angle of rotation was adjusted so that left and right breasts got matched.

Stamatakis et al., [6] used only single point curvature references. As a pre-processing stage the images were normalized to reduce the intensity variations of the two images. Wirth et al., used the non-rigid parameters of breast for alignment. The border region of left and right breasts was considered as the control point and application of multiquadric radial basis function (RBF) was used for alignment.

Good et al., [7] proposed a new model of aligning, where the image corrections and alignments were done automatically during this compression. Then to make the image into a semi-circular form, a non-linear geometrical transformation was done.

III. BILATERAL ASYMMETRY DETECTION ALGORITHMS

In the work done by Lau and Bischof [3] no specific characteristics of tumour regions were considered. Only measures like brightness, roughness and directional information were taken into consideration. The detection of asymmetry between left and right breasts was done with 10 pairs of digital mammogram images and 13 suspicious areas were identified. The sensitivity rate of 92% was obtained with 4.9% of false positives per mammogram images.

Miller and Astely [8] proposed a new asymmetry detection algorithm that considered anatomical features. The shape and gray level distribution of left and right breast images were considered. A separation was done for fat and non-fat areas of glandular disc that identified the segmented areas of consideration. A sample of 30 pairs of mammogram image was tested using this method and a sensitivity of 86.7% was achieved.

Yin et al., [4] proposed a work, where the breast images were aligned and subject to undergo a preprocessing phase for image registration. The images were segmented into two parts---breast border and nipple positions. A focus-point connecting tracker was used for breast border identification and for nipple position. A thicker skin line for parenchymal opacity was identified. Least-square method was used for translation and rotation of image registration in this proposed work.

Tahmoushet. Al [9] proposed another method, where asymmetry was identified by comparing the similarity index features of the two breasts. Similarly occurring doubtful points were filtered from the mammogram image. Modeling of these suspicious point and comparison was done using supervised learning. Bayes theorem was used for classification which resulted in 84% of accuracy.

Jelena Bozek et al., [1] proposed a new methodology for alignment and registration of left and right breast in the computer aided detection of breast cancer. This was a pre-processing step which was to be done prior to asymmetry detection. After this alignment process was done, the respective points of left and right breasts were compared for asymmetry. The differential analysis methods were used in their proposed work which was based on the technique of subtraction. The alignment process was made simpler by flipping the pair of

mammogram images so that they stayed in the same margin. This made the alignment process easier. Interpolation of the image was used where new data points were created based on the existing discrete set of data points. B-Spline interpolation method was used to compute 16 nearest pixel samples. 4 pixels in horizontal direction and 4 pixels from vertical direction were computed. To find these interpolated points the contour part of left and right breasts were computed. The image of right breast was flipped and scaled according to the alignment of the left breast. This made the comparison of the two breasts easy for detecting asymmetry. The difference was computed by subtraction of interpolated right and left breasts. The differentiated regions of the two breasts were displayed with different colors for better utilization.

In the proposed work done by Xingwei et al.,[10] a set of 100 cases of negative results of images was considered from the mammogram image database. To determine the density of the tissue, the bilateral images were examined and a computerized scheme was applied on it. A set of 20 features was extracted by this computerized method. Optimized features were selected using genetic algorithm. An Artificial Neural Network (ANN) was built based on these optimal features. The leave-one-case-out method was used to measure the performance of the ANN constructed. A Receiver Operating Characteristic (ROC) curve was used for visualizing the results of the performance achieved. It acquired 90% sensitivity. The aim of their work was to detect the high risk of asymmetry in women at an earlier stage.

Williams et al., [11] proposed a new automated method of assessing the asymmetry value of Breast mammogram. Normally a clear visualization could be seen in the breast shape and size which was common in women. This type of asymmetry when present in an abnormal way, it might lead to the risk of cancer in the near future. Segmentation of breast region was an important step in automated methodologies used for assessing breast size.

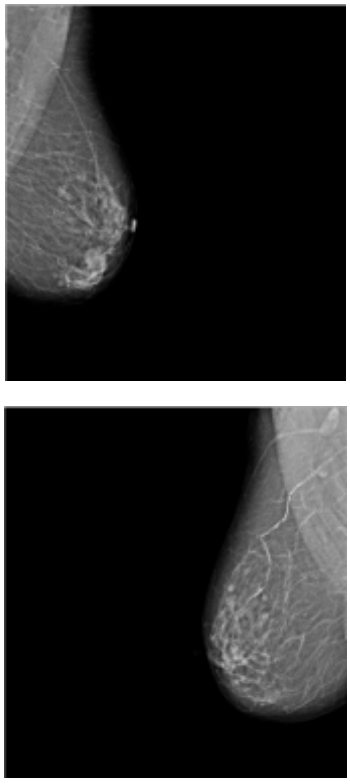

Figure 1. Mediolateral View of Left and Right breasts

Three common methods were used for detecting breast volume: Katariya method was used for Craniocaudal (CC) view, Hoe method for Medio-lateral (MLO) view and Fung method for detecting breast volume sixe from CC and MLO view. In Katariya method breast height was measured as the perpendicular distance from edge and width as the marked width across the edge. Finally volume was calculated considering the shape of the breast as a circular cone. In Hoe method MLO view was considered for assessing breast volume. Here height was calculated as the perpendicular distanced from edge to the pectoral muscle and width was measured as

superolateral - to inferomedial perpendicular distance and then volume was calculated. The Fung method used both CC and MLO view for assessing breast volume. It considered elliptical shape instead of cone on both CC and MLO view. The fluctuating asymmetry values of breast volume between groups of cases were calculated and compared for performance. This could be considered as bio-marker that alerted radiologists for interpretation of breast cancer.

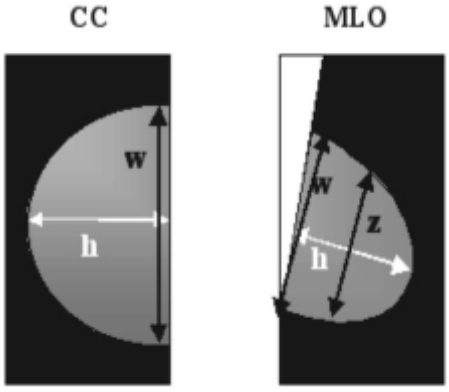

Figure 2. Measurements of breast size in CC and MLO views

In the proposed work done by Bin et al., [12] an examination was conducted with four images in CC view and MLO view of left and right breast images. A computerized scheme was applied which used an iterative threshold method to partition the breast part from the background. On each CC and MLO view, five density related image features were extracted. They are

1. Mean pixel value of the whole breast area
2. Standard deviation
3. Skewness
4. Kurtosis
5. Local variations.

This computerized scheme was applied individually to CC view of left and right breast images. A simple 3 layer Artificial Neural network was constructed, through which asymmetry density of each mammogram was calculated. This method predicted risk of women with cancer using a statistical association method. The dataset was divided into 3 subgroups of positive, benign and negative cases. Different combinations of paired subgroups were computed to detect asymmetry level of breasts to arrive at significantly vital results.

Rangayyan et al., [13] proposed a new work which emphasized that similarity and dissimilarity features played a major role in effective detection of asymmetric signs of breast cancer. Anatomical features were extracted and masking procedures were applied. Specific significant regions were extracted and the changes in the structures information were examined using spherical semi-variogram description. The density structure in mammogram was represented using Gabor filter. 188 mammograms of 47 asymmetry and 47 normal cases each were analyzed and ROC curve obtained with linear discriminant analysis. The accuracy achieved was 94% and sensitivity 100% and specificity 88%.

IV. CONCLUSION

Digital Mammography technique is accepted as the best method to detect breast cancer at an early stage. It helps the radiologists in diagnosing the symptoms that leads to the commencement of an early treatment of the patients with a risk profile. Many detection algorithms are being discussed in this paper, which proves to provide good results in reducing the false positives. But further development of new techniques is required in order to improve the performance of these algorithms.

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