ABSTRACT
Mammography is the best available tool for screening for the early detection of breast cancer. Breast cancer is the most common cancer in women. Early detection and diagnosis of breast cancer facilitated with digital mammography can increase survival rate and chances for patient’s complete recovery. Bilateral asymmetry is one the breast abnormalities that may indicate breast cancer in early stage of its development. Breast asymmetry is related to several of the known risk factors for breast cancer, and that patients with diagnosed breast cancer have more breast volume asymmetry, as measured from mammograms.

Researchers have been investigating and developing image processing algorithms that may help radiologists in giving accurate diagnosis. Most detection algorithms indicate suspicious regions that may need a better observation. In the present study, we reviewed studies for the breast asymmetry made by different researchers.

Keywords
Bilateral Asymmetry, Breast Alignment, Digital Mammography, Computer-Aided Detection

1. INTRODUCTION
Radiologists can use the differences between the left and right breasts, or asymmetry, in mammograms to help detect certain malignant breast cancers. An image similarity method is introduced to make use of this knowledge base to recognize breast cancer. Mammograms are an excellent candidate for image similarity techniques to be effective because there are images of both the left and right breasts, which should be similar if there is no cancer present. Digital mammography allows detection of breast abnormalities in early stage of breast cancer development. One of the abnormalities that may indicate breast cancer in its early stage is bilateral asymmetry.

Digital mammography is one of the best examination methods for detecting breast cancer in early stage of development and thereby increasing chances for patients’ complete recovery. It can reveal pronounced evidence of abnormality, such as masses and calcifications, as well as subtle signs such as bilateral asymmetry and architectural distortion [1].

Bilateral asymmetry, i.e. asymmetry of the breast parenchyma between left and right breast, may indicate breast cancer in its early stage. According to ACR’s (American College of Radiology) Breast Imaging Reporting and Data System [2] there are two types of bilateral asymmetry: global asymmetry and focal asymmetry.

Global asymmetry is defined when a greater volume of fibroglandular tissue is present in one breast compared to the corresponding area in the other breast and focal asymmetry is circumscribed area of asymmetry seen on two views, but it lacks the borders and conspicuity of a mass. Focal asymmetry is usually an island of healthy fibroglandular tissue that is superimposed with surrounding fatty tissue. Bilateral symmetries of concern are those that are changing or enlarging or new, those that are palpable and those that are associated with other findings, such as microcalcifications or architectural distortion [3].

Humans are susceptible to committing errors and their analysis is usually subjective and qualitative. Objective and quantitative analysis facilitated by the application of computers to biomedical image analysis leads to a more accurate diagnostic decision by the physician [4]. Computer-aided detection algorithms have been developed to aid radiologists in finding the suspicious breast abnormalities and set up the accurate diagnosis [5].

Detecting breast cancer is challenging because the cancerous structures have many features in common with normal breast tissue. This means that a high number of false positives or false negatives are possible. Asymmetry can be used to help reduce the number of false positives so that true positives are more obvious [6].

Developing ways to better utilize asymmetry is consistent with a philosophy of trying to use methods that can capture measures deemed important by doctors thereby building upon their knowledge base, instead of trying to supplant it. However, measuring asymmetry means comparing multiple images, and thus it is a more complicated process [7].

In this paper, we have tried to present a detail survey on Bilateral Symmetry for early indication of breast cancer and this work will definitely provide a concrete overview on the past, present and future aspects in this field.

2. MEASUREMENT OF ASYMMETRY
There are not many algorithms developed for bilateral asymmetry detection. It may be due to the fact that the first step in bilateral asymmetry detection is a challenging task. The first step that has to be performed before comparing images is kind of registration or alignment of the breasts. Alignment procedures have to confront many difficult problems such as the natural asymmetry of the breasts, absence of good corresponding points between left and right breast images to perform matching and distortions inherent to breast imaging.

Ferrari et al. [8] presented a procedure based upon the detection of linear directional components. They used a multiresolution representation based on Gabor wavelets. The Gabor filter responses for different scales and orientation were analyzed by using Karhunen-Loeve (KL) transform and Otsu’s method of thresholding.
Some researchers in their work performed some kind of work utilizes filtering followed by spatial analysis to determine an overall measure of similarity by combining the contextual similarity of the filtering with the spatial similarity of the analysis. This can be a useful measure for pre-screening mammograms since only an overall determination is required. A secondary goal of the work is to determine the importance of similarity or asymmetry in the computer analysis of mammograms. Figure 1 shows that spatial asymmetry is important in finding cancers in mammograms since the texture and appearance of cancer are both very similar to the texture and appearance of normal tissue in the breast.

Before the alignment right breast image is flipped so that the breasts have the same orientation thereby making the alignment process simpler. The proposed alignment method is based on the B-spline interpolation [6]. Image interpolation is a method of constructing new data points within the range of a discrete set of known data points. For the interpolation procedure the size ratio of left and right breast has to be found. In order to find the size ratio between the left and right breast the furthest point of the breast contour from the image edge is found for each breast.

The contrast enhancement phase is done using the Contrast Limited Adaptive Histogram Equalization (CLAHE) technique, which is a special case of the histogram equalization technique [9] that functions adaptively on the image to be enhanced. The pixel's intensity is thus transformed to a value within the display range proportional to the pixel intensity's rank in the local intensity histogram. CLAHE [10] is a refinement of Adaptive Histogram Equalization (AHE) where the enhancement calculation is modified by imposing a user-defined maximum, i.e. clip level, to height of the local histogram and thus on the maximum contrast enhancement factor. The enhancement is there by reduced in very uniform areas of the image, which prevent over enhancement of noise and reduces the edge-shadowing effect of unlimited AHE [11]. All images are used in compliance with Dicom standard. Mammographic imaging device is Mammmomat Novation DR that has α-Selenium direct conversion detector and uses Wolfram/Rhodium anode/filter combination [12].

The analysis for similarity or asymmetry does a comparison of the locations of the sets of suspicious points. A separator is learned with a training set of images. This separator breaks the set of suspicious points into two groups, and the populations in the groups are compared between the images. It is based upon the assumption that the presence of cancer will distort the distribution of suspicious sites, and that the distribution will be very similar from left to right breasts when there is no cancer. This is similar to comparing histograms whose parameters are learned from a test set.

3. ASYMMETRY AND ALIGNMENT
The first step in bilateral asymmetry detection is alignment of the breasts. Alignment ensures that the correct corresponding points of the left and right breast are being compared. Original right and left MLO (mediolateral oblique) images are shown in Figure 2.

Stamatakis et al. [13] aligned left and right breast using a single reference, a point of maximum curvature on the breast curve. They normalized the images to minimize differences in illumination between images before comparison.

Wirth et al. [14] proposed a method which accounts for some of the nonrigid-body characteristics associated with breasts. They selected corresponding control points between left and right

Figure 1. Mammograms of left and right breasts with cancerous area outlined. The similarity of texture between cancerous and normal tissue makes asymmetry an important tool in cancer detection.

Figure 2. Original MLO images of the: (a) right breast, (b) left breast

Figure 3. Original mammogram pair before contrast enhancement

Figure 4. Mammogram pair after contrast enhancement
mammographic image from the breast contour and according to
these control points they applied a multiquadric radial basis
function (RBF) to transform right mammographic image to match
relative the left mammographic image.

Good et al. [16] applied techniques for automatically making the
appropriate local image corrections, based on the variations in
tissue thickness during breast compression. Afterwards they used
a nonlinear geometrical transformation which geometrically
deformed the images to match a semi-circular template.

Georgsson [15] proposed method for bilateral registration based
on anatomical features and assumptions of how the female breast
is deformed under compression. He established an anatomical
coordinate system defined with pectoral muscle and nipple. The
coordinate system was used to divide breast into two boxes
containing upper and lower part of the breast. He independently
scaled each of these boxes to match the bilateral counterpart in
size and transformed the skin lines of the two breasts to match
each other.

4. BILATERAL ASYMMETRY
DETECTION ALGORITHMS

Lau and Bischof [17] used detection of structural asymmetries
between corresponding regions in the left and right breast to
detect breast tumors. They used a set of measures related to the
mammographic appearance of tumors but without characteristics
of specific tumors. They developed measures of brightness,
roughness, brightness-to-roughness and directionality. The
method was evaluated using set of 10 pairs of mammographic
images where structural asymmetry was a significant factor in the
radiologist's diagnosis. These mammographic images contained a
total of 13 suspicious areas. Final test results revealed sensitivity
of 92% with 4.9 false positives per pair of mammographic
images.

Méndez et al. [18] subtracted left and right mammographic
images and applied a threshold to obtain a binary image with the
information of suspicious areas. The suspicious regions or
asymmetries were delimited by a region growing algorithm. The
method was tested on a set of 70 pairs of digital mammographic
images and obtained a true positive rate of 71% with 0.67 false
positives per image.

Stamatakis et al. [13] proposed two methods for the comparison
of left and right breast. The first method, Single Image
Comparison (SIC), involved finding the corresponding areas
whose intensities differed more than a preset threshold. The
second method, Multiple Image Comparison (MIC), involved
generating eight pairs of images from each original pair of left
and right images. These eight pairs of images were then
bilateral compared and the resulting images were recombined
into one pair of images. A set of 10 features was calculated from
the suspicious areas detected by the comparison process.
Stepwise discriminant analysis was used to select 5 features for
final feature set. The results were tested on a data set of 50 pairs
of mammographic images. The SIC method obtained 86.8%-
accuracy with 4.9 false positives per image and MIC method
obtained 89.2% accuracy with 4.3 false positives per image.

Georgsson [15] proposed two methods for differential analysis of
bilateral mammographic images. The first method was based on
the absolute difference between the registered images and the
second method was based on the statistical differences between
properties of corresponding neighbourhoods. He tested both
methods on 100 mammographic images obtained from the MIAS
database. The absolute difference method achieved a detection
rate of 18 with 10 false positives and statistical method achieved
detection rate of 21 with 10 false positives.

Good et al. [16] developed a method which performs feature-
based analysis of local and global differences between
mammographic images. The extracted features are assumed to be
relatively invariant with respect to breast compression. After the
registration of the images with template, they applied a series of
global and local feature filters to characterize the image
properties of interest. Features are placed into feature vector and
appropriate comparison of feature vectors reveals differences
between image properties.

Miller and Astley [19] used anatomical features for detection of
breast asymmetry. Using texture analysis they segmented
mammographic images into regions of fat and nonfat tissue
which presents glandular disc. Glandular discs in left and right
breast were compared using properties of their shape and grey-
level distribution. They tested the proposed method on a data set
of 30 pairs of mammographic images and achieved classification
accuracy of 86.7% with false positive rate of 16.7%.

In another work, Miller and Astley [20] compared glandular discs
in left and right breast using shape, brightness and topology
features. Measurements of shape were used to detect
architectural distortion of the glandular disc, brightness
distribution was used to detect masses and focal densities and
topological features specified other suspicious asymmetries. The
method was tested on the data set of 104 pairs of mammographic
images and obtained classification accuracy of 74%.

Tahmoush and Samet [21] proposed the use of image similarity
to determine asymmetry. They filtered the mammographic
images to find the contextually similar suspicious points that
could be malignant. Their similarity or asymmetry analysis used
comparison of the values of the sets of suspicious points using
modeling and supervised learning of model parameters. They
used Bayes’ Theorem to incorporate asymmetry into CAD system.
Their method correctly classified 84% of images in their test set.
The method correctly classified 97% of cancerous cases and 42%
of noncancerous cases.

Ferrari et al. [22] developed a method for the asymmetry analysis
based on the detection of linear directional components using a
multi resolution representation based on Gabor wavelets. They
segmented the fibroglandular disc and decomposed the resulting
image using a bank of Gabor filters. The Gabor filter responses
for different scales and orientation were analyzed using
Karhunen-Loève (KL) transform and Otsu's thresholding method.
For quantitative and qualitative analysis of the oriented patterns
the rose diagrams were used. Their method obtained
classification accuracy of up to 74.4%.

Rangayyan et al. [23] extended the method of Ferrari et al. [20]
by including morphological measures and geometric moments of
the fibro glandular disc related to density distributions. Directional features were obtained from the difference in rose diagrams and additional set of features including Hu's moments, eccentricity, stretch, area and average density were extracted from the segmented fibro glandular discs. They aligned the directional data related to the rose diagrams with respect to the corresponding pectoral muscle edges. The differences between the pairs of the features for the left and right mammographic image were used as measures for the analysis of asymmetry. They obtained the overall classification accuracy of 84.4%.

5. CONCLUSIONS
Mammography is one of the best examination procedures for early detection of breast cancer. It can reveal breast abnormalities in early stage of development. Due to wide range of breast abnormality features and large amount of mammographic images in screening programs, use of computers in breast cancer detection can help radiologists in giving more accurate diagnosis. Bilateral asymmetry may indicate breast cancer in its early stage. There have been developed image processing algorithms for bilateral asymmetry detection, but further developments are required to improve these algorithms and their performance.

6. REFERENCES
[12] Siemens, Mammomat NovationDR, Available at: www.medical.siemens.com