CHAPTER 2

LITERATURE REVIEW

2.1. OVERVIEW

Advances in medical imaging assist the early detection of diseases. The most frequently diagnosed cancer in women aged between 40 and 60 years is mammary carcinoma. Based on the report released by World Health Organization (WHO) in www.cancer.org, (2010) there are about 7.6 million carcinoma deaths across the world. Every year, among 502,000 deaths are mammary carcinoma. Mammary carcinoma is considered to be the most deadly cancer as specified in www.breastcancer.org, (2009). To effectively treat a patient with mammary carcinoma it is required to diagnose it as soon as possible. An early diagnosis provides the opportunity to deliver medical interventions to either prevent the development of the disease or prevent the progression of the condition and emergence of symptoms. There is a rapid need for imaging solutions among applications in:

2.1.1. Echo Imaging

Real time ultrasound B-mode (brightness mode) scanning is used to image various tissue structures throughout the body. Pai-Chi Li et al (2005), is an approach for tomographic reconstruction of the sound velocity distribution and attenuation coefficient distribution in the breast using linear arrays. A reconstruction algorithm based on a convex programming formulation and incorporating the segmentation information from the B-mode image is used.
Taslidere et al (2008), detected the potential of cell growth in breast ducts using ultrasound. The stochastic decomposition model of RF echo with its coherent and diffuse components yield the image parameters that correlate closely the structural parameters of the hyperplastic stages of the breast tissue. The discrimination power of the various parameters is studied under a host of conditions - resolution, depth and coherent to diffuse energy ratio (CDR) values using a point-scatterer model simulator that mimics epithelium hyperplastic growth in the breast ducts.

Foroughi et al (2009), used synchronized data from an external tracker and pairs of Radio Frequency (RF) frames are tuned to match the known properties of the underlying elasticity estimation technique to reduce the dependency and to increase the overall quality of the images.

Farahi et al (2010), proposed an acousto-optic imaging based on ultrasound modulation of multiply scattered light in thick media. Optical absorbing objects were imaged and embedded within a thick scattering phantom using pulsed ultrasound to get a dynamic millimetric axial resolution. Jingdan Zhang et al (2010), a fully automatic system to detect cysts jointly in both B-mode and elasticity images are proposed. Ogunlade et al (2010), measures the complex permittivity of various concentrations of micro bubbles in ethylene glycol liquid phantom. Cavity perturbation technique using custom rectangular waveguide cavities, sensitive to small changes in the permittivity of the perturber, were employed.

Cosio et al (2011), reported the results of the development of a computer assisted system for breast biopsy. A three dimensional ultrasound volume is constructed from a set of tracked B-scan images acquired with a calibrated probe. These techniques represent an approach for to detect microcalcifications. Several techniques like edge enhancing filters to sharpen the tissue boundaries and improve the quality of the image are required.
2.1.2. Spectral Doppler

Spectral Doppler is an imaging technique using ultrasound to detect moving liquids. The spectrum of flow velocities is represented graphically on the Y-axis and time on the X-axis; both pulse wave and continuous wave are displayed. Kaiguo Yan et al (2010), presented a detailed system design for multimodal imaging system that combines three modalities, optical spectroscopy, ultrasonography and Acoustic Radiation Force (ARF) for improving the diagnosis of breast cancer based on noninvasive interrogation of vasculature. Piras et al (2010), developed a multimodal imaging system that combines three modalities, optical spectroscopy, ultrasonography and acoustic radiation force (ARF) for improving diagnosis of breast cancer based on noninvasive interrogation of vasculature. The system reconstructed an image using a delay-and-sum beam forming algorithm.

Te-I Chiu et al (2011), visualised the feasibility of microcalcification using optoacoustic (Photoacoustic) imaging (PAI) technique. The artificial phantom imbedded with granulated calcium Hydroxyapatite (HA), the major chemical composition of the microcalcification associated with DCIS, was used for imaging.

Xiong Wang et al (2011), developed a complete microwave induced Thermal Acoustic Imaging (TAI) model for potential biomedical imaging applications. Acoustic pressure generated by spherical breast tumor target is investigated by Finite-Difference Time-Domain (FDTD) simulations of the Electromagnetic (EM) and acoustic models.

These techniques signify the diagnosis methods to detect and classify abnormalities of the breast. The ability to assess the velocity of moving particles in the body is important for many clinical situations.
2.1.3. Segmentation

Segmentation is the process of extracting the region of interest for the analysis of manifestation of symptoms. Barbara Zitova et al (2003), reviewed classical image registration methods. The reviewed approaches are classified according to their nature and according to four basic steps of image registration procedure: feature detection, feature matching, mapping function design and image transformation and resampling.

Djamal Boukerroui et al (2003), proposed a robust adaptive region segmentation algorithm for noisy images, within a Bayesian framework. Chang et al (2005), suggested a novel technique to detect microcalcification on 3D ultrasound images involving wavelets. A multiresolution implementation of the algorithm is performed using a wavelets basis and is used to process both 2D and 3D data.

Cuiping Limet et al (2008), Duric et al (2008), Computerized Ultrasound Risk Evaluation (CURE), employed a ring transducer array to scan the whole breast in a water tank by applying reconstruction techniques to vitro and in vivo breast data acquired using the CURE device. The techniques demonstrated in-vivo tomographic imaging of breast architecture in both reflection and transmission imaging modes.

Truong An Tran et al (2008), explored the cell membrane’s responses to microbubbles’ oscillations. The results revealed that ultrasound stimulation induces a rapid hyperpolarization of cell membrane potential and the microbubble is in direct contact with the cell. These techniques as investigated by various researchers have image processing algorithms for automatic segmentation, classification and measurements of features of clinical interest.
2.1.4. Visualisation

The techniques for visualising the ultrasound data is categorised into multi-planar, volume-based and surface-based viewing. In multi-planar viewing, arbitrary 2D image slices are re-sampled. In volume-based rendering, the information within the entire 3D volume is projected onto a 2D-image plane.

Eder et al (2007), inspected ultrasonic strain images. The mechanical stiffness of parameters of soft tissue helps to improve tumor detection and diagnosis based on pathological changes. The performance of novel and Field II simulations with commercial ultrasound scanner and a tissue-mimicking phantom are suited for freehand strain imaging.

Narayanasamy et al (2007), in the study evaluated the accuracy of image volume based registration (IVBaR) of 3D ultrasound (US) image volumes of the whole breast acquired at different times. The color flow vessels provided independent measures for validation of registration of the grayscale portion of the images.

Yamazaki et al (2008), developed practical equipment for tissue elasticity imaging. A CAD system based on tissue elasticity image for diagnosing defused type diseases such as hepatic cirrhosis was developed. The tissue elasticity imaging is useful for the detection of tumor.

Maeva et al (2009), presented observations of ultrasound biomedical imaging. Scanning Reflection Acoustic Microscope (SAM) with high-frequency tone-burst ultrasonic wave reveals the details of tissue structure and serves as additional diagnostic tools.
Filippo Molinari et al (2010), presented, discussed on benchmarking and evaluation of different segmentation techniques like edge-detection, active contours, dynamic programming, local statistics, Hough transform, statistical modelling and integration of the approaches for carotid ultrasound segmentation.

Nebekert et al (2010), proposed a volume breast ultrasound (VBUS) scanner measuring sound speed using standard B-mode technology using the methods, back-projection using a Graphics Processing Unit (GPU) produces a 3-dimensional sound speed image.

These literature signify the diagnosis methods to visualise the surface of organs or structures, surface rendering by shading and illuminating the surfaces.

2.2. SPECKLE NOISE REDUCTION IN ULTRASOUND IMAGES

The acquired ultrasound image has an inherent property, the speckle noise. Speckle noise is a granular pattern, delays the interpretation of the content. Jang (1993), suggested an Adaptive-Network-based Fuzzy Inference System for a hybrid learning algorithm to identify parameters of Sugeno-type fuzzy inference systems. It applies a combination of the least-squares method and the backpropagation gradient descent method for training FIS membership function parameters to emulate a given training data set.

Abbey et al (2006), extended the ideal observer methodology developed by Smith and Wagner. A numerical approach, for evaluating the observer, acting on Radio Frequency (RF) frame data, involving inversion of large non-stationary covariance matrices was suggested.

Hansen et al (2008), applied Full Angle Spatial Compounding (FASC) to breast imaging with an add-on system to a conventional ultrasound scanner, integrated it in a custom-made examination couch. Shao-Yu Chen et al (2008), suggested the use of the normalized cuts with partial grouping constraints to segment breast tumors in cropped ultrasonic images.

Zapf et al (2009), Pulse compression techniques for 3D ultrasound computer tomography (3D USCT) is used in the approach. Damped sine pulses, linear chirps, Barker binary codes with 13 elements, Golay code sequences with 16 elements were evaluated. The evaluation was based on the well-established metrics SNR, GSNR, PSL and ISL.

Xu Liu et al (2010), proposed an automatic method to segment lesions in ultrasound images. The images are first filtered with anisotropic diffusion algorithm to remove speckle noise. The edge is enhanced to emphasize the lesion regions. Normalized cut is a graph theory with a combination of different features for image segmentation and is successfully used in object parsing and grouping.

Speckle noise is the major factor hampering the quality of ultrasound images and tends to faulty diagnosis. Speckle noise is modelled as a random multiplicative process. An evolutionary hybrid approach incorporating neural networks and fuzzy logic is desirable to suppress noise and improve the visual quality.
2.3. CONTRAST ENHANCEMENT OF ULTRASOUND IMAGES

Contrast Enhancement is the process of automatically brightening the images that appear dark or hazy and applies appropriate tone correction to deliver improved quality and clarity. Kalpathi Subramanian et al (2004), presented an interactive visualization system to identify the lesion, process, visualize and quantify the lesions from a dynamically contrast enhanced DCE-MRI volumes.

Ruey-Feng Chang et al (2006), presents two methods: threshold-based and proportion-based methods, to automatically analyze the breast density using whole breast ultrasound. The experimental results are graded from 4 (extremely dense tissue) to 1 (almost entirely fat) and respectively compared with the majority grades of three radiologists.

Bin Guo et al (2007), suggested a microwave-induced Thermal Acoustic Imaging (TAI) a promising early breast cancer detection technique. It combines the advantages of microwave stimulation and ultrasound imaging and offers a high imaging contrast, as well as high spatial resolution at the same time. A Multifrequency Adaptive and Robust Technique (MART) are presented for image formation. The effectiveness is shown by several numerical examples based on 2-D breast models.

Ruiter et al (2008), method detects local maxima in the envelope of a matched filtered signal and convolutes the result with a truncated difference of sinc-functions; the main lobe is scaled to represent the phase aberration.

Chen Chih-Yen et al (2010), presented an Image Enhancement technique based on the combination of fuzzy set and Radon Transform on ultrasound images. Experimental investigations demonstrated the texture variance of 3D ultrasound were effective and useful for differential diagnosis.
of breast tumors. Texture extraction with proposed method can find malignant more accurate than auto-correlation.

Jakia Afruz et al (2010), used a pseudo-color technique in frequency domain to enhance ultrasound images with three types of transforms. They are the Fourier transform, Discrete Cosine transform and Walsh- Hadamard transform. After obtaining the pseudo-color images, a high frequency emphasis filter or histogram stretch as a post process is applied.

Rouyer et al (2010), used high contrast and multi-parametric imaging in Ultrasound tomography. Performed with a needle hydrophone, calibration studies yield system characteristics such as field distribution or transducer element localization. Chirp excitation is used to improve contrast with pulse compression method.

The poor quality of the images misinterprets the diagnosis procedure. A system to identify to enhance the images adaptively by using the fuzzification and transformation techniques is required.

2.4. SEGMENTATION OF THE LESION

Image segmentation is the process of partitioning an image into a set of pixels. The goal of segmentation is to simplify and/or change the representation that is more meaningful and easier to analyze. Chia Hsiang Wu et al (2006), proposed a method based on Laws’ microtexture energies and Maximum A Posteriori (MAP) estimation to construct a probabilistic deformable model for kidney segmentation using texture image features and MAP estimation.
Rodriues et al (2006), proposed a novel and automatic methodology for breast lesion classification in ultrasound images. The first three steps yield an accurate segmentation of the breast lesions based on the combination of (a) novel non-extensive entropy, (b) morphologic cleaning and (c) accurate region and boundary extraction in level set framework.

Taslidere et al (2006), the goal is stochastic decomposition algorithm of the RF echo. It is used to estimate the structural parameters of the hyperplastic stages of the breast tissue leading to early breast cancer detection. Taslidere et al (2006), proposed a study to detect the discrimination power of the parameters with different depths using a point scatterer model simulator imitating epithelium hyperplastic growth in the breast ducts.

Zielinski et al (2006), the objective is a CAD system for tumor detection and classification in ultrasound breast images based on a two-dimensional Auto-Regressive-Moving-Average (ARMA) model of the breast image. The estimated parameters are used as the basis for statistical inference and biophysical interpretation of the breast image. Evaluation is done in real ultrasound images using a k-means classifier. The parameters are used to segment the ultrasound breast image into three regions: healthy tissue, benign tumor and cancerous tumor.

Schwarzenberg et al (2007), at Forschungszentrum Karlsruhe developed 3D Ultrasound Computer Tomograph (USCT) for breast cancer diagnosis. The pulse detection is demanding due to low Signal-to-Noise Ratios (SNR) caused by unfocused pulses from single emitters. An analysis of several classifiers used produced the alternating decision tree.

Chen-Han Chang et al (2008), implemented three different approaches: Video Signal Analysis (VSA), spectral estimation using
Periodogram (PER) and Minimum Side Difference (MSD) and one combined method. Performance of the approaches is investigated based on simulation.

Juan Shan et al (2008), the aim is a new automatic seed point selecting method for region growing algorithm. The method is validated on database with 105 ultrasound images with breast masses and it is compared with other automatic seed point selecting method on the same database.

Moi Hoon Yap et al (2008), used a hybrid filter, multifractal processing and thresholding segmentation in initial lesion detection and automated ROI labelling for initial lesion detection in US breast images.

Chii-Jen Chen et al (2009) suggested 3D Breast Tumor Classification Using Image Registration Framework on ultrasound images. Chii-Jen Chen et al (2009), the ratio of mean gray-scale value within whole ultrasound image and within a local Region of Interest (ROI) is adopted to individually adjust the binary threshold value. If the ratio was greater than 1, the characteristic of ROI tends to lesion and the binary thresholding value should be assigned a higher value.

Hsieh-Wei Lee et al (2009), suggested that the local variances are characterized by a few high octave energies in 1-D discrete periodized wavelet transform (DPWT). Test datasets of breast sonograms with the lesion contour delineated by a Java-based image processing program, ImageJ, are built for feature efficiency evaluation.

Sinha et al (2009), evaluated the utility of 3D automated ultrasound in conjunction with 3D digital X-ray tomosynthesis for breast cancer detection and assessment. Radiologists visually correlated the images using the software by drawing a 3D box around the suspicious lesion in one image set and isolated the anatomically correlated and compared with it another
modality image set. This improved the median rating and confidence in localizing and identifying the suspicious masses.

Bo Liu et al (2010), Nebekert et al (2010), proposed a novel approach based on the supervised texture classification. An energy function is formulated according to the differences between the actual and estimated probability densities of the intensities in different regions of ultrasound image. These methods focused on finding a credible ROI instead of precise segmentation.

Gomathi et al (2010), applied Modified Fuzzy C-Means (FCM) algorithm and Fuzzy Possibilistic C-Means Algorithm (FPCM) to lung image segmentation. Standard FCM, Modified FCM, Fuzzy Possibilistic C-Means algorithm (FPCM) are compared to explore the accuracy.

Xiangjun Shi et al (2010), develop a novel CAD system based on fuzzy support vector machine to automatically detect and classify mass. The proposed system greatly improves the five objective measurements and the area under the ROC curve is compared with those of other classification methods and radiologist assessments.

Ling Zhang et al (2011), proposed a novel CAD system based on fuzzy logic theory and transformed the ultrasound image into fuzzy domain. Xiong Wang et al (2011), proposed a Microwave Induced Thermal Acoustic Imaging method for breast ultrasound tumor detection. It processes low quality ultrasound images. An iterative method is used to find the threshold.

Image segmentation is a significant, vital and the most complex tasks in image processing. There is a critical need for segmentation algorithms to: detect the occurrence of cancer in breast ultrasound images and to identify a nodule as benign, pre-malignant or malignant.
2.5. BOUNDARY DETECTION FOR THE SEGMENTED LESION

Boundary Detection is the set of mathematical methods aiming at identifying the points in an image where the brightness changes sharply or has discontinuities. Chen yang Xu et al (1998), proposed the generalized Gradient Vector Flow (GVF) formulation to include two spatially varying weighting functions. The improvement in active contour convergence to long, thin boundary indentations, by maintaining the properties of GVF is captured.

Ying Luoa et al (2008), the objective was to create computer-aided analysis VOCAL trade II software. The VOCAL trade II software provides three modes of contour generation: Manual operation, automatic operation and semiautomatic operation.

Wei Yang et al (2008), proposed a symmetry analysis, carried out on 2D tumor contours. Reflective symmetry measure (RSML) is used to quantify the shape symmetry of breast tumor. The performance of symmetrical measures for differentiating malignant and benign breast tumors at varying scales was evaluated and compared by receiver operating characteristic (ROC) analysis.

Chii-Jen Chen et al (2009), with the help of Computer-Aided Diagnosis (CAD) system detected the characteristics of tumor and provided physicians a critical reference. The shape of a tumor is altered due to the stress caused by the ultrasound probe; the proposed sub-volume registration method is utilized to analyze the variation of tumor between pre- and post-compression.

Zhi Yang et al (2009), suggested the pixel compounding technique that synthesizes the information of an image sequence involving slow decorrelation of the speckle to form a detail-recovered and speckle reduced
image. The improvement in the image quality is evaluated quantitatively using a Figure-Of-Merit (FOM) that indicates the quality of boundary information recovery and the Contrast-to-Noise Ratio (CNR) over the phantom images.

Bo Liu et al (2010), proposed a novel level set-based active contour model for Breast Ultrasound (BUS) image segmentation. An energy function is formulated according to the differences between the actual and estimated probability densities of the intensities in different regions of ultrasound image.

Chuang et al (2010), used Coherent Point Drift (CPD) algorithm proposed by Myronenko and Song to align the corresponding feature points. In elastography images, the stiffness of malignant tumours tend to extend beyond the tumor boundaries identified in the histopathology images and the stiff areas indicate the elastography images.

Wen-Lin Chang et al (2010), presents a method to enhance the Computer-Aided Diagnosis (CAD) of the breast cancer tumors and to reduce detection time and error rate. The texture variance of 3D ultrasound is effective and useful for differential diagnosis of breast tumors.

Kaiguo Yan et al (2011), proposed the development and improvement of breast cancer diagnosis non-invasively in three modules: Diffuse Reflectance Spectroscopy (DRS), Ultrasonography and Low Intensity Focused Ultrasound (LIFU). To locate the object boundaries and active contours in image processing application of an external force is required.

Boundary detection literature is effective in segmenting an image based on location, size and shape of the structures. The design in using
Generalised Gradient Vector Force is to extend the large gradients far from the boundary while keeping gradients attached to strong edges.

2.6. INFERENCE

Mammary carcinoma is considered to be the most deadly cancer among women. There is no efficient technique to prevent the occurrence of mammary carcinoma. As a result, various literatures have concentrated on the early detection, the primary vital process towards diagnosing mammary carcinoma. It acts as a main function in mammary carcinoma diagnosis and treatment and in identifying a breast nodule is benign or pre-malignant or malignant.