CHAPTER 5

SUMMARY AND CONCLUSION

Mammary glands, commonly known as breasts, undergo significant changes in morphology and metabolic activity during physiological and pathological conditions (Milanese et al 2006). Medical thermography has been widely accepted as an adjunct screening tool to aid in the detection of breast abnormalities (Qi & Diakides 2007b). The diagnostic relevance of medical thermography has improved significantly with advancements in sensor technology and image processing algorithms (Amalu et al 2007). The clinical interpretation of thermal images looks for the thermal variations introduced by various pathological conditions of the breast tissues. Cancerous tissues can grow rapidly, invade and destroy nearby healthy tissues. The abnormal growth of the tissues causes regional vasodilatation and enhances angiogenesis in the later stage. The presence of such physiological processes prompts disruption of the symmetric thermal patterns.

The thermal variation is one of the most important indicators of an underlying dysfunction that can be measured and quantified. These variations are often subtle and are complex to analyze and interpret. Therefore, a method of analysis that helps to bring out the structural variations of thermal pattern is necessary. This also helps to differentiate among various abnormal conditions of breast tissues as they differ mainly by changes in the structure and metabolic activity. Thus, the current research is towards the early detection of the abnormal tissue growth even before visible symptoms.
In this work, an attempt has been made to analyze normal and varied pathological conditions of breast tissues namely, carcinoma, fibroadenoma, nodule and cyst. This analysis is carried out using a pipeline of processes that include preprocessing, segmentation and feature extraction. The thermal images are subjected to two different denoising methods which include block matching and 3D filtering, and orthonormal wavelet transform Stein unbiased risk estimate with linear expansion of thresholds. These preprocessing techniques are employed for low contrast thermal images to reduce the noise by preserving the important features such as edges that aid for segmentation and image analysis. The performance of denoising methods is evaluated by estimation of signal to noise ratio and gradient magnitude similarity deviation of raw and pre-processed images.

Level set methods such as reaction diffusion and adaptive level set have been adopted to segment the breast tissues. In segmentation of breast tissues, identifying tissue boundaries particularly near the lower breast boundaries and inframammary folds is complex. An effort is made to enhance the segmentation accuracy by primarily improving the edges of breast boundaries using various edge maps. The edge maps generated using Gaussian, coherence enhanced diffusion, total variation and phase congruence filtering are incorporated in the level set evolution. The performance of segmentation of breast tissues is evaluated against ground truth images using overlap and regional statistics based similarity measures.

Finally, analysis of breast abnormalities is carried on segmented breast tissues using phase based transform approaches such as Wavelet, Radon, quaternion, Riesz, steerable Riesz and multiscale quadrature filter. The texture signatures that capture structural variations at different locations, scales and orientations are extracted from the transformed coefficients and analyzed.
The results show that denoising methods such as BM3D and OWTSURELET are effective for low contrast thermal images. BM3D method is able to remove the noise effectively in homogenous areas. This method fails to retain fine structural details as it could not deliver highly sparse representation for sharp and curved edges. The denoising using OWTSURELET method is found to be more effective in removing the noise components by preserving the edge details. Gradient magnitude similarity deviation index is found to be low for OWTSURELET method which indicates its edge preserving capability. On an average, it gives reasonable SNR improvement of 72.31 dB thereby performing good smoothing and preserving important edges.

Segmentation using reaction diffusion level set method results in a correlation value of 0.98 against ground truth images. Mostly under segmentation is observed with discontinuous edges and contour leakage near infra mammary folds. As thermal images lack in sharp boundaries, intensity gradient based edge detection algorithms such as Gaussian, coherence enhanced diffusion and total variation diffusion filtering fail to form distinct and meaningful boundaries as some parts of the contour leak through the weak boundary gradients, while some parts are confined inside the breast tissue. Among various edge maps, the phase congruence edge map is able to bring out the true boundaries with significantly less spurious edges.

Reaction diffusion level set with phase congruence method could achieve significant improvement in terms of both regional statistics and overlap measures with average accuracy of 94%. The structural information is observed to be degraded due to excess or loss of breast tissues. Similar observations are made with overlap measures due to misclassification of pixels in ROI or non-ROI images.
The segmented images using phase congruence based adaptive level set method and ground truth images are highly correlated with R value of 0.99 with an average accuracy of 98%. The maximum correlation of segmented images is found to be reflected in improved measures indicating reduced breast tissues losses. Among all overlap measures, VS overlap measure results with maximum of 99% similarity between segmented and ground truth images for this method. The thin edges are observed and thus, false boundary information and under segmentation are avoided.

The values of segmentation accuracy, sensitivity and specificity are high for adaptive level set method when compared to phase congruency based reaction diffusion. The amount of overlap region is relatively improved by 2% for this method. Adaptive level set method with phase congruence edge map leads to improved detection of true boundaries with less spurious edges near lower breast boundaries and infra mammary folds. And also, most of the images are observed with continuous edges near lower breast boundaries and infra mammary folds. Even, in the case of subjects having small breasts that has very weak boundary, this algorithm results in accurate segmentation particularly near infra mammary folds.

The statistical features such as mean, kurtosis, skewness, coarseness, contrast and directionality derived from segmented breast tissues using transform techniques such as wavelet, Radon, QHT, Riesz, steerable Riesz and MQF. Monogenic signal analyses such as steerable Riesz and MQF are invariant to contrast and are found to be effective in the extraction of structural variations of thermal patterns.

Among the texture features, kurtosis, skewness, contrast and directionality features from second scale Riesz coefficients have enhanced the value between normal and abnormal conditions by 10%, 9%, 13% and 9% respectively. Similarly, kurtosis, skewness, contrast and directionality features...
from second scale MQF coefficients have enhanced the difference values between normal and abnormal conditions by 23%, 23%, 28% and 10% respectively. The skewness, contrast and directionality features are significant in differentiating the abnormal breast tissues due to the presence of heterogeneous patterns. The high magnitude value of kurtosis feature for carcinoma breast tissues is due to peaked distribution of transformed coefficients indicating the high metabolic activity.

Among denoising methods, OWTSURELET perform better than BM3D with high SNR values of 72.31 dB. Among segmentation techniques, phase congruence based adaptive level set method is observed with consistently high regional and overlap performance measure greater than 98%. Feature detection techniques such as steerable Riesz transform and MQF could significantly discriminate normal and abnormal breast tissues (p<0.01) exploiting the local organizations of scales and directions of thermal patterns. In conclusion, the proposed pipeline that integrates OWTSURELET denoising, phase congruence based adaptive level set with phase based transform techniques such as Riesz and MQF is found to be effective in analyzing breast tissues and thereby assisting the early diagnosis of breast abnormalities.

5.1 SCOPE FOR FUTURE WORK

Generation of large dataset and vigorous analysis of extracted features in classifying and identifying the abnormal thermograms can be developed. A commercially viable automated computer aided diagnosis environment for mass screening using infrared thermography can be developed. The pipeline of processes adopted for evaluation of thermal images can be extended to other modalities such as ultrasound, mammography, CT, MRI etc