Frequency Domain Approaches for Breast Cancer Diagnosis

B. Kiran Bala, Dr. S. Audithan, G. Kannan and K. Raja

1 Research Scholar, Department of CSE, St. Peter’s University, Chennai, India
2 Professor, Department of CSE, PRIST University, Tanjore, India.
3 Research Scholar, PRIST University, Tanjore, India.
4 Research Scholar, Bharathidhasan University Trichy, India.

Address For Correspondence:
B. Kiran Bala, Research Scholar, Department of CSE, St. Peter's University, Chennai, India.
E-mail: kiranbt2010@gmail.com

ABSTRACT

Breast cancer continues to be a major public health problem among females in the world. Among the various present screening tools, mammography is considered as one of the best available techniques for breast cancer diagnosis. The most common breast abnormalities that may indicate breast cancer are masses and microcalcifications. The key importance to reduce the incidence of mortality among women due to breast cancer is the diagnosis of breast carcinoma in an earlier stage. Among the numerous techniques available for breast diagnosis, frequency domain-based approaches achieve reliable outcome. In this paper, various frequency domain analysis are discussed for mammogram classification.

INTRODUCTION

According to World Cancer Research Fund International, the cancer cases around the world were estimated as 12.7 million in 2008, and is expected to rise to 21 million by 2030. The maximum cancer cases were found in Denmark. In Denmark, the number of people affected per 100,000 was 326, in 2008. The age standardized rate was at least 300 per 100,000 for Denmark, Ireland, Australia, New Zealand, Belgium, France and United States of America.

The top ten countries for breast cancer are from the countries of Europe, Oceania, and North America. Breast incidence and mortality in India is summarized below. The causes of cancers are primarily due to an environmental disease with 90% to 95% of cases attributed to environmental factors and 5% to 10% to genetics. Excluding cancers of the skin, breast cancer is the most common type of cancer in the world. One of every three cancers diagnosed is breast cancer in United States. A woman's chance of developing invasive breast cancer at some time in her life is approximately one in eight (12%).

In India, around five lakes fifty-five thousand people died of cancer in 2010 and our nation was the first of the emerging economies to join International Agency for research on cancer in 2006. Cervical cancers and breast cancers are the most commonly occurring cancer in female in India. The common cancers seen in India are mainly the tobacco-related cancers of oral cavity, throat, lungs in men and cancers of the uterine cervix and breast in women. The breast cancer incidence and mortality in India are summarized below.

- 22.9 age-standardized incidence cases per 100,000 women in 2008
- 11.1 age-standardized breast cancer deaths per 100,000 women in 2008.
- The number of cancer deaths in 2010 is 90,659

Most common cancer for women occurs in metropolitan cities Delhi, Mumbai, Chennai, Kolkata and Bangalore. 52.68% increase in the registered number of cancer cases is projected in Delhi and 26.6% increase is expected in other metropolitan cities. The age-adjusted analysis indicates that Mumbai is experiencing the...
higher incidence rate. It is estimated that about 50% cancer mortality is reported from the age group of 55 years and above (Marimuthu, P., 2008). According to the report of the Indian Council for Medical Research, the incidence of breast cancer has doubled in the metropolitan cities in the past 24 years. A computer aided diagnosis system can be very useful to draw the attention of the radiologist to a tumor which might otherwise have not noticed. Also it helps the radiologist in diagnosing accurately.

**Reviews on Microcalcification Classification:**

Microcalcifications are small calcium deposit and appear as group of bright spots in mammograms. Benign and malignant calcifications can occur with or without a mass. Benign calcifications are typically large (1–4 mm in diameter), coarse, round or oval, and monomorphic (uniform in size and shape). Malignant calcifications are typically microscopic and fine, linear branching or rod-shaped, punctuate or stellate shaped, and pleomorphic (varying in size and shape). Density, distribution pattern, number and the attributes of size are considered during benign and malignant calcifications differentiation (Veldkamp, W., N. Karssemeijer, 1996).

Discrete Shearlet Transform (DST) based microcalcification classification is presented in (Ali, J.A. and J. Janet, 2013). It is composed of two sequential stages: feature extraction and classification. Feature extraction is an essential pre-processing step to all machine learning problems such as classification and pattern recognition. In this system, the training mammogram image is decomposed by using 2-level DST with various directions. Then, the energy of each directional sub-band is used as feature for the corresponding training image.

This feature extraction method is applied to all the training samples and the features are stored in the database called as feature database and this database is used as one of the input to the classification phase. In the classification phase, the k-Nearest Neighbour (KNN) algorithm is used as a classifier. It is a method for classifying images based on closest training examples in the feature space.

An automated classification of microcalcification system using digital mammography is implemented in (Suba, C. and K. Nirmala, 2015). It is designed based on Dual Tree M-Band Wavelet Transform (DTMBWT) and Support Vector Machine (SVM) classification. At start of the process discriminative features are extracted from the mammogram images. On account to extract corresponding features DTMBWT decomposition taken place. As it is a multi-resolution analysis, predefined levels of decomposition up to 5th level are used for feature extraction. The decomposition by DTMBWT yields sub bands by filtering the given mammogram using M band filter banks. While decomposing the given mammogram by DTMBWT, the size of yielded decomposed image is equal to input mammogram size. Hence, it is very difficult to select the features from the high dimensional coefficients of the decomposed mammogram. To avoid this, the energy value of each sub bands is computed. Finally classification of microcalcification is done by two class SVM classifier, whereas the given microcalcification clusters classified into either benign or malignant.

Tetrolet transform based microcalcification classification is presented in (Indra, P., 2014). Feature extraction is the important pre-processing stage to extract all the possible features that are expected to be effective in diagnosing mammogram images, without concerning high dimensionality nature. The first module of the presented system is feature extraction, whereas features are extracted for later classification process. Initially, training mammogram image undergoes into Tetrolet decomposition up to 5th level. Then energy is computed as feature vector from higher Tetrolet sub bands by averaging them. On account of classification process the course of action is repeated for all the training images and stored in feature database. In order to classify the unknown image, the same kind of feature vector as training images is extracted using Tetrolet transform from the unknown image. Then unknown feature vector and stored feature database are fed into the KNN classifier, whereas minimum distance between both feature space is computed using Euclidean distance measure and corresponding unknown image is labelled whether it is associated with benign or malignant stage.

Non Sub-sampled Contourlet Transform (NSCT) based microcalcification classification system is introduced in (Jasmine, J.L., 2012). It is designed by building three sequential approaches. Initially in the preprocessing stage, Region Of Interest (ROI) corresponding with suspicious microcalcification area is extracted form given mammogram images. Then to achieve intrinsic features, ROI extracted image is subjected with enhancement using histogram equalization. Secondly features are extracted by exploiting NSCT, whereas the enhanced image is decomposed by using NSCT at three different scales.

From 2 to 4 the contourlet coefficients of all the sub bands are used as feature vectors individually. All the directional sub bands coefficients are normalized in order to simplify the coefficient value. This is achieved by dividing each feature vector by its maximum value. Then the energy is calculated for each vector by squaring every element in the vector. The produced values are considered as features for the classification process. The SVM classifier is built with two phases. In the first stage, the classifier is applied to classify mammogram into normal or abnormal categories. The mammogram is considered to be abnormal if it contains tumour. If abnormal, the images enter the second stage where the abnormal mammogram is further classified into malignant or benign.

Computer aided diagnosis method for detection and classification of microcalcifications is described in (Xu, W., 2007) based on Discrete Wavelet Transform (DWT) and adaptive neuro fuzzy inference system (ANFIS).
DWT is used to extract the high-frequency signal of the images. Thresholding with hysteresis is applied to locate the suspicious microcalcification region as ROI before extracting features. Finally, the suspicious microcalcification is classified with multilayer perception. Fig. 1 shows the basic block diagram of mammogram classification system using feature extraction and classification.

![Model schematic diagram of mammogram classification system.](image)

**Review on Mass Classification:**

Masses appears in the digital mammogram as bright regions of different sizes, margins (circumscribed, microlobular, obscured, indistinct, and speculated) and shapes (round, oval, lobular, irregular). They can be either cancerous (malignant) or non-cancerous (benign). Round and oval shaped masses with smooth and circumscribed margins usually indicate benign changes. On the other hand, a malignant mass usually has a spiculated, rough and blurry boundary (Gouda, W., 2012).

An automated mass classification system for mass classification is implemented in (Suba, C. and K. Nirmala, 2015). The implemented system is built based on DTMBWT for feature extraction and SVM for building the classifiers. Digital mammography images are used in this system, which is constructed by three sequential modules: ROI selection, feature extraction and classification. In order to reduce the computation time and increase the classification accuracy of the system, instead of analysing the acquired digital mammogram, only the region that contains abnormalities of size 256x256 pixels is selected from the original mammogram of size 1024x1024 pixels. On account to extract discriminative features from mammogram image, DTMBWT decomposition is subjected and energy is computed as feature vector from every DTMBWT decomposed subbands. Finally SVM classifier is employed for mass image classification.

An automated mass classification system is introduced based on DST by using digital mammogram images (Ali, A.J. and J. Janet, 2013). After extraction corresponding ROI from mammogram image, feature are extracted from it. The shearlet transform is used to represent the cropped ROI’s in multi-scale and multi-directions. The decomposition level from 2 to 4 with various directions from 2 to 64 is used in this study and the cropped images are transformed into the aforementioned levels and directions. Then the energy of each directional sub-band is extracted and used as feature vector for the corresponding training image. The feature vector is calculated for all training ROI’s and stored in the feature database. This database is used to train the classifier. The final step is the classification stage. The SVM classifier is used to classify the mass images. The kernel used in SVM is linear kernel. Initially, the SVM classifier is trained by the feature database. For an unknown mammogram image to be classified, the Shearlet energy features are extracted as done in training stage and then the trained classifier is used to classify the severity of the given mammogram image.

NSCT based mass classification system is presented in (Jasmine, J.L., 2011). At start of the process input mammogram images are cropped and enhanced for further process. The enhanced image is decomposed by using the NSCT at three different scales from 2 to 4. For an R level NSCT, we have 2R directional sub-bands. The Contourlet coefficients of all the sub bands are used as feature vectors individually. All the directional sub band coefficients are normalized in order to simplify the coefficient value. This is achieved by dividing each feature vector by its maximum value. Then the energy is calculated for each vector by squaring every element in the vector. The produced values are considered as features for the classification process. Finally SVM classifier is adopted for mammogram image classification.

DWT and Stochastic Neighbour Embedding (SNE) based mammogram image classification approach is illustrated in (Kumar, S.M. and G. Balakrishnan, 2015). Initially, DWT is applied to the given digital mammography images. The direct use of DWT decomposed sub bands may complicate the classification system. Thus to avoid this issue, SNE applied to wavelet transformed image and also applied on sub-bands of
wavelet transformed image individually. SNE is essentially used for reducing high dimensionality data into relatively low dimensional data, efficiently. Then classifier system based on SVM is constructed for mass classification. Experiments are conducted on Mammography Image Analysis society database. Mass classification system based on fast wavelet transform and ANFIS methods for mammogram images is described in (Gorgel, P., 2012). Features are extracted from ROI of the mammogram images. ANFIS is used to classify the mass image into benign or malignant.

**Conclusion**

In this study various frequency domain analyses such as DWT, DST, NSCT, and DTMBWT used for breast microcalcification and mass classification are reviewed. The main steps for an efficient classification of both microcalcification and mass system involve the extraction of ROI, feature extraction and classification. Each step can be implemented using a number of image processing methods. Diagnosis of breast cancer is one of the most challenging and active research topics in the field of image processing for the last decade. Thus, it is key important to researchers to implement diagnosis system with high accuracy and performance.

**REFERENCES**


World Cancer Research Fund International: http://www.wcrf.org/cancer_statistics