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Efficient Computer aided Diagnosis System (CAD) for Breast Cancer Detection and ICT based Health Informatics for Mass Awareness: A Critical Review and Recommendation

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Abstract— *CAD system for detection and classification of masses and micro-classification can be very useful for breast cancer detection. The idea of this review originated froam the several factors such as increasing risk of breast cancer; lack of awareness in common masses particularly in villages and sub-urban areas about preventive measures, precautions and general awareness of health issues. Therefore, this critical review aims to develop a computer-aided diagnosis (CAD) system for segmentation and classification of breast cancer images; create an awareness of breast cancer screening even without appearance of symptoms through educational program and seminar; develop an ERP system using ICT tools for creating awareness among mothers in local language; prepare teaching learning materials in local language regarding maternal and child health issues; design Mobile Apps and other small videos highlighting about precautions and preventive measures avoiding the possibility of diseases and save lives; conduct Panchayat level seminars, meetings and workshops to involve the beneficiary of villages; and reduce maternal and child deaths by awakening the masses.*

Index Terms—***CAD, Mammography, Segmentation, ICT, Enhancement, Classification.***

I. INTRODUCTION

CAD based system combines image processing techniques and expert's opinion or knowledge for obtaining improved accuracy of abnormality detection. The CAD system for detection and classification of masses and micro-classification can be very useful for breast cancer detection. There are several methods for segmentation of masses and detection of cancerous tissues. However, robustness and efficient detection remain major challenges. Recent health statistical reports suggest that the infant mortality rate is 46 deaths per 1000 live births and the maternal mortality rate is also not satisfactory in many states of India. Though government has been doing lot of things for mitigating health issues of mothers and children but problem lies in lack of awareness about how to get benefit of various health and education related initiatives [1-5].

The paper envisages meeting the challenges pertaining to lack of awareness. Use of ICT tools would cater the common masses and create awareness about precautions, measures and avoidance of various diseases. Digital mammography screening programs can enable detection and diagnose of the breast cancer which reduces the mortality and increases the chances of complete recovery. We have proposed a new combination method and it is found to be applicable to all type of normal and abnormal tissue exist in breast. One of the common problems encountered in image segmentation is choosing a suitable approach for isolating different objects from the background. There are several research contributions in the area of medical image segmentation and classification [6-10]. Significance of the work aims at achieving expected outcomes in a research area which directly deals with society and mass awareness.

II. PROBLEM STATEMENT

The following points are very important formulating the problem statement:

- In remote areas, people die more not due to lack of medical facilities, BUT die due to lack of appropriate awareness and knowledge; and
- Breast cancer detection is planned to be implemented that would serve as a telemedicine tool addressing this disease; and

Belonging to a village, I could see how pathetic situation is when many mothers and children die just

because of lack of appropriate parental or maternal knowledge related to delivery of child, monitoring the growth of child, proper medicine schedule etc. It was always in my mind right from the childhood that the government does not do anything for poor mothers and their children but as general awareness and use of ICT tools enhanced; and facilities were made better in villages or sub-urban areas; I realized that the situation of maternal and child health has not been appreciably improved. The main reason of this condition is that villagers do not know much about prevention measures of various diseases; importance of cleanliness; medicines available in health centers etc. and those who know do not bother and care about various advisories of government and health departments. This challenging issue of lack of awareness always occupied my mind to do something for poor as socio-economic cause [11-25]. Awareness drives are manifold and are implemented at various levels through government agencies, TV, radio, newspapers etc. However, effectiveness lacks in these advertisements and awareness initiatives since number of deaths of mothers and children are not very much decreasing in subsequent years. This may be due to:

- No involvement of village head or gram pramukh, teachers, women in the initiatives at local level; and
- Importance of child and maternal health not in the priority as the bread and butter means for them.

CAD will combine its results and opinion of radiologists to suggest the preventive steps towards addressing breast cancer disease.

III. REVIEW OF LITERATURE

Breast cancer incidences and their inaccurate detection in the United States, Canada and Australia are common [2-12, 26-31]. Few prominent research contributions at International level are reported here.

Zhang et al. (2012) proposed a wavelet transform and 1-D wavelet-based analysis and for segmentation by searching for the local minima of the 1-D wavelet transform. This method is simple, fast and effective for segmenting tumors in mammograms but not very effective when the target and the background regions demonstrate little difference in gray-level values. Sahakyan et al. (2012) proposed an automated technique for mammogram segmentation which uses morphological preprocessing algorithm in order to remove digitization noises and separate background region from the breast profile region for further edge detection and regions segmentation. Improvement of the algorithm to derive a smoother breast region contour could not be achieved. Quintana et al. (2011) studied the entire modeling system which is applied to a wide range of clinical situations including different spectral breast composition and thickness, micro calcification shape, size and composition. Threshold segmentation method could not provide a satisfactory performance because of the strong limitations associated with non uniform background.

Liu et al. (2011) discussed whether the mass is malignant or benign and proposed algorithm for fully automatic marker-controlled watershed transformation method to segment the mass region roughly and then a level set is used to refine the segmentation. The combination of the watershed based segmentation and level set method could improve the efficiency of the segmentation. Torrent et al. (2010) presented a supervised approach for automatic detection of micro-calcifications. The system is based on learning the different morphology of the micro-calcifications using local features, which are extracted using a bank of filters. Afterwards, this set of features is used to train a pixel based boosting classifier which at each round automatically selects the most salient one. Further work is directed by integrate a false positive reduction step into the boosting algorithm to improve the result and the contrast between the different internal structures. Yang et al.(2009) proposed a pixel compounding technique that synthesizes the information of an image sequence involving slow de-correlation of the speckle to form a detail-recovered and speckle reduced image. The improvement in 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. The improved imaging may provide alternative or better information for detection and diagnosis. Bator et al. (2009) achieved improvement of true positive (TP) ratio per image and reduction in number of false positive (FP) errors in the hierarchical template matching detector of regions of interest (ROIs) for cancerous masses by eliminating the images of linear structures from the mammograms [13].

Infantosi et al.(2008) proposed a method for evaluating gear simulated images which gave a power speckle noise of 10% and a contrast ratio of 10:53 referred to the background. For the ultra sound breast images, the method keeps the tumor boundaries without aggregating improper structures. Ikedo et al. (2007) proposed a scheme for mass detection in whole breast ultrasound images using bilateral subtraction technique which suffered from poor accuracy of detection. Horsh et al. (2007) applied a median filter to reduce speckle to yield ''lesion-like'' margins, outlining its general shape however it may miss details such as spiculation or high irregularity. Kom et al. (2007*)* proposed a segmentation approach to extract suspicious mass regions by a local adaptive thresholding technique after the mammograms are enhanced with a linear transformation filter. This did not consider the case where a mass contains the small window, the center region of a suspicious lesion is not detected. Noble et al. (2006) reviewed ultrasound segmentation methods, focusing on techniques developed for medical B-mode ultrasound images by clinical application. The choice remains which constraints to use in application specific, but many constraints hold for generic ultrasound image segmentation. Marias et al. (2004) suggested a method for quantitative description of density changes in mammogram sequences; standard mammogram form (SMF) representation of interesting tissue and their performance is also compared to the interactive thresholding method. It was argued that the use of mammogram image analysis could improve the early detection of abnormalities by providing the clinician with both quantitative information concerning temporal density and information relative to the region where these changes take place. The future work aimed to perform more validation work on automatic density measures and develop robust clinical tools.

Breast cancer is the most common cancer in women all over India and accounts for 25% to 31 % of all cancers in women in Indian cities. Mammograms and other imaging tests are used to detect abnormality, but they cannot confirm cancer. To confirm whether cancer is present, a small amount of tissue must be removed and looked at under a microscope. This procedure is called a biopsy and can confirm the presence of cancerous cells. Erwin (2011) project aims at promoting cancer prevention initiative in Northeast Indian states with a view to initiate community-based breast cancer programmes in 4 states - Mizoram, Manipur, Meghalaya and Tripura. There idea evolved from a workshop organized by Cancer Foundation of India and sponsored by DBT at Kolkata with the idea of CFI creating this unique network and executing the project with Co-PIs drawn from the main government Hospital in respective states. Breast cancer is one of the major cancers among women in the Northeast therefore three projects will be on community advocacy and one is developing a breast clinic in the hospital. It is expected that such an exercise will translate into down - staging breast cancer at the time of clinical presentation. The study tested culturally sensitive approaches to obtain survey data and provide appropriate breast health education for Kashmiri women at risk for breast cancer, who live within this socially and politically challenging environment. This study provides a foundation for future development of research and clinical programs to identify women at high risk and implement an active health surveillance monitoring program with a focus on breast cancer in Kashmir. Shekhar et al. (2011) proposed a method for automatic breast cancer detection. Classification, scoring and grading by the classification of micro cancer object of breast tumor based on feed forward back propagation neural network (FNN). The obtained accuracy of the network was 98.60% whereas the sensitivity and specificity were found to be equal 99.10% and 95.70% respectively. The system gives fast and accurate classification of breast tumors. Kekre et al.(2010) developed a vector quantization segmentation method to detect cancerous mass from MRI images. Morphological segmentation extracts other regions with tumor region and found that identification rate for proposed method as 71.5%. Singh et al. (2009) presented a fast fractal method to model breast background regions based on entropy for the detection of breast cancer. When the modeled mammogram is taken out from the original image the presence of micro-calcifications can be enhanced. The domain pool for searching the matching domain is chosen based on entropy. This reduced the encoding time by a factor of 3.12 when compared with the conventional fractal encoding method which searched the entire domain pool for a matching domain.

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IV. METHODOLOGY

We aim at reaching around 20 villages for creating awareness and addressing around 20000 people. Sample size would be 500 mammograms of cancerous and non-cancerous women with the help of radiologist. Data will be collected with the help of research scholars taking help of radiologists working in hospitals, cancer research centres and radiology centres. The method includes following major steps:

Step1: Removing noise to enhance the quality of the mammographic images: Noise cannot be completely removed but its level can be reduced in the mammographic images. The image may be corrupted by random variations in intensity, variations in illumination, or poor contrast. The random variation in image brightness is designated noise. This noise can be either image dependent or image independent. The image can also be degraded by the impact of imperfect instrument, the problem with data acquisition process and interfering natural phenomena. Therefore the original image may not be suitable for applying image processing techniques and analysis; and hence image enhancement technique is often necessary and should be taken as the first and foremost step before image is processed and analyzed. We have to analyze the different types of filters and select according to the requirement of mammographic images.

Step 2: Segmentation: Segmentation is a necessary step in medical imaging to obtain qualitative measurements such as the location of objects of interest as well as for quantitative measurements such as area, volume or the analysis of dynamic behaviour of anatomical structures over time. Segmentation is process of detecting or separating similar region from given image. Finding an accurate and efficient breast region segmentation technique still remains a challenging problem in digital mammography. For the breast mass segmentation, the calcifications with bright groups of pixels seriously hampered the progress of the segmentation.

Step3: Size and shape measurement; Masses have different density because of fat containing masses, low density, and high density; different margins (circumscribed, micro-lobular, obscured, indistinct, and speculated) and different shape (round, oval, lobular, irregular). Round and oval shaped masses with smooth and circumscribed margins usually indicate benign changes. Malignant mass usually has a speculated, rough and blurry boundary. Benign calcifications are usually larger and coarser with round and smooth contours. Malignant calcifications tend to be numerous, clustered, small, varying in size and shape, angular, irregularly shaped and branching in orientation. Masses appear as dense regions of different sizes and properties. Depending on the morphology, the masses have dissimilar malignant property. The ill-defined and speculated borders have higher probability of malignancy. It could help the radiologists in the interpretation of the mammograms and could be useful for an accurate diagnosis and detect the presence or absence of lesions from the mammograms.

Step 4: Feature Extraction: After the segmentation is performed on breast region, various image features can be extracted and the diagnosis rules can be applied to exactly detect the cancer nodules in the breasts. This diagnosis rules can eliminate the false detection of cancer nodules resulted in segmentation and provides better diagnosis. In the feature extraction and selection step the features that characterize specific region are calculated and the ones that are important are selected for the classification of the mass as benign or malignant.

- True Positive (TP), when the suspected abnormality is in fact malignant;
- True negative (TN), when there is no detection of abnormality in a healthy person;
- False positive (FP), when occurs detection of abnormality in a healthy person;
- False negative (FN), when there is no detection of a malignant lesion.

Step 5: Cancer Stage Identification: A cancer cell has characteristics that differentiate it from normal tissue cells with respect to: the cell outline, shape, structure of nucleus and most importantly, its ability to metastasize and infiltrate. TNM (Tumor, Node, and Metastasis) is another staging system researchers use to provide more details about how the cancer looks and behaves. If the radiologist detects an area of suspicion, a series of work-up procedure is recommended. The criteria for their decision are based on appearance and location.

Step 6: Performance Evaluation: The performance of a CAD System can be assessed in terms of the following [6-20]:

- Sensitivity: correctly classified percentage of ROI by radiologist. The sensitivity is the fraction of the true positive cases over the real positive cases:

$$\text{Sensitivity} = \frac{\text{TP}}{\text{TP} + \text{FN}}$$

High values of sensitivity imply minimal false negatives detection or higher true positive detection.

Specificity: correctly classified percentage of ROI by non radiologist. The specificity of the test is the fraction of the true negatives case over the real negative cases:

$$\text{Specificity} = \frac{\text{TN}}{\text{TN} + \text{FP}}$$

High values of specificity imply minimal false positive detection.

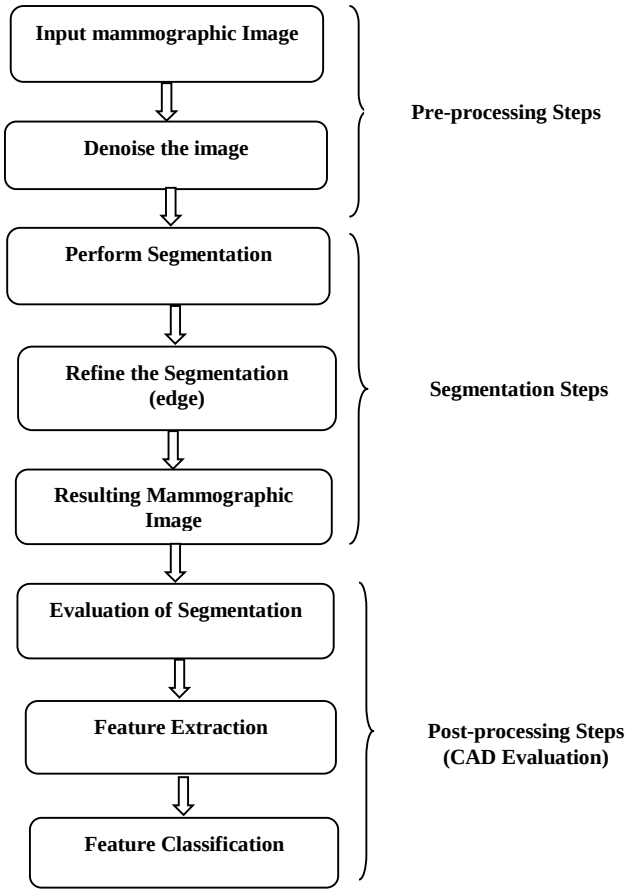

Fig.1. Mass detection and feature extraction in CAD.

Accuracy: percentage of correctly classified pathological and non-pathological cases. Total accuracy shows the performance of the diagnostic system is determined based on the combination of sensitivity and specificity and is calculated by the following formula

$$\text{Accuracy} = \frac{\text{T} + \text{T}}{\text{T} + \text{F} + \text{F} + \text{T}}$$

Figure 1 shows the steps involved for the mass detection and feature extraction for breast cancer detection.

Methodology for Awareness for Health Informatics would include following steps:

- Study of various reports and case studies;
- Medical assistance and advisory from government agencies;
- Development of ERP system using ICT tool
- Creation of teaching, training and awareness materials;
- ERP implementation
- Uploading the materials in ERP system.

V. CONCLUSIONS AND RECOMMENDATIONS

The outcomes of this work includes improving the detection of suspected areas containing some type of lesion; and to develop and design a new computer aided detection method to detect the mass region in the mammogram. Segmented image contains the suspected region which is given for feature extraction process. The extracted features are classified in to normal and abnormal region. The system gives fast and accurate classification of breast tumors. We hope to discover significant difference between the likelihood functions in malignant cases and the likelihood functions in benign cases. The planning is to create awareness among women and motivate them for early mass screening so as to detect breast cancer at early stage. ERP Solution is used for Awareness to reduce the death of Mothers and Children; and Health sector and rural population and Society as a whole will be beneficiary. The work altogether aims at solving socio-economic problem of the country. However, the implementation of the work will require lot of support and help from practising physicians and radiologists.

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