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A Review on Computer Aided Detection System for Mammographic Images

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Abstract: ***Digital image processing is important in numerous areas of research and development which employed to process digital images and generate useful characteristics from the data, which can then be used to take critical decisions with high accuracy. These techniques are also applied for applications in the medical field, specifically in the detection of Breast Cancer. Over the years due to limitations of human observations, computers have played a significant role in detecting early signs of cancer, this conclude a development of Computer Aided Detection System (CAD) of high accuracy. This paper presents a concise review on Computer Aided Detection System which can be developed as a useful decision support system for automatic detection of breast cancer, whereby the predictions from the CAD systems can be employed to enhance diagnosis from radiologists.***

Keywords: Computer aided detection (CAD), Digital Database for Screening Mammography (DDSM), Mammographic Image Analysis Society (MIAS), region of interest (ROI)

1. Introduction

Computer Aided Detection System is a combination of image processing techniques and intelligent methods that can be used to enhance the medical interpretation process can make better results in the development of more efficient diagnosis. The computer outcome assists radiologists in image analysis and diagnostic decision making. In addition, a Computer Aided Detection (CAD) system could direct a radiologist's attention to regions where the probability of an indication of disease is greatest. A CAD system provides reprod-ucible and quite realistic outcomes. [1] CAD system provides a result as a "second opinion" in order to assist radiologists in the diagnosis of cancer on medical images. [2]

In 1967, Winsberg proposes the concept of CAD system for the first time. To analyze the detection of abnormalities on mammograms Winsberg and his team examined the use of computers [3].In 1972, Ackerman and Gose expanded the concept of CAD that a computer could use to detect lesions on mammograms as micro-calcification, spiculation, roughness and shape. The first CAD approved by FDA was Image Checker of R2 Technology which detects potential micro-calcifications clusters and masses. With the help of digitizer this system convert film mammograms into digital format and prompts appear on suspicious abnormalities. Mammo-Reader from iCad and Second Look from CADx these two mammographic CAD systems was approved in 2002 which has similar principle like the Image Checker, but with different algorithms, and therefore responds differently to the potential lesions [4].Two systems have been developed to help the radiologists in reading mammogram. The first system is Computer Aided Detection (CADe) which has improved radiologists' accuracy of detection of breast cancer.

Computer Aided Diagnosis (CADx) is the second system which classifies the detected regions into malignant or benign categories to help the radiologists in recognizing the next step, biopsy or short-term follow-up mammography [5].

2. Literature Review

Several computer aided diagnosis (CAD) systems were developed in the literature to provide a second opinion for the assistance of radiologists. One of the CAD systems were developed based on three main steps such as segmentation, feature extraction and classification. In the past studies to find the discriminative features for classification of breast masses as benign or malignant these steps are well-addressed. Unfortunately, these steps require a complicated task such as pre-and post-processing steps and depended on critical domain expert knowledge about image processing. Over the years, to overcome these problems, a few CAD systems have also been developed.

In 2000, Giger developed Computer Aided Detection (CAD) diagnostic tool, in radiology to utilize the output of computerized analysis of medical images as a secondary opinion in the detection of lesions and making diagnostic assessments. [6] In recent times, CAD systems have garnered several interests from both research scientists and radiologists because of the related complex research subjects and prospective clinical applications. Since humans are prone to making errors and their analysis is generally biased and qualitative rather than quantitative then computer processing in biomedical image analysis provides a more precise diagnosis. In 2004, the physician Rangayyan and Ferrari improved biomedical image analysis using CAD leads to a more accurate diagnostic decision. [7]. In 2001, Freer and Ulissey studied the potential impact of CAD in screening, where 12,860 screening mammograms were analyzed with the aid of a CAD system over a 12 months duration. [8] The study noted that cancer detection generally

increased by 19.5% and the rate of early stage detection of malignant cancer tissue increased from 73-78%. The recall rate increased from 6.5-7.7 % and the positive predictive value of biopsy remained constant at 38%.The study conclude that CAD can enhance the detection of early stage malignancies devoid of any markedly negative effect on the recall rate or the positive negative value of biopsy.

In 2003, Ciatto et al. carried out a comparative analysis between conventional mammogram reading and CAD reading based on a national proficiency test of screening mammography in Italy. The authors deduced that the performance of single reading with CAD is equivalent to double conventional mammogram reading. [9].

In 2002, Evans et al. examined the ability of a commercial CAD system to detect invasive and persistent lobular carcinoma of the breast.[10] The system was found to be capable of detect accurately 17 of 20 cases of architectural distortion. Also, in 2000, Burhenne et al. analyzed the aptness of a commercial CAD system in the detection of masses and calcifications in screening mammography. [11] The study attained a sensitivity of 75% in the detection of masses and architectural distortion, at the rate of one false positive per image. Furthermore, in 2001 Birdwell et al. assessed the capability of a commercial CAD system in identifying benign cancer tissues that were unnoticed by radiologists. [12] The result shows that the software was able to detect five out of six cases of architectural distortion and 77% of the formerly unobserved lesions, at the rate of 2.9 false positives per image.

In 2003, Broeders et al. suggested that modifications in the detection process of architectural distortion can produce an efficient upgrade in the diagnosis of breast cancer.[13] In contrast, in 2003 Baker et al. put forward that the sensitivity of two commercial CAD systems was limited in the detection of architectural distortion, effective in less than 50% of the 45 cases of architectural distortion presented with a lesser image based sensitivity of 38% or 30 out of 80 images, at the rate of 0.7 false positive per image.[14]

Mencattini A. proposed a Computer Aided Detection (CAD) system for the extraction of the contour of tumoral masses from the ROI. This system consists three steps: artifacts removal, Contrast enhancement, Segmentation by region growing algorithm. [15] Pereira D. C. presents a set of computational tools to aid segmentation and detection of mammograms that contained mass or masses in CC and MLO views. An artifact removal algorithm is first implemented followed by an image de-noising and gray-level enhancement method based on wavelet transform and Wiener filter. Finally, a method for detection and segmentation of masses using multiple thresholding, wavelet transform and genetic algorithm is employed in mammograms which were randomly selected from the Digital Database for Screening Mammography (DDSM) [16].

Jen C. proposed a high-performance CAD system for detecting abnormal mammograms by using the two-stage classifier ADC, which applied on the PCA-based technique accompanied by robust feature weight adjustments [17].

3. Database

The mammography case samples required for the study has been taken from the Mammographic Image Analysis Society (MIAS). The Mammographic Image Analysis Society (MIAS) is an organization of UK research groups interested in the understanding of mammograms and has generated a database of digital mammograms. It contains 322 mammogram images of size 1024 × 1024 pixels with ground truth information about the abnormalities, i.e., type of cancer, severity of the diagnosis (Benign or Malignant), centre coordinates of location of the abnormality and radius of the circle enclosing the abnormality.

4. Methodology

The most effective method for early detection of breast cancer is the mammographic screening. Reading mammography is not only a time-consume error prone work but also a very important task for radiologists as they suggest patients for biopsy. However, human interpretation of mammograms is depends on training and experience it may varies. This leads to different judgments by different radiologists. Mammogram interpretation is a repetitive task which requires maximum attention for avoidance of misinterpretation. Therefore, computer-aided diagnosis (CAD) system is currently a very popular and efficient method which analyses the digital mammograms with the use of image processing. Therefore, many computer-aided detection and diagnosis systems (CAD) have been developed to assist radiologists in detecting and classifying mammographic lesions [18]. CAD technology is a recent advances in the field of breast imaging. The CAD technology basically works like a second pair of eyes, reviewing a patient's mammogram film after the radiologist has already made an initial interpretation. Computer aided detection system is combination of various image processing techniques such as preprocessing where removal of noise, artifacts and labels are get removed. Second step is enhancement which allows enhancing contrast, edges and general details in mammogram image. Next step is to divide an image into its constituent parts called as segmentation. Feature extraction is stage where statistical values of region of interest (ROI) of image are calculated. Final step is to separate the data called as classification. Details about each step are given below:

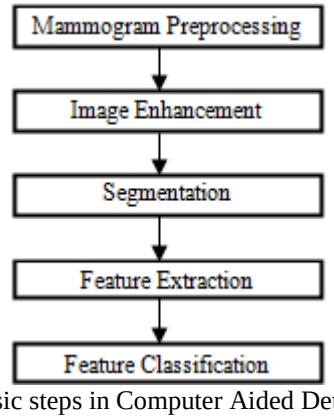

Figure 1: Basic steps in Computer Aided Detection (CAD) system for breast abnormality

1) Preprocessing

In low-level image processing Preprocessing is an important issue. The fundamental principle of preprocessing stage is to enlarge the intensity difference between objects and background. Preprocessing stage producer liable representations of breast tissue structures.

2) Image enhancement

The precision of breast cancer detection is improved by using the enhancement of mammographic images. In image processing it is important to remove the noise and to enhance the quality of image. In this stage region of interest are enhanced and the unwanted regions of the image are de-emphasized also the suppression of noise is performed in this stage.

3) Segmentation

In image segmentation subdivision of image into its constituent parts is done to obtain the required object from the background. Segmentation is done based on discontinuity and similarity of pixels. Discontinuity includes identification of isolated points or edges or lines. Similarity includes grouping of similar pixels.

4) Feature Extraction

In Feature Extraction features of the segmented region are extracted such as size, shape and texture which must be carefully chosen because desired classification task is expected to perform using this representation instead of using complete region. Features are extracted in this stage to classify type of breast tissue to distinguish normal and cancerous breasts using gray level co-occurrence matrix. These extracted features can be used for the classification stage.

5) Feature Classification

Classification of region of interest into different classes is done by using the classifier which is a mathematical model in Feature Classification. The extracted features are used to classify the mammogram images into normal and abnormal i.e., benign or malignant with high accuracy. Support Vector Machine and minimum distance classifier are used for classification purpose.

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