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Neural Network based Automatic Detection of Lesion Diagnosis in Mammogram Using Image Fusion

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Abstract

The success of treatment of breast cancer patients depends on the early detection of breast cancer. Mammographic screening has been shown to be effective in reducing mortality rates by 30%–70%. The Architectural distortion is the most common mammographic sign of Non-palpable breast cancer. Architectural distortion could appear at the initial stages of the formation of a breast tumor and may closely resemble the appearance of normal breast tissue overlapped in the projected mammographic image. Due to its subtle appearance and variability in presentation, architectural distortion is the most commonly missed abnormality in false-negative cases . It accounts for 12%–45% of breast cancer cases overlooked or misinterpreted in screening mammography.

In this paper, we present CAD methods for the detection of sites of architectural distortion in prior mammograms of interval-cancer cases. The methods are based upon Gabor filters, phase portrait analysis, a novel method for the analysis of the angular spread of power, fractal analysis, Laws' texture energy measures derived from geometrically transformed regions of interest (ROIs), and Haralick's texture features.

Keywords: *Image Fusion, Neural Netwok, Support Vector Machine,Predicted values,Computer Aided Design.*

1. Introduction

For years, cancer has been one of the biggest threats to human life; it is expected to become the leading cause of death over the next few decades. Based on statistics from the World Health Organization (WHO) ,cancer accounted for 13% of all deaths in the world in 2004; deaths caused by cancer are expected to increase in the future, with an estimated 12 million people dying from cancer in 2030. Of all the known cancers, breast cancer is a major concern among women. It is the second-common cause of cancer deaths among women.

According to published statistics, breast cancer has become a major health problem in both developed and developing countries over the past 50 years, and its incidence has increased in recent years. In the United States, in 2007, there were an estimated 178,480 new cases of breast cancer diagnosed and 40,460 deaths from this disease among women. At present, there are no effective ways to prevent breast cancer, because its cause remains unknown. However, efficient diagnosis of breast cancer in its early stages can give a woman a better chance of full recovery.

Therefore, early detection of breast cancer can play an important role in reducing the associated morbidity and mortality rates. Computer-aided detection or diagnosis (CAD) systems, which use computer technologies to detect abnormalities in mammograms such as calcifications, masses, and architectural distortion, and the use of these results by radiologists for diagnosis, can play a key role in the early detection of breast cancer and help to reduce the death rate among women with breast cancer. Thus, in the past several years, CAD systems and related techniques have attracted the attention of both research scientists and radiologists. For research scientists, there are several interesting research topics in cancer detection and diagnosis systems, such as high-efficiency, high-accuracy lesion detection algorithms, including the detection of masses, detection of architectural distortion, and the detection of bilateral asymmetry. Radiologists, on the other hand, are attracted by the effectiveness of clinical applications of CAD systems. The aim of this paper is to provide an overview of CAD systems and related techniques developed in recent years. It is also intended to draw the attention of more research scientists to the research field of CAD for breast cancer, and advance research on the detection and diagnosis of breast cancer and related techniques, such as image processing, computer technology, and radiological imaging. In the context of a screening program, a "detection mammogram" refers to a mammogram on which cancer is detected, and the term "prior mammogram" refers to a mammogram acquired at the last scheduled visit to the screening program prior to the detection of cancer. When breast cancer is detected in a screening program in a particular individual, the case is referred to as "screen-detected cancer." The term "interval cancer" indicates a case where breast cancer is detected outside the screening program in the interval between scheduled screening sessions. Studies on prior mammograms of interval-cancer cases with the particular goal of detection of architectural distortion could help in developing strategies for the detection and treatment of breast diseases at their early stages.

2. Literature Survey

There are several imaging techniques for examination of the breast, including magnetic resonance imaging, ultrasound imaging, and X-ray imaging. Mammography is a specific type of imaging that uses a low-dose X-ray system to examine the breast, and is currently the most effective method for detection of breast cancer before it becomes clinically palpable]. Mammography offers high-quality images at a low radiation dose, and is currently the only widely accepted imaging method used for routine breast cancer screening. Current guidelines of the American Cancer Society (ACS) recommend that women aged 40–49 years have a routine mammogram every one to two years, with the first beginning at age 40. A good amount of research on diagnosis of breast cancer with WBCD is found in literature. Many of them show good classification accuracy. Albrecht, Lappas, Vinterbo, Wong, and Ohno-Machado, applied a learning algorithm that combined logarithmic simulated annealing with the Perceptron algorithm and the reported accuracy was 98.8%. Pena-Reyes and Sipper], used the classification technique of fuzzy-GA method, reaching a classification accuracy of 97.36%. Setiono], employed the classification based on a feed forward neural network rule extraction algorithm. The reported accuracy was 98.10%. Quinlan achieved 94.74% classification accuracy using 10-fold cross validation with C4.5 decision tree method. Hamiton, Shan, & Cercone, obtained 94.99% accuracy with RIAC method, while Ster & Dobnikar, obtained 96.8% with linear discreet analysis method. The accuracy obtained by Nauck and Kruse was 95.06% with neuron- fuzzy techniques. In Goodman, Boggess, and Watkins . used three different methods, optimized learning vector quantization (LVQ), big LVQ, and artificial immune recognition system (AIRS), and the obtained accuracies were 96.7%, 96.8%, and 97.2%, respectively. In the method proposed by Abonyi and Szeifert, an accuracy of 95.57% was obtained with the application of supervised fuzzy clustering technique. In Polat and Gunes ,least square SVM was used and an accuracy of 98.53% was obtained. Mehmet Fatih Akay, increased the accuracy to 99.51%, by combining SVM with feature selection.

3.Detection Of Distortion Mammograms

3.1.Preprocessing

Approximate segmentation of the breast portion in the mammographic image is performed by using Otsu's thresholding methodBy this method,the unwanted parts of the mammogram will be eliminated so that we can have the exact portion of the breast imager.

3.2.Filtering

The morphological open operation is an erosion followed by a dilation, using the same structuring element for both operations. Performs morphological opening filtering on the grayscale or binary image IM with the structuring element SE.This Filtering process is done by dilation followed by erosion.

3.3 Gabor Filtering On Mammogram

Gabor filter is a directional filter used to separate the pixels in mammogram image with respect to different orientation of the vessels or nerves or other tissues converging towards the nipple of the mammogram image. The Gabor kernels are all self-similar since they can be generated from one filter, the mother wavelet, by scaling and rotating via the wave vector. Hence, a band of Gabor filters is generated by a set of various scales and rotations. In this paper, we use Gabor kernels at five scales and eight orientations with the parameter to derive the Gabor representation by convolving face images with corresponding Gabor kernels. For every image pixel we have totally 40 Gabor magnitude and phase coefficients, respectively, that is to say, we can obtain 40 Gabor magnitude and 40 Gabor phase faces from a single input face image. In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. The Gabor filters are self-similar: all filters can be generated from one mother wavelet by dilation and rotation.

4. Feature Extraction

In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (e.g. the same measurement in both feet and meters) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input

4.1.Laws' Texture Energy Measures

Laws' texture energy measures are based on convolution kernels that emphasize specific structural patterns, and could be used to generate useful features related to the intersecting tissue structures, spiculations, and node-like patterns of architectural distortion.

4.2.Haralick' Texture Feature

The most commonly used measures of texture, in particular of random texture, are the statistical measures proposed by Haralick. Unlike Laws' texture energy measures, some of Haralick's measures may not be directly related to the intersecting structures, spiculaions, and node-like patterns of architectural distortion, but they may provide useful information regarding the statistical properties of the given ROI or image. The local binary pattern operator is defined as a gray-scale invariant texture measure, derived from a general definition of texture in a local neighborhood. Through its recent extensions, the LBP operator has been made into a really powerful measure of image texture, showing excellent results in many empirical studies. The LBP operator can be seen as a unifying approach to the traditionally divergent statistical and structural models of texture analysis.

4.3 Neural Network Design

A multilayer feed forward network, consisting of an input layer, three hidden layers and an output layer, is adopted in this paper. The input layer is composed by a number ofneurons equal to the dimension of the feature vector (nine neurons). Regarding the hidden layers, several topologies with different numbers of neurons were tested. A number of three hidden layers, each containing 15 neurons, provided optimal NN configuration. The output layer contains a single neuron and is attached, as the remainder units, to a nonlinear logistic sigmoid activation function, so its output ranges between 0 and 1. This choice was grounded on the fact of interpreting NN output as posterior probabilities. People have implemented model neurons in hardware as electronic circuits, often integrated on VLSI chips. Remember though that computers run much faster than brains - we can therefore run fairly large networks of simple model neurons as software simulations in reasonable time. This has obvious advantages over having to use special "neural" computer hardware.

4.4 Image Fusion

Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images.Image fusion can also be implemented in mammogram image in such a way to predict the lesion effectively. The fusion methods such as averaging, Brovey method, principal component analysis (PCA) and IHS based methods fall under spatial domain approaches. Another important spatial domain fusion method is the high pass filtering based technique. Here the high frequency details are injected into upsampled version of MS images. The disadvantage of spatial domain approaches is that they produce spatial distortion in the fused image. Spectral distortion becomes a negative factor while we go for further processing, such as classification problem. Spatial distortion can be very well handled by frequency domain approaches on image fusion. The multiresolution analysis has become a very useful tool for analysing remote sensing images. The discrete wavelet transform has become a very useful tool for fusion. Some other fusion methods are also there, such as Lapacian pyramid based, curvelet transform based etc. These methods show a better performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion. Use of image fusion to add anatomical information from CT, MRI, to nuclear medicine's functional images.

Historically, digital computers evolved from the von Neumann model, and operate via the execution of explicit instructions via access to memory by a number of processors. On the other hand, the origins of neural networks are based on efforts to model information processing in biological systems. Unlike the von Neumann model, neural network computing does not separate memory and processing. Neural network theory has served both to better identify how the neurons in the brain function and to provide the basis for efforts to create artificial intelligence. Artificial intelligence and cognitive modeling try to simulate some properties of biological neural networks. to construct software agents (in computer and video games) or autonomous robots.

5. Tables, Figures and Equations

5.1 Figures

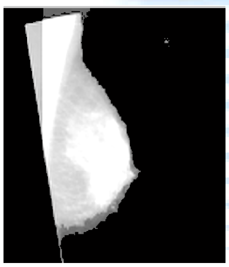

Fig.1.Original Mammogram

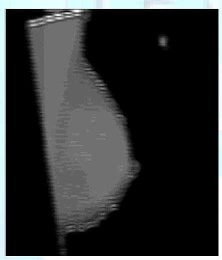

Fig:2 Magnitude Response

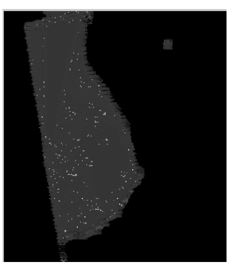

Fig::3 Phase Response

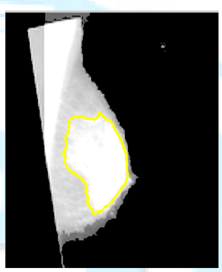

Fig:4 Defected Image

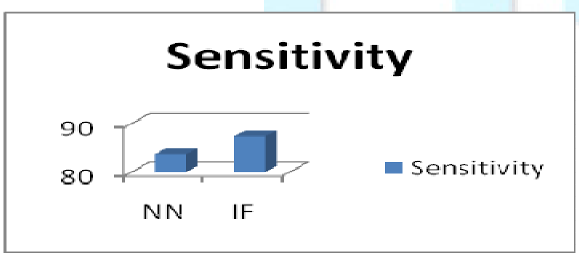

Fig:6 Performance Comparision for sensitivity

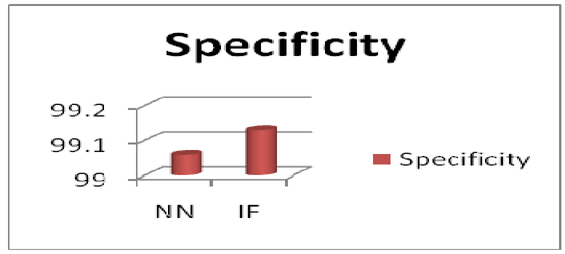

Fig:7 Performance Comparision for Specificity

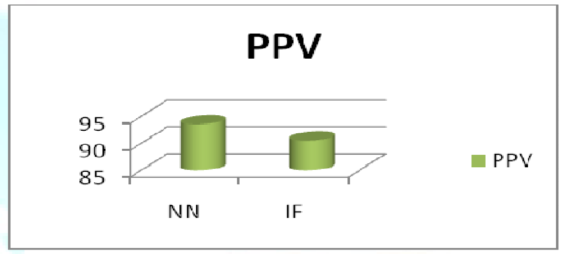

Fig:8 Performance Comparision for Positive Predictive value

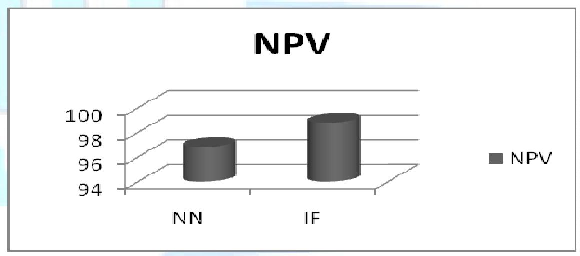

Fig:9 Performance Comparision for Negative Predictive value

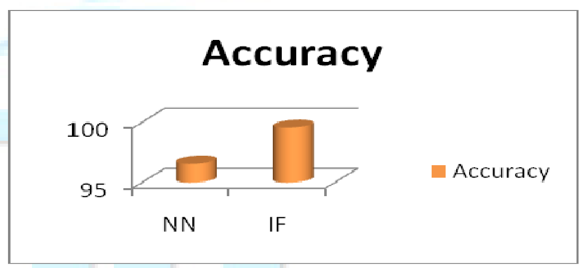

Fig:10 Performance Comparision for Accuracy

Table 1: Performance Comparision

Methd	Se	Sp	Ppv	Npv	Acc
NN	0.8	0.96	0.935	0.968	0.965
IF	0.873	0.99	0.904	0.98	0.995

NN-Neural Network, IF-Image Fusion, Se-Sensitivity, Sp-Specificity.Ppv- Positive Predictive value,Npv- Negative Predictive Value,Acc- Accuracy

4. Conclusion

The results obtained in the present study on the automatic detection of architectural distortion in prior mammograms of interval cancer cases are important and indicate that Gabor filters, phase portraits, fractal analysis, the Haralick's features, and Law's texture features as well as Neural Network can be used to achieve the detection of subtle signs of early stages of breast cancer in mammograms.

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