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ARTIFICIAL NEURAL NETWORKS IN IMAGE PROCESSING FOR EARLY DETECTION OF BREAST CANCER.

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Artificial neural networks (ANNs) have been widely used in image processing for various applications, including early detection of breast cancer. One of the main advantages of using ANNs for early detection of breast cancer is their ability to learn from data. ANNs can be trained on large sets of data and can learn to detect patterns in images that are not visible to the human eye. This ability to learn from data can help to improve the accuracy of early detection of breast cancer, which is crucial for the successful treatment of this disease The current state of research in this field is promising. Many studies have shown that ANNs can be used to improve the accuracy of early detection of breast cancer. However, more research is needed to further improve the accuracy of ANNs and to address the challenges mentioned above. The purpose of this review is to analyse the contents of recently published literature with special attention to techniques and states of the art of NN in medical imaging.

INTRODUCTION

Breast cancer is one of the main causes of death among women and the most frequently diagnosed non-skin cancer in women. Breast cancer occurs when the cell tissues of the breast become abnormal and uncontrollably divided. These abnormal cells form large lump of tissues, which consequently becomes a tumour. Such disorders could successfully be treated if they are detected early. Thus, it is of importance to have appropriate methods for screening the earliest signs of breast cancer.
In image processing for breast cancer diagnosis, various techniques are used to analyse digital images of the breast tissue, such as mammograms, ultrasound, and magnetic resonance imaging (MRI). The goal is to detect any abnormalities or suspicious regions in the breast tissue that may indicate the presence of cancer. One common technique used in image processing is computer-aided detection (CAD) which uses algorithms to automatically identify regions of the breast tissue that may be cancerous. CAD can be used to analyse mammograms, and it can help radiologists identify small tutors or abnormalities that may be difficult to see on the images.
Another technique used in image processing is image segmentation which is used to separate the breast tissue in the image into different regions, such as the tumour, normal tissue, and background. Image segmentation can be used to create a 3D model of the breast tissue which can be used to analyse the tumour and plan treatment.
Deep learning models are also used in image processing for breast cancer diagnosis. These models are trained on large dataset of mammograms and can be used to classify mammograms as normal or abnormal. These

models can also be used to predict malignancy of breast cancer.

NEURAL NETWORK USED IN MEDICAL IMAGE PROCESSING

In medical image processing, neural networks can be used for a variety of tasks, such as image classification, segmentation, and detection. For example, a neural network can be trained to classify an image of a breast as normal or abnormal. Another neural network can be trained to segment an image of the breast and identify the location of a tumour.

1. Preprocessing:

Preprocessing is an important step in medical image processing, as it can improve the accuracy and efficiency of the downstream analysis and diagnosis. Some common preprocessing techniques used in medical image processing include:

- Image enhancement*:* Techniques such as histogram equalization, contrast stretching, and filtering can be used to improve the visibility of structures and features in the image.
- Image registration: This technique is used to align multiple images of the same area of the body, taken at different times or using different modalities. This can be used to create a 3D model of the area of interest, or to monitor changes over time.
- Image normalization: In this technique, the image is transformed so that the intensity values have a standard distribution. This can improve the performance of the downstream analysis and diagnosis.
- *Data augmentation*: In this technique, images are transformed or modified to increase the size of dataset, this can be done by applying different geometric transformations like rotation, flipping, and scaling. This can improve the robustness and generalization of the neural network models.

2. Medical Image Segmentation:

Medical image segmentation is a technique used in medical image processing to separate an image into different regions, such as tumours, organs, and background. This can be used to create a 3D model of the area of interest, or to identify the location of the tumour.
There are several techniques for medical image segmentation, including:

- Thresholding: This technique separates an image into two regions, based on a threshold value. Pixels with intensity values above the threshold are classified as one region, and pixels with intensity values below the threshold are classified as another region.
- Watershed segmentation: This technique is based on the concept of "catchment basins" and "watersheds" and can be used to separate an image into different regions based on intensity values.
- Region growing: This technique starts with a seed point and iteratively adds neighbouring pixels to the region based on a similarity criterion.
- Active contours: This technique uses an energy function to model the object of interest and an optimization algorithm to minimize the energy to find the contours.
- Deep Learning based segmentation: This technique uses convolutional neural networks (CNNs) to segment the image. These models are trained on large datasets of images and can be used to segment images with high accuracy.

3. Object Detection and Recognition:

Object detection and recognition are techniques used in medical image processing to locate and identify specific structures or objects in an image. These techniques can be used to detect tumours, organs, or other structures of interest in medical images.

- Object detection: This technique is used to locate specific objects or structures in an image. For example, a tumour detection algorithm may be trained to identify the location of a tumour in a mammogram.
- Object recognition: This technique is used to identify and classify specific objects or structures in an image. For example, an object recognition algorithm may be trained to classify a mass in a mammogram as benign or malignant.

There are several techniques for object detection and recognition in medical images, including:

- Template matching: This technique compares a known object or structure to different regions in an image and identifies the location of the best match.
- Feature-based methods: This technique extracts features from the image, such as texture, shape, or intensity, and uses them to classify or detect objects or structures.
- Deep learning-based methods: These techniques use convolutional neural networks (CNNs) or other deep learning models to detect and classify objects in images. These models are trained on large datasets of medical images and can be used to detect and classify objects with high accuracy.

ANN IN MAMMOGRAPHY

Mammography is one of the most effective methods used in hospitals and clinics for early detection of breast cancer. It has been proven effective to reduce mortality as much as by 30% [3]. The main objective of screening mammography is to early detect the cancerous tumour and remove it before the establishment of metastases [3].

The early signs for breast cancer are masses and microcalcification but the abnormalities and normal breast tissues are often difficult to be differentiated due to their subtle appearance and ambiguous margins [3]. Only about 3% of the required information are revealed during a mammogram where a part of suspicious region is covered with vessels and normal tissues. This situation may cause the radiologists difficult to identify a cancerous tumour. Thus, computer aided diagnosis (CAD) has been developed to overcome the limitation of mammogram and assists the radiologists to read the mammograms much better [10]. ANN model is the most commonly used in CAD for mammography interpretation and biopsy decision making. There are two ways used in ANN to assist in mammography interpretation: first, applying classifier directly to the region of interest (ROI) image data and second, understanding the situation from the features extracted from the pre-processed image signals [2]. Figure 1 shows an example of ANN structure with multifeatured input data and multi-hidden layers.

Microcalcification is deposition calcium in the soft breast tissues. They are quite minute in quantity and size. It is found in a cluster or pattern of circles/lines together with extra cell activity in breast region [2]. Many researchers have developed CAD system using artificial neural network to detect microcalcification. In late 90's the application of ANN in CAD mammography was found to have limitation in terms of data overfitting

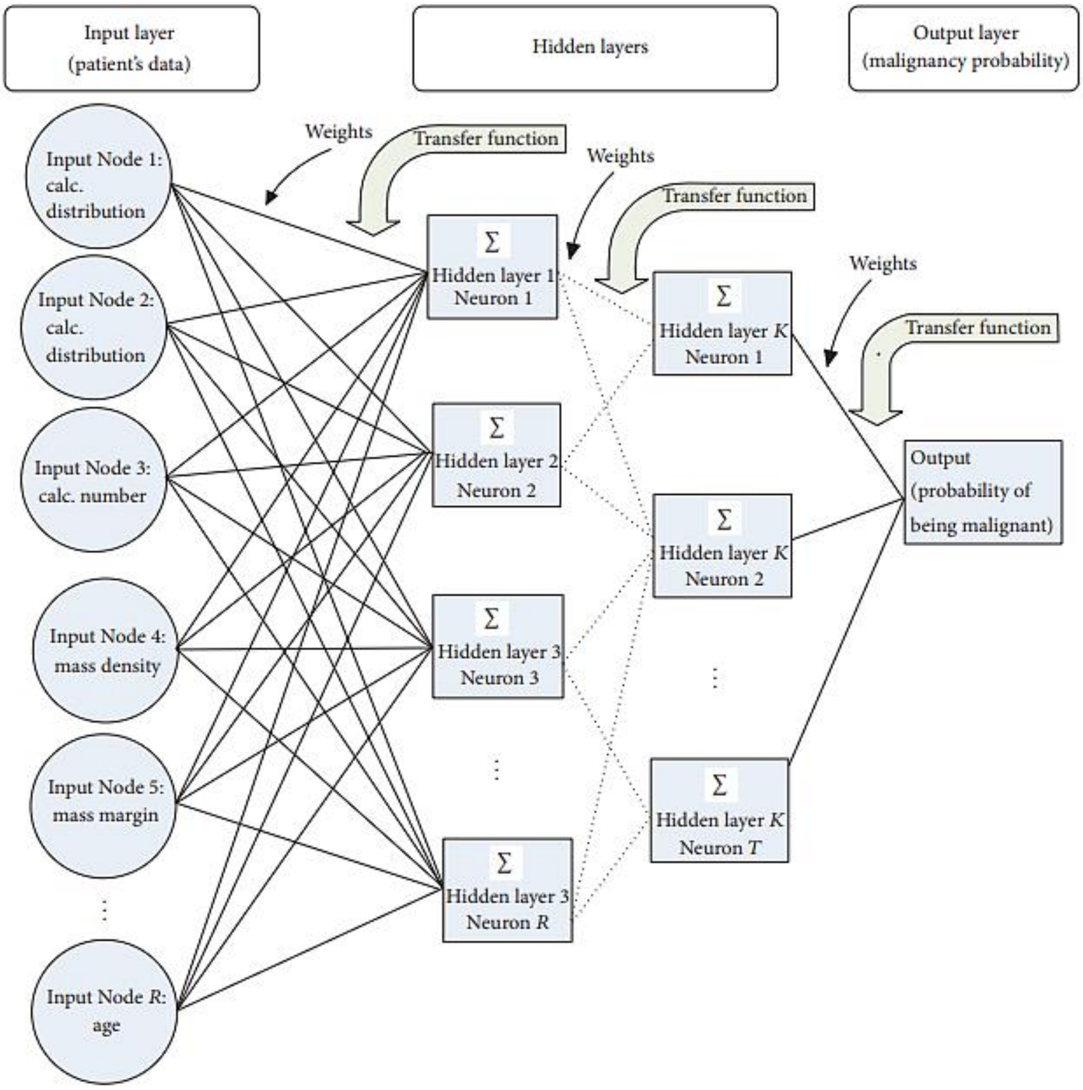
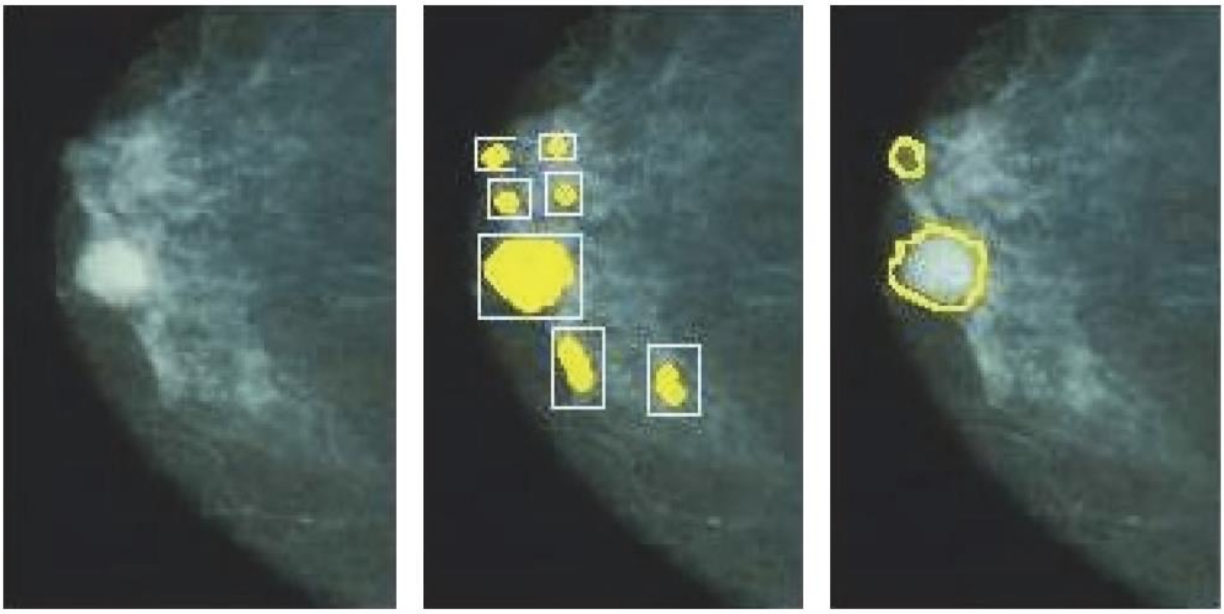


FIGURE 1: Structure of a typical ANN for classification of breast tumors in mammography [12].

Thus, Bayesian belief network (BBN) was compared with ANN classification method to identify the positive mass regions based on a set of computed features in CAD. The same database was used in ANN and a BNN with topologies optimization using a genetic algorithm (GA) to test the performance and robustness of the ANN and BBN. However, the result shows that there is no significant difference between using an ANN and using a BBN in CAD for mass detection if the network is optimized properly. In Alayliogh and Aghdasi, wavelet-based image enhancement technique has been used to improve the detection of breast cancer. Input feature vectors containing spatial and spectral image were employed in neural network classifier. Microcalcification detection has been performed by using a multistage algorithm comprising the image segmentation and pattern recognition to classify the microcalcifications whereas biorthogonal spline wavelets have been used in image enhancement to separate the image into frequency bands without affecting the spatial locality. The result shows that spatial and spectral feature are promising ways to detect microcalcification.



(a) (b) (c)

Figure 2: Results (from (a)–(c)): original image, image after first stage of NN processing, and image at second stage of NN processing using Gabor wavelets as input for mammogram image.

ANN IN ULTRASOUND

Neural network (NN) also plays its role in ultrasound images in detecting breast cancer. Buller[4] was one of the first who used neural network in breast cancer detection for ultrasound images. In his work, he separated the training process for benign and malignant cases by feeding the first system only with images containing benign lesion and the other with images containing only malignant lesion. He also introduces "spider web" topology which are able to produce two vectors that are further used in the classification process. The first vector represents the localized effects in a defined neighbourhood and the other represents the global attributes. The technique brings high advantages as the spider web topology is sensitive to small area and hence provides better results in small area by putting more weights on the localized effects. This technique can actually be improved taking into account the extra parameters of texture and shape. Besides, three-layer NN consisting of input, output, and hidden neurons was used. They also execute the training process by leaving one out before training and use the left out as tester. From the result, texture implementation achieved a very good result on both solid and liquid lesion. Classification is an important technique used widely to differentiate cancerous and noncancerous breasts. Denser breast has higher risk in having cancer. Knowing this, Sahiner et al. [5] in their paper describe the importance of texture images in classification of dense breast tissue. They also introduce convolution CNN classifier to replace the backpropagation methods where the images are fed directly into the network. The strength of this method is that no image of tumour is fed into the network. The drawback is the high computational cost which in turn makes the technique probably unsuitable for real-time operation.

ANN IN THERMAL IMAGING

Artificial neural networks (ANNs) have been used in the field of thermal imaging for the detection of breast cancer. Thermal imaging, also known as thermography, is a noninvasive method that uses infrared cameras to capture images of the heat emitted by the body. These images can be analysed to detect changes in temperature, which can indicate the presence of breast cancer.

ANNs have been used to analyse thermal images of the breast to detect breast cancer by recognizing patterns in the temperature distribution. For example, a research paper might use an ANN to train a model to differentiate between normal breast tissue and cancerous tissue based on their temperature profiles.

One of the advantages of using ANNs for the detection of breast cancer in thermal imaging is that they can handle large amounts of data and can learn to recognize complex patterns in the images. Additionally, ANNs can be trained to make diagnostic decisions based on the thermal images, which can improve the accuracy and efficiency of the screening process.

However, it's important to note that thermal imaging is not a substitute for mammography and should be used in combination with other methods. Moreover, thermal imaging is not FDA approved for breast cancer detection and it is not widely used in clinical practices.

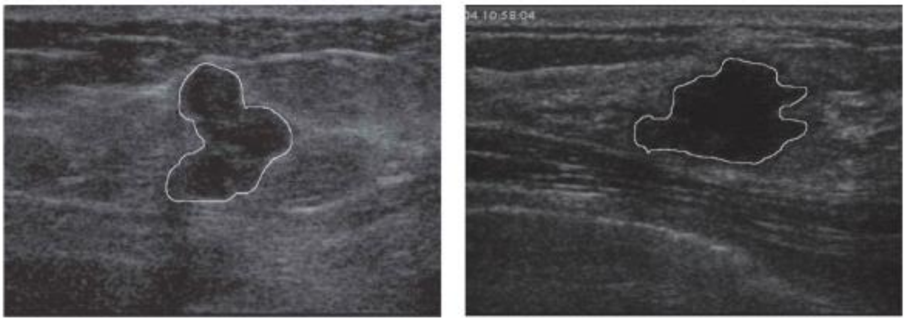


Figure 3: Segmentations of cysts for breast ultrasound image using ANN

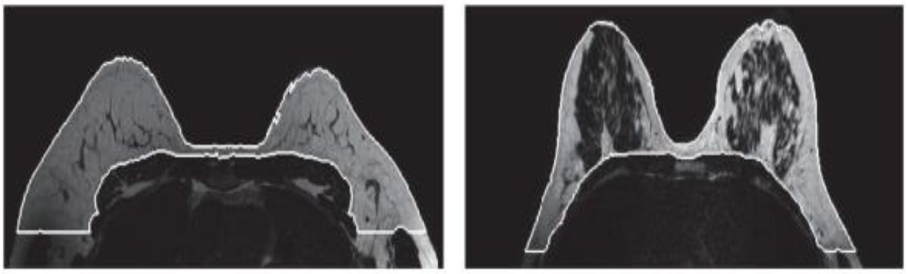


Figure 4: Multistate CNN used to segment small fatty breast and medium dense breast for MRI image

ANN IN MRI

Artificial neural networks (ANNs) have been used in the field of magnetic resonance imaging (MRI) for a variety of tasks, such as image segmentation, tissue characterization, and diagnostic decision-making.

For example, an ANN can be trained to segment an MRI image, to automatically identify and classify different structures in the image, such as the brain, tumours, blood vessels or muscles. This can be useful for applications such as brain imaging, where it's important to differentiate between different structures of the brain.

Additionally, an ANN can be used to classify different types of tissue in an MRI image, such as healthy tissue, benign tumours, and malignant tumours. This can be useful for applications such as cancer detection, where it's important to identify the type of tissue present in the image.

An ANN can also be used to make diagnostic decisions based on the MRI images, such as identifying the presence of a certain disease. This can be useful for applications such as Alzheimer's disease, where it's important to identify the presence of the disease in an early stage.

Overall, ANNs have the potential to improve the accuracy and efficiency of MRI systems, and they have been used in many research papers in the field of medical imaging.

DISCUSSION

For the last few decades, several computer-aided diagnosis (CAD) techniques have been developed in mammographic examination of breast cancer to assist radiologist in overall image analysis and to highlight suspicious areas that need further attention. It can help radiologist to find a tumour which cannot be spotted using naked eye. As technologies keep growing, many researchers are concerned about the development of intelligent techniques which can be used in mammography to improve the classification accuracy.

For ultrasound applications, in the field of determining breast cancer malignancy, CAD frameworks utilizing ultrasound images are widely used due to their non radiation properties, low cost, high availability, speedier results, and higher accuracy. An improved version of the breast cancer detection using ultrasound images has been introduced, which works on a three-dimensional ultrasound imaging that can give more in-depth information on the breast lesion compared to the conventional two-dimensional imaging. This three-dimensional imaging joins each of the two dimensional characteristics.

Furthermore, in order to handle the vulnerability nature of the ultrasound images, some methods and methodologies based on ANN have also been introduced. A majority of the research works that utilize ANN have acquired noteworthy results. Hybrid methods, which combine two ANN techniques, have recently been developed for the detection and classification of breast cancer. A twophase hierarchical NN is also found to be promising rather than using the image analysis separately. It can also be seen that the larger the number of inputs to the ANN, the better the accuracy of the output in identification and classification of breast cancer. However, the number of hidden neurons does not seem to have a big impact on the accuracy of the system. To state which individual ANN is the best is quite subjective depending on the application and various variables to be considered.

Table 1: Summary of methods with NN in breast cancer detection

S. No	Methods	Input	Purpose	Dataset	Result
1.	Particle Swarm Optimized Wavelet Neural Network (PSOWNN	Mammogram	Improve classification accuracy in breast cancer detection and reducing misclassification rate	216 mammograms	(i) Sensitivity 94.167% (ii) Specificity 92.105% (iii) AUC 0.96853 (iv) Youden's index 0.86272 (v) Misclassification rate 0.063291
2.	New algorithm based on two ANNs	Mammogram	Classification of masses	30 cases and 60 mammograms	(i) True positive (TP) rate 93.6% (73/78), (ii) Number of the FPs per image 0.63 (38/60).
3.	ANN	Mammogram	Classification of microcalcification and nonmicrocalcification	24 mammograms	(i)TP detection rate for individual microcalcification is 73% and 92% for non microcalcification
4.	ANN and BBN	Mammogram	Compare performance of ANN and BBN	3 independent image database	(i) True positive (TP) rate 93.6% (73/78), (ii) Number of the FPs per image 0.63 (38/60).
5.	Spider web technology with NN	Ultrasound	Classify and separate benign and malignant lesion	25 sonograms	69% accuracy in malignant, 66% accuracy in benign, 66% accuracy in no lesions.
6.	Multi layer Feed forward Neural Networks (MFNN)	Ultrasound	Classification of benign and malignant lesion	140 pathological proved tumours	95% accuracy, 98% sensitivity, 99% negative predictive, 89% positive predictive.
7.	ANN with 3D infinite element analysis	IR	Tumour prediction	200 patients	Good detection, poor sensitivity.
8.	Backpropogat-ion NN	IR	Early detection of breast cancer	19 patients	Accuracy 95%
9.	Classify MR images by hybrid perceptron NN	MRI	Early detection of breast cancer	138 normal cases, 143 abnormal cases	Accuracy 86.74%
10.	Extraction of breast region and multi state CNNs	MRI	Breast density evaluation and Abnormality localisation	23 women	Average precision 99.3%

CONCLUSION

Neural network plays an important role in detection of carcinogenic conditions in the breast. The technique acts as a stepping stone in the detection of cancer. In this review, we show that NN can be used in many medical applications which we categorized into four main medical applications that are widely used in breast cancer detection. These four medical applications include mammogram, ultrasound, and thermal and MRI imaging. This shows that NN is not restricted by the application.

In all applications, NN's main purposes were automated classification and segmentation. The types of data that need to be classified include calcification and noncalcification, benign and malignant, dense and normal breast, and tumorous and nontumorous. Different variation of NN can be applied as classifier. Feed-forward backpropagation NN is by far the simplest form of NN, as the name suggest, the input nodes do not have interrelation between each other, and more importantly, the units do not form a repetitive cycle or loops. Feedforward backpropagation can only pass data from current layer to subsequent layer; hence the data is moving in one fix direction from input to output.

The trend now is going towards hybrid NN like SOM model. Combination of statistical methods such as bootstrap is being used together with NN too. SOM and bootstrap methods require lesser training data and hence are useful when we do not have many training data. Besides, people utilize SVM with NN in order to achieve a better performance. In conclusion, NN is widely used in medical image applications, creatively combined with other methods in order to achieve better accuracy, sensitivity, and also positive predictive value.

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