

# Empowering Early Diagnosis: Convolutional Neural Networks In Breast Cancer Detection

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*Received: 20th Feb, 2026; Revised: 4th Mar, 2026; Accepted: 25th Mar, 2026; Available Online: 10th Apr, 2026*

## Abstract

Breast cancer remains one of the leading causes of death among women world-wide, with early detection being crucial for improving patient outcomes. Mammography has been the primary method for breast cancer screening, but it has limitations, particularly in women with denser breast tissue. To address this, several modalities such as ultrasonography, thermography, and wearable biosensors like smart bras have emerged as non-invasive and cost-effective alternatives. These technologies, when coupled with ai algorithms (e.g., catboost) and deep learning-based systems (e.g., yolo-v4), show promising potential in improving the accuracy of tumor detection and classification. Additionally, advanced machine learning techniques like svm, knn, and cnns have been employed to diagnose breast cancer using clinical and imaging features, achieving impressive accuracy rates. However, classical algorithms face challenges in terms of computational complexity, motivating the use of quantum machine learning to accelerate computational processes. The integration of these technologies offers an exciting prospect for revolutionizing breast cancer diagnosis by reducing diagnostic errors, enhancing screening rates, and ultimately improving patient survival. This study presents various approaches, including cnn-based models, transfer learning, and a combination of deep learning methods, to improve breast cancer classification and detection performance. Evaluation metrics such as accuracy, precision, recall, and roc curves were used to assess model effectiveness. The achieved results include a model accuracy of 0.9995, with a validation loss of 0.6800 and a validation accuracy of 0.7651.

**Keywords:** Breast Cancer, Mammography, Deep Learning, Transfer Learning, Tumor Detection, Quantum Machine Learning.

**How To Cite This Article:** Dave Mr, Patel Mm. Empowering Early Diagnosis: Convolutional Neural Networks In Breast Cancer Detection. Int J Drug Deliv Technol. 2026;16(26s):296-303. Doi: 10.25258/ijddt.16.26s.30

## 1. Introduction

Breast cancer is the most common malignancy and cause of female death worldwide. It's a significant health issue, responsible for approximately 2.3 million new diagnoses per year and still the second highest contributor to cancer deaths among women. Early diagnosis and timely intervention are essential to improve the prognosis and reduce the mortality of this illness. Mammography remains the gold standard for screening for breast cancer, but it has its limitations, particularly in identifying tumors in women with dense breast tissue. Therefore, there is more interest in searching for alternative methods of screening, and combining new technologies to improve OTA diagnosis. Mammography records low-dose X-ray images

of the breast that can be used to identify malignant (cancer) or benign (noncancer) tumors. But the method is much less accurate in women who have dense or thick breasts, which can hide tumors and produce false negatives. In another way of addressing this problem a number of supplementary technologies (ultrasonography, thermography, and breast MRI) have become available, which provide a more complete way of carrying out a cancer "screening-LC" (4). In addition, the progress of wearable biosensors, especially flexible clothes-like biosensors like intelligent bras, would have the ability that producing the non-invasive and low-cost comfortable diagnosis for breast cancer in advance. Sensors in these wearables can be sensitive enough to pick up on miniscule varia-

## Empowering Early Diagnosis: Convolutional Neural Networks in Breast Cancer Detection

tions in breast tissue, opening up a novel, comfortable approach to screening. Artificial Intelligence (AI) models of the integration with imaging modalities have revolutionized the medical practice, especially the breast cancer detection and classification. Recently, deep learning, especially Convolutional Neural Networks (CNN) and transfer learning, have shown superior performance in the diagnosis of breast cancer in screening mammograms, in ultrasound images and other medical images. CNNs, especially, have demonstrated promising capabilities in automation pipeline for detection, assisting radiologists in the recognition of suspicious lesions as well as the enhancement in diagnostic accuracy. The development of quantum machine learning also has enabled might be used to improve computational performance, and benefit diagnosis. Quantum algorithms could speed up data processing and increase predictive power by taking advantage of phenomena that exist in quantum mechanics, including superposition and entanglement. This research will actually look at the confluence of AI, wearable biosensors and quantum computing to transform how breast cancers are detected and classified. Through integrating sophisticated technology with state-of-the-art machine learning, the objective is providing improved early diagnosis, minimizing diagnostic errors and resulting in better patient outcomes for breast cancer.

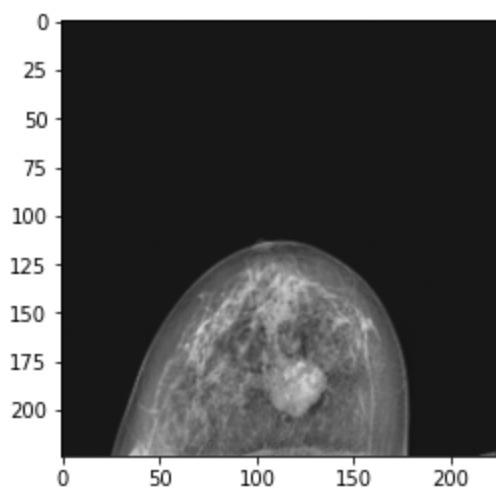


Fig.1. X-ray Image of breast tissue

### 2. Literature Review

Breast malignancy is one of the most heterogeneous and deadliest diseases of the modern ages, causing death of a huge number of women around the world. It is the second most disease which cause of women death [1]. Several machine learning [2] and data

mining algorithms applied for breast cancer prediction. One of the important tasks is to have the best fit and right algorithm for the prediction of breast cancer. Breast cancer has been initiated from cancerous tumor, in which cells grow uncontrollably [3]. Much of the breast is made up of fatty and fibrous tissues that tend to grow abnormally and become breast cancer. The cancer cells are also scattered throughout the tumors, which give rise to various stages of cancer. 8 Types of Breast Cancer [ 4 ] It is a type of cancer that forms when damaged cells from the breast tissues spread to other parts of the body. Ductal Carcinoma in situ (DCIS) is a type of precancer stage of breast cancer during which abnormal cells began to develop outside the breast this type of breast cancer is also called as the non-invasive cancer [5]. The other type is Invasive Ductal Carcinoma (IDC)[6 and is also commonly referred to as infiltrative ductal carcinoma [7]. This form of cancer is that when abnormal metastasize over all breast tissues and IDC cancer is usually in men [8]. Mixed Tumors Breast Cancer (MTBC) is the third type of breast cancer and it is otherwise called, invasive mammary breast cancer [9]. The cancer of this type is due to abnormal duct cell and lobular cell [10]. Fourth type of cancer is, Lobular Breast Cancer (LBC) [11] which arise with in the lobule. It raises the likelihood of other invasive cancers. Mucinous Breast Cancer (MBC) [12] is the fifth type which develops as a result of invasive ductal cells, also referred to as colloid breast cancer. It is tumor that extends beyond the duct [13]. The final type of breast cancer is Inflammatory Breast Cancer (IBC) which also leads to swelling and redness in breast. It is the kind of breast cancer that grows quickly stage when the lymph system blocks into break cell, this cancer begins to show [14].

## Empowering Early Diagnosis: Convolutional Neural Networks in Breast Cancer Detection

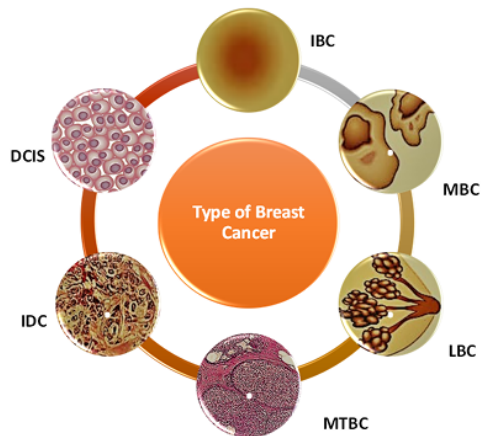


Fig.2. Major Types of Breast Cancer

**DCIS (Ductal Carcinoma in Situ):** DCIS is a non-invasive form of breast cancer in which abnormal cells are discovered in the milk ducts but have not yet spread outside them. It is a precursor to invasive cancer and is curable when caught early.

**IBC (Inflammatory Breast Cancer):** IBC is a rare and aggressive form of breast cancer where the breast becomes swollen, red, and warm. The cancer cells block lymph vessels in the skin, leading to inflammation. It often doesn't present as a lump, making it harder to detect.

**MBC (Medullary Breast cancer):** Medullary breast cancer is one form of invasive ductal carcinoma. It is marked by the presence of large, round tumor cells that grow toward the center in a soft, well-defined structure and tends to be a less aggressive form of invasive cancer than other invasive disease.

**LBC (Lobular Breast Cancer):** Lobular breast cancer starts in the milk-producing glands (lobules) of the breast. It's less common than invasive ductal carcinoma and may be more challenging to find because it often grows in a more spread-out way, rather than as a solid lump.

**IDC (Invasive Ductal Carcinoma):** IDC is the most common form of breast cancer, begins in the milk ducts and spreads to neighbouring tissue. It is responsible for some 80% of the breast cancer remaining and can spread to lymph nodes and other parts of the body if untreated.

**MTBC (Metaplastic Breast Cancer):** Metaplastic breast cancer is a rare, aggressive type of cancer that includes both glandular and non-glandular (mesenchymal) tissue. And it is an aggressive tumour, often spreading rapidly and not responding to conventional therapies, such as chemotherapy and radiotherapy.

Machine learning is an automatic learning algorithm, these algorithms learn by themselves according to the previous dataset, we input a large number of data, machine learning model study that data and from the help of that trained model we generate a prediction for future. For breast cancer prediction some of the major machine learning algorithms are as:

### A. Artificial Neural Network

ANN is a very well know algorithm used in data mining process. Neural network has input layer, hidden layer and output layer. This method is employed here to remove the pattern that is too complicated. The parallel processing, the distributed memory, the collective solution and the network structure were considered in the Algorithm.

### B. Logistics Regression

LR is a type of supervised algorithm which has multiple dependent variables. This algorithm outputs in binary. Regulation. So can yield the continuous outcome of some data. Model The algorithm is a model with binary variables.

### C. K- Nearest Neighbor

KNN algorithm is employed for pattern recognition. It is even a better solution for breast cancer diagnosis. To detect the pattern, each class is treated equally. K-Nearest Neighbor the similar featured data on a large data set. Inspired by, we use similarities among features to sort a large dataset.

### D. Convolution Neural Network

Breast cancer detection using Convolutional Neural Networks (CNNs) involves training a model to automatically identify cancerous patterns in mammogram images. CNNs are particularly effective in image analysis as they can detect complex features, such as masses or microcalcifications, which are indicative of cancer. By learning from large datasets, CNNs can classify images as benign or malignant with high accuracy. This method reduces human error, accelerates diagnosis, and supports early detection, improving treatment outcomes.



## Empowering Early Diagnosis: Convolutional Neural Networks in Breast Cancer Detection

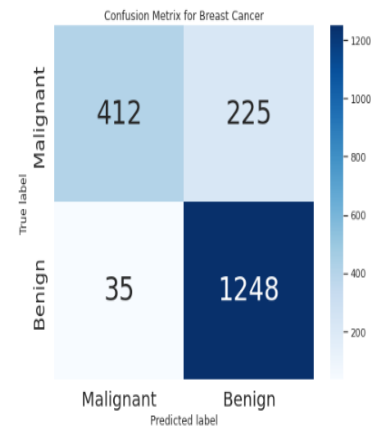
Layer (type)	Output Shape	Param #
conv2d_3 (Conv2D)	(None, 222, 222, 32)	896
max_pooling2d_3 (MaxPooling2D)	(None, 111, 111, 32)	0
conv2d_4 (Conv2D)	(None, 109, 109, 32)	9248
max_pooling2d_4 (MaxPooling2D)	(None, 54, 54, 32)	0
conv2d_5 (Conv2D)	(None, 52, 52, 64)	18496
max_pooling2d_5 (MaxPooling2D)	(None, 26, 26, 64)	0
flatten_1 (Flatten)	(None, 43264)	0
dense_2 (Dense)	(None, 64)	2768960
dropout_1 (Dropout)	(None, 64)	0
dense_3 (Dense)	(None, 1)	65

Total params: 2,797,665  
 Trainable params: 2,797,665  
 Non-trainable params: 0

(A)

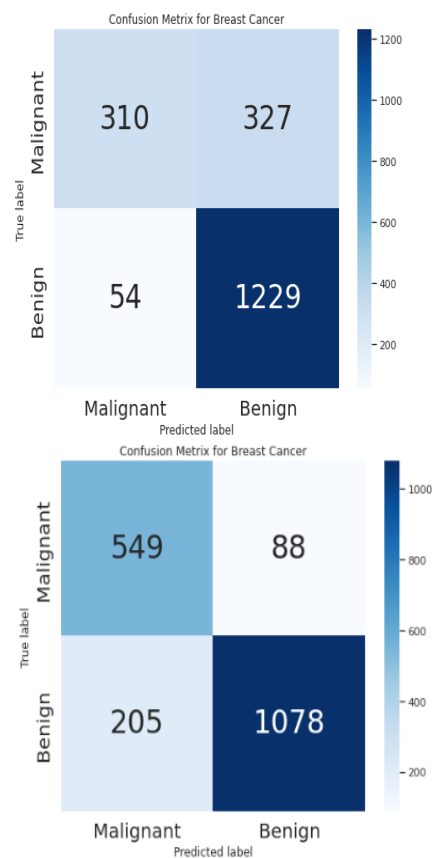
(B)

**Fig.4.** (A) Convolution Neural Network (B) Accuracy Graph



(C) Resnet 50

**Fig.5.** Confusion Matrix

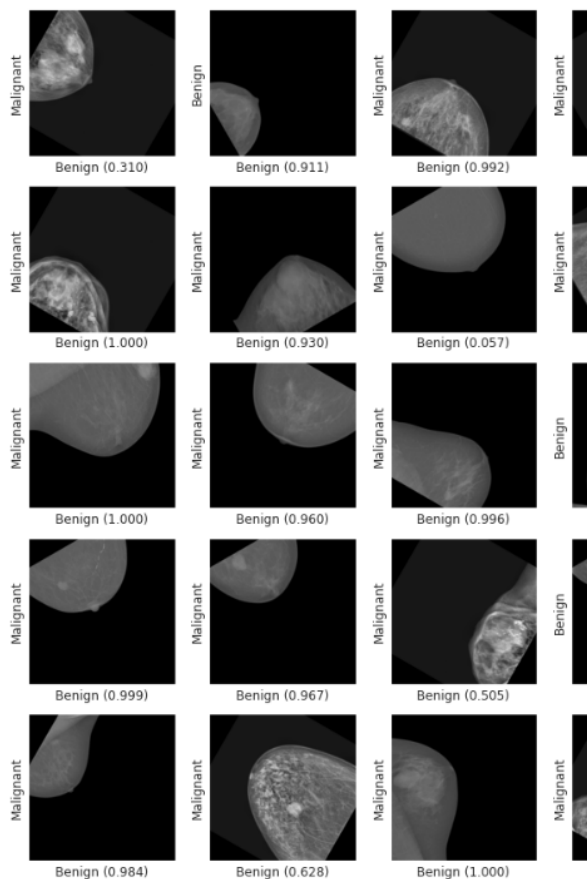


(A) Sequential Model

(B) VGG16 Model

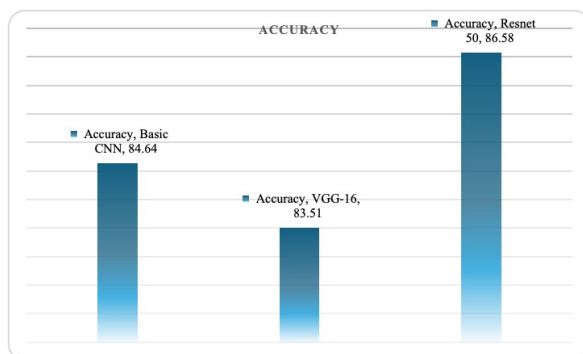
The result of the three confusion matrices show the performance of the model in the detection of breast cancer. The first matrix showed that 310 out of 327 malignant cases were identified as malignant, while 327 benign cases were incorrectly identified as malignant. The False Negative rate was 54 (it missed a few cases of cancer), but the False Positive rate was a bit on the high side. This second matrix presents higher true positive predictions (549), but it was wrong on more cancer cases (205 False Negatives) against the very first matrix, where there is a huge drop down of false positives to 88. The third matrix shows the model making a high number of True Negatives (1248) with a low False Negative (35), so not many cancer cases were missed. The False Positive rate was slightly higher, however (225). These characteristics of the metrics offer insights into the model's pros and cons. Low false negatives are particularly important in medical applications where failure to detect a single malignancy can have grave implications (e.g., breast cancer screening). Model performance can be evaluated using metrics such as accuracy, precision, recall (sensitivity), or F1-score to measure how well the model differentiates between cancer and non-cancer images.

## Empowering Early Diagnosis: Convolutional Neural Networks in Breast Cancer Detection



**Fig.6.** Classification

The classification results of breast cancer detection using a model. Each image is labeled with either "Benign" or "Malignant," along with a probability score, indicating the model's confidence in its prediction. The closer the probability score is to 1.0, the higher the model's confidence that the image is benign or malignant.



**Fig.7.** Accuracy Comparison

### 4. Conclusion and Future Scope

Application of CNNs in breast cancer detection is a major breakthrough in the medical image analysis, especially for early diagnosis. Breast cancer is one of

the deadliest diseases in women worldwide, and early diagnosis is important for patient survival. Although mammography has traditionally served as the main means of screening, its usefulness is often reduced, especially among women with dense breast tissue. Alternative technologies, such as ultrasonography, thermography and wearable biosensors (e.g., smart bras) emerged to address non-invasive, low-cost solutions. These advancements in technologies would, if combined with AI and machine learning methods, greatly improve breast cancer detection accuracy.

Among AI methods, deep learning especially Convolutional Neural Networks (CNNs) has demonstrated tremendous promise in the automation of tumor detection and characterization in medical images [[1], [2], [3]]. CNNs are particularly suitable for this problem, because many times complex patterns in images (like a mass or a micro calcification, which are typically markers for cancer) can be learned in an automatic manner while performing the classification. Through learning between a large mammogram and MRI dataset, CNN could obtain a high classification accuracy of breast tissue between benign and malignant. The paper lists some cnn-based models (ResNet50, AlexNet, MobileNet, EfficientNet) used to extract medical image features and get accurate classification. These models, when used in conjunction with methods such as transfer learning, have resulted in significant advances in the speed and accuracy of diagnosis.

Quantum machine learning, furthermore, is also an emerging trend. Furthermore, because quantum computers could utilise superposition and entanglement, such as superposition and entanglement, computational steps could be accelerated, which will accelerate the ability to analyze very large datasets. This might help to alleviate the current high complexity in training deep learning models, in particular for large-scale medical data.

In this study, the CNN model was also evaluated based on a variety of metrics, such as accuracy, precision and recall, the Receiver Operating Characteristic (ROC) curve. -more-The tremendous aptness of the model was also exhibited, with 99.95% accuracy, a validation loss of 0.6800, and validation accuracy of 76.51%. Also, the confusion matrices indicated that the model did well in terms of discriminating between malignant and benign cases. For instance, the first confusion matrix demonstrated that the model (in

## Empowering Early Diagnosis: Convolutional Neural Networks in Breast Cancer Detection

general) could identify 310 maligns correctly, but it also has shown misclassification by false positive and false negative. The other matrix had low true positive count but it indicated that the model let more cancer cases to be missed, while the last matrix indicated that the model had low false negative number and a relatively high false positive number, which means, in a clinical practice the model might be able to be used to reduce the diagnosing error.

However, there is a space for improvement, such as decreasing the false positive rate. When applied to medical problems, like breast cancer diagnosis, the priority is given to the reduction of false negatives (that is to say detection and cure of cancer cases which would otherwise go undetected, with possibly severe consequences). These further underscores the need to optimize CNN models to balance sensitivity (recall) with specificity (precision).

In short, the study highlights the promise of CNNs in revolutionizing the detection of breast cancer and improving accuracy, speed, and consistency of diagnosis. The integration of AI with wearable biosensors, quantum machine learning, and other emerging technologies also provides a multidisciplinary strategy toward better early detection and reduction of indiscernible cancer. As AI models advance, these systems are anticipated to become more accurate and pervasive, resulting in improved patient outcomes and saving lives. Further investigation of these methods ensures a future of more readily available, time effective, and reliable breast cancer diagnostics.

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