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A Novel Approach for IDC and ILC Kind of Breast Cancer Prediction

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Abstract: Breast cancer is one of the most deadly illnesses that affect women. The remarkable survival rates of this type of diseases are a result of early identification. Various machine learning techniques were employed to predict breast cancer early on. MRI imaging is a widely used early detection method. This framework uses a few machine learning methods to introduce automatic prediction of the type of breast cancer. Contrast Limited Adaptive Histogram Equalization(CLAHE) technique is used to reduce the noise , the DCNN model which contained VGG16, ResNet 50, and DenseNet201 modules used to extract features from breast mammogram images. This framework uses a few machine learning methods to introduce automatic prediction of the type of breast cancer. This research also compares another5 ML techniques with the proposed model such as Logistic Regression, Navie Bayes classifier, KNN, AdaBoosting and random forest techniques. The WDBC dataset, which is available for public access and comprises 1800 pictures and the data from 450 breast cancer patients who had digital mammography between 2018 and 2022, was used to assess this model. Accuracy and precision were used to evaluate the proposed model's performance. The simulation results show how successful the suggested model is due to its high accuracy and low computational needs.

Keywords: *Breast Cancer, Deep Convolutional Neural Network, Deep Learning, Machine Learning, Support Vector Machine.*

1. Introduction

Individuals of all ages and socioeconomic backgrounds are susceptible to the catastrophic consequences of cancer. While there are many distinct forms of cancer, breast cancer is among the most common diseases that affect women. The tissues in the breast area range widely in composition from incredibly hard tissues to notably fatty tissues. Mutations that cause healthy cells to divide and multiply uncontrollably, resulting in a mass of cells known as a tumor, are the cause of breast cancer. Tumors can be classified as malignant or abnormal noncancerous benign tumors. A tumor classified as malignant is one that has the potential to spread to other areas of the body and has the capacity to infiltrate neighbouring tissues. A "benign tumor" is defined as a tumor that is tightly packed, grows slowly, and does not spread to the tissues around. This challenge highlights the necessity for researchers to concentrate on enhancing the prognosis and diagnosis of cancer [1].

Breast cancers vary from one another. Breast cancers are classified according to the kind of tissue in which they first appear. The normal behaviour of breast cancer depends on where it first appears. Physicians can use this information to determine which therapy will work best. The most common types of BC are as follows: Ductal Carcinoma, Lobular Carcinoma, Inflammatory Breast Cancer, Mixed tumor Breast Cancer, Mucinous Breast Cancer which is shown in figure 1.

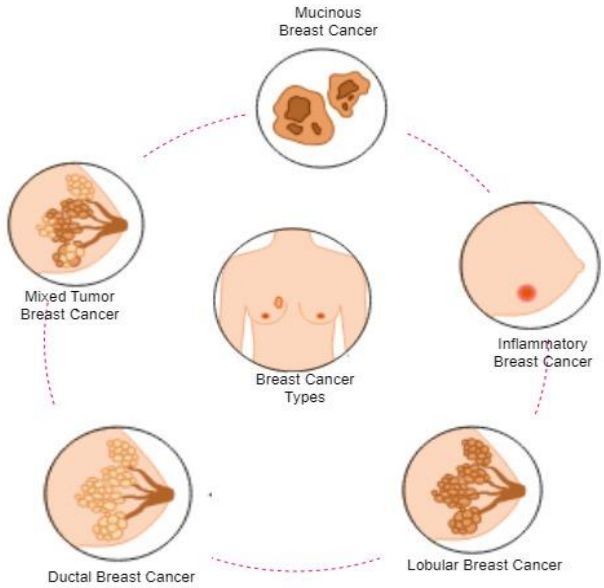

Fig.1. The common types of Breast Cancer

According to the National Breast Cancer Foundation, IDC (Invasive Ductal Carcinoma), also known as infiltrative breast cancer, is the most frequent kind of breast cancer, accounting for 70–80% of all diagnoses. IDC is also the most prevalent kind of breast cancer in women. Intraductal carcinoma is another name for ductal carcinoma in situ, or DCIS. Although DCIS starts in the milk duct cells, it has the potential to progress into a more invasive type of cancer. The American Cancer Society estimates

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that DCIS accounts for one in five newly diagnosed incidences of breast cancer. Unless it goes untreated or undiscovered, in which case it might spread to other places, DCIS is a highly manageable condition which is shown in figure 2. Eighty percent of cases are IDC, which invades surrounding breast tissues. It is feasible to classify IDC based on the conditions surrounding HER2 and hormone receptors [2].

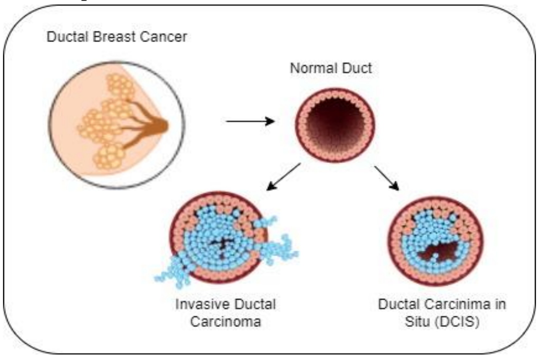

Fig.2. Forms of Ductal Carcinoma

Like IDC, The milk-producing glands called lobules are the initial site of invasive lobular carcinoma (ILC), which can spread to other parts of the body. The incidence of ILC has significantly increased during the past 20 years, mostly in the post-menopausal population. Approximately 1 in 10 cases of invasive breast cancer are ILC, according to the American Cancer Society. Compared to IDC, this type of breast cancer is frequently more difficult to identify with a mammography. Hormone replacement therapy and better diagnostic methods are probably to blame for this. ILC had a ability to spread to the other parts of the body. LCIS is a kind of cancer which will be spread inside the lobule itself, but ILC will spread out of lobules also which is shown in figure 3.

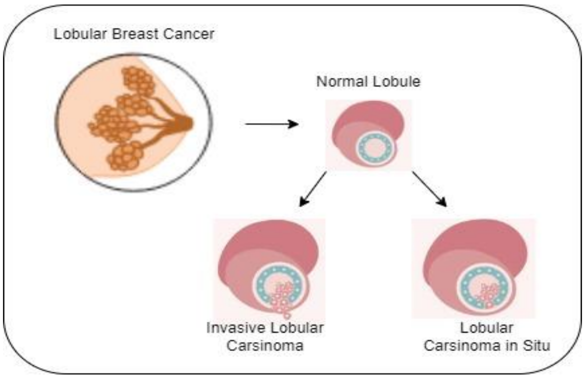

Fig.3. Forms of Lobular Carcinoma

Furthermore, some breast cancers are categorized as mixed-type carcinomas because they exhibit variable percentages of NST and other breast cancer types. Tumors that have a non-specialized pattern in 10%–49% of the tumor and a specialized pattern in at least 50% of the tumor fall into this category. Together with ILC, mixed invasive ductal and lobular carcinomas (IDC-Ls) make up around 5% of all breast cancer cases. The tumor cells may form inside the ducts as well as in the lobules also.

Rapidly spreading inflammatory breast cancer (IBC) is an uncommon kind of the disease. IBC rarely results in breast tissue lumps, in contrast to the majority of breast malignancies. Rather, it manifests as a rash that gives the affected breast's skin an orange peel-like feel. IBC develops when cancerous cells obstruct lymph vessels, which are tiny, hollow tubes that let lymph fluid escape your breast. Because of the inflammation caused by the blockage, it is simple to confuse IBC for an infection.

One uncommon kind of breast cancer is mucinous breast cancer. Its moniker originates from the mucin that envelops the cancer cells. One kind of invasive breast cancer is mucinous breast cancer. This implies that it may extend from the breast to other bodily areas. Paget's disease of the Nipple, an uncommon and severe variant, begins in the milk ducts and spreads to the nipple epidermis and areola. All subtypes of BC (HER2-positive, ILC, and IDC) are included in metastatic BC, often known as stage IV, which is renowned for being incurable.

Treatment for breast cancer necessitates early detection. Thus, proper screening technology is required in order to diagnose breast cancer. Thermographs, mammograms, and ultrasounds are common imaging modalities used to screen for this illness. Mammography can help in breast cancer early detection. When mammography is not successful, women with thick breast tissue usually use diagnostic ultrasonography. Due to these factors thermography and radiography may be able to detect small malignant tumors with more accuracy than ultrasound. This paper offers readers a succinct summary of the situation of the condition of breast cancer diagnosis today and the need for more advanced techniques for diagnosis [3].

The objective of this study is to create an effective model based on machine learning. The suggested method may identify cancer in digital images with different densities, and outcomes can be contrasted with those achieved by applying cutting-edge models. The authors introduced a machine learning strategy to identify breast cancer in digital mammograms with changing density. This investigation can lead to improved early diagnosis and customized treatment of IDC and ILC kind of cancer. It may also have an impact on research, cost-effectiveness, and worldwide healthcare accessibility, which could transform the way breast cancer, is treated and potentially save lives. Healthcare costs can be decreased and breast cancer management can get better as an effect of machine learning's ability to diagnose breast cancer.

2. Related Work

2.73 million Women worldwide received a breast cancer diagnosis in 2023, with 685,000 of those cases ending in death. At the end of 2023, there were 7.8 million women worldwide who had received a BC diagnosis in the preceding 5 years, making it the most common malignancy. Breast cancer can strike a woman at any age after puberty and is more common in older age groups. It is detected in women across the globe. The below table 1 explain about the related literature survey of detection of kinds of breast cancer.

Machine learning-powered automated breast cancer type (IDC or ILC) prediction is presented in this research. Deep Convolutional Neural Networks (DCNNs) were the feature extraction model employed, and to minimize noise, contrast-limiting adaptive histogram equalization was used for digital images of breast cancer. The feature selection classifier model is SVM classifier model to classify IDC and ILC kind of breast cancer. Additionally, the study compares five algorithms: KNN, Random Forest, Ada Boosting classifiers, Naïve Bayes classifier, and Logistic Regression. A large set of 1800; to evaluate the technology composite images were used. This dataset contains the digital mammography results from 450 women between 2018 and 2022.

Table 1. Literature Review of Breast Cancer

Reference	*Algorithm used*	*Dataset Used*	*Description*	*Year*
Anak et al.,	KNN algorithm, CAD technique	Cancer hospital, Indonesia at 2017	The proposed method explain about the classification of breast cancer types IDC and ILC	2018
AAA Gunawan et al.,	SVM algorithm, CAD method	Dr Sutomo Hospital Surabaya	Used to classify the X ray images as ILC and Idc kind of breast cancer	2022
Khalid.Aet al.,	CNN improvement based Breast cancer Classification	3002 images	A powerful deep learning algorithm that can identify breast cancer in digital mammography with different densities	2023
Al-Nawashi et al.,	CNN, CLAHE algorithms	1400 mammograms	Proposed a model which will used to detect breast cancer and also compared with five ML classification algorithms	2024
Zhang T et al.,	ML based technique like MDL-IIA model	Generic dataset	A deep learning-based algorithm that uses diagnostic mammography and ultrasound pictures to predict the molecular subtypes of breast cancer.	2023
Zuo D et al.,	ML techniques like, adabooster, XG booster, MLP,SVC, RF, LR used	342 women dataset	This technique evaluate the 10 ML techniques, among those AdBoosting gave the best results for breast cancer recurrence	2023
Hager Saleh et al.,	Deep RNN, Keras-tuner optimization technique	BCWD dataset	These ML based technique predicting and dignosis of breast cancer effectively and also compare five ML classification algorithm with the proposed model	2022
Kumaraswamy E et al.,	CAD with pretrained CNN models	DataBiox dataset	The proposed model evaluate the IDC BC grade classification using ML techniques	2023
Hayum A.A et al.,	K-means Clustering, Modified Recurrent Neural Network, FCNN	MIAS and DDSM datasets	This model proposed efficient classification model for breast cancer using FCNN technique.	2024
Zarif S et al.,	Hybrid deep learning model as CNN+EfficientNet V2B3	Kaggle open-access database	The proposed model will evaluate the IDC and non IDC tissues using Whole Side Images.	2024
Ravi P et al.,	KNN, SVM, CNN,AlexNet	Breakhis dataset	The creation of a diagnostic tool was the goal of the project that would help medical professionals with the initial digital assessment of histopathological breast tissue slides for IDC that were collected during surgical biopsy.	2023
Sushovan Chaudhury et al.,	Grad CAM with Transfer Learning	Kaggle dataset	This study proposed the automatic IDC cancer evaluation using transfer learning technique	2023

3. Proposed Approach

This research represents a novel method for automatically distinguishing between IDC and ILC types of breast cancer in digital images. A flow diagram representing the block diagram of the proposed method for identifying IDC and ILC kind of breast cancer is shown in Figure 4. Here, are the steps involved in implementing the suggested method.

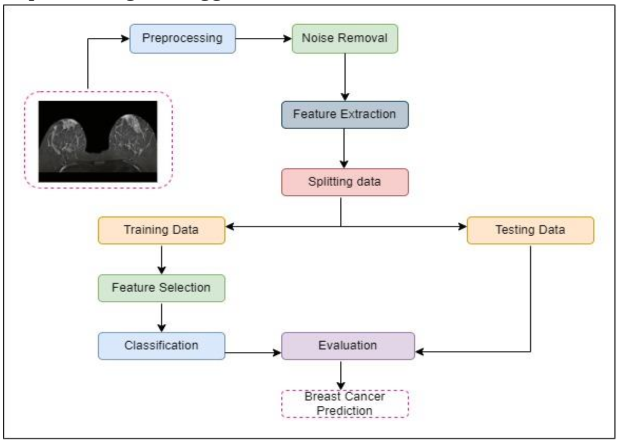

Fig.4. Block diagram for proposed framework

3.1. Pre-Processing

Preprocessing is required to get images ready to be used as an input to a model. For example, the fully linked layers of CNN require image arrays of a consistent size. Preprocessing models may reduce training and inference times. Reducing the size of the input images can save a lot of training time without having a big impact on the model's functionality if the images are big. While pre-processing techniques include geometric image modifications, such as scaling, rotation, and translation, their main objective aims to enhance the image data by either strengthening key aspects required for further processing or by reducing accidental distortions [6]. Here examine the pre-processing described by Equations 1 and 2 in this paper:

$$d_1^i\ (m,n) = \begin{cases} d_1^i(m.n), if e^i(m,n) \le T^i \\ d_1^i(m.n), if e^i(m,n) > T^i \end{cases} \quad (1)$$

$$e^i(m,n) = \begin{cases} \left| d_1^i(m.n) \right|, if \left| d_1^i(m.n) > \right| d_1^i(m+1,n) \right| \\ 0, and \left| d_1^i(m.n) > \right| d_1^i(m-1,n) \right| \end{cases} \quad (2)$$

3.2. Noise Removal

In general, denoising, often known as DE, is the method used to eliminate unwanted noise or distortions from data. Stated differently, DE noising is the process of eliminating noise from a digital picture. Before beginning the picture processing stage, DE noising is essential since images acquired from a database frequently include noise from a variety of sources, including image acquisition, 9 coding, transmission, and processing. It is required to use a Non-Linear Wiener filter with quad tree decomposition and a 4th order partial derivative in order to remove undesired noises [7].

$$(g)=\frac{1}{\sigma 4\sqrt{2\pi}} e^{\frac{(g-m)^2}{2\pi}} dg \quad (3)$$

Here the formula, m stands for the Gaussian noise's mean value, σ2 for the noise's standard deviation in image, and g for each image pixel. This CLAHE (or "Contrast Limited Adaptive Histogram Equalization" algorithm must be applied after DE noise reduction process is finished to adjustment of the varying illumination. Critical data in a breast picture can be significantly improved by using the CLAHE method to enhance contrast.

The figure 5 describe about the before processing and after processing of CLAHE algorithm which will remove the noise. Figure 6 explain about the visual representation of histograms before and after the CLAHE algorithm.

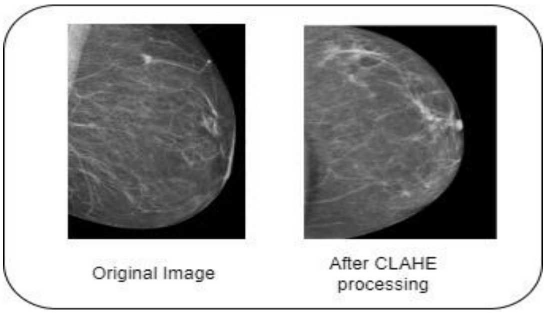

Fig.5. the CLAHE algorithm before and after

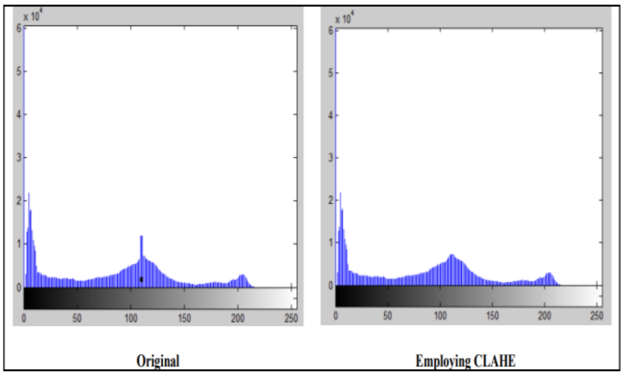

Fig.6. Graphical representation of histograms

3.3. Machine Learning Model

In order to avoid learning new features repeatedly, machine learning involves learning features for one task and then applying them to another. Usually utilized for this are CNN models that were developed using the most popular datasets [16]. After examining an input image, the DCNN model weighs different factors. After examining an input image, the DCNN model weighs different factors in an attempt to identify images that are similar in multiple layers as shown in figure 7.

The sequential model, which forms the basis of the architecture presented in this research, allows the model to organize the network's successive layers in a sequential fashion, beginning at the input and moving toward the output. The input image is pre-processed through the CLAHE algorithm which will remove the noise of image. And then features extraction done through the deep CNN models. The convolution layer uses filters to scan the input image according to its dimensions and perform convolution operations. The stride and filter size, which show how far apart subsequent receptive filters are from one another, are the hyper-parameters of this model. A feature map is the term used to describe the resultant output. A two-dimensional convolutional layer is added during the processing of the original breast images with VGG16 [22]. The number of output channels is the first input passed to the convolution layer function with ResNet50. In the suggested method, spatial convolution was achieved by using a (3x3) filter kernel with a stride of 1. The picture's height and width are traversed by the kernel. In order to evaluate the variances, and also carried out analyses employing a range of kernel sizes, from 1 to 7. It has been noticed that employing a small kernel size of (1×1) limits the network's capability. The usage of padding had been considered in this model to ensure that the chosen stride and filter completely cover the input image.

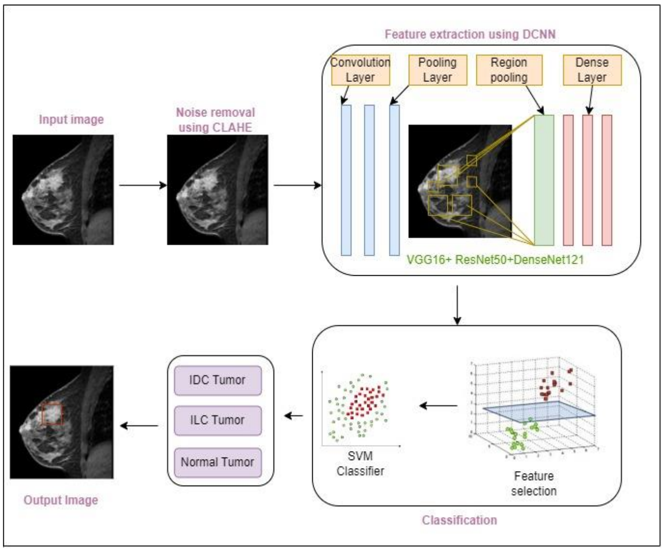

Fig.7. Architecture diagram of proposed system

This approach makes use of the RELU (or "Rectified Linear Unit") activation function, which is written as f(x) = max(0,x). Here, the input is denoted as x. The feature map's spatial dimensions are decreased when max pooling is used [17]. By choosing the maximum value within a predetermined window size for each dimension along the axis of the feature, the Max-pooling function minimizes the size of the input representation. Further convolutional layers are also used to duplicate the process; these layers yield, 32 and 64 output channels respectively. A 2x2 max pooling filter is used at first. The dense layer is a fully connected layer used to extract from max pooling. The features are extracted from these deep CNN systems [21].

After feature extraction, the classification is done through the SVM classification model [18]. One of the most effective classification tools for pattern recognition algorithms is the SVM learning component of machine learning. Compared too many other classification algorithms [24], SVM method performs better in pattern recognition issues and offers superior classification results. Binary classification is carried out using SVM, which divides a collection of training vectors that divide the data point $x_i = \{x_1, x_2, \dots x_m\} \in R^d$ into two separate classes (x_1, y_1), (x_2, y_2),..., (x_m, y_m), where d is dimension and $y_i \in \{-1, +1\}$. The input vector should then be transformed into a new, higher-dimensional feature space named $\phi{:}R^d \rightarrow H^f$, where d<f as illustrated in Figure 8. In the newly created feature space, the optimal dividing hyper plane is then created by the kernel function K (x_i, x_j), which is the product of the input vectors x_i and x_j, where K (x_i, x_j) = F (x_i) F (x_j). To be more precise, every

vector on one side of the hyper plane is labelled as -1 for IDC, and every vector on the another side is labelled as +1 for ILC.

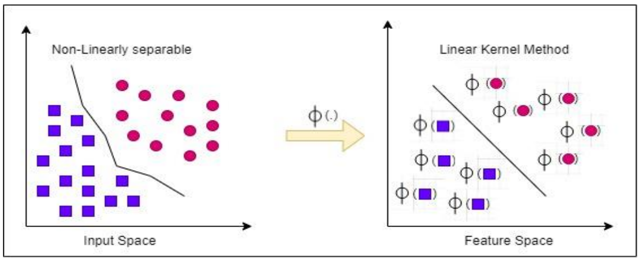

Fig.8. Illustration of Linear kernel method based SVM classification

4. Results Evaluation

A classifier's accuracy and precision can be examined using a variety of evaluation instruments. The approach built with MATLAB version 2017 and tested it on a large number of mammography images. The computer had an Intel Core i7 processor and 8GB of RAM installed which is used for the testing. This study's objective is to assess the suggested approach's performance accuracy and precision and compare it with the most recent ML methods. In this work, the BC prediction is done by ML classifiers such LR , Ada Booster, NB (Naive Bayes), RF and KNN[20] which is shown in Table 2 and graphically shown in Figure 9.

Table 2: Evaluation of several classification models

Classifier	Accuracy	Precision
Logistic Regression (LR)	0.9637	0.9376
Ada Booster	0.9563	0.9272
Random Forest(RF)	0.9587	0.9677
K-Nearest Neighbor (KNN)	0.9441	0.9202
Naive Bayes	0.9498	0.9131
Proposed Approach	0.9845	0.9945

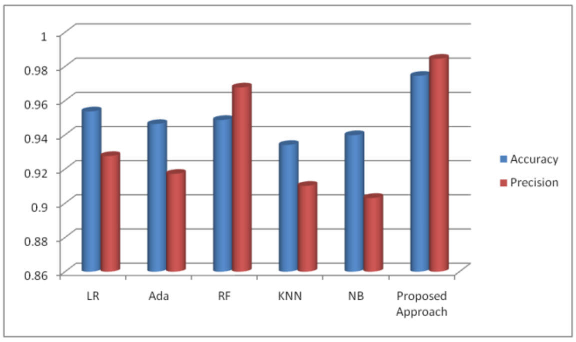

Fig.9. Graphical Evaluation of several classification models

The proposed method improves the results of breast cancer screening and helps with automatic illness identification. The outcomes show a high accuracy of 98.45% and a noteworthy precision of 99.35%.

5. Conclusion and Future Perspectives

Breast cancer has the greatest cancer death rate. It's critical to identify breast cancer at early stage. Breast cancer data can be used to diagnose using various machine learning techniques. This work presents the BC prediction type using ML techniques. Noise was minimized using CLAHE; Features were extracted using DCNN models like VGG16, Res Net50, and DenseNet121. SVM was used as the classifier model to classify breast cancer type as IDC or ILC. Additionally, five algorithms are analyzed in this study: Logistic Regression, Random Forest, Ada Booster, KNN, and Naïve Bayes classifier. To test the proposed technique 1800 digital images were used to classify the breast cancer technique from 450 cancer patients. System performance is measured by precision and accuracy. Proposed model's great precision and minimal computing power make it effective in simulations. In the future, dimension reduction methods can be used to lower the number of dimensions in datasets and ensemble machine learning methodologies to enhance evaluation of each unique model. Researchers, data scientists, and medical experts must collaborate in order to achieve significant progress in the identification of breast cancer and its treatment.

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