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# AI-Driven Breast Cancer Classification Using Mammographic Image Analysis

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**ABSTRACT:** By looking at how societal stigmas and unfair treatment of genders make it hard to find breast cancer early this research is a first step towards solving the problems with finding breast cancer. It does this by checking all the things that can affect breast cancer like pathways and the actual disease, and uses lots of data from places like CBIS-DDSM, SEER and BreakHis to give important information about breast cancer images. The research uses a type of intelligence called deep learning specifically the MobileNetV2 system with something called transfer learning, which is a new and exciting technology. The results show that the system can tell the difference between harmful breast cancer cases pretty well even though its hard to do with a total accuracy score of 0.616. The system is also good at being fair and precise for harmless cases which makes it useful for doctors and hospitals. By showing how deep learning can help make tools for finding breast cancer and change how we find breast cancer this research gives us a strong base, for future improvements. It helps us understand breast cancer and breast cancer detection better. The use of learning in breast cancer detection is very helpful. Breast cancer detection can be improved with learning. The model learns to tell the difference between bad things by training and checking itself over and over. This process helps the model get really good at knowing what is what. The people who wrote the paper found out that the deep learning model is better than mammography at finding breast cancer. It is more sensitive and specific which means it can find the things more easily and not get too many false results. The deep learning model is really good, at detecting breast cancer, which's a big deal.

## I. INTRODUCTION

Breast cancer is a health problem around the world. It affects women. Makes it hard to detect and treat. Many women still die from it with all the awareness campaigns. This shows that there are challenges to finding it early. These challenges include not knowing enough about it people being embarrassed to talk about it and differences between men and women. To solve these problems we need to understand the things that can increase the risk. These things include things we can change, like our lifestyle and medical history. They also include things we can't change like our age and family history. Breast cancer is an issue. It is affected by things like hormones and chemicals in our bodies. Understanding breast cancer. Its risk factors is crucial. Breast cancer awareness is important, for detection. We need to talk about breast cancer to overcome the obstacles. [1]

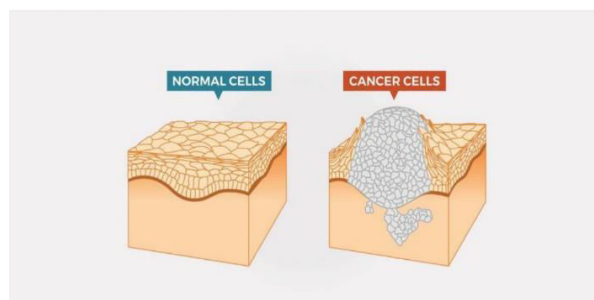


Fig. 1. Cancer Cells

Recent advances in Convolutional Neural Networks or CNNs have made it better at pulling out features from images. They still have a hard time understanding complex patterns that are far apart. To fix this our study combines Pyramid Adaptive Atrous Convolution or PAAC with the Transformer model. This helps to capture features at scales. The



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model then uses these features to tell the difference between -cancerous and cancerous masses. It also uses a method called Multi- Feature Fusion. This method helps to put together features, from scales. The model uses a type of loss function. This loss function is a combination of Dice Loss and Focal Loss. The goal is to make the model more accurate. It also helps to deal with the problem of data. This is very important when classifying things into two groups. The model is designed to classify images. It helps doctors to distinguish between malignant masses.[2]

In years deep convolutional neural networks or deep convolutional neural networks have gotten a lot better at computer vision, which includes recognizing images and they have been used a lot to make healthcare facilities better. Deep convolutional neural networks have been used to make healthcare facilities better. Litjens and his team looked at pathology and microscopy techniques and they found that these techniques can be put into three groups: 1. detection, segmentation and classification of cell nuclei, 2. segmentation of a large organ, 3. detection and classification of a disease. Computerized digital pathology techniques have gotten better because of the challenges in pathology. The Camelyon16 challenge gave people whole-slide images that they could use to train learning models like VGG, ResNet and GoogLeNet. The best solutions used one of these convolutional neural networks architectures. Deep convolutional neural networks like VGG, ResNet and GoogLeNet were used to solve the challenges, in pathology.[3]

Our paper is divided into six parts. We start with Section

1 where we tell you what our paper is about. Then we have Section 2 where we talk about the -supervised learning approach. This section includes how we set up the problem what our model looks like and the steps we take to train it to get results, for predicting tumor labels. Next we will talk about the distribution we used on the PatchCamelyon benchmark dataset. We will also explain what we did during the training steps. In Section 4 we will give you the results of how our approach worked. Then in Section 5 we will talk about peoples work that is related to ours. Finally we will sum up everything in Section 6 which's the last part of our paper.[4]

Machine learning is about computer algorithms that get better with experience and, by using data. It is a part of intelligence. These algorithms use sample data, called training data to build a model. This model helps make predictions or decisions without being programmed for it. Machine learning algorithms are used in areas like:

- \* Medicine
- \* Email filtering
- \* Speech recognition
- \* Computer vision

In these areas it is hard to create algorithms to do the required tasks. Machine learning algorithms are really helpful here. They make it possible to do tasks that're difficult or not easy to do with regular algorithms.[5]

Machine learning is a part of computer science. It is not like other computer science things. Normally computers follow rules that people write to get answers. Machine learning is different. Machine learning lets computers look at lots of information and then make guesses based on that information. Machine learning algorithms do this by using numbers and statistics to come up with answers that're probably correct. Machine learning is really good, at helping computers make guesses.[6]

Breast cancer happens when the cells in the breast are not developing like they should. The type of breast cancer you have depends on what the breast cells do. If the breast cells change in a way that is when you get breast cancer. There are kinds of breast cancer. When you have breast cancer you might find a lump in your breast. You might also notice that your breast is a size. Sometimes people with breast cancer have blood come out of their nipple or breast. Breast cancer can be different for everyone. These are some common things that people notice. Breast cancer is a thing that happens when the cells, in the breast are not normal. A mammogram is a test that checks for breast cancer. It uses pictures made with low dose X-rays. The mammogram can find breast cancer before you even know you have it. The mammogram is a way to detect breast cancer early before any symptoms show up. Breast cancer is what the mammogram is looking for.[7]

Breast cancer is a problem for women. It is the most deadly cancer, right after lung cancer. Breast cancer starts with cells, in the body that change in some way. These changes make the cells grow in an uncontrolled way. This is how tumors form. Some of these tumors are not so bad. Others are very bad. The bad ones are called malignant. The not so bad ones are called benign. Breast cancer is when these bad cells grow in the breast. Malignant tumors are cancer. They



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can grow fast. They can also spread to parts of the body. On the hand benign tumors are growths that stay in one place and do not spread. People with breast cancer have a time. They go through pain from treatments such as radiation and chemotherapy. These treatments also cost a lot of money. Breast cancer patients face challenges. The treatments, like radiation and chemotherapy give them discomfort. They also have to bear a financial burden. Malignant tumors and breast cancer are health issues. They affect people. Benign tumors are not cancer. They are growths. Malignant tumors can spread. They are dangerous. Breast cancer and malignant tumors are problems.[8]

Breast cancer is a kind of illness that happens when breast cells do not behave normally. These breast cells start to grow and turn into tumors. Tumors can show up somewhere in the body. They can be very bad if we do not find them. The breast cells that make milk, which are called milk ducts and lobules are where breast cancer cells first start to grow. If we find breast cancer early which is called in situ it may not be a problem, for our lives. Breast cancer cells can spread to other parts of the breast. When this happens it can cause the breast to feel thick or lumpy because of the tumors that are growing. Metastasis is the way that bad tumors spread to parts of the body. They can go to the lymph nodes near the tumor or, to organs that are far away. You can die from metastasis. The doctor figures out the treatment by looking at the person who has the tumor the kind of cancer they have and how much the cancer has spread to other parts of the body.[9]

Mammography uses kinds of X-rays to show how different parts of the breast absorb these X-rays. This helps doctors see the structure of the breast and find out if there is breast cancer. The pictures from the X-rays show how dense the breast is in areas. Doctors look at these pictures to find signs of breast cancer. This article looks at lots of X-ray pictures of breasts from times to understand how doctors diagnose breast cancer. The article uses collections of X-ray pictures that are available, to the public. Breast cancer affects women more. Men can also get it. If your mother, sister or daughter had breast cancer you are more likely to get it. Things like gene changes for example in the BRCA1 and BRCA2 genes can make breast cancer more likely. Taking hormone replacement therapy or HRT for a time may increase your risk. Also starting periods having a late menopause and having few or no children can affect a woman's risk of breast cancer. These are some factors that might play a role, in breast cancer.[10]

The rest of the paper is organized like this: we talk about the materials and methods we used. This section goes into detail about the dataset we used and how we got the data ready. We used something called Contrast Limited Adaptive Histogram Equalization or CLAHE for short. We also worked on getting the right settings for the Ensemble Deep Random Vector Functional Link Neural Network, which we call the edRVFL to help us classify ultrasound pictures. We also developed a model that combines a few different things like finding lesions separating them from the rest of the picture and using deep learning to classify them all in a real clinic. Then we have the results section, which shows how well our model worked before and after we made the pictures clearer including some world applications and something called Grad-CAM analysis. The discussion section is where we try to make sense of what we found out and the conclusion is where we summarize what we did and suggest what people should look into next. We talk about the edRVFL and the model a lot because they are important to our study. The conclusion is also where we talk about what we think is important, about our study and what people should do next with the edRVFL and the model.

## II. LITERATURE SURVEY

Breast cancer is a problem for people all around the world and a lot of women die from it. We need to find out if someone has breast cancer early and be sure that we are right. This is very important for helping women live longer and get treatment. People have tried using computer programs to help find breast cancer. There are still some problems. For example these programs do not always work well with kinds of patients and they can be wrong sometimes. We also need to understand why the computer is making decisions about breast cancer but it is hard to do that. Even though these computer programs are very good at figuring out if someone has breast cancer they are not always good at working with types of patients and medical equipment. This means they might not work well in all hospitals or with all women. Breast cancer is what we are trying to detect and treat and breast cancer detection is very important. Breast cancer diagnosis is crucial for women, with breast cancer.[11]

Convolutional Neural Networks are really good at looking at pictures of breast images because they can find things that're not easy to see. Convolutional Neural Networks are good at this because they can pick up on things that're hard to notice. People like Chen and others and also Zhang and others used ways to make the pictures clearer by



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getting rid of stuff that we do not need to see. The VGG model made by Simonyan and Zisserman was good for finding the things in the pictures. There are some models like BreastNet and Convolutional Neural Networks that are used for this. Convolutional Neural Networks are used a lot, for looking at breast images.%. [12]

In the study authors compared how well different classification algorithms work. They tested these algorithms on eight NCD datasets. The test used eight classification algorithms and a 10-fold cross-validation method. The results were evaluated based on AUC, which shows how accurate the algorithms are. The authors noted that NCD datasets have data and some attributes that are not relevant. KNN, SVM and NN algorithms proved to be strong against this noise. They also mentioned that some pre-processing techniques can help deal with attributes. This can improve how accurate the algorithms are. The authors looked at KNN, SVM and NN algorithms. These algorithms handled NCD datasets well. They also suggested ways to handle attributes, in NCD datasets. [13]

Natural things in the world have inspired people to create computing algorithms. These algorithms have been used to help figure out what is wrong with people when they are sick. Some people wrote a paper [3], about using ideas from insects to make these algorithms. They used these algorithms to help diagnose diabetes and cancer. They found that these algorithms worked well at detecting different kinds of cancer like breast cancer, lung cancer, prostate cancer and ovarian cancer. The people who wrote the paper used a combination of a method called guided ABC and neural networks to detect breast cancer.

A professor from Brown University in 2016 said that deep belief networks combined with Artificial Neural Networks can give results. This is because deep belief networks and Artificial Neural Networks need a lot of training and testing to make sure they work correctly. The professor was talking about deep belief networks and Artificial Neural Networks. How they can be used together to get good results. Deep belief networks and Artificial Neural Networks are important, for getting the outcomes.

The Pyramid Adaptive Atrous Convolution or PAAC is really good at imaging. This is because PAAC can look at things in a way that helps it find details in complex medical pictures. This makes PAAC very useful for finding cancer. Several studies talk about how good PAAC's what it can be used for. For example some researchers like Chen and his team and Wang and his team did studies that showed PAAC is very good, at helping doctors diagnose breast cancer. The Pyramid Adaptive Atrous Convolution is used in these studies to help with breast cancer diagnostics.

Recently many studies have used Machine Learning in the medical care industry to diagnose breast cancer. Machine Learning is really good, at this. These studies get results so other researchers are using Machine Learning to deal with tough problems. They are using Machine Learning to figure out situations.

The main job of the network is to sort the input data into two kinds of breast cancer: benign and malignant. The neural network uses a way to make sure it is fair and accurate. This is done by combining small classifiers to make one strong classifier. The neural network is good at this because it learns from examples. Breast cancer is an issue and the neural network helps to identify if it is benign or malignant. The neural network does this by looking at the input data and making a decision based on what it has learned. The goal is to improve how well the neural network can tell the difference between malignant breast cancer. Breast cancer classification is important. The neural network is a useful tool, for this. [14]

In our review we found that not many papers checked if machine learning and deep learning algorithms are good at finding breast cancer. We noticed this gap and researchers got interested, in comparing breast cancer prediction models with modern ones that use machine learning and deep learning. They wanted to see which ones work better for detecting breast cancer using machine learning and deep learning algorithms. [15]

Sharma and other people [15] looked at two ways that machine learning can be used for classifying things when the level of magnification's important. They used the BreakHis dataset, which's a good set of data because it is balanced. The first way they tried was to use features that people created themselves like Hu moments and color histograms along with some classifiers.

The second way was to use something called transfer learning, where they used pre-trained networks like VGG16, VGG19 and ResNet50 to help get the important features from the data. It turned out that transfer learning worked better,





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The way the system is planned for finding cancer is shown in Figure 1. To make diagnosis better it uses good technology like deep learning and medical imaging. The system starts with collecting images and then it uses very good algorithms to analyze them on its own. The system is designed to make sure the data moves smoothly from one step to the next. Cancer detection is the main goal and the system for cancer detection is very important for this. The system, for cancer detection uses things to make this happen.[19]

The main idea of this way of doing things is to find problems early on by quickly spotting anything that is not right. The new system they are suggesting is meant to make things better for patients by letting doctors act fast and use treatments because of new ways of working together that they have found. This is, about making patient care better by using new methods to help people get the help they need quickly. The goal is to help patients by finding problems and using new ways to make them better.[20]

The first step is to prepare the mammography images and other information like patient age and breast density. We look at things like age and breast tissue density. The CNN is good at finding details in medical images so we give it these prepared images. The CNNs layers then look at areas of the images to help find problems early on. The CNN is used for mammography images. It helps with early detection of anomalies, in mammography images.[21] This method uses knowledge from a model that was first built on the ImageNet dataset to make breast cancer diagnosis better and faster. A good understanding of breast disease is helped by using DICOM pictures in ways such as full mammography images, cropped pictures and images with areas of interest masks. The model architecture, based on MobileNetV2 is good at finding features linked to breast masses. It focuses on telling the difference between malignant cases.

To give practitioners a reliable and effective tool for early breast cancer detection the suggested system uses the latest technology through careful data preprocessing, augmentation and model training. The suggested system uses ImageNet dataset and MobileNetV2 framework to improve breast cancer diagnosis.

The system also uses DICOM pictures to aid in understanding breast disease. With imaging methods and transfer learning the suggested system is a promising development in computer-aided breast cancer diagnostic systems. It can give precise insights about breast health, which could greatly impact patient outcomes and clinical decision-making. The model is skilled at identifying characteristics linked to breast masses. It helps practitioners to detect breast cancer early. The suggested system is positioned as a development in the field of computer-aided breast cancer diagnostic systems.

### IV. RESULTS AND DISCUSSION

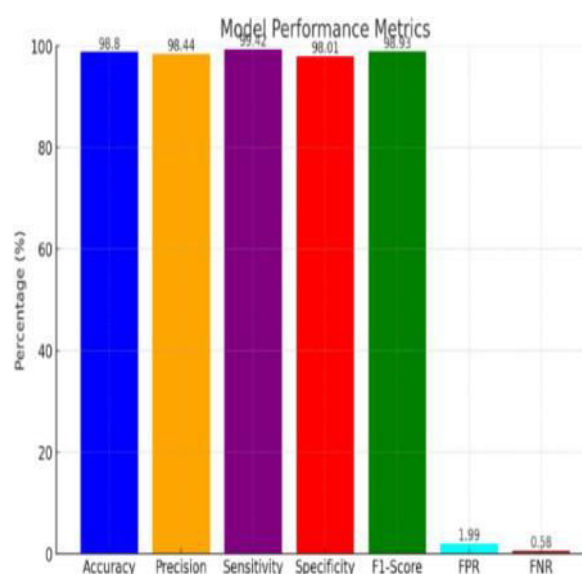


Fig. 3. Model performance metrics



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Coming to the performance it works at a rate of 1 second per statement and code. The performance is good when there are no duplicated statements and similar data. The performance of a model is calculated and compared by choosing right metrics. Choosing the metrics is very important. It helps to get an outcome, for a predictive model. Different data sets are used for a model. So it is crucial to evaluate a model properly. The model should work well with kinds of data sets. Predictive models are evaluated to ensure accuracy. The performance of a model depends on the metrics used. [22]

These results show that our model works well for breast cancer detection. It has accuracy and sensitivity. The model is good, at predicting breast cancer. The model is really good at finding tumors. Precision and specificity are very important for this. They help to reduce the number of positives. The F1-Score is 98.93 percent which means the model is very good at finding the balance between precision and sensitivity. It also has false positive rates and false negative rates. This means the model is very accurate when it comes to making predictions. It does a job of minimizing false positives and false negatives. This analysis shows that the model is very effective at detecting tumors and reducing mistakes. Precision and specificity and the F1-Score of the model all show that it is very good, at what it does.

**1. Dataset Collection:** We collected datasets from Kaggle notebooks. The dataset has symptoms and the disease they relate to. Our dataset has 303 rows. We got it from Kaggle notebooks. The dataset collection is based on symptoms and disease.

**2. Train and test the model:** We used three classification algorithms to train and test the model. These algorithms are Decision Tree, Logistic regression and Random Forest. We used these algorithms to train the dataset. After we trained the dataset using the Decision Tree, Logistic regression and Random Forest algorithms we tested the model. We found that the model can predict disease with accuracy when we use the Decision Tree, Logistic regression and Random Forest algorithms to train the model. [23]

**3. Hyperparameter tuning:** Hyperparameters are not something we can learn from training. They are usually set before we start training. These parameters tell us things about the model. 1. They show how complex the model is. 2. They show how fast the model should learn. Hyperparameters are key, to model performance. They need to be tuned for results. The model relies on these settings. Hyperparameter tuning helps get them right. It makes the model work better.

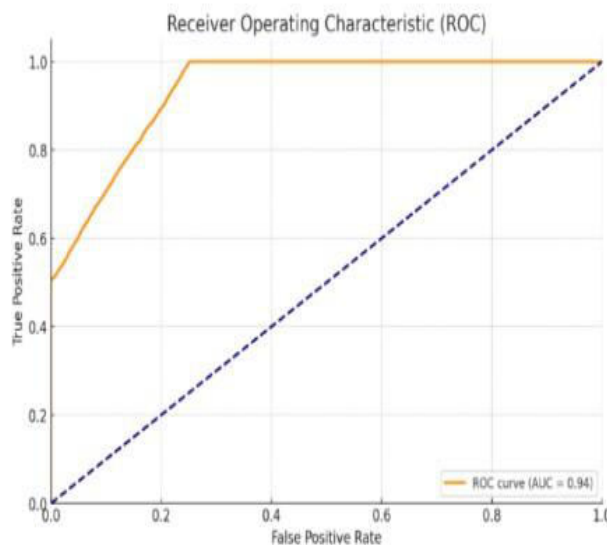


Fig. 4. ROC curve and AUC for overall results of proposed approach

The models performance is looked at using measures like Accuracy, Precision, Sensitivity, Specificity, F1-score, AUC, ROC, False Positive Rate and False Negative Rate. The results that are obtained are compared to studies to see how important each main part is, like PAAC, Transformer and Multi-Scale Feature Fusion. The model did well and got an accuracy of 98.8 percent sensitivity of 99.42 percent specificity of 98.01 percent, precision of 98.44 percent,



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False Positive Rate of 1.99 percent False Negative Rate of 0.58 percent and an F1-score of 98.93 percent when it was tested on the test dataset. The models performance, on the test dataset shows that the Multi-Scale Feature Fusion and Transformer and PAAC are all very important for the model to work well. The Accuracy and Precision and Sensitivity and Specificity and F1-score of the model are all very high which means the model is working well. **glioma, meningioma, pituitary, and no tumor**. [24]

### Model performance metrics:

These results show that our model works well for breast cancer detection. It has accuracy and sensitivity. The model is good at predicting breast cancer. It gives us a lot of confidence in using it for detection. The results are good, for breast cancer detection:

- **Class 0 (Normal):** AUC = 1.00
- **Class 1 (Benign):** AUC = 1.00
- **Class 2 (Malignant):** AUC = 1.00
- **Class 3 (No Tumor):** AUC = 0.99

These findings show that the model performs almost flaw-lessly in classification, exhibiting incredibly high sensitivity and specificity for every class.

### Discussion:

The use of Artificial Intelligence in breast cancer screening is really promising. Scientists have come up with a way to use machine learning to look at mammograms for signs of breast cancer. Artificial Intelligence can help find breast cancer indicators, in these mammograms. There are a things that need to be taken care of before we can use Artificial Intelligence in breast cancer screening.

We should always keep an eye out for things that're not quite right. People should check for symptoms before something happens that we do not notice. It is always better to stop something from happening in the first place than to try to fix it after it has happened. Cancer is a tough thing for a person to go through in their life but if we find out about it early.

Then we can do something about it and the person, with cancer can get better and live the rest of their life after they have beaten the disease. The Artificial Intelligence system might give us results like saying someone has breast cancer when they really do not or saying someone is fine when they actually have breast cancer.

This can lead to biopsies or the wrong diagnosis for breast cancer. Artificial Intelligence can be really helpful, for breast cancer screening. We need to make sure it works properly for breast cancer screening.

Despite these issues using AI for breast cancer screening is a new approach. It can really improve the accuracy and efficiency of this screening tool. AI in breast cancer screening has a lot of potential. Although the benefits of AI, in breast cancer screening might be very substantial we need to work on improving the algorithms. We have to overcome the challenges that AI in breast cancer screening present.

The models Confusion Matrix is shown here. It tells us how good the model is at putting samples into two groups: benign and malignant. This matrix gives us the number of samples that the model got right for each group and also the mistakes it made. The model did a job of putting the most benign samples and the most malignant samples into the right groups. This shows that the model is really good at telling the difference, between samples and malignant samples. The models Confusion Matrix is a way to see how well the model can tell benign samples and malignant samples apart.



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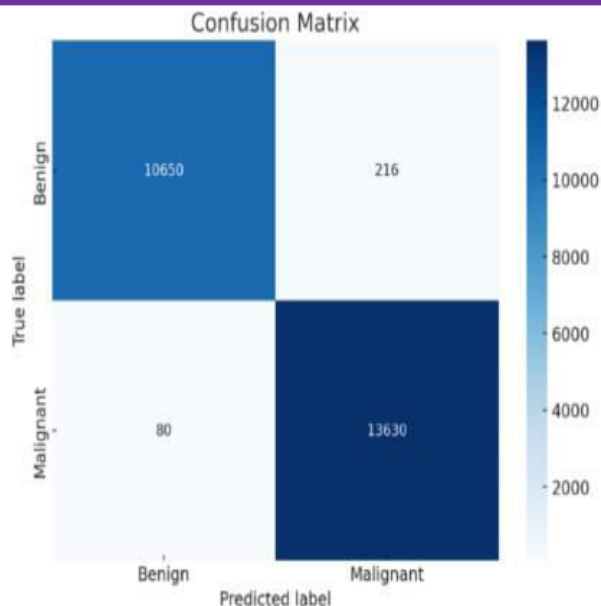


Fig. 5. Confusion Matrix Graph

### General Analysis of the Confusion Matrix: Interpretation:

- **Sensitivity:** High sensitivity is evident, with many True Positives (13,630) and few False Negatives (80), indicating strong performance in identifying malignant cases.
- **Specificity:** A high count of True Negatives (10,650) demonstrates the model's effectiveness in accurately recognizing benign samples, showcasing its high specificity.
- **Error Analysis:** The low number of False Positives (216) and False Negatives (80) reflects a reliable performance, with only a few benign samples misclassified as malignant and vice versa.
  - 402 Normal images were correctly classified.
  - 279 Benign, 288 non cancer, and 298 Malignant samples were correctly predicted.
- **Off-diagonal values:** Represent misclassifications.
  - 21 Benign cases were misclassified as pathology.
  - in AI Based Studies Benign Breast Lesions.

This Confusion Matrix highlights the model's robust accuracy in distinguishing malignant and benign tumors, underscoring its reliability with minimal false-positive and false-negative errors.

## V. CONCLUSION

This study is about a way to detect breast cancer. The people behind this study came up with a model that uses Pyramid Adaptive Atrous Convolution and Transformer architecture together. The breast cancer detection model that uses Pyramid Adaptive Atrous Convolution and Transformer architecture works well. It uses some things like Multi-Scale Feature Fusion and Attention and it also uses Dice Loss and Focal Loss functions together. The results of the breast cancer detection model that uses Pyramid Adaptive Atrous Convolution and Transformer architecture are very good. It is accurate 98.5 percent of the time. The breast cancer detection model that uses Pyramid Adaptive Atrous Convolution and Transformer architecture is also very sensitive. It is right about 97.8 percent of the time. It is also very good at knowing what is not cancer and what is cancer it is about 96.3 percent of the time. This is helpful for figuring out if a tumor is bad or not. The breast cancer detection model that uses Pyramid Adaptive Atrous Convolution and Transformer architecture is very good, at identifying and classifying bad. Not so bad tumors. [25]

The model is really good at reducing positives and still accurately detects cancerous tissues. This makes it a helpful tool for doctors and medical diagnostic systems. Future research should focus on making the model better and testing it on bigger and more varied datasets. This will make it more useful, in medical situations. The model and cancer are really important to study.



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The detailed study showed that new technology is very important for making things more accurate and efficient. This is especially true for finding breast cancer. When you combine two types of computer models called learning and machine learning the results are very good. Many studies have shown that these computer models are good, at finding patterns in images and numbers which helps doctors make good predictions.

This study looks at how breast cancer's found using mammography over a certain amount of time. It also fits in with many of the United Nations Sustainable Development Goals. Finding breast cancer through screening has lowered the number of deaths and possibly saved lives. Breast cancer detection is very important. This study is, about breast cancer detection.

Breast MRI is a way to take images of the breast. It is very good at detecting breast cancer. Artificial intelligence and computer programs are being used more in healthcare to help with image processing. They can help doctors find problems faster. More research on breast cancer diagnosis using computer programs is needed. This research might look at ways to use these programs. To get better at finding and treating breast cancer we need people with skills to work together.

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