An Efficient Approach for Diagnosing the Breast Cancer Using Deep Learning Technique

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Abstract

Background: Now a days breast cancer is one of the deadliest diseases found in most of the matured women. The Cancer disease is curable if it is diagnosed at initial stages. But once it goes to the final stages it is very hard to cure and which leads the patient to death.
Objectives: In this paper, we proposed a model to diagnosis the cancer which gives a clinical support to the physician for initial diagnosis of breast cancer. In general, the cancer disease is identified if there is a tumour growth is appeared in the human body. But before the tumour grows, there may be change in textures of the different biological parts in the region of breast where tumours can be grown. Here, in this paper, we propose an image processing technique to detect the change in structural parameters of the mammography images.
Methods: The proposed image processing technique and convolutional neural network were combined here which forms a layered approach in deep learning. Here, we prefer manual prediction of the images rather than automatic bulky predictions so as to ensure an image is correctly predicted whether it is malignant or benignant.
Results and Conclusion: As based on the experimental results, we prove that the proposed work attains outstanding results compared to the ideal CNN approach in terms of wide variety of parameters such as accuracy of detection, Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Prediction Value (NPV), Mathew's Correlation Coefficient(MCC).

Keywords - *Breast cancer, benign, malign, Convolutional Neural Network, Image Processing, image pre-processing, accuracy, loss, Sensitivity, Specificity, PPV, NPVM confusion matrix, keras, tensor flow, epochs, convolutional layer.*

1. Introduction

Cancer is one of the deadliest diseases around the world. Among all types of cancers, women are mostly affected by breast cancer which can turn to fatal if it is not diagnosed earlier. Currently the first procedure of diagnosing breast cancer is by taking mammography images. After that radiologist and physician clinically detect the mammography image as malign or benign only if a tumour is found on those mammography image regions. But this is not the accurate may of diagnosing breast cancer because tumours can be observed only at the end of early stages and stage 1. So, in such a condition there is a huge chance of spreading cancerous cell to various part of our

body. Thus, always detection of cancerous cell in stage 0 or starting of early stages is preferable and is more prone for curing. Also diagnosing at earlier stages will also reduce the struggle faced by the patient. In Fig.1, we can see the different stages of breast cancer. The first two stages are the initial stage of cancer formation. Basic tissue texture change and cancerous cell formation occurs. There won't be much changes to health condition and patient can't recognize any symptoms or pain. From stage 2, it starts growing and it will start easily spreading to nearby cells thus forming a cluster of cancerous cell and patient start getting various changes in health condition and symptoms. It clearly shows at the end of stage 1 the cancerous cell will start spreading and difficult to treat and this will also increase the number of chemotherapy and radiation counts thus making the patient week. So, it is always better to diagnose earlier.

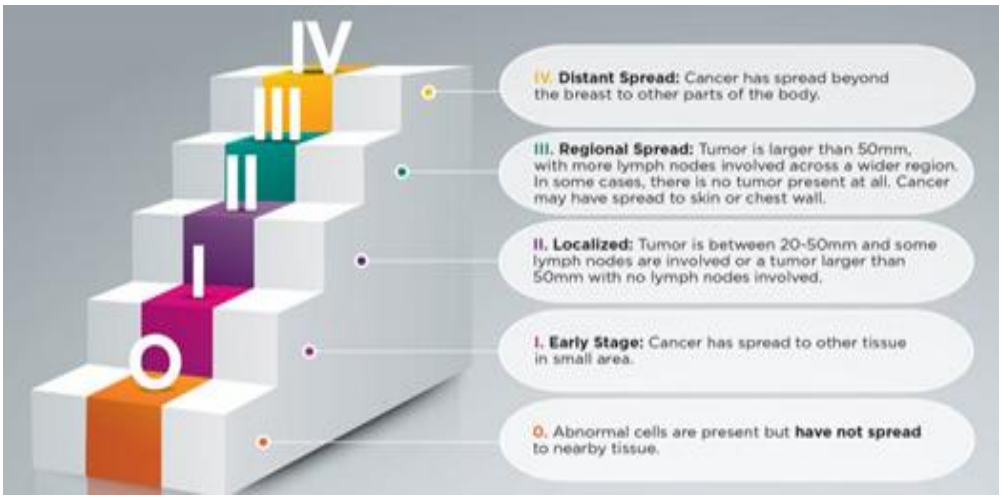

Fig. 1. Different stages of breast cancer
(Courtesy to Memorial Sloan Kettering Cancer Center)

Fig. 2 shows the statical chart of breast cancer diagnosed in various stages. From this chart, we can clearly analyse any women diagnosed cancer at stage 0 is almost close to 1 percentage. This is because using mammography images without tumour there is limit for diagnosis for a doctor's eye. Also, we can see the percentage is increasing when the stage increases.

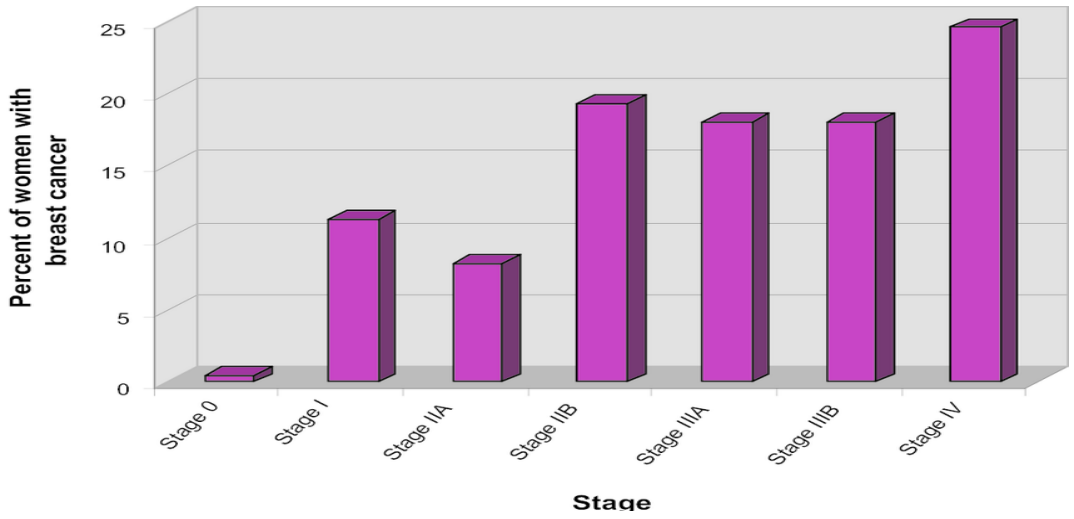

Fig. 2. Statistical chart of women diagnosed in various stages.

In [1], a web-based application is developed to detect breast cancer detection platform which need an input image and classifies as benign and malignant image. The CNN using keras and shiny packages in R programming are used to create the user interface. The performance of the system is evaluated through various performance metrics such as sensitivity, specificity, geometric mean etc. This web-based application will be very helpful to doctors and can be easily accessible for clinical people. For operating this web-based application only basic browsing skill is necessary. So, it will be more reliable and very useful for diagnosing assistance. They mainly use images from breast tissues which is strained with haematoxylin and eosin. This is one of the best works which helps for clinical technicians who have very less computer technical knowledge to use machine learning based software. Similarly, to make it handier we can develop an android based application to make it more user friendly and for easy accessibility. In [2], it deals with combination of supervised and unsupervised deep learning models. The uses image from database of screening mammography as input and uses K-NN and fuzzy c means for image segmentation, which is combination of supervised and unsupervised learning. Also, they mention about the noise and misclassification in image classification. To overcome this problem, they have added window mean and standard deviation to the model. One of the drawbacks of this proposed model is they are using black and white Xray image as input and this input is used as an older method of diagnosing medium.

In [3], various machine learning algorithms were discussed for the classification of breast cancer. Due to limitation of sticking to single machine algorithm in a model. In this proposed system they added most of the supervised and unsupervised algorithm and calculate the outcome values such as true positive, false positive, true negative and false negatives of these algorithms and compared the values to check which model is more reliable for breast cancer classification. The main disadvantage of this model is only working for grey scale images. Comparing to colour images, thegrey scale images are very difficult to capture the texture difference in the early stages. So, it will be very difficult to diagnose in the early stages. Late diagnosing always increase the risk rate and reduces the treatment chances. From the studies of [4] it clearly explains different challenges faced by convolutional neural network. It works only for smaller, overfitting, wrong hyperparameters fixing, high noise in the dataset etc. Also, various measures were dealt in [4] to overcome these challenges.

While choosing the parameters for training we have to tune each and every parameter for the respective model. This is because only by selecting best suitable parameters for the model can only increase the accuracy and reduce the loss function without overfitting. So, parameters like epochs, batch size, optimisers, different functions should be chosen only after proper testing. In our model we have used grid testing to test the requirements of various hyperparameters which should be used in our model to produce the output without overfitting and also different convolutional layers and number of neurons will also affect these hyper parameters. If the data set chosen is small in number, then always chances of getting overfitted is high. So, we have to choose dataset in large amount. Always quality of dataset determines the quality of the model. Another challenge of increasing the size of dataset is increased amount of unwanted data or noise in it. To overcome this challenge, we have to use different averaging methods and adding the deviation of data that is standard deviation of dataset to the model. Also, there is different normalisation methods to find the parameters which slows down or reduces the efficiency of the model. So, by using normalizations such as batch normalisation, it will change those parameters to non-trainable parameters. Before developing each deep learning model, we have to choose the dataset, hyper parameters, different optimization methods, normalisation methods, mean, standard deviation and other parameters correct to fit into our model to improve the performance metrices. [5] shows a special a special approach to breast cancer classification. The proposed system combines the usual method of image classification with old classifier methods such as support vector machines (SVM) and logistic regression (LR). The paper mainly focuses on using pretrained CNN activation features on SVM and LR for automatic

classification of breast cancer. Finally, after calculating all the performance metrics they compared the result of both the model and they found CNN+LR as slightly better that CNN+SVM. We have various metrices which checks the performance of a model. Some of these metrices are accuracy, F1 score, precision, sensitivity, specificity, geometric mean, Matthew's correlation coefficient etc. In this paper [6] it discusses about how Matthew's correlation coefficient is better or it advantages over accuracy and precision. Matthew's correlation coefficient (MCC) basically checks the quality of the binary model by taking true and false positive measures into consideration. The authors mentioned bot accuracy and F1 score as one of the commonly used metrices for performance evaluation but these can show overoptimistic inflated result. Mostly on imbalanced dataset. And also mentions MCC as more reliable statistical which produce good result only if good results are obtained in all the outcome values such as true positive, true negatives, false positives, false negatives, proportionally to both positive and negative area. In this paper they prove with different mathematical steps and use cases how MCC is more preferable to evaluate performance over accuracy and F1 score.

The main objective of any machine learning model is to produce a model with highest accuracy. But we should always ensure whether the accuracy is increased without overfitting. Always accuracy of a model is determined by the hyperparameters used in the model. In [7],deals with how to choose different parameters to improve the accuracy of the model. There are various techniques to find the hyperparameter values in a model. In our proposed system we have used grid test to test the parameter required in our model to improve the accuracy. Coming to image classification always as quality of dataset matters, quality of image also matters. So, in [8] they have splatted dataset into 4 sub datasets. Each group contains images of different magnifications such as 40x, 100x, 200x, 400x. After performing training to the model, they concluded that for training 200x and 400x image produced excellent results. And for evaluating metrics such as f1 score 200x and 40x produced better results. So, after checking both the result that for a model training and testing is equally important. We can see 200x is common in both training and testing. Thus, it is better to choose 200x magnificent images as dataset for image classification using CNN.

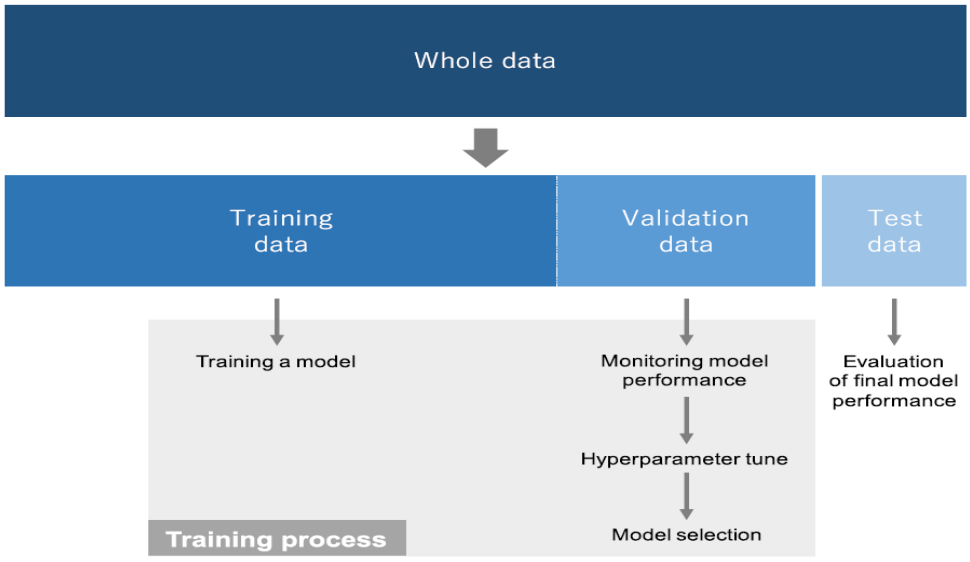

Fig. 4. Different types of data in machine learning image classification

Why we prefer Convolutional Neural Network over other classification algorithms when it comes to image classification. In [9], discussed about CNN and its functionalities. CNN is a layered approach of classification. They are mainly used in natural language processing, image net, computer vision. In CNN after image is processed, different numbers of filters are added to the

image based on the developer's requirement in the model. After adding filter then comes the pooling. In pooling basically dimensional reduction takes place and there will be uniformity between the pixels. Max pooling is one of the commonly used efficient pooling method. Then comes the activation layer. They convert the pixels to desired method of classification. For binary classification mainly we use ReLu or sigmoid function which convert the pixel values to ones and zeroes. After that we can use normalisation layer which actually remove the parameters which slows down the performance of the model. After all these functions are done, all these layers are added to fully connected layer where each layer are attached with neurons and forms a fully connected network. Finally, they concluded that CNN is the powerful machine learning algorithm which is used for image, face recognition, video recognition.

In the proposed system of [10], the fuse older way of hand-crafted features into modern convoluted neural network. They combined hand-crafted features such as HOG, LBPHist, colour hist etc into convoluted layers which is proved improved performance of the model not outstandingly but better. Mainly CNN feature is dominating but these hand-crafted features has been an add on to the model. Figure 5 shows the architecture of CNN combined with hand crafted features.

We all know that how handcrafted image processing changed to current machine aided image classification technique. In [11], discussed the challenge faced during previous method of hand-crafted classification. If the dataset size increases it will be challenging task to do all pre-processing and classification technology. Hence, this model discusses the advantage of machine learning in image classification and how easily we can use CNN for classification of images in multi classes with less time. Also, it specifies the advantages of each layer in multi layered approach of image classification using CNN as we mentioned in above journals. The main criteria of image classification is feature extraction which mainly used to reduce the dimension or remove the unnecessary variables in the model. In [12], focused on the challenges during feature extraction in deep learning models and how to overcome these challenges by using different approaches and various pre-processing technics and challenges of deep leaning models are discussed. We all know training images using CNN from scratch is a very difficult task. In [13], introduced an alternative approach for this problem. The alternative idea is to use a fine-tuned pre trained dataset for a large instinct of labelled dataset. Also, they tested with pretrained dataset and from scratch and the result showed the performance of pretrained dataset is more comparing from training from scratch. And also found pre trained images are more robust than normal images.

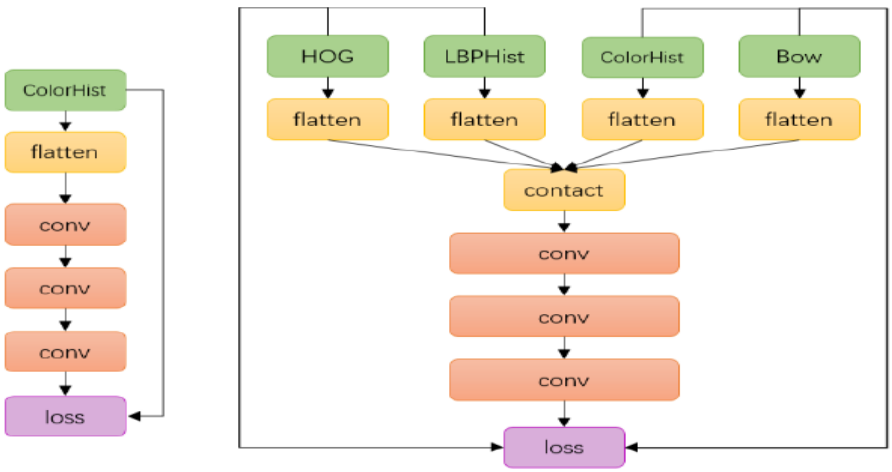

Fig. 5 Architectural diagram of hand-crafted features fused with CNN

In [14] and [15], feature extraction is done using CNN and classification is done using various supervised and unsupervised algorithms like logistic regression, SVM, k-nearest neighbour etc. In both the paper after implementing and by evaluating the performance they found SVM always outperforms all other algorithm in image classification. This model does feature extraction that any other model because they used CNN for feature extraction. Now we can check the proposed system for image classification fully using CNN and manual approach of image malignant and benignant prediction in later sections.

2. Objectives

To overcome the problem of late diagnosis of breast cancer, in this paper we are introducing machine aided diagnosis using deep learning technique. We use mammographic image as input. In stage 0 there will be structural changes in tissues near the area where tumour can be grown, so in our model we are going to predict the disease condition using convolutional neural network algorithm (CNN). CNN is a class of deep neural network mainly used for machine image analysing. CNN is a type of improved multi-layered perceptron where each layer is fully connected to each other like a network. Main advantage of CNN is they use very little pre-processing of image comparing to other image classification algorithms. Basically, there are 3 layers for convolutional neural network such as input layer, hidden layer, output layer. Input and output layers are basically front and back visible end but the middle layer determine the end products. In middle hidden layer it mainly consists of pixel conversion, activation function which is followed by adding filters, pooling and normalisation layer.

We use mammography images as input for training and testing, then we use different pre-processing techniques to remove noise and make all the images uniform in the structural parameters. The hyper parameters vary from model to model. So, for correctly checking the parameters we use grid test to determine the values of those attributes in our model.

Fig. 3 shows various steps in the image processing using convolutional neural network. First, we have to input a proper mammography image. Quality of dataset always affect the quality of any model. The basic step is to use a proper mammography dataset.

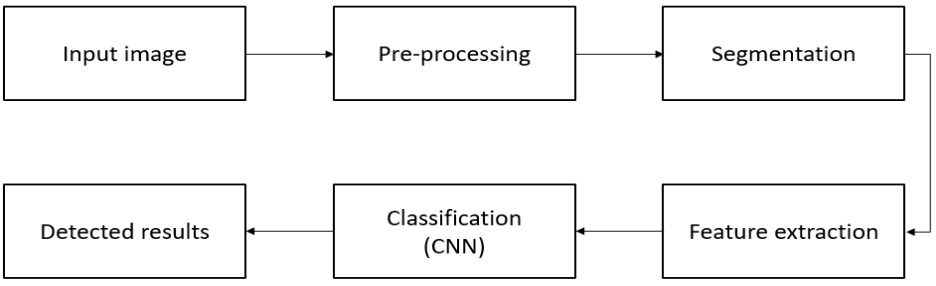

Fig. 3. Steps in image processing using CNN

Image pre-processing is one of the important processes in process to be done carefully. Choosing of hyperparameter value while doing pre-processing is one of the key aspects of this step. This is because each model has their unique hyperparameter values. So, choosing correct hyperparameter will always improve the accuracy and stability of the model. After image pre-processing, we have to start with image segmentation. Segmentation is the process of partitioning pixels in a digital image. Main motive behind image segmentation is to simplify or change image specification to an easier way for analysing. They are mainly used for locating the boundaries and curves. After image segmentation then comes feature extraction. Feature extraction is a type of dimensional reduction process, in which initial set of data is reduced into small groups. So, it will

be easier to classify and access. The main character of large datasets are they have a greater number of variables. These variables require more amount of computing resources to process them. So, by feature extraction it helps to extract best features from this large amount of data sets. This is mainly used for easier character recognition.

After feature extraction we use convolutional neural network algorithm to diagnose breast cancer at the earlier stages Final step is to detect the results as either malignant or benign. While predicting the result we can choose different approaches like automatic prediction for a bulky inputs and also manual prediction for each input. But coming to medical fields we should always prefer manual approach because unlike statistical predictions for any technical industries for medical fields the results should be clean and accurate because we are dealing with a patient's life condition and future procedures. Comparatively automatic prediction will be a bit faster but here in medical fields we always need a precise and clear result for the assistance for a doctor. So, with the observation of doctors with these results can create an accurate diagnosis for breast cancer. So, our proposed model mainly uses convolutional neural network algorithm to diagnose breast cancer using keras and tensor flow packages.

3. Methods

The proposed system provides an advantage of curing the cancer at the initial stage through an efficient image processing technique with machine aided analysis which gives a great assistance to doctor to detect breast cancer before stage of spreading. In this proposed work, a deep learning technique using convolutional neural network algorithm is developed using keras and TensorFlow libraries. CNN mainly deals with media processing. Fig. 6 shows the basic architecture of our model. The consist of 3 layers, such as input layer, hidden layer and middle layer. In any neural network all the middle layers are hidden because their inputs and outputs are masked by the activation function and convolutions. Table 1 shows various hyper parameters used in our model that we go after running grid test for ourmodel. In CNN include layers which perform convolutions. After convolution layer then comes pooling layers, fully connected layer and normalisation layer. Here in our model, we use ReLu activation function which converts all positive pixels to 1 and all zeros and negative pixels to 0. So, the pixels of each image will have a uniformity and it is very easy to classification and analysis. All the hyper parameters are chosen by following up the grid test to avoid overfitting which is a major drawback of CNN.

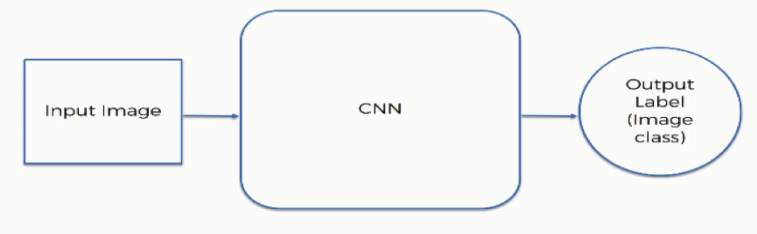

Fig.6 Basic architecture of proposed model

To calculate loss function of our model we use binary cross entropy which calculates the average measure of difference between 2 probability distribution for random events. Binary cross entropy is followed by sigmoid activation function. Sigmoid activation function is monotonic function which is used to find probability which exist between 0 and 1. In our model we are using the combination of sigmoid and ReLu activation function, so our model will be optimised accurately. In this approach, a batch normalization is used in the normalization layer and it provides to enhance the capability and of the deep neural network. It normalises the input layer by

recentring.Weeliminate the arguments from training which minimizes the model capability and modify them to non-trainable arguements. This model diagnoses breast cancer based upon the parameter changes in the mammography images, so there is no need of visible tumour growth to detect cancer in that region to diagnose cancer. Thetensorflow and keras libraries are used to develop this framework. This model diagnoses breast cancer based upon the parameter changes in the mammography images, so there is no need of visible tumour growth to detect cancer in that region to diagnose cancer. We use tensorflow and keras libraries in Jupyter notebook to implement this model. They are purely python-based framework used to implement neural networks.

Table 1. Hyper parameters of proposed model

Parameters	**Values/Attributes**
Training images	8000
Testing images	1600
Epochs	30
Batch size	32
Class mode	Binary
Activation function	ReLu and sigmoid
Normalization	Batch normalization
Pooling	Max pooling
Optimizer	Adam
Loss function	Binary cross entropy

Fig.7 represents the detailed architecture of CNN. Here it is clearly explained the layer approach of neural network. Various step carried after an input image is processed to produce desired output. In this model we have taken 8000 input images for training which belong to two classes benign and malign and 1600 test images. We have chosen batch size as 60 which run to 8 epochs to test the accuracy and loss function and estimated time of finishing. After finding training accuracy we have to test the model with 102 random images to check the predictions with expected results. Here in our model rather than preferring automatic prediction of bulky images, we are testing each image separately because coming to medical field the result should always clear because it deals with a human life and future procedures to be followed.

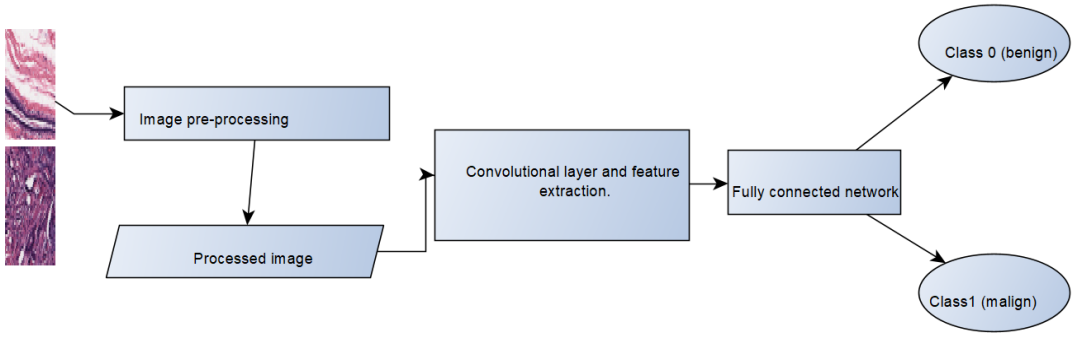

Fig. 7 Proposed Architecture of image processing using CNN

After predicting random images, we will check the efficiency and various other metrices with the classification outcomes from the confusion matrix like Accuracy, Precision, F1 score, Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value, recall, True Positive Rate, False Positive Rate, Geometric Mean, ROC curve and Matthews's Correlation Coefficient.

Algorithm: Evaluation process using CNN model

```
Load input image();
imageAugmentation();
loadModel();
For  each epoch in epochNumberdo
    For each batch in batchSizedo
Ŷ = model (features);
        Loss =crossEntropy(y, Ŷ);
        Optimization(loss);
Accuracy();
bestAccuracy = max(bestAccuracy, Accuracy);
    End For loop
 End For loop
Return
```

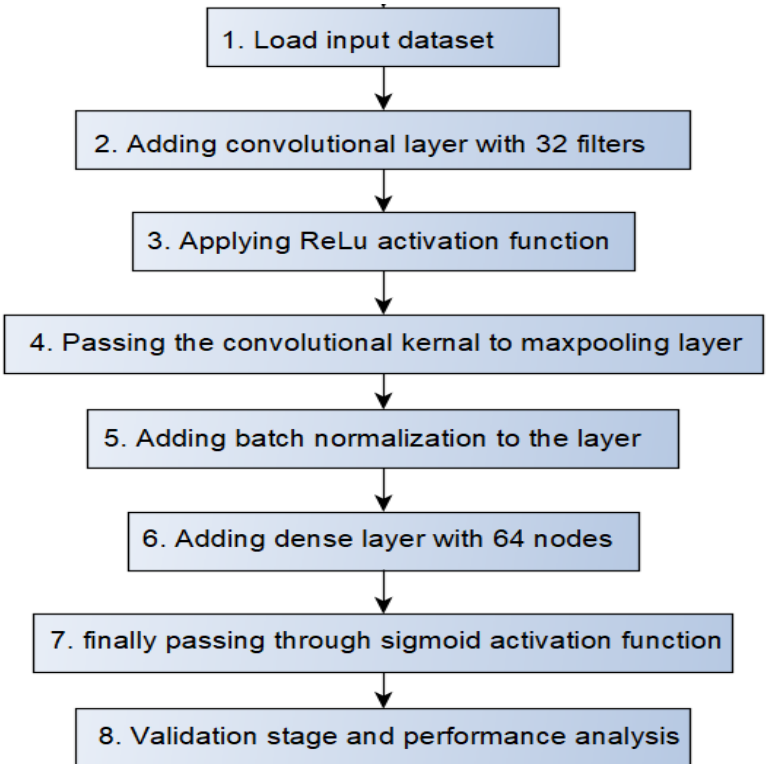

Fig.8 Workflow of Proposed methodology

4. Results and Discussion

The proposed model of breast cancer using image processing can produce a better assistance to doctors for diagnosing cancer from starting stage itself. Our model has produced more accuracy and less loss comparing to a base model with less execution time in the given number of epochs.

After finding the training accuracy we validated 102 random images with manual approach of prediction. Then, we formulated confusion matrix based on the expected and actual prediction and produced outcome values which is shown in the table 2.

```
Confusion matrix :
 [[44  7]
 [ 2 49]]
Outcome values :
 44 7 2 49
Classification report :
              precision    recall  f1-score   support

           1       0.96      0.86      0.91        51
           0       0.88      0.96      0.92        51

    accuracy                           0.91       102
   macro avg       0.92      0.91      0.91       102
weighted avg       0.92      0.91      0.91       102
```

Fig. 9. Output ofconfusion matrix

Table 2. Performance analysis using outcome values

Metrices	**Values**
Accuracy	0.912
Sensitivity	0.863
Specificity	0.961
Positive predicted value	0.956
Negative predicted value	0.875

After performance analysis, we computedReceiver Operating Characteristics (ROC) curve which plots to true positive rate and false positive rate and is calculated in table 3. ROC curve indicates the classification rate between these two values.

Table3. Parameters for ROC curve

Parameters	**Values**
True positive rate (TPR)	0.86
False positive rate (FPR)	0.039

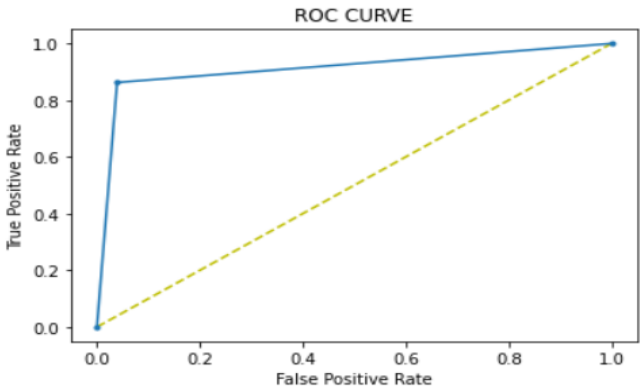

Fig. 10. ROC curve

The geometric mean and Matthew's correlation coefficient of the proposed model were calculated and is shown in Table 4. The table 5 represents the accuracy and loss after 30th epoch for our model. After we made a plot which shows Accuracy epoch relation and loss epochs relation of our model. Fig.11. represents the respective plots.

Table.4.Performance of the proposed work

Metrices	**Values**
Geometric mean	0.91
Matthew's Correlation Coefficient	0.837

Table 5 Validation and training metrics after 30 epochs

Parameters	**Values**
Training accuracy	0.9563
Training loss	0.1077
Validation accuracy	0.9688
Validation loss	0.07299

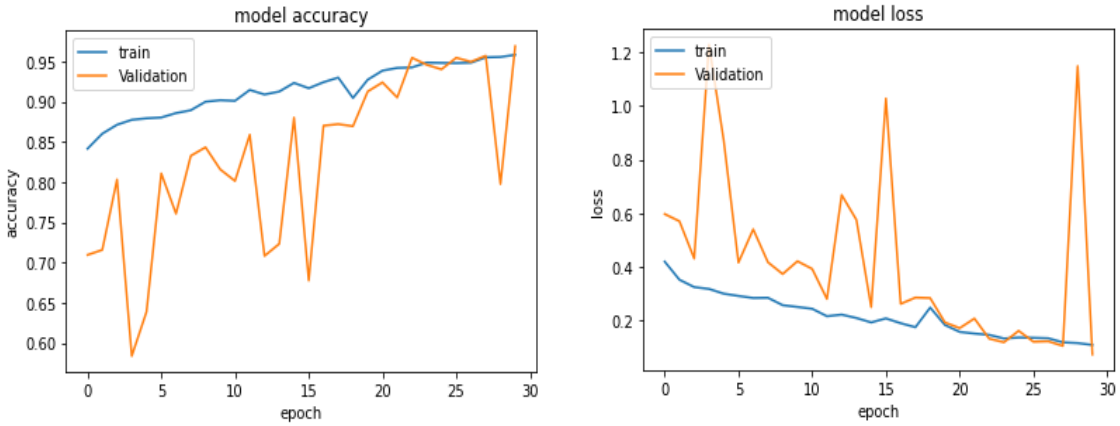

Fig. 11 Accuracy-epochs vs loss- epoch graph

Table 6 proves the efficiency of the model using the quantitative analysis of performance metrics of the proposed model. Proposed model outstands the base model not only in training efficiency but also it has better result in predicting outcome values. Also, the numerical values of each outcome results don't have much variation between them unlike the base model. This proves the proposed model is consistent in predicting the results. MCC of the proposed model is more than the existing which states about balanced performance evaluation of proposed model is higher than that of existing model. These comparisons totally proves that proposed model using python frameworks is efficient in training and evaluation comparing to the existing work using shiny package in R programming.

Table 6. Quantitative analysis of existing and proposed model's performance metrices

Metrics	**Existing work (Using Shiny package in R programming with CNN)**	**Proposed work (Using python deep learning frameworks in anaconda navigator with CNN)**
Accuracy	0.891	0.912
Sensitivity	0.835	0.863
Specificity	0.896	0.961
PPV	0.750	0.956
NPV	0.832	0.875
G-mean	0.897	0.91
MCC	0.813	0.837

5. Conclusion and future work

Identifying the cancer at the initial stage is one of the major criteria's for the proper treatment. With human eye it is impossible to diagnose cancer in very early stages before tumour or any structural change occurs in the appearance. For easy diagnose or for better assistance for doctor, it requires a machine aided support which can notice the changes in texture of tissues or cells near the region of interest. Our model provides such an assistance to doctors to recognise the changes in mammography images in the basic or zeroth stage. So, this deep learning model of breast cancer diagnosing using convolutional neural network can be used as a partial assistance to the doctors and cannot be used as a full independent platform to detect cancer. Our model has produced the output with quality values for the analysis of performance metrics.

For the future work, we can develop an android or web-based application based on deep learning where we can input our images and check the result which can be more effective and efficient than existing system and it will be handier to use. Also, we can develop a robot-based

mammography scanning and predicting machines which will scan and detect tumour or cancerous symptoms in the region of interest within less or no time. This model can be used as a stepping stone for the future told models.

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