Comparison of feed forward, Cascade forward and Layer Recurrent Algorithm model for breast cancer prediction

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Abstract. The number of cases of Breast cancer seems to be constantly increasing worldwide in the recent years. According to 2012 world cancer report, the breast cancer incidence rate in Asia appears to be 37.5% and the mortality rate is 13.21%. As per the recent statistics report of 2018, it has been estimated that the number of new cases of breast cancer is 14% in India. The percentage is higher when compared to lung cancer, oral cancer and other types of cancers. It has been identified that it occurs mostly in the age group between 41-50 years and the distribution of this is found to be 42%, whereas it is 18%, 24% for the age groups of 31-40 and 51-60 respectively. The five stages of survival include the survival rate of 100%, 98%, 88%, 52%, 16% for each stage respectively. Diagnosis in the early stage can reduce the death rate. Even during the stage 3 if the cancer is predicted, it can be treated. Machine learning using Artificial Neural Network(ANN) techniques can be effectively utilised for the prediction of cancer. In the proposed method, networks designed using various ANN Algorithm are used to predict the breast cancer if it is benign or malignant. Three different networks such as feed-forward back prop, Cascade forward and layer recurrent has been implemented. The performance measures such as Accuracy, error, specificity, sensitivity, positive predictive value and negative predictive value are obtained. From the table 2, it is inferred that among these algorithms, feed-forward algorithm has better performance compared to other two algorithms. ANN has been a powerful tool for analyzing the data when there are non-linear interactions between the input and the output to be predicted. The results show that the accuracy of ANN for the prediction was better than other approaches. The Wisconsin breast cancer database has been used for the analysis. The results are very competitive and can be used for diagnosis, prognosis, and treatment.

Index Terms- Breast Cancer, Neural Network, Wisconsin dataset, Feed-forward, cascade, layer recurrent.

1. Introduction
The uncontrolled growth of cells in an organ is called tumors which are termed as cancer. There are two kinds of tumors, benign and malignant as shown in Figure 1. Benign are non-cancerous tumors, non-invasive, slow growing and it has a capsule like structure which forms the outer layer. These type of cancer are non-contagious and are not life threatening whereas, malignant or cancerous tumors are proliferate, highly invasive, grows rapidly and life threatening. Breast cancer is the most frequently occurring disease among women worldwide. It occurs in both men and women. Breast cancer is the leading cause for mortality between ages 40 and 55. Diagnosis in early stage can reduce the death rate.
Breast Cancer screening is the process of checking the presence of Cancer cells in women who has the early symptoms of breast cancer.

At present the widely used screening technique is mammography which is 90% sensitive to cancer cells, which means it cannot detect the 10% cancer cells. With the help of existing technologies such as data mining and machine learning, diagnosis can be made more accurate and medical errors can be minimized.

2. Literature Review

There has been large number of machine learning techniques and algorithms. The utilization of data science and machine learning approaches in medical fields proves to be productive as such approaches may be considered of great assistance in the decision making process. With an unfortunate increasing trend of breast cancer cases, there comes a big deal of data which is of significant use in clinical and medical research and more to data science and machine learning application in this domain. Comprehensive surveys are found to be in existing approaches.

Abien Fred M. Agarap [1] presented an application of different machine learning algorithms for the diagnosis of breast cancer and they exhibited better performance on the binary classification of breast cancer. Venkatesan P and Suresh M L [2] have implemented the ANN model for breast cancer survival prediction. They have presented the ability of the neural network to generalize to new population samples and concluded that the ANN model performs better than logistic model. Mihir Borkar et al., [3] have developed an ANN model that helps to determine if patients have breast cancer or not. If patients have a cancerous tumour it can be determined by analysing certain attributes of the cells. Data obtained from 699 patients have been used to train the network. The results were tested using ROC analysis. Chandra et al.,[4] in 2014 have developed ANN with extreme learning techniques for diagnosing breast cancer based on Breast Cancer Wisconsin Dataset. Results showed that Extreme Learning Machine Neural Networks (ELM ANN) have better generalization classifier model than BP ANN. The development of this technique is promising as an intelligent component in medical decision support systems. R.R.Janghel et al.,[5] presented a number of neural network approaches for disease diagnosis. A number of configurations of these networks were trained and tested against the Breast Cancer database. The results showed the ability of the different neural networks to classify the applied input into either of the two classes. It has been suggested that working on better attributes and methods of diagnosis may largely boost the diagnosis accuracy.

Kalpana Kaushik and Anil Arora [6] presented the Databases of breast cancer (Wisconsin Breast Cancer (WBC), Wisconsin Diagnosis Breast Cancer (WDBC) and Wisconsin Prognosis Breast Cancer (WPBC) by using classification accuracy and confusion matrix based on 10-fold cross validation method. Also, a fusion at classification level between these classifiers to get the most suitable multi-classifier approach for each data set was introduced. Recently, the neural network has become a popular tool in the classification of cancer datasets. Ahiotment et al., [7] proposed a method by reducing the dataset of Wisconsin Diagnostic Breast Cancer (WDBC) to one-dimensional feature vector computing an Independent Component (IC). The original data with 30 features and reduced one feature (IC) are used to evaluate diagnostic accuracy of the classifiers such as k-Nearest Neighbor (k-NN), ANN Radial Basis Function Neural Network (RBFNN), and Support Vector Machine (SVM). The comparison of the proposed classification using the IC with original feature set is also tested on different validation (5/10-fold cross-validations) and partitioning (20%–40%) methods. These classifiers are evaluated based on how the tumors are categorized as benign and malignant in terms of specificity, sensitivity, accuracy, F-score, discriminant power, and the Receiver Operating

Figure 1 Classification of tumor
Characteristics (ROC) curve with its criterion values including Area Under Curve (AUC) and 95% Confidential Interval (CI). This represents an improvement in diagnostic decision support system, while reducing computational complexity. Esraa A. AL-Dreabi et al.,[8] developed a diagnostic system that could classify breast tumors as either malignant or benign to provide a faster and more reliable method for patients. HtetThazinTikeThein and Khin Mo MoTun [9] have proposed an approach for breast cancer to distinguish between different classes of breast cancer. This approach is based on the Wisconsin Diagnostic and Prognostic Breast Cancer and the classification of different types of breast cancer datasets. AutsuoHiga [10] has implemented two powerful classification algorithms namely decision tree and ANN that have been applied for breast cancer prediction.

3. Artificial Neural Network

ANN is one of the artificial intelligence techniques that provide solution for classification and regression problems. It is observed as a best technique for data mining tasks. It has framework for different machine learning algorithms to perform together with data inputs. ANN learns how to predict the output from a set of attributes. The algorithm learns to predict with a training datasets. It has been observed from a lot of research that ANN provided good accuracy in breast cancer prediction. The goal of ANN is to find solution to problems in a similar manner that a human brain does. The network is trained with the training dataset using different algorithms.

3.1 Feed-Forward Model

The Network contains feed-forward topology and it will work in one direction, which means the information must flow from input to output in only one direction with no back-loops. The feed-forward algorithm consists of input layer, hidden layers and output layer. While training this network, calculations are carried from input layer to output layer through the hidden layers, and error values were then propagated to previous layers. Feed-forward networks have one or more hidden layers of neurons followed by an output layer of neurons as in Figure 3.1 and its working is shown in Figure 3.2

![Figure 3.1 Basic Feed-Forward topology](image1)

![Figure 3.2 Working of Feed-Forward](image2)

The feed-forward artificial neural network can lead to long mathematical descriptions where solving the ANN’s parameter optimization problem is complicated and impractical.

3.2 Cascade Forward Network Model

Cascade forward models are similar to the feed-forward networks, but the only difference is, it includes a weight connection from the input to each layer and from each layer to the successive layers. While two-layer feed forward networks can effectively learn any input-output relationship, feed-forward networks with more layers might learn complex relationships more quickly. Cascade forward network has connections from layer 1 to layer 2, layer 2 to layer 3, and layer 1 to layer 3 as shown in Figure 3.3. These networks also have connections from the input to all three layers. The additional connections will improve the speed of the network learning process.

![Figure 3.3 Cascade Forward model](image3)
3.3 RECURRENT MODEL
In recurrent model, information is transmitted in both directions, forward and also backwards i.e. it has feedbacks as in Figure 3.4. Different recurrent artificial neural networks such as Hopfield, Elman, Jordan, bi-directional and other networks are just special cases of recurrent artificial neural networks.

![Figure 3.4 Basic recurrent topology model](image)

3.4 Layer Recurrent Model
Layer recurrent neural networks are also similar to feedforward and cascade networks, in which each layer has a recurrent connection with a tap delay associated with it. This allows the network to have an infinite dynamic response to time series input data. This is similar to time delay and distributed delay layer networks which have finite input responses and is shown in Figure 3.5

![Figure 3.5 Layer recurrent model](image)

4. Methodology
The flow of methodology is shown in Figure 4.1.Wisconsin diagnostic breast cancer (WDBC) dataset is used to implement the machine learning algorithm for the breast cancer diagnosis. There are 569 data entries which contain 32 columns where the first column contains patient ID and the next followed by diagnosis results(benign or malignant) and the rest of the column has the attributes. In the dataset which has 569 entries there are 212 malignant cases and 357 benign cases. The features are the mean, standard deviation and worst of Radius, Texture, Perimeter, Area, Smoothness, Compactness, Concavity, Concave points, Symmetry, Fractal dimension.

The system has to be trained with set of data so that it can give the result depending on past experience. The higher the training rate the greater the accuracy. But training the system will consume a lot of time. The training and testing data should be separated so that the accuracy will be large with minimum number of training data. The ANN is implemented using MATLAB software with Neural Network tool.

Performance evaluation has been done using the various performance measures such as, Accuracy, Error, Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value and Confusion matrix. A confusion matrix will comprises of actual and predicted results of the cancer. From the confusion matrix the true positive(tp), true negative(tn), false positive(fp) and false negative(fn) values are generated. These values are used to find various performance measures.
5. Result And Discussion
The experiments have been conducted using WISCONSIN Breast Cancer Dataset. The data set has been divided as training and testing dataset in the ratio of 70-30% respectively. The three different algorithms such as feed-forward back propagation, Cascade forward and layer recurrent has been implemented. The performance measures such as Accuracy, error, specificity, sensitivity, positive predictive value and negative predictive value are found for the three algorithms. From the table 2, it is inferred that among these algorithms, feed-forward algorithm has better performance compared to other two algorithms.
The training window of the three models, the regression graph and the performance of the three models, FF model, CF model and LR model are shown below.

Figure 5.1 Training window of FF

Figure 5.2 Regression graph of FF

Figure 5.3 Performance graph of FF

Figure 5.4 Training window of CF

Figure 5.5 Regression graph of CF

Figure 5.6 Performance graph of CF
Table 5.1 Comparison of performance measures of FF, CF and LR algorithm

| Parameters                | Feed-Forward | Cascade | Layer Recurrent |
|---------------------------|--------------|---------|-----------------|
| Accuracy                  | 0.9534       | 0.9302  | 0.927           |
| Error                     | 0.0466       | 0.0698  | 0.073           |
| Sensitivity               | 0.8730       | 0.8253  | 0.8666          |
| Specificity               | 1.000        | 0.9908  | 0.9642          |
| Positive Predictive Value | 1.000        | 0.9811  | 0.9285          |
| Negative Predictive Value | 0.9316       | 0.9075  | 0.9310          |

From figure 5.2, Feed forward algorithm has 95% accuracy with less error of 4% whereas the sensitivity and specificity is 87% and 100% respectively. It can predict the positive values with 100% efficiency and negative value with 93% efficiency. Cascade networks gives 93% accuracy with 6% error. The sensitivity and specificity values obtained were 82% and 99% respectively. The algorithm can predict the positive values with 98% efficiency and negative values to 90%. In Layer recurrent network the accuracy is 92% with the error rate of 7%. Sensitivity and specificity is 86% and 96% respectively. The algorithm predicts the positive value to 92% and prediction of negative value is 93%.
It is inferred that among these algorithms, feed-forward algorithm has better performance compared to other two algorithms.

6. Conclusion

The experiment was conducted using WISCONSIN Breast Cancer Dataset. The dataset was divided as training and testing dataset in the ratio of 70-30% respectively. Three different algorithms such as feed-forward back prop, Cascade forward and layer recurrent has been implemented. The performance measures such as Accuracy, error, specificity, sensitivity, positive predictive value and negative predictive value are obtained. From the table 5.1, it is inferred that among these algorithms, feed-forward algorithm has better performance compared to other two algorithms.

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