

Lung Cancer Prediction using Feed Forward Back Propagation Neural Networks with Optimal Features

Dr. S. Senthil

*Director, School of Computer Science and Applications,
Reva University, Bangalore, Karnataka, India.*

Orcid Id: 0000-0002-5947-0715

B. Ayshwarya

*Research Scholar, School of Computer Science and Applications,
Reva University, Bangalore, Karnataka, India.*

Orcid Id: 0000-0002-2869-6316

Abstract

The major cause of deaths in human beings is Lung Cancer, Since the lung cancer symptoms appear in the advanced stages so it is hard to detect which leads to high mortality rate among other cancer types. Hence the early prediction of lung cancer is mandatory for the diagnosis process and it gives the higher chances for successful treatment. It is the most challenging way to enhance a patient's chance for survival. In this paper a computer aided classification method for lung cancer prediction based an evolutionary system by a combination of architectural evolution with weight learning using neural network and Particle Swarm Optimization is implemented. This method proposed different variants and hybridize it with evolutionary algorithm to improve its performance and uses global searching of PSO and local searching ability of neural network gives better lung cancer prediction as cancerous and non-cancerous. The classification is performed and the results were evaluated with the performance comparison of various algorithms. This prediction system is useful for the doctors to take an appropriate decision based on patient's condition

Keywords: Lung Cancer, small cell lung cancer, Neural Networks and Particle Swarm Optimization.

INTRODUCTION

Lung cancer [6] is one of the cancer types that leads to death. The Lung diseases are the disorders which affect the lungs and it is unpredictable medical conditions worldwide especially in India. Lung cancer constitutes 12.8% of all cancer types worldwide, also it constitutes 17.8% of the cancer deaths and it increases by 0.5% every year globally worldwide. The cause of cancer in males represents 38.6%, and in females it represents 5.2%. However, it is suggested that 15% of lung cancer patients live 5 years or more after the diagnosis, together with this early diagnosis and used drugs when they are diagnosed early [1,2]. It makes it possible at computer aided diagnosis of lung cancer by evaluating these parameters.

Lung cancer is a disease which arises due to growth of unwanted tissues in the lung and this growth which spreads beyond the lung are named as metastasis which spreads into other parts of the body. But in some case of cancers the initial growth in lung are named as carcinomas that derived from

epithelial cells. If this uncontrolled growth can be detected successfully at early stages, which helps to diagnosis the risk of invasive surgery and increased survival rate. Lung disease which affects the parts of lungs and cause infections such as tuberculosis, influenza, pneumonia and other breathing problems such as asthma, Chronic Obstructive Pulmonary (COPD) disease and [10].

The two major types of lung cancer [2] are Non-Small Cell Lung Cancer (NSCLC) and Small Cell Lung Cancer (SCLC) or oat cell cancer that grows and spreads in various ways which is to be treated differently. If the patients have symptoms of both cancer types, then it is called as mixed small cell/large cell cancer. Non-Small Cell Lung Adenocarcinoma (NSCLA) is more common than SCLC and it commonly grows and spreads slower than SCLC. SCLC is linked with smoking features and grows faster by forming a large tumor that can spread throughout the body.

Computer Aided Diagnosis (CAD) system is very helpful for doctors in detection and diagnosing abnormalities earlier and faster [3] and it is a second opinion for doctors before suggesting biopsy test. Several techniques are available for lung cancer diagnosis but those techniques are more expensive, time consuming and having less capability for detecting the lung cancer. Hence, a new prediction method is essential to predict the lung cancer in its early stages.

In this paper an integrated framework for predicting lung cancer is introduced using Neural Network with Particle Swarm Optimization. Neural networks deals with different problem solving methods in which the neurons are being trained and tested by given database [17]. The lung cancer features are extracted for predicting the cancer stage based on certain feature used in the system. Feature selection is used to identify predictive subsets of cancer cells within a database and reduce the number of cancer cells presented to the computation method. Better performance can be achieved by discarding some features.

Problem Identification

There are numerous systems available to analyze lung cancer such as Chest Radiography (x-beam), Computed Tomography (CT), Magnetic Resonance Imaging (MRI output) and Sputum

Cytology [4-5]. Yet, the greater part of these systems is costly and tedious. The majority of these techniques to identifying the lung cancer in its propelled stages, results in low patients' survival. Many researches have been proposed number of techniques for processing of images and automated classification system giving varying results. But still there is need of more classification accuracy, recognition rate and minimum classification error rate. Hence, the essential effective method for diagnosis of lung cancer is required.

The remainder of this paper is organized as follows; Section II reviews briefly some of the recent work published in the area of lung cancer and classifiers used for prediction and diagnosis. Section III introduces and describes the proposed evolutionary algorithm. Experimental Results of the proposed technique are presented in Section IV. Finally, Section V concludes the paper.

RELATED WORKS

Lung cancer research is the most concerning region of enthusiasm for restorative field. The early diagnose of the cancer can help in expanding the death rate of people. This is very tedious, and their accurateness relies on the capacity of operator's. Chauhan *et.al* (2016) [1] has overviewed different methods to recognize lung cancer like ANN (Artificial Neural Network), picture handling, LDA (Linear Dependent Analysis), SOM (Self Organizing Map) and so on. From the conclusion, it is prescribed to utilization of Support vector machines as a classification tool. Support Vector Machine (SVM) are supervised learning models that analyze data and recognize patterns.

Krishnaiah *et.al* (2013) [2] gives an outline of the diagnosis on different lung cancer datasets by employing the data mining techniques and optimization techniques for the diagnosis of lung cancer. Knowledge Discovery in Databases (KDD), integrates data mining techniques to recognize and exploit the cancer patterns among large number of variables, and to predict the outcome of a disease using the certain medical cases stored within datasets.

Tiwari *et.al* (2016) [3] introduced an image processing technique for prediction of lung cancer and furthermore for early detection and treatment to prevent the lung cancer. To predict the lung cancer various features are extricated from the pictures along these lines, pattern recognition-based methodologies are valuable to predict the lung cancer. A far reaching audit for the expectation of lung cancer by past analyst utilizing image processing techniques was exhibited. The image processing techniques with the computational insight based methodologies are helpful for the prediction and decision making of lung cancer.

D'Cruz *et.al* (2016) [10] developed a framework for lung cancer detection in early stages. In this framework, initially the data preprocessing is carried out to enhance the image. Then the given samples are trained and tested under data mining techniques and neural networks that are essential for the undertaking of medical process to detect. The obtained results from the feature extraction of the input images are used to classify as cancerous or non-cancerous by utilizing Back

Propagation Neural Network (BPNN). On the premise of the extracted feature images, the stage of cancer is decided which is helpful to the doctors for diagnosing.

Utilization of different Artificial Intelligence techniques for medical diagnosis of diseases has as of late turned out to be across the board. Artificial Neural Networks (ANN) is used to classify the data of Breast Cancer and Lung Adenocarcinoma is given by Mandal *et.al* (2015) [14]. A Multilayer Feed Forward Neural Network is adopted to identify growth which is taken from the Microarray Data and UCI Machine Learning Data. Back Propagation Rule are employed for training the network. The cross validation is used for testing the given datasets with various numbers of hidden layers and linked nodes. If there should be an occurrence of UCI dataset (breast cancer), it is reasoned that the accuracy of the system increments with various combination of hidden layers and linked nodes. In NCBI dataset (lung disease), it shows that increasing number of nodes and hidden layers which leads to increment of accuracy to specific level. Accordingly, by developing the automated diagnosis system based neural network used to predict the cancer patient's condition.

Kaur *et.al* (2015) [9] assessed a new feature selection technique using hybrid genetic and particle swarm optimization and classification of lung CT images utilizing MLP-NN is investigated. It is connected to lung CT images engaged as the input. The guided image filter is connected to remove noises and the preprocessed images are given as input for feature extraction. Further the features are extracted utilizing MAD technique. Extracted features are chosen utilizing GAPSO algorithm. Furthermore, finally classify the features utilizing MLP-NN. Resulted image is acquired utilizing GAPSO-MLPNN. The experimental result indicates high Geometry Accuracy, high Bit Classification Rate and low Bit Error Rate in different testing data. This technique adequately functions admirably for the detection of lung diseases.

Kuruville *et.al* (2014) [6] presented a Computer Aided Diagnosis (CAD) classification method in Computed Tomography (CT) images for cancer detection based neural network. The whole lung is segmented from the CT images and the features are determined from the segmented image. The measurable parameters such as mean, standard deviation, skewness, kurtosis, fifth focal moment and 6th focal minute are estimated for cancer classification. The classification process is employed by feed forward back propagation neural networks for better classification.

PROPOSED METHODOLOGY

Lung disease is the uncontrolled development of strange cells that affect one or both lungs [22]. The main objective is to predict and early detection of lung cancer by using neural network with optimal features. Initially the Lung database are collected and given as input to the system. Then data preprocessing is applied on the input images, for the enhancing the image to get the high contrast images. The enhanced images are trained and tested by neural network compared with sample training database. Particle Swarm Optimization (PSO) is applied to extract the features of the given input images and further process is proceed to detect the lung cancer. On this

basis, neural network classifier is employed to analyze those input images features are classified as cancerous or non-cancerous.

Data Pre-processing

The initial step for lung cancer detection is the preprocessing step to fill the missing data and to eliminate the unnecessary information from the dataset. The missing data are imputed using K nearest neighbor method with three neighbors to make full dataset more reliable.

Training and Testing samples

The input data samples are trained and tested by using neural network. Initially the weights of neural network of the input data are chosen randomly. The neural networks are trained with a sample data for learning and to perform classification process then with testing dataset. The classification result of the tested data is weighed to check the frequency error or the error rate which occur during classification process and the error are resolved by changing the weights in the dataset [6].

Feature Extraction

Lung cancer dataset consist of huge number of features and it is significant to extract for minimizing the complexity of detection process [10]. The tumor caused due to multiplication of cancer cells (features) in the lung which is to be extracted in this detection system. This feature extraction process is performed by adopting PSO. The feature extraction is the part of the pattern recognition techniques is done on the input data for retrieving the relevant features which is to be more informative, non-redundant and collect the information about the cancer to predict the patient conditions for interpretations.

Neural Network Classifier

The input sample is classified as cancerous or non-cancerous depend on the extracted features which is accomplished by neural network classifier [19]. Neural network is an interconnected network of neurons that transmits the electrical signals patterns. An Artificial Neural Network (ANN) is a cluster of learning neurons based on biological neural networks (human brain). Generally, a neural network consists about 100 billion neurons and each neuron connected up to 10000 other neurons

Artificial neural networks are generally presented as systems "neurons" which are all interconnected and which exchange messages between different neurons [11]. The connections have numeric weights that can be adapt based on experience, creating neural nets adaptive to inputs and capable of learning. The advantage of ANNs is that they are often suitable to solve

problems that are too complex to be solved by the conventional techniques, or hard to find algorithmic solutions.

For the above general model of artificial neural network, the net input can be calculated as follows:

$$Y = X_1 W_1 + X_2.W_2 + \dots \dots \dots X_m W_m \quad \text{---(1)}$$

$$\text{Net input } Y_{in} = \sum X_i.W_i. M_i \quad \text{---(2)}$$

The output can be calculated by applying the activation function over the net input.

$$Y = f(Y_{in}) \quad \text{---(3)}$$

Output = function (net input calculated)

There is one layer for the input variables and another layer for the output. The layers include:

- Input Layer - Input layer includes input units indicates the unrefined information provided for the network.
- Hidden Layer - This layer includes the hidden units based on the input unit's behavior and the weighted neuron are denoted as which connect these input with the hidden units.
- Output Layer - This layer based on the specificity of the hidden units and the weighted neuron.

Layers consists of number of interconnected nodes which denotes an activation function [18][20]. Patterns are represented via the input layer and it is represented as $X_1, X_2, X_3, \dots, X_n$ which communicates with one or more hidden layers where the actual processing is done by system of weighted connections is shown in the figure 1. The hidden layers then link to an output layer then the result is output is indicated as $out_1, out_2, \dots, out_m$. Between these two layers there is occurrence of many computation node are represented as hidden layers [12]. The signal given to one neuron which forwarded to all other neurons and it is connected in fractions equivalent to the weighted neurons.

Steps for Neural Network

Input- Lung Cancer Dataset
 Output- trained Neural Network
Step 1 - Receive an input
Step 2 -Weight the Input (Each input sent to the network should be weighted)
Step 3 - Sum all the weighted inputs
Step 4 - Generate the Output

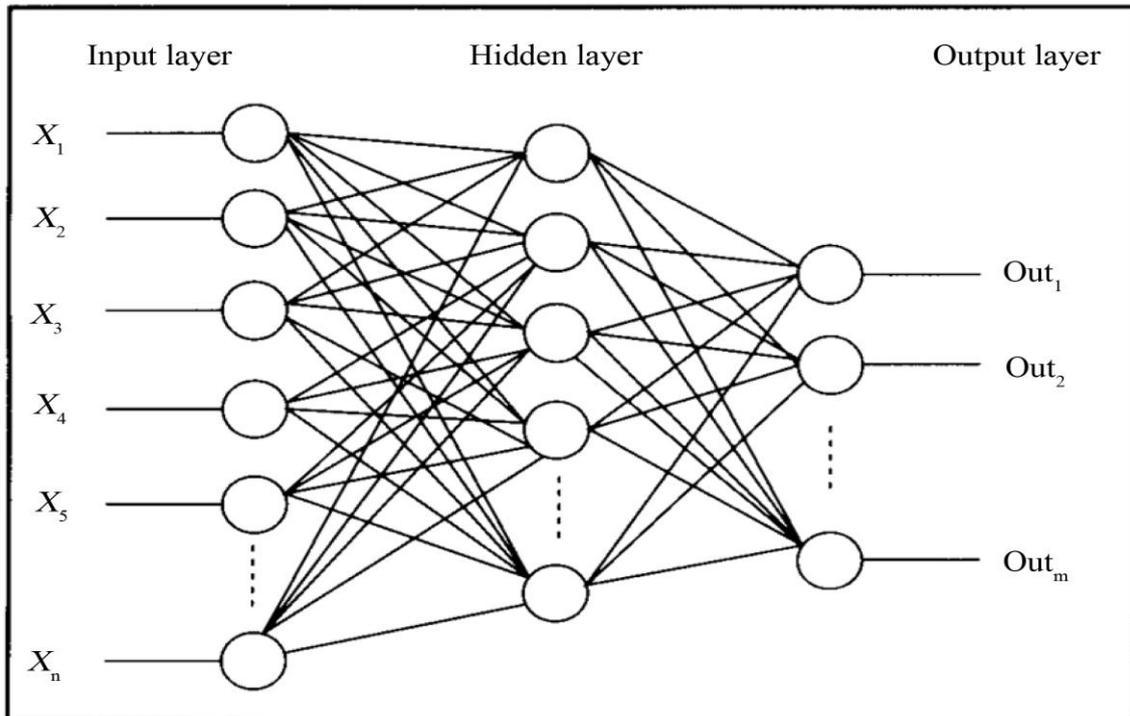


Figure 1 Neural Network

The output is analyzed based on a sigmoid function or some suitable function by each neuron. The main advantage of neural networks is their ability to learn from patterns [13]. The two key components of neural network structure are neurons and weighted direct relations, which connect one layer of neurons with another layer of neurons. In the training phase, certain weights of the layers connections are adjusted. ANN models can be trained for these features from sample data and this information can be used to predict or categorize data in a dataset.

Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a searching algorithm based on group. PSO is related to Genetic Algorithm (GA) which is derived from population. Particle Swarm Optimization is a self-adaptive global search related on optimization method [15]. PSO is a robust stochastic optimization technique based on the movement and intelligence of swarms PSO is very popular because it is easy and valuable with less computational cost and fast speed in wide range of application. This PSO technique is based on animal behaviors such as the bird flocking in which each particles are represent as population of random solutions.

The particle behavior is influenced based on their ability to train from the previous experience and also from their neighbor to adapt the flying speed and the direction of the target. Though, each particles can manage the current position, velocity and the best position and the swarm is targeting the global best solution. Unlike GA there is no selection algorithm and no crossover operation.

Here by implementing the particle swarm optimization in software maintainability application to determine the best optimization [16]. The optimization starts with one or more initial candidates. In this technique to achieve best optimization and quick convergence component is separated into two parts i.e. good experience (pbest) and bad experience (pworst) of all particle. Every particle memorizes its pbest and pworst to attain the destination in least amount of time and with optimum solution. By utilizing both experiences particle may bypass its worst position and achieve the last position simply and quickly.

- Each particle keep on tracking its neighbors which are accompanied with the best solution (fitness) achieved by that particle in the solution space this value is denoted by personal best, pbest.
- Another best position is tracked by the PSO is the best value obtained so far by any particle in the neighborhood of that particle which is denoted by gbest.

Steps for Particle Swarm Optimization algorithm

- Step 1-** Start the particles with some random position and velocity vectors.
- Step 2 -** Measure value of fitness for all particle.
- Step 3 -** if fitness (p) best when compare with the fitness (pbest) and pbest=p.
- Step 4 -** Allocate best particle pbest value to gbest.
- Step 5 -** Velocity for each particle is calculated.
- Step 6 -** Particle velocity and position is updated

Two vectors of velocity and position is used for the entire particle. Initialize particle with velocity vectors and random position in the look for space. All particles have fitness value after that evaluate the fitness value for every particle (p) is calculated according to its current location. All the particles know it's better position (pbest), which holds the better solution. Then fitness (p) is best than fitness (pbest) than pbest=p. choose the better particle as gbest for all particles. Finally update the position and velocity of each particle. PSO produces higher quality solutions. Consider a swarm with N particles of D-dimensional flying in the solution space in which each particle i , re-position itself as x_i in the direction of the global optimum base on the following two factors.

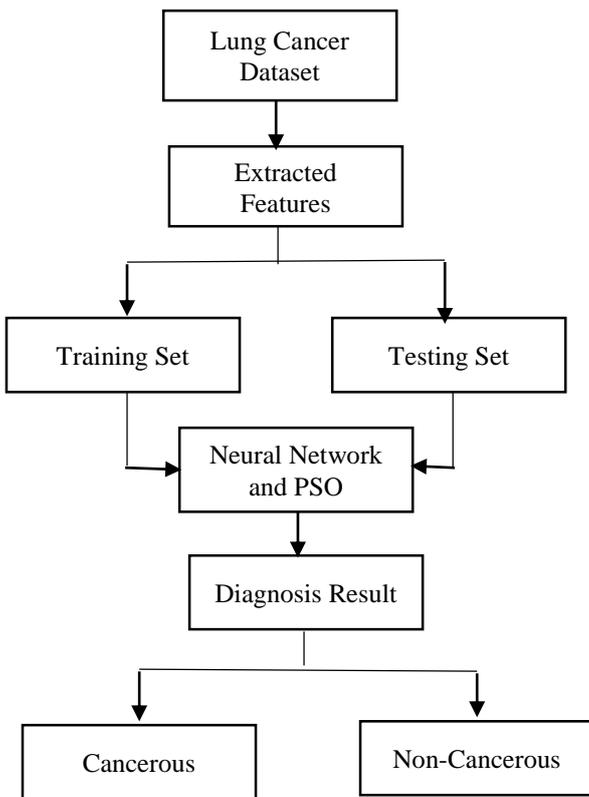


Figure 2 Flowchart for Proposed NN-PSO

a) The best position achieved by itself (pbest I) expressed by

$$p_i = (p_{i1}, p_{i2}, \dots, p_{iD})$$

b) The best position achieved by the whole swarm (gbest), for a given subset of the swarm which expressed by

$$p_g = (p_{g1}, p_{g2}, \dots, p_{gD})$$

The difference between the current position of the particle i and the best position of its neighborhood is represented as

$$(p_{g_xi})$$

The velocity defines the amount of change that will be applied to the particle. It denoted as

$$v_i(t) = v_i(t-1) + _1C1 \times (p_i - x_i(t-1)) + _2C2 \times (p_{g_xi}(t-1))$$

Figure 2 shows the flowchart for proposed NN-PSO. After completion of above processes, the last stage is the diagnosis stage. The obtained result shows that whether the given cancer image as in normal or in abnormal state. In this paper a proposed a Lung cancer prediction system based on neural network and Particle Swarm Optimization is implemented. This lung cancer prediction system proves that which helpful for the doctors for detection of a lung cancer.

EXPERIMENTAL RESULTS

The performance evaluation of proposed Neural Networks with Particle Swarm Optimization are simulated using MATLAB under windows environment. The implementation of this framework is performed on lung cancer dataset obtained from the UCI machine learning repository site [8]. The lung dataset given as input to the neural network and the data is divided into training data and test data. The training set for the neural network consists of 70% of the total dataset and the testing set is 30% of the total data. The proposed method is effectively compared with K-Nearest Neighbor [21], Support Vector Machine [23], Bayes Network [2] and Neural Network [6] in terms of performance metrics obtained from confusion matrix shown in table 1

TABLE 1: CONFUSION MATRIX

| | | Predicted Class | |
|--------------|--------------------|---------------------|---------------------|
| | | Prediction Positive | Prediction Negative |
| Actual Class | Condition Positive | True Positive (TP) | False Negative (FN) |
| | Condition Negative | False Positive (FP) | True Negative (TN) |

Performance Metrics

- True Positive (TP) - The Extracted dataset containing cancer nodule is classified as cancerous.
- False Positive (FP) - The Extracted dataset without cancer nodule is classified as cancerous.
- True Negative (TN) - The Extracted dataset without cancer nodule is classified as non-cancerous.
- False Negative (FN) - The Extracted dataset containing cancer nodule is classified as non-cancer

Accuracy

This means as many times the different samples or images are tested with the same algorithm and the machine or system provides results how much accurate. The accuracy is the proportion of true results (both true positive and true negative) in the total data.

$$Accuracy(A) = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

Sensitivity

Sensitivity means that how accurately a cancer test identifies people as presence of lung cancer.

$$\text{Recall(R) or Sensitivity} = \frac{TP}{(TP + FN)}$$

Specificity

Specificity means that how accurately a cancer test identifies people who do not have lung cancer.

$$\text{Precision(P) or (1 - Specificity)} = \frac{TP}{(TP + FP)}$$

ROC plot

A Receiver Operating Curve (ROC) is a measure of discriminatory performance for the given model and computing the area which is under the curve. In recent years the ROC became more popular because of the wide availability of computer software to compute the area under the curve. ROC is a plot of sensitivity by 1-specificity values which derived from several classification techniques used to classify the datasets as normal and abnormal.

Table 2 shows the performance comparison for the proposed method neural Network and PSO in terms of performance metrics such as accuracy, Specificity and Sensitivity.

TABLE 2 : PERFORMANCE COMPARISON OF NN-PSO

| Classifiers | Accuracy (%) | Specificity (%) | Sensitivity (%) |
|-----------------|--------------|-----------------|-----------------|
| K-NN | 68.9 | 72 | 59 |
| Bayes Network | 74.6 | 79 | 72 |
| SVM | 85.4 | 83.8 | 81 |
| Neural Network | 91.5 | 89.8 | 89 |
| Proposed NN-PSO | 97.8 | 94.8 | 92 |

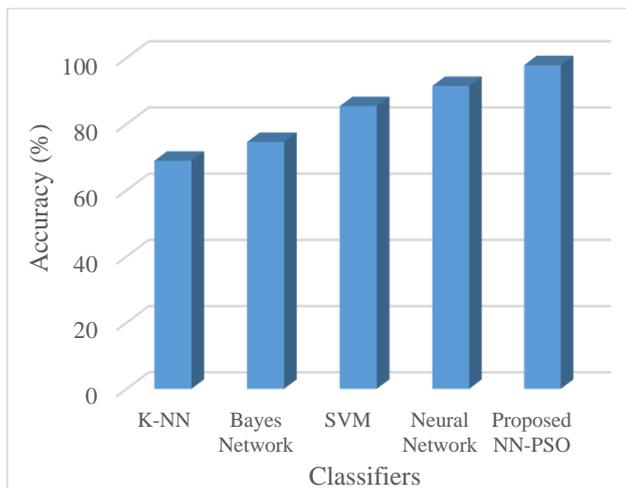


Figure 3 Accuracy Comparison for NN-PSO

Figure 3 shows the accuracy comparison for proposed Neural Network and Particle Swarm Optimization. It is clear that the proposed method achieves Classification accuracy of 97.5% and it predict the accurate cancerous cells.

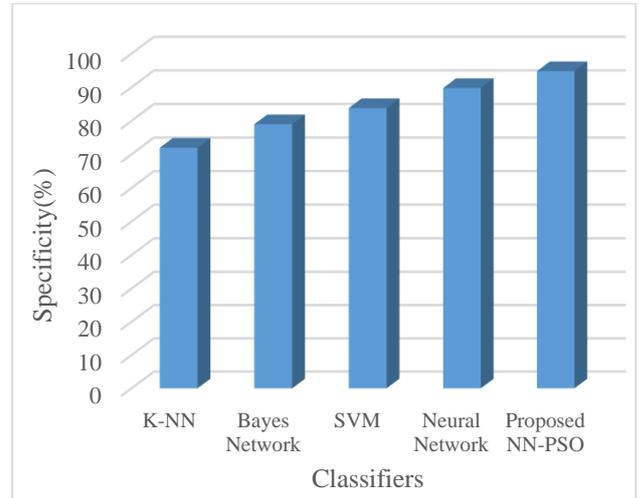


Figure 4 Specificity Comparison for NN-PSO

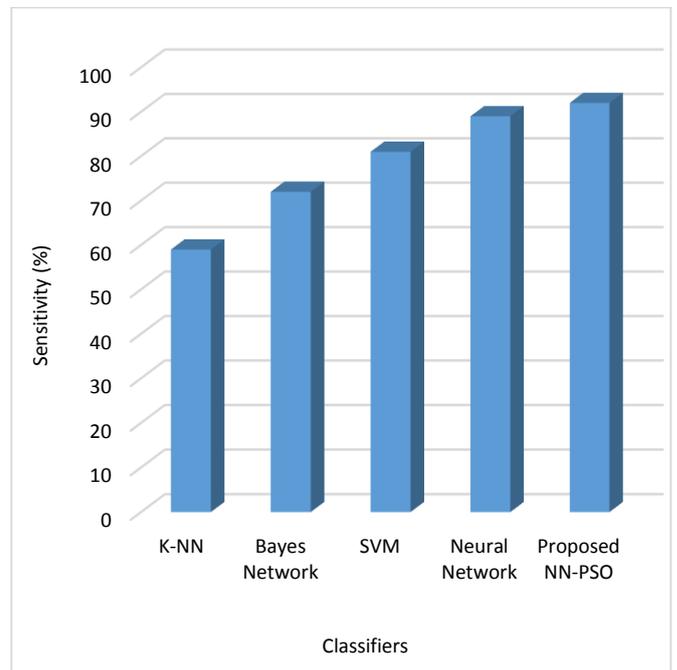


Figure 5 Sensitivity Comparison for NN-PSO

Figure 4 and 5 shows the specificity and sensitivity comparison of proposed Neural Network and Particle Swarm optimization. The proposed method achieves effective results when compared to other classifiers.

Table 3 shows the ROC plot for neural network with selected 50,100,150, 200 and 250 neurons and compared with other classifiers

TABLE 3: ROC PLOT FOR NN-PSO

| Neurons | K-NN | Bayes Network | SVM | Neural Network | Proposed NN-PSO |
|---------|-------|---------------|-------|----------------|-----------------|
| 50 | 0.014 | 0.024 | 0.056 | 0.08 | 0.1 |
| 100 | 0.55 | 0.36 | 0.4 | 0.5 | 0.7 |
| 150 | 0.848 | 0.72 | 0.66 | 0.78 | 0.87 |
| 200 | 0.89 | 0.8 | 0.72 | 0.83 | 0.92 |
| 250 | 0.92 | 0.85 | 0.76 | 0.89 | 0.95 |

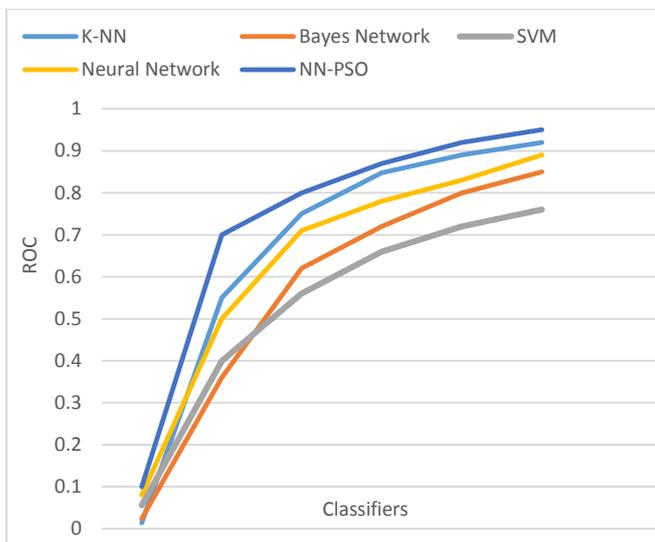


Figure 6. ROC Plot for NN-PSO

Figure 6 shows the ROC plot for proposed Neural Network. ROC curve is a two dimensional representation that proves that the neural network as the best suited for lung cancer prediction. The rate was 97% achieved by the ANN technique it should notice from this curve that the area under the curve is almost 1.

CONCLUSION

Prediction of lung cancer is most challenging problem in the medical field due to structure of cancer cell, where most of the cells are overlapped each other. There are over 100 different types of cancer and one of them is lung cancer. In lung cancer treatment delay results in high mortality rate. Detection of cancer in earlier stage is curable. In this work lung cancer prediction based neural network and Particle Swarm Optimization is implemented. ANN has many advantages such as long training time, high computational cost, and adjustment of weight. The main aim of this system is to provide the earlier warning to the users and it is also cost and time saving benefit to the user. The performance evaluation of proposed method shows effective results and it indicates that neural network can be effectively used for lung cancer diagnosis to help oncologists. The prediction could help doctor to plan for a better medication and provide the patient with early diagnosis.

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