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Research paper

Lung cancer detection and classification on CT scan images using enhanced artificial bee colony optimization

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Abstract

In recent years, prediction of cancer at earlier stages is obligatory to increase the chance of survival of the afflicted. The most dreadful type is lung cancer, which is identified as one of the most common diseases among humans worldwide. In this research work, the raw input image which usually suffers from noise issues are highly enhanced using Gabor filter image processing. The region of interest from lung cancer images are extracted with Otsu's threshold segmentation method and 5- level HAAR discrete wavelet transform method which possess maximum speed and high accuracy. The proposed Enhanced Artificial Bee Colony Optimization (EABC) is applied to detect the cancer suspected area in CT (Computed tomography) scan images. The proposed EABC implementation part, utilizes CT (Computed Tomography) scanned lung images with MATLAB software environment. This method can assist radiologists and medicinal experts to recognize the illness of syndromes at primary stages and to evade severe advance stages of cancer.

Keywords: *Image Segmentation; Artificial Neural Network; Enhanced Artificial Bee Colony Optimization.*

1. Introduction

The most serious universal health issue is Cancer. The mortality rate of cancer victims is greatly high when it relates to lung cancer, because the survival rate is very limited even after detection. The most wide spread and dreadful disease is lung cancer. The death rate of lung cancer patients can be minimized with early analysis and identification. Earlier the detection, higher is the success survival. Gradually, every year there is an increase in the casualty rate of lung cancer. It is reviewed that 85% of males and 75% of females are suspected with lung cancer due to cigarette smoking [1].

In general, the main part affected by Lung cancer is the chest. The natural flow of lymph spreads out cancer affected cells to the center portion of chest, which makes worst scenario for the patient to survive. Lung cancer is commonly divided into two main classes as small cell and non-small cell, based on the characteristics of cell formation. There are four stages of lung cancer from 1 through 4. Depending on the tumor size and location of lymph node, the stage varies. Depending on stages of cancer cell discovered, the possibility of the survival is identified. This necessitates the detection of lung cancer at an early stage. It also increases the possibility of survival of victims. In modern technology, plain chest X-ray does not suit for lung cancer detection. Hence, use of CT scan image is suggested to facilitate effective identification of lung cancer. Identification process of lung cancer cells at the early stage should be the life saving process to many cancer affected victims throughout the world. Image enhancement, image segmentation and feature extraction process are the most significant in lung cancer detection. The implementation of proposed Enhanced Artificial Bee Colony optimization based classification techniques has been found to improve the speed and accuracy rate compared with previous methods.

This research paper is organized as follows. Section 2 deals with review of literature. Section 3 explains the methodology of the research work. Section 4 explains the lung cancer prediction using Enhanced Artificial Bee Colony optimization technique. Section 5 clearly specifies the dataset description. Section 6 shows the results obtained from various analyzed methods.

2. Review of literature

Several works exists on detecting lung cancer. Image processing based diagnosis had greatly improvised the accuracy of detection. This section discusses the importance of existing works related to detection of lung cancer, based on image processing. Sharma et.al. (2011) [2] in their work proposed an automatic computer aided diagnosing system which uses CT scan images collected from NIH/NCI Lung Database Consortium. They used several methods to find the presence of lung cancer. Anam Tariq et.al. (2013) [3] modeled a two stage approach using computerized system to find lung nodules in CT scan images. In the first stage, they did segmentation of lung and in the second stage feature extraction and classification were performed to find out the presence of cancer. Sundararajan et.al. (2010)[4] developed a support vector machine for the detection process of pneumoconiosis. Pneumoconiosis is an occupational and a restrictive lung disease caused by the inhalation of dust, in mines and from agriculture. The researcher applied textural features to find the disjointed segments of the lungs and concentrated on subset of lung complaints. Le (2011) [5] developed a complex system for detecting various lung disorders. They used image processing technique for the determination of lung nodule, but they had not used false positive reduction process.

Chaudhary et.al. (2012) [6] devised a new method based on image processing to detect lung cancer. They produced more accurate result by performing necessary steps like image preprocessing, image segmentation, enhance the raw image and feature extraction. Gabor filter is used for image enhancement along with fast fourier transform, to extract the features to be reviewed. Hashemi et.al. (2013) [7] focused on improving the efficiency of diagnosing lung cancer by implementing region grow algorithm for segmentation [22]. Initially, they used liner filtering for removing noise in the raw image and enhanced the quality of image. Contrast enhancement is applied to perform segmentation. Then, the segmented images are classified as malignant, benign and advanced lung nodules by proposing fuzzy inference system. Schilham et.al. (2006) [8] developed a model using k-nearest neighbor (k-NN) classifier for the images collected from JRST database. Gaussian scale space maxima are used along with multi scale to detect variant sized lung nodules. From their simulation result, it is proved that the proposed method outperforms at higher false positive rates. Pereira et.al. (2007a) [9] proposed a sliding band filter method. It is based on merging of radial gradients to sense the lung nodule by means of the JSRT database deprived of false positive reduction process. S.K. Vijai Anand et.al. (2010) [10] anticipated lung tumor from CT images with the aid of image handling techniques tied with neural network classification to identify the type of tumor is benign or malignant. S.L.A. Lee et.al. (2008) [11] projected a random forest tree based classifier to discover all the nodules in the images and detailed a low false detection rate. The projected process comprises three stages namely image acquirement, removal of background and detection of lung nodules. Lung nodules are determined by exhausting images from LIDC lung databases. Vijay A. Gajdhane et.al. (2014) [12] proposed detection of lung cancer by image processing techniques with the help of CT scan images. Three steps were mainly used all over the report. The steps used in their work are pre-processing, feature extraction and classification process. Ada (2013) [13] proposed a method with a combination of feature extraction and Principal Component Analysis (PCA). Histogram equalization is used for pre-processing the images and features were extracted with the help of PCA. Sudha. V, Jayashree. P et.al. (2012) [14] proposed an efficient lung nodule detection system using CT scan images. The proposed method performs two steps; first lung region segmentation carried out through thresholding and then morphological operations were used for segmenting the lung nodules. Fan Zhang et.al. (2013) [15] suggested Support Vector Machine (SVM) based classifier by means of feature based imaging classification method, to categorize the lung nodules in Low Dose. Computed Tomography glides into four groups that are, well constrained, vascularised, juxta-pleural and pleural-tail. S. Sivakumar et.al. (2013) [16] developed a well-organized lung nodules detection scheme by performing nodule segmentation. For nodule segmentation, weighted fuzzy probabilistic clustering was carried out for lung cancer images [25]. SVM used for classification purpose. Sunil Kumar et.al.(2014) [17] proposed, Computer Aided Diagnosis (CAD) that detects the lung cancer at early stage, using various image processing techniques with the help of CT scan images [24]. This research work introduces the natural behavioral based method for detection and classification of lung cancer in which it produces high true positive rate in an effective manner [27].

3. The methodology

The proposed Enhanced Artificial Bee colony Optimization consists of three vital processes for designing and development of lung cancer detection. The Pre-processing is carried with image enhancement and feature extraction process. The extraction process further follows segmentation that uses 5-level HAAR wavelet transformation technique. Finally, the classification of lung cancer images is done. All the above processes are carried out in MATLAB. The overall framework involved in the lung cancer detection system can be viewed in Figure 1.

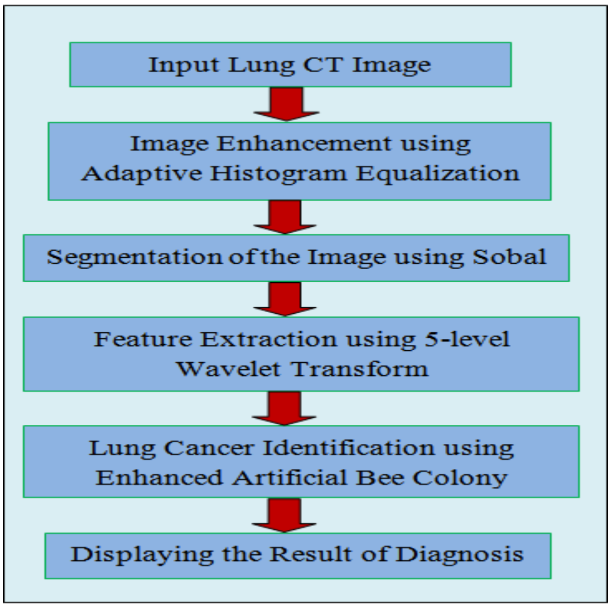

Fig. 1: Overall Framework of the Proposed Lung Cancer Detection.

The initial step of the lung cancer detection model is to collect the lung CT image. The lung CT images collected from Lung Image Database Consortium and Image Database Resource Initiative (LIDC-IDRI) [18] [23] are stored as images and accessed using MATLAB. The CT scan images are best suited for the detection process, owing to their low noise [28] [29]. The acquired CT scan images are stored as JPEG/PNG format before improving the clarity by removing little noise present in the images. Computed Tomography (CT) scan images have improved quality, low noise and misrepresentation of lung diagnosis. Hence, CT scan lung images are taken as input for preprocessing. Sizes of images are 512 X 512-pixel rate.

3.1. Image enhancement using adaptive histogram equalization

In this section, the enhancement of the input CT scan images is conceded by applying adaptive histogram equalization, which is an extension of conventional histogram equalization process. This process improves the image contrast and is well suited for improvising the local contrast images in more detailed manner with pixel noise elimination [26] [27]. The enhancement of each pixel is carried out with the help of small neighboring area of an image, by applying histogram equalization. While using Adaptive histogram, there is a chance of noise amplification as well as artifacts in boundary regions [19,20]. In order to overcome the artifact occurrence in images, the Contrast Limited Adaptive Histogram Equalization (CLAHE) is applied with the function “adapthiseq” operator on the selected small regions in the lung images, which is termed as tiles. While using histogram equalization, they work on the entire regions. While using CLAHE, they operate on small region of images which greatly enhances the source image. Each tile's contrast is improved, so that the histogram of the production region nearly matches a quantified histogram. After execution of the equalization process, it associates with the neighboring tiles using bilinear exclamation to remove exaggeratedly persuaded borders. The amplification of noise is also done in this method for limiting the contrast especially in homogenous areas. The process is clearly represented in figure 2.

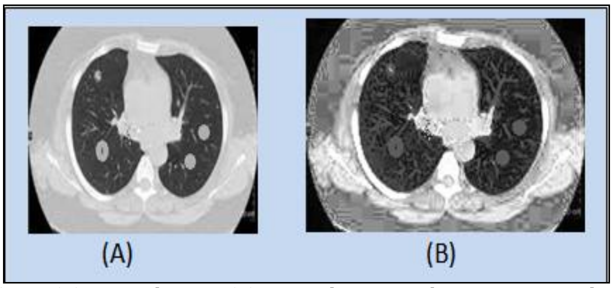

Fig. 2: (A) Original Image (B) Original Image with Histogram Equalization.

3.2. Lung image segmentation

The process of image segmentation is carried out for dividing the image into segments in order to get more detailed information on the selected lung image. The main motive of the segmentation process is to simplify the image representation into more meaningful manner and for analyzing them easily and effectively. The process of segmentation generally divides the images into fundamental regions and objects. The resultant of the segmented objects covers the entire image into a set of notable regions extracted from it. The watershed algorithm uses marker control is used for segmenting and the procedure is explained below. (Figure 3)

Step1: Computing an image whose dark regions are considered as objects to be segmented.

Step2: In the foreground determination process, markers are used for finding the connected blocks of pixels within identified objects.

Step3: The unwanted part of an image is denoted using back ground markers.

Step4: The segmentation of the image easily differentiate the foreground and background marked places

Step5: Finally, find the segmentation part of the image using watershed transform.

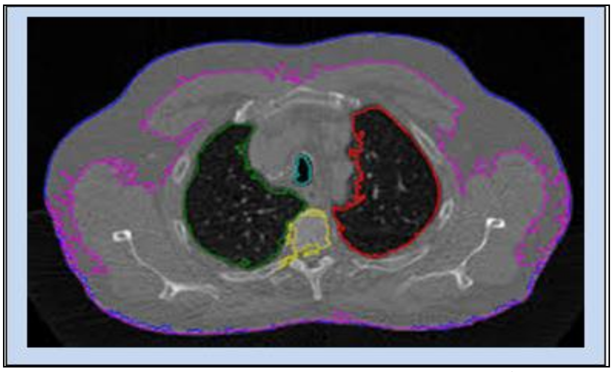

Fig. 3: Image Segmentation Using Watershed Transform.

3.3. Feature extraction using 5 level haar wavelet transform

In general, the lung image consists of more number of texture data for determining the unique parts. Extracting the lung image pattern with noiseless process helps to increase the quality of matching the database images. This is done by applying five-level haar wavelet transform for decomposing the image as tiny as possible.

The steps for feature extraction using five levels HAAR wavelet transform are as follows:

Step 1: Perform 2D DWT with Haar up to 5-level decomposition on the input lung image.

Step 2: During the process of level 4 and 5 the division detail gives the feature vectors of the lung image.

Step 3: The obtained vectors of feature of lung image code are in the binary form

Step 4: Save the binary code of the lung image in database.

3.4. Block diagram of feature extraction

Figure 4 shows the decomposition of the lung image with down sample of 5 and storing the approximation (cA) and feature (cH, cV, cD) matrices.

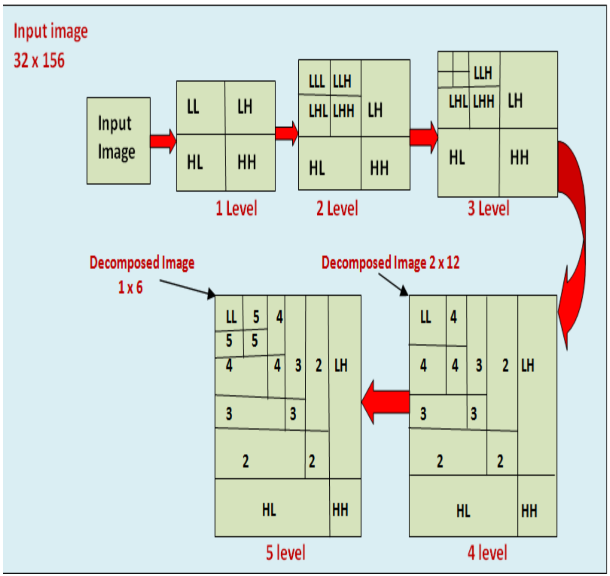

Fig. 4: Decomposition Process.

Step1: The selected lung image is normalized and used as input and it is represented as i.

Step2: Determine rows blocks, call the filter functions for low pass and high pass filters (LPF ()) and (HPF ()).

Step3: Down sample the image columns by 2 and retain uniform index columns.

Step4: Take into account the image column blocks from lung, perform the low pass and high filter on the image.

Step5: Down sample the image rows by 2 and keep uniform index rows.

Step6: Exchange Rows and Columns of filter entries.

Step7: Collecting approximation matrix coefficient & Feature matrix coefficient in term of Low to Low (LL) for approximation, Low to High (LH) for horizontal, High to Low(HL) for vertical and High to High(HH) for diagonal.

Step8: Yield Decomposed lung image for level 1.

Step9: Recurrence step 2 to step 7 for i+1 lung image and decompose selected image for level 2, level 3, level 4 and level 5.

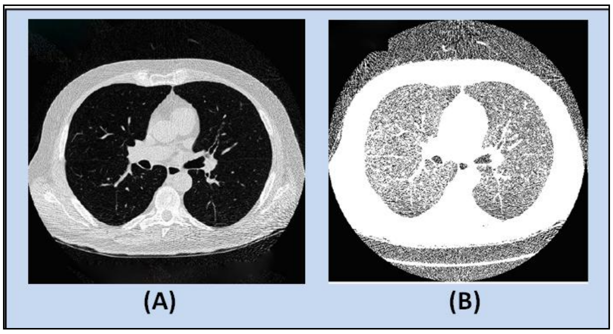

Fig. 5: (A) Original Image (B) Enhanced by 5 Levels HAAR Wavelet Transform.

3.5. Artificial neural network (ANN) for prediction of lung cancer

In various medical issues like cancer detection, analysis of biochemical changes and finding pathological issues are most successful and prominent in Artificial Neural Network. Depending on the selection of network parameters, the performance of the ANN will attain better result. Related to the dataset, the number of input, hidden and output neurons has to be chosen. In ANN, a set of image features which consist of most significant features of an input image are fed as input to the network. The developed network trained using sample of known targets by feed forward neural network, which consist of hundred of weights in back propagation. The ANN performance is assessed by testing the output of the network with the expected output. The outcomes are then validated to determine the accuracy of testing [30]-[36].

4. Enhanced artificial bee colony optimization for prediction of lung cancer

In Artificial Bee Colony (ABC) algorithm, the possible solution for optimization is represented as the position of food resource problem. The amount of a food source is correlated to the quality of the solution associated with it. The amount of on looker bees and the employed bees are equal to the possible number of solution regards to population. In ABC algorithm, there are three important control parameters: they are the amount of food sources which is equal to the number of onlooker bees or employed bees (SN), the limit value and maximum cycle number (MCN). The recruitment rate of honeybees denotes how soon the bee colony determines and reveals a new discovered food source. Depending on the efficiency of the fast discovery and utilization of the best resource, the progress and the survival rate of bee colony will be. Proper case study of the existing problem and the way of deploying the proposed method in an effective way is very important.
In ABC algorithm, though onlookers and employed bees perform the process of discovery in search space, the scout bees perform the process of exploration. Comprehensive pseudo-code of ABC algorithm is given below [21].

Procedure for Artificial Bee Colony Optimization Algorithm

Step 1: Set round =1
Step 2:Set ABC variables parameters
Step 3:Estimate the fitness of all single images
Step 4: Repeat
Step 5:Build solutions using bees designated as employees.
Allocate feature subset patterns which is represented using binary bit string to all employed bee
Create fresh feature subsets FVi
Input the resultant feature subset to the concern classifier
Calculate the fitness (fitnessi) of the feature subset of images
fitnessi= 1/(1+finessti)
Compute the probability probi of solution of feature sunset
Probi = fitnessi/($\sum_{i=1}^{m} fitness_i$)
Step 6:Build solution space using onlookers
Choose a feature related to probability probi
Create the new solutions Si for the onlooker bees from the existing solutions, xi selected
depending on probi and evaluate them
Perform the process of greedy selection for the onlooker bees.
Step 7:Define the unrestricted solution for the scout, if survives, and substitute it with a new
arbitrarily created solution xi by
$X_i^j = X_{min}^j$ + rand [0,1] ($X_{max}^j - X_{min}^j$)
Step 8:Remember the finest solution attained so far.
Step 9: round = round + 1
Step 10: until round = MCN

4.1. Working principle of enhanced artificial bee colony optimization

In this proposed research work, the process of ABC algorithm is enhanced by introducing adaptive way of lung cancer detection. Initially, the random set of population of solutions is generated, which in future stages keep on adaptively changing. The average population size of the food source position of consequent generations is taken from each individual among the present population is given below:
Step1: Set the initial population of solutions xi,G. Then state pol as variable (Initialize pol=0)
Step2: for (i=0; i<lung_images; i++)
Step3: intpol= pol+ lung_images[i][D];
Step4:lung_images=(int)(pol/lung_images)+0.5);
Step5: Patterned population size, as amount of lung images equals half of the bee colony size
Step6: Then follow steps from 3 to 6 defined above in the Pseudo code of ABC optimization algorithm

5. Dataset description

To stimulate this research proposal and progress-events in this area, the National Cancer Institute (NCI) formed the Lung Image Database Consortium – the LIDC (7–9). The task of the LIDC is: (a) to cultivate an image database as a web of available universal inquiry source for the improvement, teaching, and assessment of CAD methods for lung cancer detection and diagnosis using CT and (b) to make this database to empower the relationship of recital of CAD methods for discovery and organization of lung nodules with three-dimensional, time-based and obsessive pulverized fact. Consequently, the LIDC is certain to make three classes of objects to be noticeable:
Step1: Nodules ≥ 3 mm in diameter, irrespective of recognized histology
Step2: Nodules < 3 mm in diameter of an uncertain nature
Step3: Non-nodules ≥ 3 mm in diameter
Step4: Nodules that are < 3 mm but are clearly benign (i.e. solidly calcified) were precisely left out from being marked, as were non-nodules < 3mm.
This simulation analysis takes 100 lung images for this research work. Those chosen lung images are used to analyze the performance with the proposed algorithm.

6. Results and discussion

This research work is designed and developed using MATLAB Tool. The lung images are collected from the LIDC open repository. With the assistance of image processing toolbox, image preprocessing, segmentation and feature extraction is done. Its functionalities are used in proposed enhanced artificial bee colony based lung cancer detection system.

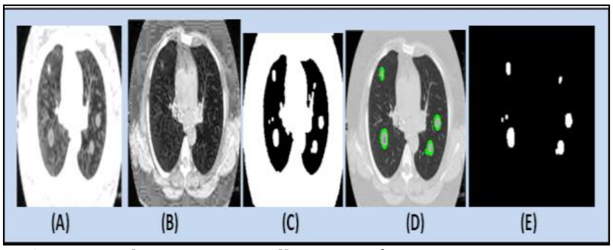

Fig. 5: Sample Image 1 Overall Process of Lung Cancer Detection.

(A) – Original image with histogram equalized
(B) – Dilated gradient mask
(C) – Gabor filtered enhanced image
(D) – Cleared border image
(E) – Possible location of cancer is traced by green boundary

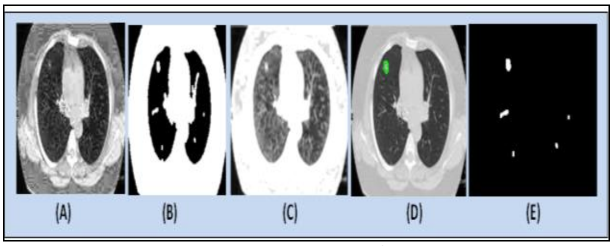

Fig. 6: Sample Image 2 Overall Process of Lung Cancer Detection.

(A) – Original image with histogram equalized
(B) –Gabor filtered enhanced image

(C) – Dilated gradient mask
(D) – Cleared border image
(E) – Possible location of cancer is traced by green boundary
The proposed enhanced artificial bee colony detects the lung nodules around 3 mm diameter , which is possible at the earlier stage itself. Thus, it provides the facility for the earlier diagnosis of lung cancer which will greatly improve the survival rate of the victims. It also differentiates between cancerous and non-cancerous candidate nodules using enhanced artificial bee colony optimization approach. On one hand, we have established an automatic system for early identification of lung cancer using lung CT images in which a high level of sensitivity has been achieved, with a reasonable amount of false positives per image. This leads to a standstill system from delaying the radiologist's diagnosis. On the other hand, the proposed system is capable of noticing lung nodules with diameter ≥ 3 mm, which means that the system is capable of detecting lung nodules when they are in their initial stages [21, 22].

Table 1: Performance Analysis of Artificial Neural Network Classifier

Methods	TPR	FERR
ANN	78.9	21.1

Performance Evaluation Metrics: In order to measure the proposed classifier performance two different evaluation metrics are used in this paper. They are True positive Rate (sensitivity) and False Error Rate(specificity) that are counted based on the number of true positives, false positives and false negatives.
True Positive Rate (TPR): It measures the ratio of positives that are correctly identified as cancerous as cancerous and non-cancerous as non-cancerous
False Error Rate (FERR): It measures the ratio of negatives that are correctly identified as cancerous as non-cancerous or vice versa.
Result of Artificial Neural Network on Lung cancer Detection: Table 2 shows the performance of the ANN with the CT scan images of lung nodules and the model performs the classification of an input image as cancerous or non-cancerous from its learning capability. The True positive rate of the ANN is 78.9% and its false acceptance rate is 21.1%.

Table 2: Performance Analysis of Artificial Neural Network Classifier

Methods	TPR	FERR
EABC	92.4	7.6

Result of Artificial Bee Colony Classifier on Lung cancer Detection: Table 3 shows the performance of artificial bee colony optimization in which the given sets of images are compared with the existing known information of cancerous and non-cancerous images. Depending on the evaluation of fitness function, the images with high fitness value are used for learning, and classify lung nodules based on the gathered information. The True positive rate of this method is 81.3 and the false error rate is 18.7%.

Table 3: Performance Analysis of Artificial Bee colony Classifier

Methods	TPR	FERR
ABC	81.3	18.7

Comparison of Proposed Enhanced Artificial Bee Colony Optimization: Figure 8 shows the comparison of the proposed EABC with the other two existing techniques Artificial Neural Networks and Conventional Artificial Bee colony Optimization. The Classification of lung images suspected to be cancer or not is highly identified by EABC by achieving high True positive rate with low False Error rate.

Table 4: Comparison of Proposed Enhanced Artificial Bee Colony Optimization

Methods	TPR	FERR
ANN	78.9	21.1
ABC	81.3	18.7
EABC	92.4	7.6

For simulation analysis, this proposed method uses CT images which are collected from the open repository of NIH/NCI Lung Image Database Consortium (LIDC) dataset that delivers the chance to do the recommended research. This simulation analysis takes nearly hundreds of lung images. Those chosen lung images are used to analyze the performance of the proposed framework. The analysis rules are then produced from those images and the generated rules are delivered to the classifier for the training process. After the training process is complete, a lung image is sent to the proposed system.

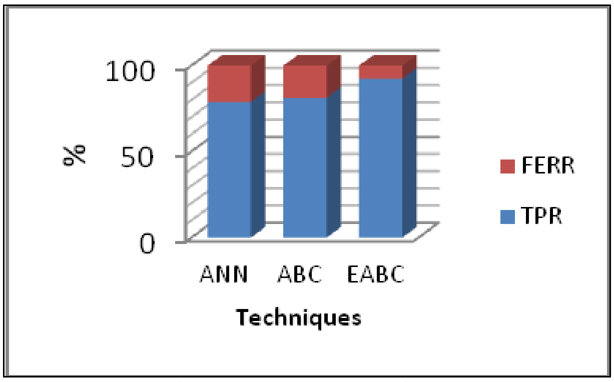

Fig. 7: Comparison of Proposed Enhanced Artificial Bee Colony Optimization with Other Two Existing Techniques.

Then the proposed system will progress through its sequence of steps and finally it will perceive whether the provided lung image is affected with cancer or not. On the other hand, the users have established an enhanced artificial bee colony based detection system for early detection of lung cancer. Using CT scan images of lungs in which very high sensitivity level has been attained, with a sensible amount of false positives per image, (92% sensitivity with 0.04 false positives per image)will avert the proposed system from delaying the radiologist's diagnosis.

7. Conclusion

In this work, detection of lung cancer on CT scan images is carried out with the aid of image processing, which improves the quality of the input lung images for earlier detection of disease. Simultaneously, time taken for the whole process is also considerably less. The abnormality of the lung nodules or the tissues is easily determined as targeted images. The lung image quality and accuracy are the important issues of this research; image quality valuation as well as improvement stages were deployed on low pre-processing techniques using Gabor filter within the rules of Gaussian. The proposed technique is effectual for segmentation ideologies to be a region of interest foundation for feature extraction using 5 level haar wavelet transform. The proposed methodology produces more promising result while comparing with the other existing approaches. Trusting on overall features of the images, a normality or abnormality comparison is done. The foremost features detected for accurate lung cancer images are done using pixels percentage which developed using the enhanced artificial bee colony optimization, which classify the percentage of the possibility of lung cancer nodules more accurately.

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