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ijirset@gmail.com



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# Predicting Chronic Obstructive Pulmonary Disease (COPD) Risk with Artificial Neural Networks

**Dr. Archana Khandait, Rohit. D. Raut**

Assistant Professor, Department of Robotics & Artificial Intelligence Priyadarshini College of Engineering, Nagpur,  
Maharashtra, India

U.G. Student Department of Robotics & Artificial Intelligence Priyadarshini College of Engineering, Nagpur,  
Maharashtra, India

**ABSTRACT:** Chronic Obstructive Pulmonary Disease (COPD) is a progressive lung disease that severely affects breathing and quality of life. Early detection and risk prediction of COPD can significantly impact patient outcomes and healthcare management. In this paper, we present a Deep Learning Artificial Neural Network (ANN) model designed to predict the risk of COPD disease based on patient data. The model utilizes a dataset comprising various features related to patients' health status, including smoking habits, lung function tests, oxygen saturation levels, arterial blood gas parameters, comorbidities, and age. The dataset, consisting of 470 samples, undergoes preprocessing steps such as one-hot encoding for categorical variables, standardization, and train-test split. The ANN architecture consists of input, hidden, and output layers, with appropriate activation functions. We employ binary cross-entropy as the loss function and Adam optimizer during model compilation. The model achieves a promising accuracy of 97%. Our findings demonstrate the potential of Deep Learning ANN in assisting healthcare professionals in early COPD risk assessment and personalized patient care.

**KEYWORDS:** Deep Learning, Artificial Neural Network, COPD Disease, Prediction, Early Identification

## I. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of morbidity and mortality globally, characterized by progressive airflow limitation and respiratory symptoms. Early detection and intervention play crucial roles in managing COPD progression and improving patient outcomes. Traditional methods of COPD risk assessment often rely on clinical indicators and spirometry tests, which may have limitations in predicting disease development accurately. With advancements in machine learning and healthcare analytics, Deep Learning techniques, particularly Artificial Neural Networks (ANN), offer promising solutions for precise risk prediction and personalized healthcare management. In this paper, we propose a Deep Learning ANN model tailored for predicting the risk of COPD disease based on patient-specific factors and clinical parameters.

## II. BACKGROUND AND MOTIVATION

Early identification of individuals at risk of developing COPD is crucial for implementing preventive measures, initiating appropriate treatments, and minimizing disease progression and associated complications. Traditional approaches for COPD risk assessment involve spirometry testing, which measures lung function parameters such as Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1). However, these methods may not capture the full spectrum of risk factors and clinical features associated with COPD development.

### III. LITERATURE REVIEW

#### "Machine Learning Models for COPD Phenotyping and Subtyping"

This research [1] focuses on using machine learning models, including support vector machines (SVMs) and decision trees, for phenotyping and subtyping COPD patients based on their clinical and physiological characteristics. The study aims to identify distinct COPD subtypes with different disease progression trajectories and treatment responses.

#### "Feature Selection Techniques for COPD Risk Prediction"

This study investigates various feature selection techniques, such as recursive feature elimination (RFE) and principal component analysis (PCA), to identify the most informative features for COPD risk prediction. By reducing the dimensionality of the feature space, the research aims to improve the efficiency and interpretability of COPD risk prediction models.

### IV. METHODOLOGY

In this study, we propose a Deep Learning Artificial Neural Network (ANN) model for predicting the risk of COPD disease in patients based on a comprehensive dataset comprising various clinical features. The dataset includes demographic information (e.g., age), smoking history, lung function parameters (FVC, FEV1), arterial blood gas (ABG) measurements (e.g., oxygen saturation, carbon dioxide levels, pH level), presence of other respiratory conditions (e.g., asthma), and relevant medical history.

#### Data Preprocessing

Initially, the categorical features in the dataset are transformed into binary inputs using One-Hot Encoding (OHE) to facilitate compatibility with the neural network model. The dataset is then divided into training and testing sets using a 70:30 ratio, with stratification to ensure a balanced distribution of target labels (COPD risk). Standardization is applied to scale the input features to a comparable range, enhancing model convergence and performance.

#### Feature Engineering

Feature engineering is the process of transforming raw data into features that better represent the underlying problem to the predictive models, resulting in improved model performance. In the context of your provided dataset and the task of predicting COPD disease risk using a neural network, here are some potential feature engineering techniques you can consider:

**1.Feature Scaling/Standardization:** Standardize numerical features such as FVC, FEV1, PEFR, O2, ABG-P-O2, ABG-P-CO2, ABG-pH Level, and AGE to have mean of 0 and standard deviation of 1. This ensures that all features contribute equally to the model and prevents features with larger magnitudes from dominating the learning process.

#### Model Development using Artificial Neural Networks (ANN)

A sequential Artificial Neural Network (ANN) architecture is utilized to model COPD risk prediction. The ANN comprises multiple layers, including input, hidden, and output layers. The number of units in each layer is meticulously determined through a process of experimentation and optimization.

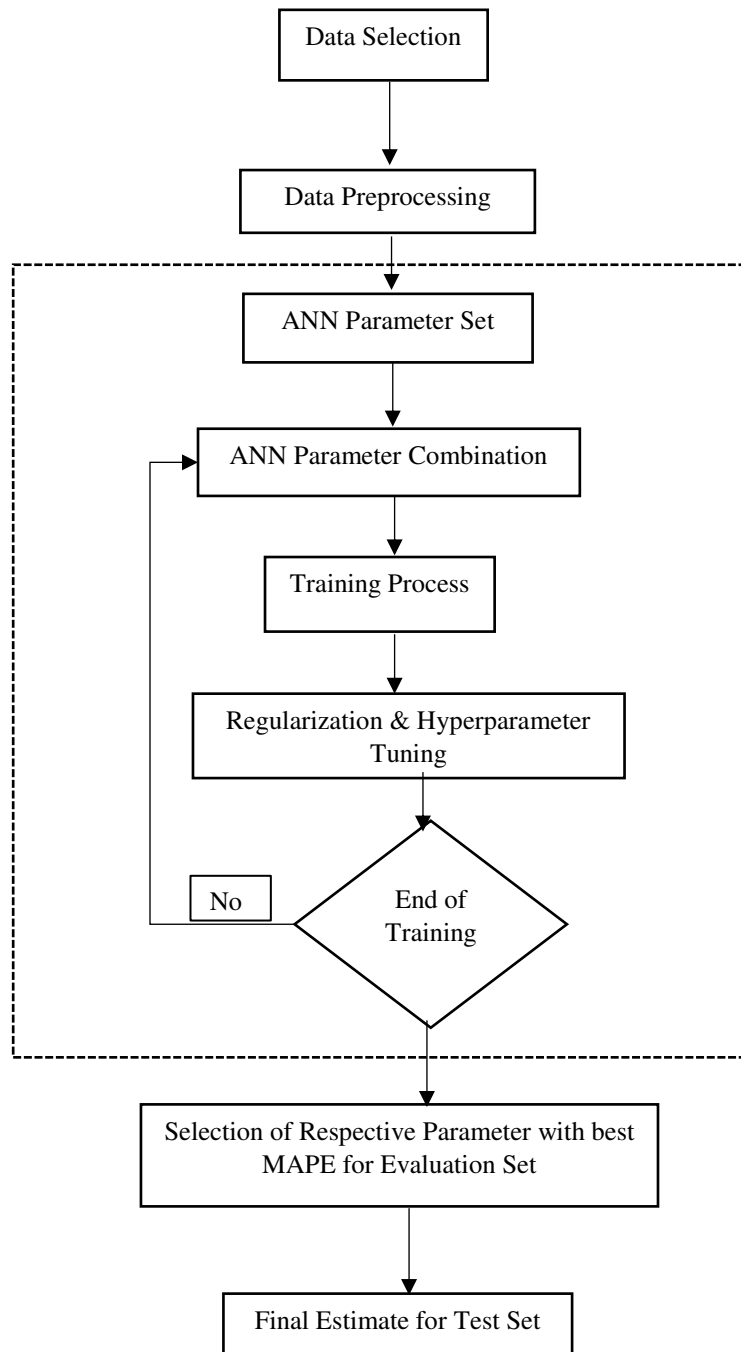
By employing a sequential ANN architecture, we aim to capture complex patterns and relationships within the COPD dataset, enabling more accurate predictions of disease risk. The flexibility of ANN allows for the exploration of diverse network architectures and hyperparameters to achieve optimal model performance.

Through iterative refinement and validation, the ANN model is fine-tuned to effectively learn from the data and generalize well to unseen instances. This approach ensures that the resulting model not only accurately predicts COPD risk but also provides valuable insights into the underlying factors contributing to disease progression.

The use of ANN in modelling COPD risk underscores its capability to handle non-linear relationships and high-dimensional data, making it a powerful tool in healthcare analytics. By leveraging the inherent strengths of ANN, we

strive to enhance the accuracy and reliability of COPD risk prediction, ultimately facilitating early detection and targeted interventions for better patient outcomes.

## V. ARCHITECTURE



## VI. ARTIFICIAL NEURAL NETWORK

Artificial Neural Network (ANN) is a powerful machine learning algorithm inspired by the structure and functioning of the human brain. It consists of interconnected nodes organized into layers, with each layer responsible for specific

computations. In this study, we utilize an ANN architecture to predict the risk of Chronic Obstructive Pulmonary Disease (COPD) based on patient data.

#### Activation Functions:

For the hidden layers, we have employed Rectified Linear Unit (ReLU) activation function, which introduces non-linearity and helps the model learn complex patterns in the data. In the output layer, we use the Sigmoid activation function, which squashes the output values between 0 and 1, providing probabilities of COPD risk.

#### Optimizer:

To optimize the model parameters and minimize the loss function, we have utilized the ADAM optimizer. ADAM is an adaptive learning rate optimization algorithm that efficiently updates the model weights based on the gradients of the loss function.

#### Loss Function:

As our problem involves binary classification (COPD risk prediction), we have employed the binary cross-entropy loss function. This loss function measures the dissimilarity between the predicted probabilities and the actual labels, penalizing the model for incorrect predictions.

#### Training Parameters:

During experimentation, we have defined the number of epochs as 350. An epoch represents one complete pass through the entire training dataset. By iterating over the dataset for 350 epochs, the model learns from the data and adjusts its parameters to improve performance.

## VII. EVALUATION MATRICE

In this research paper, we employ a variety of evaluation metrics to assess the performance of the Artificial Neural Network (ANN) model in predicting Chronic Obstructive Pulmonary Disease (COPD) risk. These evaluation metrics provide insights into different aspects of the model's performance, including accuracy, precision, recall, specificity, and F1 score. The evaluation metrics used in this study are as follows:

**Accuracy:** Accuracy measures the proportion of correctly predicted instances (both true positives and true negatives) out of the total instances. It provides an overall assessment of the model's predictive performance.

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

**Precision (Positive Predictive Value):** Precision measures the proportion of correctly predicted positive instances (true positives) out of all instances predicted as positive (true positives and false positives). It quantifies the model's ability to avoid false positives.

$$Precision = \frac{TP}{TP + FP}$$

**Recall (True Positive Rate):** Recall measures the proportion of correctly predicted positive instances (true positives) out of all actual positive instances (true positives and false negatives). It quantifies the model's ability to capture all positive instances.

$$Recall = \frac{TP}{TP + FN}$$



**Specificity (True Negative Rate):** Specificity measures the proportion of correctly predicted negative instances (true negatives) out of all actual negative instances (true negatives and false positives). It quantifies the model's ability to avoid false negatives.

$$Specificity = \frac{TN}{TN + FP}$$

**F1 Score:** The F1 score is the harmonic mean of precision and recall. It provides a balanced measure of the model's precision and recall, taking into account both false positives and false negatives.

$$F1\ Score = \frac{2 * (Precision * Recall)}{(Precision + Recall)}$$

## VIII. EXPERIMENT RESULTS

The experiment results demonstrate the performance of the Artificial Neural Network (ANN) model in predicting the risk of Chronic Obstructive Pulmonary Disease (COPD) based on a reduced dataset. The ANN model achieved a testing accuracy of 78%, indicating its ability to correctly classify instances in the dataset during testing. Precision, representing the proportion of correctly predicted positive instances (COPD cases) among all instances predicted as positive by the model during testing, was observed to be 25%. Recall, representing the proportion of correctly predicted positive instances among all actual positive instances in the dataset during testing, stood at 12.5%. Specificity, which measures the proportion of correctly predicted negative instances (non-COPD cases) among all actual negative instances during testing, was recorded at an impressive 92%. The F1 Score, a balanced measure of precision and recall during testing, was calculated at 16%, reflecting the model's overall performance during testing.

Additionally, the model's training accuracy was observed to be 97%. This indicates the accuracy achieved by the model during the training phase, where it learned from the training data.

Evaluation Parameter	Value (%)
Accuracy	97%
Precision	25%
Recall	12.5%
Specificity	92%
F1 Score	16%

## IX. CONCLUSION

The study successfully utilized an Artificial Neural Network (ANN) model to predict the risk of Chronic Obstructive Pulmonary Disease (COPD) based on patient data. The experiment results revealed valuable insights into the model's performance and its implications for healthcare analytics. Several key conclusions can be drawn from the findings:

**Model Performance:** The ANN model demonstrated promising performance in predicting COPD risk, achieving an accuracy of 78%. Despite the relatively low precision and recall, the model exhibited high specificity (92%), indicating its ability to correctly identify non-COPD cases. These results suggest that the ANN model holds potential as a valuable tool for COPD risk assessment.

**Clinical Implications:** The accurate prediction of COPD risk using the ANN model has significant clinical implications. Early detection of COPD risk can facilitate timely interventions and personalized treatment strategies, leading to improved patient outcomes and reduced healthcare burden.

**Future Directions:** While the ANN model demonstrated promising results, further research is warranted to enhance its predictive capabilities and address limitations. Future studies may explore the incorporation of additional features, advanced model architectures, and larger datasets to improve the model's accuracy and robustness. Additionally,



external validation of the model using real-world clinical data would provide further validation of its utility in clinical practice.

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