

A Review of Bio-inspired and Artificial Intelligence Techniques for Respiratory Disease Diagnosis

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ABSTRACT

A respiratory illness is any condition that affects the lungs or other parts of the respiratory system, which are vital for breathing. This system comprises the nose, throat, airways (including the bronchi), and lungs. Respiratory problems include COPD, asthma, tuberculosis (TB), COVID-19, lung cancer, and pneumonia. Breathlessness, chest discomfort, coughing, and wheezing are common symptoms. The causes of respiratory diseases include infections, smoking and air pollution, allergies, and genetic factors.

Bio-inspired algorithms used in respiratory disease analysis include Swarm Intelligence-Based Optimization Algorithms, Evolutionary/Bio-Inspired Algorithms, and Human-Inspired/Game-Inspired Optimization Algorithms.

Artificial Intelligence Algorithms, such as Machine Learning (ML) and Deep Learning (DL) techniques, include Classical ML Algorithms and DL Algorithms, which are widely used for diagnosis and classification. Respiratory diseases can be acute or chronic, and effective treatment and management depend heavily on initial identification.

Keywords :— Chronic Obstructive Pulmonary Disease (COPD), Tuberculosis, COVID-19, Bio-inspired algorithm, Artificial Intelligence algorithm.

I. INTRODUCTION

An Artificial Intelligence (AI) algorithm consists of mathematical and computational frameworks that learn from information, identify patterns, reason, and make decisions with little human input. These algorithms enable machines to exhibit human-like intelligence, including learning, problem-solving, and language understanding. AI algorithms are applied in many fields, including Healthcare, Education, Banking and Finance, E-commerce and Retail, Agriculture, Business, Transportation, Manufacturing, Security, and Entertainment. Artificial Intelligence algorithms are commonly classified into Machine Learning (ML) Algorithms, Deep Learning (DL) Algorithms, and Bio-inspired Algorithms.

Respiratory diseases affect 545 million people. COPD (Chronic Obstructive Pulmonary Disease) affects approximately 200 million people. Since the pandemic began in late 2019, nearly 780 million confirmed COVID-19 cases have been reported globally. More than 7.1 million confirmed deaths have been recorded worldwide. An estimated 8 million people were newly diagnosed with Tuberculosis.

The primary focus of this study is Chronic Obstructive Pulmonary Disease (COPD), a chronic lung disease that damages the lungs' air sacs and airways, leading to breathing difficulties. COPD is diagnosed using chest radiography and High-Resolution Computed Tomography (HRCT). COVID-19 is a respiratory infection caused by the SARS-CoV-2 virus. It spreads through respiratory droplets released when an infected individual coughs, sneezes, speaks, or breathes. Diagnostic methods for COVID-19 include virological testing, chest X-rays, and computed tomography. Mycobacterium tuberculosis

causes tuberculosis, a contagious disease. Although pulmonary tuberculosis primarily infects the lungs, it may also involve other organs. Tuberculosis spreads through the air when an affected patient coughs, sneezes, or speaks. Chest X-ray, sputum examination, and molecular tests are used to diagnose tuberculosis.

Feng et al. (2025). The primary objective of the study was to develop a high-performing predictive model to support early detection of COPD and informed decision-making in clinical contexts. The performance of Extreme Boosting and CatBoost, two powerful gradient boosting algorithms, will be evaluated to ascertain the most powerful model for detecting Chronic Obstructive Pulmonary Disease (COPD). Essential evaluation metrics, including recall, F1-score, precision, accuracy, and AUC-ROC, indicated that the XGBoost algorithm outperformed CatBoost [4].

Ye et al. (2021) focused on leveraging machine-learning-based predictive models to improve the efficiency and accuracy of COVID-19 diagnostic procedures. The model Harris Hawks Optimization Fuzzy K-Nearest Neighbor (HHO-FKNN) achieved superior performance compared to conventional classifiers and standard KNN-based approaches. The proposed model showed improvements in classification accuracy, sensitivity, specificity, and overall diagnostic reliability, making it suitable for rapid COVID-19 detection [5].

Sahlol et al. (2020). In the proposed method, essential features were extracted from chest radiographs using pre-trained deep learning models that capture high-level visual patterns associated with tuberculosis. The proposed Artificial Ecosystem-Based Optimization deep learning framework

achieved high accuracy, sensitivity, specificity, and F1-score [9]. Figure 1 shows the different kinds of Respiratory diseases.

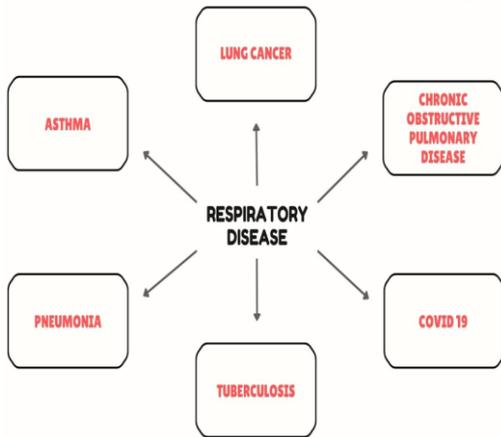


Fig. 1.1 Different types of Respiratory Diseases

II. RELATED WORKS

Shallu S et al. (2022). The main aim is to establish a precise structure for classifying CT scan images into healthy lungs, affected lungs (Chronic Obstructive Pulmonary Disease [COPD]), or fibrosis-affected lungs. The classification process is divided into three stages. Lung CT scans are used in the first stage to extract features. Machine Learning (ML) techniques are applied in the second and third steps, namely feature selection and lung disease detection. For feature selection, an Improved Grasshopper Optimization Algorithm (IGOA) is proposed. IGOA identifies an optimal subset of features that enhances classification accuracy while simultaneously reducing computational expenses after retrieving features from CT medical imaging. Each feature subset selected by IGOA is subsequently evaluated using three Machine Learning (ML) classifiers: Random Forest (RF), K-Nearest Neighbor (KNN), and Decision Tree (DT). Experimental findings indicate that IGOA eliminates roughly 71.01% of irrelevant features, retaining 28.99% of all extracted traits. In addition, IGOA achieves an impressive classification accuracy of 99.8% [3].

Nebojsa B et al (2022). This work presents the Chaotic Oppositional Fruit Fly Optimization Algorithm (COFFO) as a wrapper-based feature selection. COFFO incorporates chaos-based and oppositional position-based learning strategies to enhance the performance of the original fruit fly optimization algorithm. The mean fitness values and standard deviations are analyzed, and statistical tests are conducted, proving that COFFO greatly exceeds the original FFO and excels all rival techniques. The optimal fitness value, average fitness value, standard deviation, classification accuracy, and feature selection ratio were employed to evaluate the efficacy of COFFO across 21 standardized datasets in the ensuing phase. The proposed algorithm achieves excellent results, outperforming existing methods, particularly the original FFO, by selecting highly discriminative feature subsets. Overall, COFFO achieves exceptional classification accuracy and demonstrates significant dimensionality reduction.

Additionally, the proposed COFFO can solve a variety of NP-hard optimization problems in domains such as wireless sensor networks, cloud computing, and portfolio optimization, thereby improving machine learning models [6].

Yongliang Y et al (2023) introduced an optimization algorithm and studied self-protection behavior modeled analytically. Using benchmark functions, the CEC 2020 suite tasks, and three truss design challenges, the effectiveness of the suggested CMPA is evaluated and contrasted with other top metaheuristic optimizers. According to the statistical results, CMPA performs better than the algorithms used to compare it. Additionally, the characteristics of a gantry crane's main girder are determined using CMPA. The results show that the main girder's mass and deflection have increased by 16.44% and 7.49%, respectively [7].

Seifedine K et al. (2022). This study proposes an automated tuberculosis detection system based on the VGG-UNet architecture that integrates both segmentation and classification of chest X-ray images. The recommended procedure consists of multiple steps: (i) collecting and resizing photos; (ii) deep feature extraction; (iii) lung region segmentation (iv) creating local binary patterns (LBP) and extracting features; (v) employing the Spotted Hyena Algorithm (SHA) for the selection of optimal features; (vi) concatenating features in series; and (vii) categorizing and verifying the outcomes. A total of 3,000 images (1,500 healthy and 1,500 TB cases) are used for evaluation, and the experiments are implemented in MATLAB. The suggested approach employs pretrained models to more accurately detect tuberculosis in chest X-rays; a Fine Tree classifier achieves a classification accuracy of above 99% [10].

III. METHODOLOGY

A. Chronic Obstructive Pulmonary Disease

Suganya J et al. (2025). This study proposes an innovative methodology that combines Improved Weighted Quantum Ant Bee Optimization (IWQABO) with a Deep Convolutional Neural Network (DCNN) to improve the accuracy and efficiency of pulmonary emphysema diagnosis using CT images. While the DCNN adeptly extracts features from intricate image datasets, the IWQABO model fine-tunes the network's hyperparameters to improve categorization performance. This research used two datasets: the CTED dataset and a real-time emphysema dataset, and the experimental findings show notable gains in classification performance, achieving 95.8% precision, 94.5% sensitivity, and 96.3% specificity. These findings surpass those of conventional diagnostic techniques, including spirometry and manual CT evaluations [1].

Naman G et al. (2019). This work focuses on classifying lung Computed Tomography (CT) scan images into healthy lungs and diseased lungs, specifically those with Chronic Obstructive Pulmonary Disease (COPD) and fibrosis. Three main steps are involved in achieving this goal: using machine learning classifiers to identify lung diseases, extracting pertinent features from lung images, and selecting

characteristics. Zernike moments, Gabor features, Tamura texture features, and Haralick texture features, based on the gray-level co-occurrence matrix, are employed to create a detailed feature pool from segmented lung images. The second phase, three evolutionary feature selection algorithms: The Improved Grey Wolf Algorithm (IGWA), Improved Crow Search Algorithm (ICSA), and Improved Cuttlefish Algorithm (ICFA) are employed to select optimal feature subsets from the extracted data, aiming to enhance classification accuracy while reducing computational complexity. In the final phase, four Machine Learning (ML) classifiers—Decision Tree, K-Nearest Neighbor, Support Vector Machine, and Random Forest—are utilized. According to the experimental results, IGWA removed 52.3% of the extracted features, ICFA removed the fewest features, and ICSA discarded the highest proportion of irrelevant features. However, IGWA achieved the highest classification accuracy of 99.4%, followed by ICSA at 99.0%, while ICFA achieved a comparatively lower accuracy of 97.3% [2].

B. COVID 19

Law Kumar S et al. (2024). The outcome of this research, which used a modestly substantial publicly available dataset, shows that the proposed method outperforms many state-of-the-art techniques in identifying COVID-19 cases from chest CT images. This study's feature selection (FS) method effectively removes roughly half of the initial data, yielding a subset containing the most significant characteristics. With an accuracy of up to 95.99%, the suggested clinical decision support system performs admirably. Additionally, it achieves an F1-score of 0.9697, an Area Under Curve (AUC) of 0.9966, a sensitivity of 0.9888, a specificity of 0.9728, an average precision-recall intersection of 0.9655, and a precision of 0.9721. Additionally, by enabling more frequent and thorough assessments of pulmonary areas affected by SARS-CoV-2, the suggested approach of requiring Chest CT scans for each patient could improve hospitals' understanding of COVID-19 [8].

C. Tuberculosis

Muthumarilakshmi S et al (2025). This research presents an AI-based method, called the Artificial Intelligence Traditional Deep Learning Chest X-Ray Binarized Simplicial Convolutional Neural Network (AI-TDL-CXR-BSCNN), which employs a Binarized Simplicial Convolutional Neural Network (BSCNN) to swiftly and precisely detect and pinpoint tuberculosis in chest X-ray images. Initially, a set of chest X-ray images is collected and processed using the Robust Maximum Correntropy Kalman Filter (RMCKF) with scaling and normalization. The lung areas are then separated by segmenting the processed images with Weighted Multi-View Evidential Clustering (WMVEC). The segmented images are subsequently processed using the Refined Linear Chirplet Transform (RLCT) to extract essential features such as shape, color, and texture. To detect tuberculosis in chest X-ray images and classify them as either tuberculosis or normal, the extracted features are then fed into a Binarized Simplicial

Convolutional Neural Network (BSCNN). The Multiplayer Battle Game-Inspired Optimizer (MBGO) is employed to optimize the weight parameters of the BSCNN. The proposed AI-TDL-CXR-BSCNN approach is implemented using Python and demonstrates substantial improvements in accuracy, precision, sensitivity, F1-score, Receiver Operating Characteristic (ROC) curve, specificity, Intersection over Union (IoU), and Dice Coefficient. Overall, the suggested approach outperforms current techniques, achieving 97% accuracy for typical cases and 99% for tuberculosis patients [11].

N. K. Roopa et al. (2024) aim to develop an automated structure for detecting tuberculosis (TB) using an algorithm they refer to as CLBO_DenseNet. Within this framework, preprocessing is performed using an adaptive bilateral filter to remove external noise and artifacts. The ResUNet++ model, trained using the CLBO approach, is then used to segment images. This stage involves the extraction and refinement of several features, like Gray-Level Co-occurrence Matrix (GLCM) characteristics, Completed Local Binary Patterns (CLBP), Discrete Wavelet Transform (DWT), Local Variance Patterns (LVP), and geometric attributes. These features are then combined into a single feature vector, which is passed to the detection stage. The DenseNet model trained with CLBO is then used for classification. Experimental findings reveal that the proposed CLBO_DenseNet framework exhibits remarkable performance, achieving an accuracy of 98.90%, a Positive Predictive Value of 94.60%, a Negative Predictive Value of 93.30%, an F1-score of 96.10%, a dice coefficient of 96.50%, a True Positive Rate of 97.60%, and a True Negative Rate of 94.60% [12].

IV. RESULT AND DISCUSSION

Bio-inspired algorithms are applied in various Healthcare fields, involving Tuberculosis, Chronic Obstructive Pulmonary Disease, and COVID-19. This research primarily focuses on Artificial Intelligence and Bio-inspired algorithms, including Machine Learning, Deep Learning, Meta-heuristics, and Genetic Algorithms. Compared to Traditional Artificial Intelligence algorithms, bio-inspired algorithms show improved prediction. Table 1 compares various algorithms used for respiratory disease diagnosis. Figure 4.1 shows the Diagnosis of respiratory disease prediction methods.

TABLE I: SHOWS THE COMPARISON OF VARIOUS ALGORITHMS FOR RESPIRATORY DISEASE

Algorithm	Accuracy	Precision	Recall	F1-Score
IWQABO-DGCNN	96.3%	95.8%	96.1%	96%
IGWA	99.4%			
AI-TDL-CXR-BSCNN	97%			98%
CLBO_DenseNet	98.9%	94.6%	97.6%	96.1%

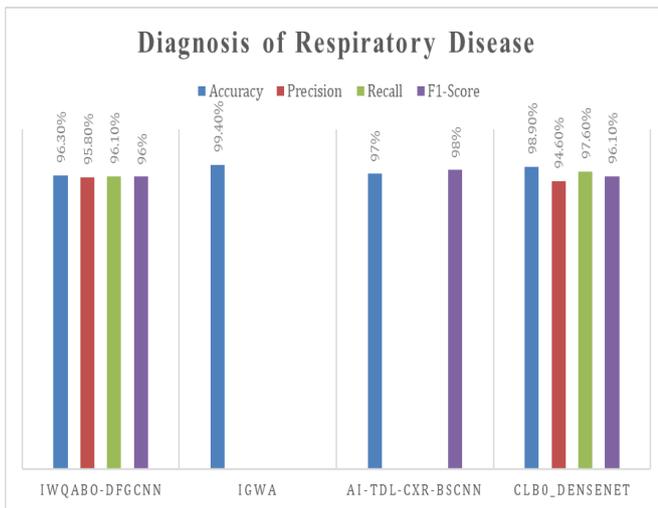


Fig. 4.1 Diagnosis of Respiratory Disease

V. CONCLUSION

This research work focuses on Healthcare, specifically on Chronic Obstructive Pulmonary Disease, COVID-19, and Tuberculosis, which affect millions of people across the world. All these diseases have various causes and symptoms. Chronic Obstructive Pulmonary Disease is diagnosed using spirometry. COVID-19 disease is detected using RT-PCR or antigen testing. Tuberculosis disease is diagnosed using the Sputum test (AFB/GenEXpert). Early diagnosis can improve life and help one live a healthy life. Bio-inspired algorithms include the Genetic algorithm and meta-heuristics algorithms; these algorithms are implemented for the classification and prediction of these diseases.

VI. FUTURE ENHANCEMENT

The above-mentioned papers are applied to classify, predict, and detect several diseases. Hybrid Bio-inspired and Artificial Intelligence algorithms can help detect the disease at an early stage. In the future, combining bio-inspired and Artificial Intelligence algorithms will be used to detect and predict disease. Various tests and scans help people stay healthy and lead healthy lives. New techniques are applied to handling imbalanced and incomplete medical datasets to secure prediction accuracy. Early detection of these diseases can help patients increase their lifespan.

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