How to Cite:
Ullal, B. S., Veena, K. N., & Karthik, R. (2022). Computational intelligence model for analysis of intricate details of pulmonary disorder patients. *International Journal of Health Sciences*, *6*(S3), 9521–9527. https://doi.org/10.53730/ijhs.v6nS3.8252

Computational intelligence model for analysis of intricate details of pulmonary disorder patients

Babitha S. Ullal
Sudent, M.Tech, VLSI and Embedded system, REVA University, Bangalore, Karnataka-560064
*Corresponding author email: babitharoshan91@gmail.com

Veena K. N.
Associate Professor, School of E & C Engineering, REVA University, Bangalore, Karnataka – 560064
Email: veenakn@reva.edu.in

R. Karthik
Professor and Deputy Director, School of E & C Engineering, REVA University, Bangalore, Karnataka – 560064
Email: dir.sporc@reva.edu.in

***Abstract*---**A computational model is planned and designed using python as the programming language and atom text editor to analyze the medical issue of pulmonary patient in view of the information gathered from his/her breathing pattern. The span of breath and the breath rate are contributing as input parameter to the model and the computational model diagnoses the kind of issue that the patient is experiencing. This exploration work essentially focuses on two disorders, Chronic Obstructive Pulmonary Disease (COPD) and Upper Respiratory Tract Infection (URTI) and distinguishes the two cases from that of a healthy person. Based on the diagnosis carried out, it guides the particle size to be used in the nebulizer to treat the objective region of the lung. It additionally ascertains the level of wheeze and crackle in the breath of the patient.

***Keywords*---**COPD, URTI, intelligence model, computational model, FFNN.

Introduction

Due to the present trend of increase in air pollution there is a rise in number of pulmonary patients. These patients suffer from different types of disorders [5].

Manuscript submitted: 18 March 2022, Manuscript revised: 9 April 2022, Accepted for publication: 27 May 2022

Out of these different pulmonary disorders, this paper classifies patients of 2 types of pulmonary disorder i.e, Chronic Obstructive Pulmonary Disease (COPD) [2] and Upper Respiratory Tract Infection (URTI) and differentiates these cases from a healthy individual using a computational model that works on feedforward and backpropagation. Further, if the patient is suffering from pulmonary disorder (COPD - Chronic Obstructive Pulmonary Disease and URTI - Upper Respiratory Tract Infection), then the model analyses the disorder of the patient, calculates the percentage of wheeze and the percentage of crackle in the patient's breath data and further guides about the particle size that the nebulizer must generate from the aerosol mist to target the area of the lung i.e, upper, middle or lower part of the lung. This research work currently targets only 2 of the pulmonary disorders- COPD and URTI.

Description and Method

The information about the breath pattern is gathered from the patient through audio recording using various sensors attached to the body of the patient [3],[5] and this readily available pre-recorded data is used in the project. The project aims to design a program to detect the health condition of the patient based on the breathing pattern i.e, respiration rates and breath duration. The input parameters to this AI model are:

- Breath duration
- Respiration rates
- Wheeze and crackle

The output parameters of the model are:

- Diagnosis of the type of disorder:
  - COPD
  - URTI
  - Healthy individual
- Particle size of the medicine and the target area.

The dataset of text files used has the required data available for around 125 patients, with more than 7 text files recorded for each patient. Based on the type of sensors used for recording the data, each data file is different from the other. The data files found will not have all the data as per the requirements [5]. In some cases, the information will be repetitive and some other times because of functional limitation the information may be corrupted. In both the situations the data must be corrected to suit the requirements of the research and any repetition found should be eliminated. This expands the accuracy of the proposed model [4],[6]. Corruption of data occurs when either the breath sample recorded is such that more than one cycle of breath is considered as one cycle or the recorder records only partial duration of breath due to improper switching on and off of the recorder by the operator operating the instrument.

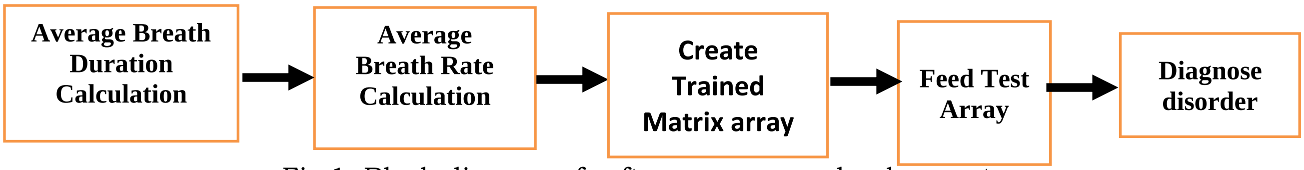

Fig 1. Block diagram of software program development

In both the types of errors, the following program eliminates the error by filtering off those values of breath duration which fall outside the normal breathing range of the patient. This process is carried out for every data file used in the project. The pseudocode is as below:

```
x = 'file_name_to _check _for_corruption'
cnt=0
for every line in data_file:
    cnt = cnt+1
    d = Value(col 1) – Value(col 0)
    add the value to the list "diff"
Calculate the average value of the list
Calculate (60/ Average value)
```

Each text file name is entered into the program, assigned to the variable 'x', and the list of difference between every successive inhalation and exhalation is prepared for each text file. If the values in this list are such that the initial and last value lie out of normal range, it is deleted, and the file is saved. Also, if any long duration of breaths (2 or more breaths combined) is found, they are deleted. This step prepares the file for the next level of analysis. After the preprocessing of the data is done, it is ready for further processing. The block diagram depicting the steps in the diagnoses of the pulmonary disorder followed in the software program development is as in fig-1. After this, the average of the data in the list prepared is calculated which gives the average breath duration of the patient. From this data, respiration rate of the patient is obtained by the formula as "60 **/** Average breath". After each file is cleaned using the above technique, and the average breath duration and the respiration rate is calculated. This data is fed as input to the Computational model and the model using the program written in python, classifies the fed data into one of the categories i.e healthy or COPD or URTI. It also guides the particle size to be used in the treatment of the patient and the target area of the lung.

Based on the value of breath duration and respiration rate a suitable matrix is generated dynamically and this is fed as input to the Computational model. The computational model runs several epochs (1000) of the feedforward network and the back propagation network and finally classifies the given matrix into one of the 3 categories i.e, Healthy or COPD or URTI. The model uses one hidden layer with 10 nodes in it. The program uses tanh function and its derivative, sigmoid function and its derivative as activation functions and log loss function and its derivative in the calculations. The pseudocode for the software program written in python to implement the proposed idea is as below:

```
import numpy as np
import warnings
import matplotlib.pyplot as plt
warnings.filterwarnings('ignore')
open the file containing the test file names
For each file:
    1)Prepare list of Crackles, wheezes, and average
            breath value.
    2)Calculate the percentage of wheeze, crackle
    3)Calculate the respiration rate as (60/ average
            breath value)
Define functions of tanh and its derivative
Define functions of sigmoid and its derivative
Define functions of logloss and its derivative
class Layer:
    activation_functions = {
        'tanh': (tanh, d_tanh),
        'sigmoid': (sigmoid, d_sigmoid),
    }
    Learning_rate = 0.1
Define functions of feedforward and
                    backpropagation
x_train = np.array([[0,0,1],[1,0,0],[0,1,0]])
y_train = np.array([0,0.5,1])
epochs =1000
layers = [Layer(3,10,'tanh'), Layer(10,1,'sigmoid')]
for each epochs:
    1)Call the feedforward function and
            backpropagating function
    2) Train the weights and calculate the loss value
while True:
    Enter the test data
    if C == '':
        print('Have a great day. Bye!!!')
        break
    C = int(C)
    A = np.array([x4[C]]).T
    for each layer:
        1)Call feedforward function
    if A is around 0.0:
        print('Diagnosed as COPD')
        print('The preferred particle size is between
                1μm to 5μm targeting lower lung')
    elif A is around 0.5:
        print('Diagnosed as URTI')
        print('The preferred particle size is 6μm to
                8μm, less than 10μm targeting upper
                lung'')
    elif A is around 1:
        print('The patient is Healthy')
```

```
print('Wheeze and crackle percentage')
```

Results

The dataset is divided in the ratio of 80:20, with 80% of data used for training the model and 20% of data is used as test data. The plot of loss curve is as in figure – 2.

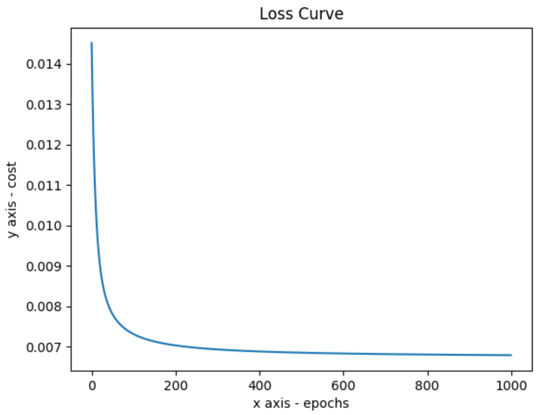

Fig 2. Plot of loss curve (Cost versus epochs)

The deviation of the obtained value from that of the required value is as in table - 1.

Table 1
Comparison of expected and obtained values

Diagnosis	Expected value	Obtained value
COPD	0.0	0.0028882
URTI	0.5	0.49918053
Healthy	1.0	0.99822561

From the above values it is observed that the accuracy of the model is greater than 99%.

Conclusion

The program can successfully diagnose the patient suffering from either COPD or URTI. Also, if the person is healthy, the model identifies him as a healthy individual. Based on the input parameters fed to the model, it also calculates the percentage of wheeze and the percentage of crackle in the patient's breath. The model does the calculation without any error for the dataset considered. It further guides the target area to be medicated. The work can be further extended to other types of pulmonary disorder diagnoses.

References

1. Ari, A. (2014). Jet, ultrasonic, and mesh nebulizers: an evaluation of nebulizers for better clinical outcomes.
2. Ümran Işık, Ayşegül Güven, Hakan Büyükoğlan Biyomedikal Mühendisliği Bölümü, Erciyes Üniversitesi, Kayseri Tıp Fakültesi, Dahili Tıp Bil., Göğüs Hastalıkları Abd., Erciyes Üniversitesi, , Kayseri (2015) Chronic Obstructive Pulmonary Disease Classification with Artificial Neural Networks
3. Victor Basu Department of Computer Science and Engineering Jalpaiguri Government Engineering College West Bengal, India, Srinibas Rana,Assistant Professor Department of Computer Science and Engineering Jalpaiguri Government Engineering College West Bengal, India(2020)Respiratory diseases recognition through respiratory sound with the help of deep neural network
4. Hasan Zafari1 , Sarah Langlois2 , Farhana Zulkernine3 School of Computing Queen's University Kingston, Ontario, Canada, Leanne Kosowan4 , Alex Singer5 Department of Family Medicine Rady College of Medicine, Rady Faculty of Health Sciences, University of Manitoba Winnipeg, Manitoba,Canada(2020).Predicting Chronic Obstructive Pulmonary Disease from EMR data
5. Reetodeep Hazra Electronics and Communication Engineering Techno International New Town Kolkata, India, Dr. Sudhan Majhi Electrical Engineering Indian Institute of Technology Patna Patna, India (2020).Detecting Respiratory Diseases from Recorded Lung Sounds by 2D CNN
6. Bosco, A. P., Rhem, R. G., & Dolovich, M. B. (2005). In vitro estimations of in vivo jet nebulizer efficiency using actual and simulated tidal breathing patterns. *Journal of aerosol medicine, 18(4), 427-438.*
7. Barrons, R., Pegram, A., & Borries, A. (2011). Inhaler device selection: special considerations in elderly patients with chronic obstructive pulmonary disease. *American Journal of Health-System Pharmacy, 68(13), 1221-1232.*
8. Bhome, A. B. (2012). COPD in India: Iceberg or volcano?. *Journal of thoracic disease, 4(3), 298.*
9. Pranayam for Treatment of Chronic Obstructive Pulmonary Disease: Results From a Randomized, Controlled Trial,Anupama Gupta, MD, Rajesh Gupta, MD, Sushma Sood, MD, and Mohammad Arkham, *BNYS*
10. Brandsma, C. A., de Vries, M., Costa, R., Woldhuis, R. R., Königshoff, M., & Timens, W. (2017). Lung ageing and COPD: is there a role for ageing in abnormal tissue repair?. *European Respiratory Review, 26(146), 170073.*
11. Dixon, L. C., Ward, D. J., Smith, J., Holmes, S., & Mahadeva, R. (2016). New and emerging technologies for the diagnosis and monitoring of chronic obstructive pulmonary disease: *A horizon scanning review. Chronic respiratory disease, 13(4), 321-336.*
12. Hanania, N. A., Sharma, G., & Sharafkhaneh, A. (2010). COPD in the elderly patient. *In Seminars in respiratory and critical care medicine (Vol. 31, No. 05, pp. 596-606). © Thieme Medical Publishers.*
13. Hess, D., Fisher, D., Williams, P., Pooler, S., & Kacmarek, R. M. (1996). Medication nebulizer performance: effects of diluent volume, nebulizer flow, and nebulizer brand. Chest, 110(2), 498-505.

14. Hoenig, M., Baeten, H., Vanhentenrijk, S., Ploegaerts, G., & Bertholet, T. (1997). Evaluation of various commercially available nebulization devices for inductively coupled plasma atomic emission spectrometry. *Analusis, 1(25), 13-19.*
15. Jindal, S. K., Aggarwal, A. N., Chaudhry, K., Chhabra, S. K., D Souza, G. A., Gupta, D., ... & Vijayan, V. K. (2006). A multicentric study on epidemiology of chronic obstructive pulmonary disease and its relationship with tobacco smoking and environmental tobacco smoke exposure. *Indian Journal of Chest Diseases and Allied Sciences, 48(1), 23.*
16. Kelly, P. M., O'Sullivan, A., McKenna, C., Sweeney, L., & MacLoughlin, R. (2016*). Effect of Nebulizer Type and Position on Aerosol Drug Delivery during Support Mechanical Ventilation and Spontaneously Breathing for Tracheostomized Adult Patients. Poster presented at DDL27: Edinburgh.*
17. Khassawneh, B. Y., Al-Ali, M. K., Alzoubi, K. H., Batarseh, M. Z., Al-Safi, S. A., Sharara, A. M., & Alnasr, H. M. (2008). *Handling of inhaler devices in actual pulmonary practice: metered-dose inhaler versus dry powder inhalers. Respiratory care, 53(3), 324-328*.
18. Shalini Sivadasan, PhD1 , Akshaya Krishnan, MPharm1, Sathish Venkatasamy Dhayalan, PharmD1 , and Rajasekaran Aiyalu (2021). A Systematic Review on KAP of Nebulization Therapy at Home
19. Deepak Talwar D., Ramanathan R., Lopez M., Hegde R., Gogtay J., Goregaonkar G.(2020). The emerging role of nebulization for maintenance treatment of chronic obstructive pulmonary disease at home.
20. Zaccagnini M., Esquinas A.M., Karim H.M.R.(2019). In response to Galindo-Filho et al. A mesh nebulizer is more effective than jet nebulizer during noninvasive ventilation of COPD subjects: A few practical points.
21. Park, H.M., Chang, K.H., Moon, S.-H., Park, B.J., Yoo, S.K., Nam, K.C (2021). In vitro delivery efficiencies of nebulizers for different breathing patterns
22. Sayed, N.E.E., Abdelrahman, M.A., Abdelrahim, M.E.A. (2021). Effect of functional principle, delivery technique, and connection used on aerosol delivery from different nebulizers: An in-vitro study

Websites

1. www.blf.org.uk
2. www.healthline.com
3. www.lunginstitute.com
4. www.cdc.gov/copd/data.html
5. www.credenceresearch.com
6. www.ncbi.nlm.nih.gov