Clinical Decision Support System for Chronic Obstructive Pulmonary Disease using Machine Learning Techniques

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***Abstract*— In last two decades, Artificial Intelligence (AI) has become a major tool in every domain in general and medical applications in particular. AI is globally accepted and used for designing medical applications to support medical practitioners in diagnosing and treating patients effectively and efficiently. Chronic Obstructive Pulmonary Disease (COPD) is a kind of obstructive lung disease. Patients suffering from COPD makes breathing uneasy. COPD's incidence of sickness and death rates are rising and it is now the fourth leading cause of death globally. In this paper, we are discussing need for Clinical Decision Support System (CDSS) for COPD which helps the physicians to provide better and effective diagnosis and treatment strategies. In addition, we have designed a CDSS for COPD which is discussed in detail in this paper. The CDSS encompasses Machine Learning techniques like Classifier Ensemble methods, Support Vector Machine, Neural Networks, and Decision Trees.**

Index Terms*— *Artificial Intelligence, COPD, CDSS, Machine Learning, Classifier Ensemble, Support Vector Machines, Neural Networks, Decision Trees.

I. INTRODUCTION

This paper proposes an Electronic Health Record (EHR) - integrated CDSS System for COPD in out-patient setting. The CDSS will utilize GOLD criteria (Global Initiative for Chronic Obstructive Lung Disease) (updated 2017) procedures for the diagnosis and treatment of COPD. The proposal will include various interventions, clinical workflow improvements, the system architecture, the logic and the user interface. COPD is one of the disease which is spreading rapidly worldwide. Its occurrence, illness and death rates are growing and COPD is fourth main cause of death globally. COPD is generally under-diagnosed, though the disease is a life-harming, which is not completely mutable. The WHO, in the year 2012 has said that about Two Hundred and Ten Million people around the globe have COPD [1]. By 2030, COPD is projected that it will be third largest cause for mortality globally.

The evolution of COPD is slow, therefore it is not diagnosed until the age 40. One of the most significant origin of COPD is by smoking. The active, passive smokers, industrial chemicals and air pollution add great risk for COPD.

COPD can be just controlled as there is no permanent cure for it. Through treatment and management strategies we can improve the quality of life and reduce the symptoms of COPD. In today's era, the technology has reached a new level specially the use of Machine Learning (ML) in bio-medical field, helping to diagnosis effectively, efficiently and more accurately. The proposed CDSS helps the physicians to diagnosis COPD and the stage with which the patient is suffering from and also provide a suitable treatment and management strategies to the patients.

II. MOTIVATION

COPD diagnosis is mainly dependent on 3 different aspects. We look at the symptoms of the patients, evaluation of lung function and the calculation of the reactions to gulped pharmacological agents. The above mentioned test are informative, they need lot of time to be invested and the important factor is they are dependent on the physician's professional experience.

Under-diagnosed of COPD is a major issue [2, 3, 4, 5, and 6] and this may be due to several factors like the patient not visiting the doctor or the doctor not conducting required test for the diagnosis. The growth of under-diagnosed is due to the time span between the visits to the doctor. Almost all the symptoms of COPD are generally found in a regular smoker. And normally a smoker hardly pursue medical advice especially for cough and sputum production [7].

Spirometer (Fig. 1) is one of the device used for diagnosing of COPD. But the spirometry test can be conducted effectively and accurately only by trained staff. Spirometer test may not produce accurate results for young or aged patients [8]. The standards for identifying COPD is still under discussion [13, 14]. Therefore a well-constructed CDSS helps the physicians to diagnosis COPD and also provide a right treatment and management strategies for the patients suffering from COPD.

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Fig. 1. Spirometer device

III. MACHINE LEARNING FOR THE DIAGNOSIS OF DISEASE

Machine Learning (ML) is one of the most emerging technology in today's era. ML gives the ability to computers to learn without being programmed.

The current project consists of broadly three main objectives, firstly, designing a Supportive Vector Machine model for the initial evaluation of COPD, this model makes an effort to persuade the standards to distinct COPD patients when assumed a set of patient description and medical reports. This model will help the patients to pursue quick assessment and treatment. Timely finding and precise diagnosis will help the patients improve their quality of life with lowering risk factors and harmful to life. Once it is found that the patient is suffering from COPD, the next stage is to identify the severity of the disease. This is done by the implementation of Artificial Neural Network, by constructing the Multilayer Perceptron Neural Network (MLPNN) with 3 layers can be used to design an efficient Clinical Decision Support System (CDSS) for the diagnosis of various stages of COPD. The MLPNN is trained by back-propagation algorithm which is very efficient method, which is the second objective of our study. Once the stage of the disease is being classified, the next step is to enable improvement of treatment outcomes and to detect the interaction of drugs and the possible side effects associated with it by employing knowledge base system and prediction techniques.

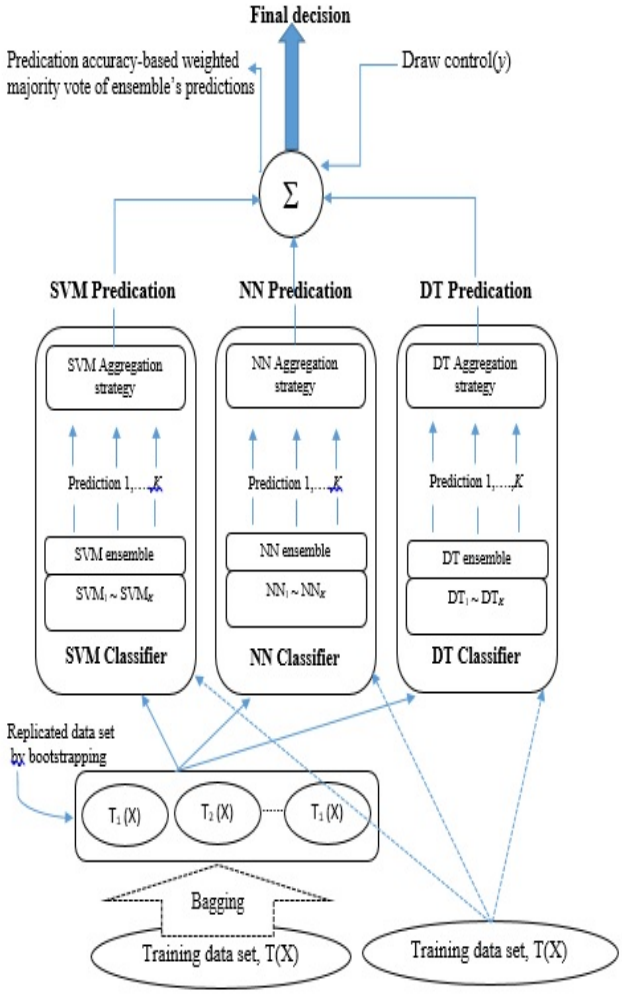

Fig. 2. Working of ML techniques in the CDSS component

IV. LITERATURE REVIEW

COPD is a one of the leading chronic respiratory syndrome that is affecting many people globally. COPD has key result due to the extreme illness and death rates [11, 12]. The British Medical Research Council well-defined chronic bronchitis as "day-to-day constructive cough for a minimum 3 successive months for more than 2 consecutive years [13].

Wig et. al. in 1964 [14] conducted a study to know the occurrence of COPD in India in some of the places like rural Delhi. His study outcome says that 3.36% in Men and 2.54% in Women was the occurrence of COPD. Viswanathan et. al. in the year 1966 [15] conducted a study to know the occurrence of COPD and reported that 2.12% in Men and 1.33% in Women, these test were conducted in Patna, India. Few years down the line, Radha et. al. [16] conducted the study and noticed there was a rise in the growth of occurrence of COPD in Delhi. She reported in 1977 that 8.1% in Males and 4.6% in Females [17].

COPD has many risk factors, to name few are smoking (active and passive), industrial pollutants, bio-mass gas etc. COPD may also occur due to the deficiency of Alpha1-Antitryspin and it may be found in young people. A study says that the occurrence of COPD due to the deficiency of

Alpha1-Antitryspin is 1 to 2% only [18] around the globe.

Forey BA et. al. [19] has conducted a study in which he made conclusion that smoking is major cause for the occurrence of COPD. He also discussed the other factors which may cause COPD like air pollution, industrial exposure to dust or fumes, inhalation of bi-mass smoke and patients suffering from Tuberculosis (TB) [20] may suffer from COPD. Depression is almost found in every patients suffering from COPD [21]. Worldwide it is predicted that COPD will be the 3rd largest killing dieses by 2030 [22].

The Decision Support System (DSS) uses information and models from various areas [23], to upkeep a multipart decision making and solve problems with ease. DSS helps the physicians to construct and discover the inferences of their decisions [24].

V. PROPOSED ARCHITECTURE OF CDSS FOR COPD

The architecture of Clinical Decision Support System for COPD (Fig. **3**), we first collect the basic information of the patient followed by medical history like smoking history, alcoholic consumption rate, allergy, TB history, Cardiac problem, Asthma, Wheezing, Breathlessness, Hypertension, and Symptoms of COPD. Once the medical history of the patient is collected we conduct Spirometer test, the results of the Spirometer result values (FEV1/FVC) is used for knowing the stage of COPD the patient is suffering. The different stages of COPD with the FEV1 values are shown in the below table 1.

TABLE I. CLASSIFICATION OF DIFFERENT STAGES OF COPD WITH FEV1 VALUES

COPD Severity	FEV1 Results
Mild	FEV1 >= 80% predicted
Moderate	50% <= FEV1 < 80% predicted
Severe	30% <= FEV1 < 50% predicted
Very Severe	FEV1 < 30% predicted

Once the patient is diagnosed with COPD (Mild, Moderate, Severe stage) we have designed Treatment and Management strategies wherein the videos of exercises, yoga's, breathing techniques, Pulmonary Rehabilitation and Medications are available. The CDS also has a module designed for providing information on inhalers, inhaler devices, and nebulizers. Here we display normally prescribed drugs for different stages of COPD using GOLD criteria. In treatment and management a module which helps the patient quit smoking test is also designed. The doctors can maintain the progress of the patients by writing the remarks. The system automatically displays the next PFT test date. A follow up module is also available.

The CDSS has a module, Drug-Drug interaction checker which helps the physicians or patients to check the interaction with the drugs which have been prescribed for COPD or other Co-morbidities. COPD patients may have the following Co-morbidities dieses they are: Asthma, Antibiotics, Depression, Dementia, Diabetics, Heart Failure, Hypertension, Hypotension, and Osteoporosis.

A patient with COPD aged above 50+ may have the following two co-morbidities they are: 1. Depression and 2. Dementia.

Depression is one of the most common mental illness affecting great section of society at present recognizing symptoms for this mental disorder is not an easy task by a victim, so we have developed a module for investigation to know whether the patient is suffering from depression or not. This module works as a diagnostic and reference tool for medical personnel. We conduct Depression test using Hamilton Scale test, where the patient is asked to answer several queries by the physician depending on the answers given by the patient the score card will be generated with the scores. Using the score values we can get to know whether the patient is suffering from the Depression or not. If the patient is suffering from Depression it also classifies the stage from which he is suffering from and provides the treatment and management strategies for Depression.

Dementia is a common word for a deterioration in mental ability severe enough to interfere with daily life. Memory loss is an example. The purpose of this module is to develop a system which can be used by the psychiatrist to conduct Dementia examination. There are several test which are conducted on patient to check whether they are suffering from Dementia or not. This module will help diagnose various aspects of memory which includes orientation, concentration, attention, judgment etc. There are six examinations which are suggested by the National Institute and Aging, USA. This examinations includes Mini–Mental State Examination (MMSE), Functional Activities Questionnaire (FAQ), Blessed-Dementia Information-Memory-Concentration Test (BIMC), Blessed Orientation-Memory-Concentration (BOMC), Short-Term Memory recall Test (STMT), and Short Term Memory Questionnaires (STMQ) which were included in the present study. Alzheimer is the most common forms of dementia. Dementia is a type of Neurodegenerative disorder, it occurs due to a loss of cognitive dysfunctions, and it is usually occurs in the patient above the age of 60. In the present study we conduct all the above six Neuropsychological examinations for classifying various stages of Dementia like mild, moderate, sever. If the patient is suffering from Dementia it also classifies the stage from which he is suffering from and provides the treatment and management strategies for Dementia.

The proposed CDSS also has a module Quit Smoking test which is used by the physicians to help the patients quit smoking if they are diagnosed by COPD.

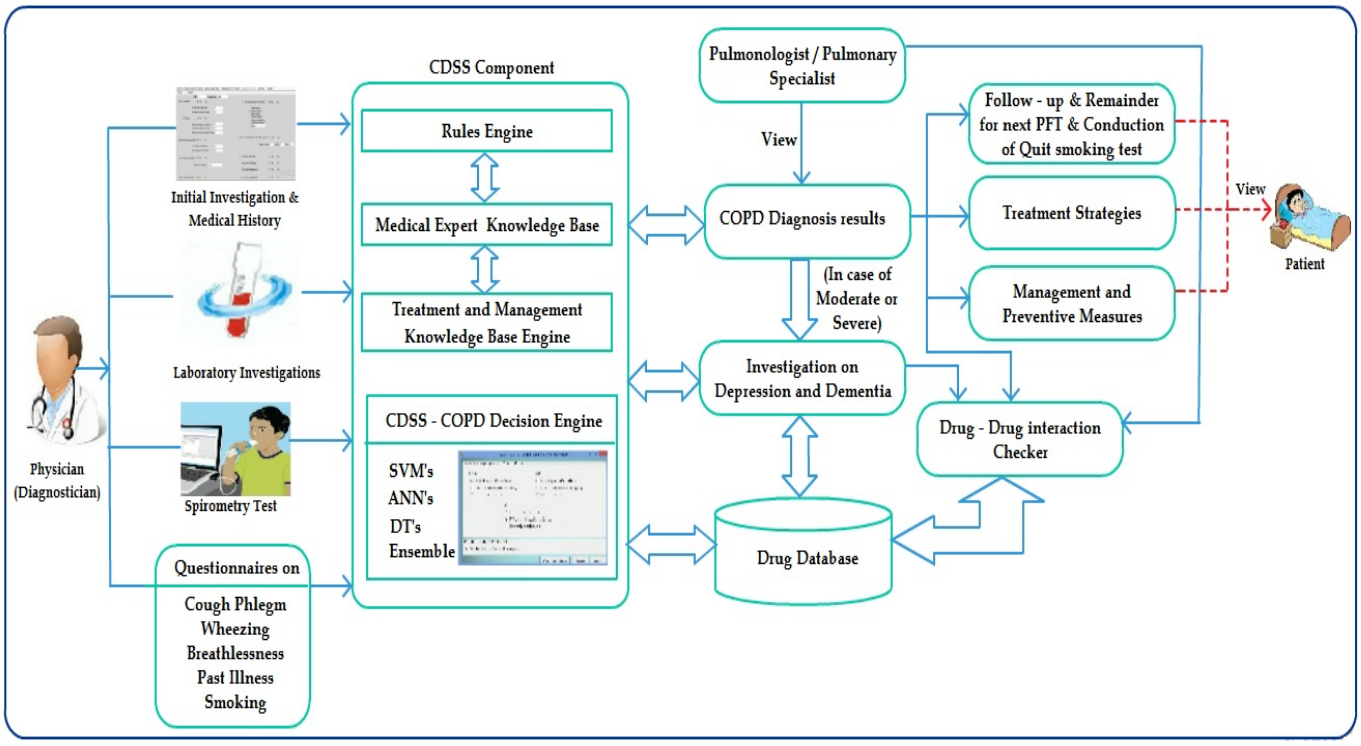

Fig 3. Proposed Architecture of CDSS for COPD

VI. POSSIBLE OUTCOMES

With the increase of life expectancy and the consequent increase in the number of patients suffering from Chronic Obstructive Pulmonary Disease (COPD), there is an urgent need for the development of an automated model which can diagnose the COPD disease accurately so that early detection and correct diagnosis can lead to disease-retarding therapies which can slow disease progression and reduce patient and caregiver stress and morbidities. Therefore, pulmonarylogist all over the world are looking for new automated model which can help in the diagnosis and management of chronic obstructive disorders. In this context, the current study aims at developing a new model which can be used by the Pulmonologist, Radiologists or Respiratory Therapist to get the information to classify disease more accurately rather than deciding through experience.

VII. CONCLUSION

Clinical Decision Support System is need of the hour for physicians which helps in the diagnose COPD accurately and efficiently. The proposed CDSS can classify the different stages of COPD the patient is suffering from. It also has a Drug-Drug interaction checker module to check the interactions between the COPD and its associated comorbidities diseases. The patients suffering from COPD and if their age is above 55 it is necessary to check two important comorbidities associated with COPD that is Depression and Dementia both test are part of the proposed CDSS. It also has a quit smoking test which helps the patients quit smoking if they are diagnosed with COPD. The CDSS has a well-defined Treatment & Management strategies to improve the quality of life of the patients suffering from COPD.

VIII. FUTURE SCOPE

The future scope for this proposed CDSS is, we can design our own portable spirometer device with a small LED screen on it which runs without any computer device attached to it and shows the readings of the FEV1 values and also if required it can print the results too. We can also design a device using the above architecture which can store the patient's data in the cloud and provide access to the details like medical history, spirometer test results values (the spirometer can be integrated to the device) and generate the best treatment and management strategies for the patients suffering from COPD using Machine Learning techniques. The device will be very helpful in the rural areas where the hospitals does not have spirometer device and Pulmonologist.

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