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Comparison between the different Artificial Neural Network (ANN) accuracy in diagnosis of asthma

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Abstract: Asthma is a chronic disease that is caused by inflammation of airways. Diagnosis, predication and classification of asthmatic are one of the major attractive areas of research for decades by using different and recent techniques, however the main problem of asthma is misdiagnosis. This paper simplifies and compare between different Artificial Neural Network techniques used to solve this problem by using different algorithms to getting a high level of accuracy in diagnosis, prediction, and classification of asthma like: (data mining algorithms, machine learning algorithms, deep machine learning algorithms), depending and passing through three stages: data acquisition, feature extracting, data classification. According to the comparison of different techniques the high accuracy achieved by ANN was (98.85%), and the low accuracy of it was (80%), despite of the accuracy achieved by Support Vector Machine (SVM) was (86%) when used Mel Frequency Cepstral Coefficient MFCC for feature extraction, while the accuracy was (99.34%) when used Relief for extracting feature. Based in our comparison we recommend that if the researchers used the same techniques they should to return to previous studies it to get high accuracy.

Keywords: Artificial Neural Network, Machine Learning, Support Vector Machine, Impulse Oscillometry, Spirometer.

مقارنة بين اختلاف دقة الشبكات العصبية الاصطناعية في تشخيص مرض الربو

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المستخلص: الربو هو أحد الأمراض التنفسية المزمنة والتي تحدث نظرا لالتهاب في الشعب الهوائية. تشخيص الربو وتحديده وتصنيفه يعتبر أحد أكثر المجالات التي جذبت الكثير من الباحثين في العقود الأخيرة وذلك من خلال استخدام الطرق والتقنيات المتنوعة والحديثة في هذا المجال. تكمن المشكلة الحقيقية والاساسية لمرضى الربو في عملية التشخيص الخاطئ لهم. في هذه الورقة تم التلخيص والمقارنة بين الطرق الحديثة والمختلفة التي استخدمت الشبكات العصبية الاصطناعية في حل هذه المشكلة باستخدام الخوارزميات المختلفة للحصول على مستويات دقة عالية في عملية تشخيص والتنبؤ وتصنيف مرض الربو، ومثال على هذه الطرق: (طريقة خوارزميات تنقيب البيانات، طريقة

خوارزميات التعليم الآلي، خوارزميات التعليم الالي العميق)، وتم شرح عمل هذه التقنيات الثلاث اعتمادا على مرور البيانات بثلاث مراحل: مرحلة جمع البيانات، مرحلة استخراج المميزات، مرحلة التشخيص والتصنيف. وفقاً لمقارنة بين التقنيات المختلفة فإن الدقة العالية حققتها تقنية الشبكات العصبية كانت (98.85%) والدقة المنخفضة (80%)، على الرغم من ان الدقة التي حققتها تقنية الة المتجهات الداعمة باستخدام تقنية (MFCC) لاستخراج المميزات كانت (86%)، بينما الدقة التي حققتها باستخدام تقنية (Relief) لاستخراج المميزات كانت (99.34%). وبناءً على المقارنة التي تمت نوصى الباحثون في حال استخدامهم نفس التقنيات التي ذكرت بالرجوع إلى الدراسات السابقة وذلك للحصول على أعلى دقة في التشخيص.

الكلمات المفتاحية: الشبكات العصبية الذكية، التعليم الالى، الة المتجهات الداعمة، جهاز قياس التذبذب النبضى، مقياس التنفس

Introduction

Asthma is a common chronic respiratory disease affecting 1- 18% of the population around the world. Asthma is characterized by a variety of symptoms like a wheeze, shortness of breath, and/or cough, and by variable expiratory airflow limitation. Both symptoms and airflow limitation characteristically vary over time and in intensity. [1] Most of the asthmatic patients are misdiagnosed and confused with chronic obstructive pulmonary disease (COPD). A good follow up and control of asthma symptoms can reduce morbidity and mortality, as a result, it was necessary to provide a system that can help physicians to get a high level of accurate successful diagnosis. Consequently, handling and awareness of asthma is one of the most important medical research zones.

Spirometry is one of useful investigation in pulmonary medicine, for asthma it is under- utilized [2]. It was found that the percentage of medical practitioners who used it in diagnosis of asthma in children is 21% and this could be due to unavailability of spirometer, difficulty in interruption and lack patient cooperation [3]. Owed to the number of limitations and lack of access of spirometer, the defect in interpreter of the result specifically for patient of younger age, also as the performance of the spirometer depends on patient`s cooperation which may be impossible by those younger children[3]. Therefore Impulse Oscillometry (IOS) has been introduced as an alternative, where it offers several advantages, non-invasive, only need just " passive cooperation" form patient, and easy to perform. The golden advantage of (IOS) is accurate and specific than spriometer on distinguishing between the normal people and those who have asthma. Many researchers have tried to use artificial Neural Network and data mining technologies in areas of Spirometer and (IOS) data classification.

In the last decades, researchers have another solution for diagnosis and classification which is Artificial Neural Network (ANN) and data mining and they are the most implemented methods, they have proven to be a useful classifier in the field of diagnosis and deeper understanding of medical data.

An Artificial Neural Network (ANN) is a parallel distributed processing system capable of solving complex classification problems, by their remarkable ability to derive meaning from complicated or imprecise data, ANNs can become excellent classifiers and be able to learn and generalize from data by using different learning processes or learning rules to acquire their knowledge. [2]

Data mining has attracted many researchers and analysts in the information industry and in research organizations as a whole, due to the availability of large amounts of data and the immediate need for transforming such data into meaningful information and knowledge [4], otherwise one of the most important application of data mining in the domain of machine learning is diagnosis. The efficient algorithms of machine learning are K- nearest neighbors (K- NN), Support Vector Machine (SVM), Random Forest, Naive Bayes, last square support vector machine (LSSVM), as well as Convolution Neural Network (CNN) which is a class of deep, feed forward artificial neural network, that can extract topological properties from an image.

In this paper, a brief literature review has been done in order to give an efficient and high accurate level of diagnosis of asthmatic, by using different classifiers techniques.

Materials and Methods.

In this section we will describe the different techniques that are used by researchers for classification, feature extraction, and data acquisition in diagnosis of asthma.

In [5] there are two methods that are used for collecting data from 25 patient: one by using questionnaire and the other one by using patient clinical diagnostic investigation, then the data collected by questionnaire used by expert system with support of different machine learning algorithms technique (PSO, CSAMM, BB, BN, C4.5) for diagnosis the specific type of respiratory diseases, also the clinical investigation results were tested to get accurate diagnosis by using aforementioned algorithms. The accuracy achieved by those algorithms was 84.16%, 84.32%, 82.21%, 81.17%, and 83.83% respectively.

In [6] the number of subjects were 20 (10 healthy, 10 asthmatic) also the number of respiratory sounds recorded was 40 in total, the sounds were acquisited by using Sony ECM- T150 electret condenser, then all sounds passed into amplification and band pass filtering to extract the noise caused by heart sound, hospital area, sounds of movement of microphone, after that the original sound signals transformed by using discrete wavelet. The transformed sound signal function to get new convenient form to the machine learning models, then the new form was classified by two machine learning algorithms models first one combined random forest algorithm (random forest, adaboost combined), the second one artificial neural network, and the accuracy achieved by both was 90%, and 80% respectively.

In [7] the method which is used for collecting data from 112 patients clinical files based on questionnaires distributed to be answered by parents and their children, then the Principal Component Analysis (PCA) (one type of machine learning algorithm) used to extract the features, after that the Least Square Support Vector Machine (LSSVM) used was for classification of data by maximizing the predictive accuracy. 95.45% was the accuracy achieved by the 10- flod cross validation prediction method.

The same aforementioned data used in [7] was used again in [8], the difference was in the other two stages which are: feature reduction through partial least square regression and classification

algorithms which are (MLP- PNN), the same accuracy was achieved by both classification algorithms (96.77%).

In [12] the total number of candidates were 254 (169 asthmatic- 85 non asthmatic), then the feature extraction depended on two steps: First step was exclusion of incomplete file from the dataset, the second step was selecting the data by using Relief- F algorithm. After that three of the data mining algorithms were used for classification: the first and easiest algorithm K- NN, the second and efficient algorithm SVM, and a third and general algorithm was Random Forest. The result was achieved by K- NN when the number of neighbors was 5, also the result achieved by SVM (0.99, 0.97, and 0.98 for specificity, sensitivity, and accuracy, respectively), and by random forest (0.98, 0.92, and 0.96 for specificity, sensitivity, and accuracy, respectively).

In [9] the methods which are used to store the data on computers were developed by the researchers who used their own cost- effective and easy- to- use electronic stethoscope. This electronic stethoscope is compatible with any device. The number of recorded lung sounds from 1630 patient was 17,930, then the data passed to extract their features by two different algorithms Mel Frequency Cepstral Coefficient (MFCC), and spectrogram, also those different extracting algorithms used with different machine learning algorithms in classification: Support Vector Machine (SVM), Convolutional Neural Network (CNN) respectively. In addition, those algorithms used to classify four individual phases of data: (1) healthy versus pathological classification; (2) rale, rhonchus, and normal sound classification; (3) singular respiratory sound type classification; and (4) audio type classification with all sound types.3 Moreover the same and highest accuracy achieved by both classification algorithms (SVM- CNN) was 86%, with healthy versus pathological classification phase.

the number of data used in [5] 1250 divided into (728 asthmatic, 522 healthy), based on static and dynamic assessment results, beside the static result which collected d by using most commonly devices (spirometry (SPIR) and Impulse Oscillometry (IOS)), and dynamic result which depended on symptoms, bronchial dilation (BDT) and bronchial provocation tests (BPT),then all dynamic and static assessment results passed to be classified using Artificial Neural Network (ANN) classification algorithms, Furthermore the accuracy was achieved (97.11% for asthmatic, 98.85% for healthy).

The Table (1) below summarized all papers which are compared and used on this paper based on six common sectors.

Table (1) summary of all paper

Papers names Author's (date)	Problem description	Proposed solution	Method of Collecting Data	No of Data	Classification Algorithms and Results
Survey on Asthma Prediction Using Classification Technique Mrs. J. Cathrin Princy 1, Mrs. K. Sivaranjani (7,july,2016)	misdiagnosis of asthmatic disease	Using data mining classification and Prediction techniques by using common machine learning techniques such as (SVM, ANN, BN, PSO, CSAMM, Random Forest)	- 1): Questionnaire Clinical diagnosis	25 patient	1. CSAMM:84.32% accuracy 2. Backpropogation:82.21% accuracy 3. C4.5: 83.83% accuracy 4. Bayesian network: 81.17% accuracy 5. PSO: 84.16% accuracy
			- 2): Questionnaires distributed to be answered by parents and their children	112patients	1. ANN the accuracy was 96.77% By passing through two stage: - First stage: feature reduction by using PLS - Second stage:classification by using those techniques: - MLP (accuracy 96.77, sensitivity 96.15% and specificity 100%) - PNN (sensitivity 100%, specificity 80%, accuracy 96.77%
			(2013- 3): Questionnaires distributed to be answered by parents and their children	112 patients	SVM: 95.54% of accuracy.
			(2014- 4): sounds were acquisition by using electret condenser microphone	20 (10 healthy, 10 asthmatic)	Random Forest and AdaBoosted Random Forest classifiers: 90% of accuracy, sensitivity 90% and specificity 90%. ANN:80%
			(2013- 5) Data of patients which visited	254 (169 asthmatic- 85 non	5) SVM: specificity, sensitivity, and accuracy were 0.9934, 0.9737, 0.9870

Papers names Author's (date)	Problem description	Proposed solution	Method of Collecting Data	No of Data	Classification Algorithms and Results
			hospital of Tahran	asthmatic)	
Classification of lung sounds using convolutional neural networks Murat Aykanat1*, Özkan Kılıç1, Bahar Kurt2 and Sevgi Saryal3 (2017)	Difficulty to find or create pattern easily after collected data from the environment	Invention technique used by researchers to collect, analysis, and diagnosis	2017) Recording respiratory audio by using.Net application which installed on Laptop with high quality	Recorded sounds from 1630 patient was 17,930	<u>CNN and SVM</u> (1) healthy versus pathological Classification, (CNN 86%, SVM 86%,) (2) rale, rhonchus, and normal sound classification (CNN 76%, SVM 75%) (3) singular respiratory sound type classification (CNN 80%, SVM 80%,)
Classification of Asthma Using Artificial Neural Network Badnjević1,2,3,4, L. Gurbeta 1,2, M. Cifrek5, D. Marjanovic1 2018	problems of asthma management which based on misdiagnosis and classification of asthma	Using ANN to classify asthma by using lung condition and further information measuring by IOS, Spirometry	2018) - Static assessment based on IOS, Spirometry results. - dynamic assessment based on BDT and/or BPT	1250 subjects (728 asthmatic, 522 healthy)	ANN: Accuracy of 98.85%. Sensitivity and specificity were assessed, as well, which were 97.11% and 98.85%, respectively

Discussion

Comparing accuracy of diagnosis between different studies is not easy because of the difference in the classifier technique, structure, and design. Thus we will be discussing the accuracy based on three common items that caused the difference in accuracy of asthma diagnosis: Number of subjects, Feature extraction techniques, and apparatus of diagnosis of asthmatic patients. Expert system one of most common artificial neural network system, developed in [5] with number of machine learning algorithms (CSMM, PSO, Backpropogation, C4.5, Bayesian network) the number of subjects were (25), the highest accuracy was 84.32% by "CSMM", despite of using different algorithms the accuracy was low compared with [7] which achieved accuracy 95.54% by using machine learning algorithm (LSSVM) with PGA feature extraction technique, and number of subjects (112).

On the other hand, researchers in [6] used a combination of machine learning algorithms (random forest algorithm, adaboost algorithm) achieved 90% accuracy while ANN achieved 80% accuracy,

however, both (random forest algorithm, adaboost algorithm, ANN) had the same number of subjects (250), moreover (normalization, wavelet decomposition) feature extraction technique, While the ANN when used in [10] achieved 94% accuracy with number of subjects (200 children), estimation by using height and sex were used rather than feature extraction technique. In addition, ANN achieved (98.85%) accuracy in [5] with a number of subjects (1250) which used Spirometry (SPIR) and IOS measuring test results as input vectors of the ANN.

The most important function of data mining is classification, the classifiers are used by data mining (K- NN, BN, ANN, and SVM) which are used in [11] the highest accuracy achieved by SVM (99.34%), the number of subjects 254 (169 asthmatic- 85 non asthmatic) used by all classifiers, feature extraction technique was Relief. CCN classifier with STFT feature extraction, and SVM classifier with MFCC feature extraction are both used in [9] the highest accuracy achieved both was (86%), the number of subjects (1630). Whereas if the researchers return to the experiences achieved by using SVM with Relief feature extraction technique in [11] it was possible to gain better results than [9].

From all studies aforementioned we can conclude that the accuracy of diagnosis varies and it depends mainly on three factors: the number of subjects, Feature extraction techniques, and apparatus of diagnosis.

Conclusion:

Asthma is a chronic disease of the airways that transport air to and from the lungs, the core obstacle of asthma is misdiagnosis. Prediction, classification and diagnosis are one of the most attractive and important medical research areas by using modern and new techniques of artificial neural networks. In this paper we compared different techniques which were used to solve this problem by using different algorithms to getting a high level of accuracy. Based on the results of compared we found the high accuracy achieved by using ANN was (98.85%), low accuracy by using ANN 80%, while SVM algorithm which used for classification achieved 86% when MFCC used for feature extraction, and achieved (99.34%) when used Relief for extracting feature, for that we suggest if the researcher return to previous studies the high level of accuracy will be achieved, also the distinguished level of accuracy mainly based on three factors: number of subjects, feature extraction techniques, and apparatus of diagnosis.

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