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RESPIRATORY DISEASE RECOGNITION THROUGH RESPIRATORY SOUNDS USING RECURRENT NEURAL NETWORK

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ABSTRACT

Using deep neural networks or deep learning, it is possible to predict respiratory disorders such COPD, URTI, bronchiectasis and pneumonia. We have built an application embedded with a deep neural network model that predicts the state of its respiratory system based on the respiratory sound that is input. It more accurately and precisely classifies not just the aforementioned diseases but also whether or not a person's respiratory system is healthy.

KEYWORDS- Respiratory disease recognition, Deep neural network,GRU (Gated Recurrent Unit),sound data, data augmentation, feature extraction, classification, COPD(Chronic obstructive pulmonary disease), URTI (Upper Respiratory Tract Infection)

INTRODUCTION

In this research study, we'll talk about how deep learning might be utilised to identify respiratory illnesses based solely on breathing sounds.

Audios of the respiratory system are crucial markers of respiratory health and disease. As an illustration, wheezing is a typical symptom of obstructive airway diseases like asthma or chronic obstructive pulmonary disease (COPD). The challenge was handled using various neural network model architectures, and we selected the model that would produce the best results for us. We also added more data to the data set. The dataset we used consisted of respiratory sounds collected from various patients at various points on the chest. The idea of using deep neural networks to recognize respiratory diseases through respiratory sound is a novel approach that has emerged in recent years. While traditional methods for diagnosing respiratory diseases rely on physical examinations, medical history, and imaging tests, this approach offers a non-invasive and potentially more accurate way to diagnose respiratory diseases. Deep neural networks have shown remarkable success in various tasks, including speech recognition, image recognition, and natural language processing. Applying these techniques to respiratory sound analysis is a promising development that could significantly improve the accuracy and reliability of respiratory disease diagnosis. Furthermore, this approach has the potential to be applied in resource-limited settings where access to advanced imaging technologies or specialized medical professionals may be limited. A deep neural network-based diagnostic tool could potentially provide a low-cost and scalable solution for diagnosing respiratory diseases in these settings.

TECHNOLOGIES USED

RNN

Recurrent Neural Network is referred to as RNN. It is a kind of artificial neural network made for processing sequential input in which the elements' order is important. For applications like speech recognition, time series analysis, and natural language processing, RNNs are especially helpful. RNNs contain a recurrent connection that enables them to retain knowledge about prior inputs, in contrast to conventional feedforward neural networks that analyse each input independently and do not keep track of previous inputs. The network may learn and generate predictions using the current input and the context that past inputs have provided thanks to this recurrent link, which creates a loop within the network. The fundamental principle underlying RNNs is that they can detect patterns or temporal connections in sequential data. RNNs can model and produce sequences of different lengths because they incorporate the concepts of time and memory. A word in a sentence or a timestamp in a time series are examples of input elements that an RNN processes in each step. It also updates its internal hidden state, which acts as a recollection of previous inputs. The network can then use the current input and the prior hidden state in its calculations by passing this hidden state on to the following stage.

GRU

Gated Recurrent Unit is referred to as GRU. It is a specific kind of recurrent neural network (RNN) architecture that was developed as an improvement over more intricate Long Short-Term Memory (LSTM) networks and conventional RNNs. Sequential data's long-term dependencies can be successfully captured by GRUs. Information flow inside the network is managed by gating mechanisms that are part of the GRU architecture. GRUs are able to selectively update and retain pertinent information from earlier time steps thanks to these gating mechanisms, which control the amount of information that is sent through the network.

PYTHON TKINTER

Python offers multiple options for developing GUI (Graphical User Interface). Out of all the GUI methods, tkinter is the most commonly used method. It is a standard Python interface to the Tk GUI toolkit shipped with Python. Python with tkinter is the fastest and easiest way to create the GUI applications.

RELATED WORKS

[1] Rocha BM, Mendes L, Couceiro R Henriques J, Carvalho P, Paiva R. Detection of Explosive Cough Events in Audio Recordings by Internal Sound Analysis Internal Sound Analysis. 39th Annu Int Conf IEEE Eng Med Biol Soc 2017;2761-6 The author conveys a new method for the discrimination of explosive cough events, which is based on a combination of spectral content descriptors and pitch-related features. After the removal of near-silent segments, a vector of event boundaries is obtained and a proposed set of 9 features is extracted for each event. Two data sets, recorded using electronic stethoscopes and comprising a total of 46 healthy subjects and 13 patients, were employed to evaluate the method. The proposed feature set is compared to three other sets of descriptors: a baseline, a

combination of both sets, and an automatic selection of the best 10 features from both sets. The combined feature set yields good results on the cross-validated database, attaining a sensitivity of 92.3±2.3% and a specificity of 84.7±3.3%. Besides, this feature set seems to generalize well when it is trained on a small data set of patients, with a variety of respiratory and cardiovascular diseases, and tested on a bigger data set of mostly healthy subjects: a sensitivity of 93.4% and a specificity of 83.4% are achieved in those conditions. These results demonstrate that complementing the proposed feature set with a baseline set is a promising approach.

[2] L. Mendes, Ioannis Vogiatzis, Eleni Perantoni, Evangelos Kaimakamis, Ioanna Chouvarda, N. Maglaveras, Jorge Henriques, Paulo de Carvalho, Rui Pedro Paiva. Detection of crackle events using a multi-feature approach. 38th Annu Int Conf IEEE Eng Med Biol Soc. IEEE; 2016;367983 the author states that the automatic detection of adventitious lung sounds is a valuable tool to monitor respiratory diseases like chronic obstructive pulmonary disease. Crackles are adventitious and explosive respiratory sounds that are usually associated with the inflammation or infection of the small bronchi, bronchioles and alveoli. In this study a multi-feature approach is proposed for the detection of events, in the frame space, that contain one or more crackles. The performance of thirty-five features was tested. These features include thirty-one features usually used in the context of Music Information Retrieval, a wavelet based feature as well as the Teager energy and the entropy. The classification was done using a logistic regression classifier. Data from seventeen patients with manifestations of adventitious sounds and three healthy volunteers were used to evaluate the performance of the proposed method. The dataset includes crackles, wheezes and normal lung sounds. The optimal detection parameters, such as the number of features, were chosen based on a grid search. The performance of the detection was studied taking into account the sensitivity and the positive predictive value. For the conditions tested, the best results were obtained for the frame size equal to 128 ms and twenty-seven features.

[3] Guntupalli KK, Alapat PM, Bandi VD, Kushnir I. Validation of automatic wheeze detection in patients with obstructed airways and in healthy subjects. J Asthma. 2008;45(10):9037 the author states computerized lung-sound analysis is a sensitive and quantitative method to identify wheezing by its typical pattern on spectral analysis. We evaluated the accuracy of the VRI, a multi-sensor, computer-based device with an automated technique of wheeze detection. The method was validated in 100 sound files from seven subjects with asthma or chronic obstructive pulmonary disease and seven healthy subjects by comparison of auscultation findings, examination of audio files, and computer detection of wheezes. Three blinded physicians identified 40 sound files with wheezes and 60 sound files without wheezes. Sensitivity and specificity were 83% and 85%, respectively. Negative predictive value and positive predictive value were 89% and 79%, respectively. Overall inter-rater agreement was 84%. False positive cases were found to contain sounds that simulate wheezes, such as background noises with high frequencies or strong noises from the throat that could be heard and identified without a stethoscope. The present findings demonstrate that the wheeze detection algorithm has good accuracy, sensitivity, specificity, negative predictive value and positive predictive value for wheeze detection in regional analyses with a single sensor and multiple sensors. Results are similar to those reported in the literature. The device is user-friendly, requires minimal patient effort, and, distinct from other devices, it provides a dynamic image of breath sound distribution

with wheeze detection output in less than 1 minute.

[4] B. M. Rocha1, D.Filos, L. Mendes, I. Vogiatzis, E.Perantoni, E.Kaimakamis, P.Natsiavas, A. Oliveira, C. Jcome, A. Marques, R. P. Paiva, I. Chouvarda,P. Carvalho, N. Maglaveras. Respiratory Sound Database for the Development of Automated Classification. International Conference on Biomedical and Health Informatics ICBHI 2017: Precision Medicine Powered by Health and Connected Health pp 33-37. " the author conveys that the automatic analysis of respiratory sounds has been a field of great research interest during the last decades. Automated classification of respiratory sounds has the potential to detect abnormalities in the early stages of respiratory dysfunction and thus enhance the effectiveness of decision-making. However, the existence of a publically available large database, in which new algorithms can be implemented, evaluated, and compared, is still lacking and is vital for further developments in the field. In the context of the International Conference on Biomedical and Health Informatics (ICBHI), the first scientific challenge was organized with the main goal of developing algorithms able to characterize respiratory sound recordings derived from clinical and non-clinical environments. The database was created by two research teams in Portugal and in Greece, and it includes 920 recordings acquired from 126 subjects. A total of 6898 respiration cycles were recorded. The cycles were annotated by respiratory experts as including crackles, wheezes, a combination of them, or no adventitious respiratory sounds. The recordings were collected using heterogeneous equipment and their duration ranged from 10 to 90 s. The chest locations from which the recordings were acquired were also provided. Noise levels in some respiration cycles were high, which simulated real-life conditions and made the classification process more challenging.

[5] Ashok Mondal, Parthasarathi Bhattacharya, and Goutam Saha. Detection of Lungs Status Using Morphological Complexities of Respiratory Sounds. Scientific World Journal. 2014; 2014: 182938.doi10.1155/2014/182938.PMCID:PMC3933370 The author conveys that Traditionally, the clinical diagnosis of a respiratory disease is made from a careful clinical examination including chest auscultation. Objective analysis and automatic interpretation of the lung sound based on its physical characters are strongly warranted to assist clinical practice. In this paper, a new method is proposed to distinguish between the normal and the abnormal subjects using the morphological complexities of the lung sound signals. The morphological embedded complexities used in these experiments have been calculated in terms of texture information (lacunarity), irregularity index (sample entropy), third order moment (skewness), and fourth order moment (Kurtosis). These features are extracted from a mixed data set of 10 normal and 20 abnormal subjects and are analyzed using two different classifiers: extreme learning machine (ELM) and support vector machine (SVM) network. The results are obtained using 5-fold cross-validation. The performance of the proposed method is compared with a wavelet analysis based method. The developed algorithm gives a better accuracy of 92.86% and sensitivity of 86.30% and specificity of 86.90% for a composite feature vector of four morphological indices.

[6] Chamberlain D, Kodgule R, Ganelin D, Miglani V, Fletcher RR. Application of Semi-Supervised Deep Learning to Lung Sound Analysis. 38th Annu Int Conf IEEE Eng Med Biol Soc; 2016;8047 the author is trying to convey that the analysis of lung sounds, collected through auscultation, is a

fundamental component of pulmonary disease diagnostics for primary care and general patient monitoring for telemedicine. Despite advances in computation and algorithms, the goal of automated lung sound identification and classification has remained elusive. Over the past 40 years, published work in this field has demonstrated only limited success in identifying lung sounds, with most published studies using only a small numbers of patients (typically N<;20) and usually limited to a single type of lung sound. Larger research studies have also been impeded by the challenge of labeling large volumes of data, which is extremely labor-intensive. In this paper, we present the development of a semi-supervised deep learning algorithm for automatically classify lung sounds from a relatively large number of patients (N=284). Focusing on the two most common lung sounds, wheeze and crackle, we present results from 11,627 sound files recorded from 11 different auscultation locations on these 284 patients with pulmonary disease. 890 of these sound files were labeled to evaluate the model, which is significantly larger than previously published studies. Data was collected with a custom mobile phone application and a low-cost (US$30) electronic stethoscope. On this data set, our algorithm achieves ROC curves with AUCs of 0.86 for wheeze and 0.74 for crackle. Most importantly, this study demonstrates how semi-supervised deep learning can be used with larger data sets without requiring extensive labeling of data.

[7] Lartillot O, Lartillot O, Toiviainen P, Toiviainen P. A matlab toolbox for musical feature extraction from audio. Int Conf Digit AudioEffects2007;(Ii):18 the author conveys that We present MIRtoolbox, an integrated set of functions written in Matlab, dedicated to the extraction of musical features from audio files. The design is based on a modular framework: the different algorithms are decomposed into stages, formalized using a minimal set of elementary mechanisms, and integrating different variants proposed by alternative approaches – including new strategies we have developed –, that users can select and parametrize. This paper offers an overview of the set of features, related, among others, to timbre, tonality, rhythm or form, that can be extracted with MIRtoolbox. Four particular analyses are provided as examples. The toolbox also includes functions for statistical analysis, segmentation and clustering. Particular attention has been paid to the design of a syntax that offers both simplicity of use and transparent adaptiveness to a multiplicity of possible input types. Each feature extraction method can accept as argument an audio file, or any preliminary result from intermediary stages of the chain of operations. Also the same syntax can be used for analyses of single audio files, batches of files, series of audio segments, multichannel signals, etc. For that purpose, the data and methods of the toolbox are organised in an object-oriented architecture.

[8] Almir Badnjevic, Lejla Gurbeta, and Eddie Custovic. An Expert Diagnostic System to Automatically Identify Asthma and Chronic Obstructive Pulmonary Disease in Clinical Settings. SCIENTIFIC REPORTS(2018) 8:11645 DOI:10.1038/s41598-018-30116-2 the author states that Respiratory diseases such as asthma and chronic obstructive pulmonary disease (COPD), are affecting a huge percentage of the world's population with mortality rates exceeding those of lung cancer and breast cancer combined. The major challenge is the number of patients who are incorrectly diagnosed. To address this, we developed an expert diagnostic system that can differentiate among patients with asthma, COPD or a normal lung function based on measurements of lung function and information about patient's symptoms. To develop accurate classification algorithms, data from 3657 patients were used and then independently verified using data from 1650 patients collected over a period of two years. Our results

demonstrate that the expert diagnostic system can correctly identify patients with asthma and COPD with sensitivity of 96.45% and specificity of 98.71%. Additionally, 98.71% of the patients with a normal lung function were correctly classified, which contributed to a 49.23% decrease in demand for conducting additional tests, therefore decreasing financial cost.

[9] Geraldo Luis Bezerra Ramalho, Pedro Pedrosa Rebouas Filho, Ftima Nelsizeuma Sombra de Medeiros, Paulo Csar Cortez.Lung disease detection using feature extraction and extreme learning machine. Sociedade Brasileira de Engenharia Biomdica.(Brazilian journal of biomedical engineering) version ISSN 1517-3151 conveys that The World Health Organization estimates that by 2030 the Chronic Obstructive Pulmonary Disease (COPD) will be the third leading cause of death worldwide. Computerized Tomography (CT) images of lungs comprise a number of structures that are relevant for pulmonary disease diagnosis and analysis. METHODS: In this paper, we employ the Adaptive Crisp Active Contour Models (ACACM) for lung structure segmentation. And we propose a novel method for lung disease detection based on feature extraction of ACACM segmented images within the cooccurrence statistics framework. The spatial interdependence matrix (SIM) synthesizes the structural information of lung image structures in terms of three attributes. Finally, we perform a classification experiment on this set of attributes to discriminate two types of lung diseases and health lungs. We evaluate the discrimination ability of the proposed lung image descriptors using an extreme learning machine neural network (ELMNN) comprising 4-10 neurons in the hidden layer and 3 neurons in the output layer to map each pulmonary condition. This network was trained and validated by applying a holdout procedure. RESULTS: The experimental results achieved 96% accuracy demonstrating the effectiveness of the proposed method on identifying normal lungs and diseases as COPD and fibrosis. CONCLUSION: Our results lead to conclude that the method is suitable to integrate clinical decision support systems for pulmonary screening and diagnosis.

[10] .Integrated Approach for Automatic Crackle Detection Based on Fractal Dimension and Box Filtering International Journal of Reliable and Quality E-Healthcare. Volume 5 Issue 4, October 2016. doi - 10.4018/IJRQEH.2016100103and Box Filtering. International Journal of Reliable and Quality E-Healthcare. Volume 5 Issue 4, October 2016. doi - 10.4018/IJRQEH.2016100103 the author conveys that Crackles are adventitious respiratory sounds RS that provide valuable information on different respiratory conditions. Nevertheless, crackles automatic detection in RS is challenging, mainly when collected in clinical settings. This study aimed to develop an algorithm for automatic crackle detection/characterisation and to evaluate its performance and accuracy against a multi-annotator gold standard. The algorithm is based on 4 main procedures: I recognition of a potential crackle; ii verification of its validity; iii characterisation of crackles parameters; and iv optimisation of the algorithm parameters. Twenty-four RS files acquired in clinical settings were selected from 10 patient with pneumonia and cystic fibrosis. The algorithm performance was assessed by comparing its results with a multi-annotator gold standard agreement. High level of overall performance F-score=92% was achieved. The results highlight the potential of the algorithm for automatic crackle detection and characterisation of RS acquired in clinical settings.

[11] Dataset link - https://bhichallenge.med.auth.gr/

RESULTS

The system had an accuracy of 91% and a precision score of 89%. We were able to successfully integrate the deep learning model with a user interface that could make the overall testing process easy.

CONCLUSION

Medical research and medical science could be progressed further with the help of artificial intelligence. The neural network architecture has performed better than our expectations. But still, it needs a lot of improvements to achieve higher accuracy during prediction. We hope our research would inspire future researchers to work on this subject and wish they would approach with a better and encouraging solution. Future enhancements would be to add real time testing features along with improving the number of diseases that can be diagnosed using this system. Also testing various other machine learning methods and also using transfer learning to improve the overall performance of the system.

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