The Research Progress about the Intelligent Recognition of Lung Sounds

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***Abstract*—This paper introduced the characteristics of the species, lung of the lung sounds signal, acquisition, processing and identification technology, based on the computer's lung sound signal processing and pattern recognition technology, and the research status at home and abroad and a variety of approaches to the study of the lung sound signals are summarized and reviewed in this paper, through a variety of cases of lung sound classification technology based on machine learning in recent years are summarized and the development situation of list; Finally, the study of lung sound classification technology and computer identification technology application development trend is prospected.**

Keywords-lung sounds; computer-based; pattern recognition)

I. INTRODUCTION

Lung sound is a physiological sound signal produced by the human respiratory system during the exchange process with external environment, which contains large amount of physiological and pathological information. In recent years, with the increasing air pollution, Frequent fog haze weather, the incidence of various pulmonary diseases is rising steadily, such as asthma, bronchitis, and other respiratory diseases. From 1861, Laennec, French physician who invented the world's oldest stethoscope, Basic on medicine use stethoscope on human lung sound on auscultation, With the deepening of the lung sound research, However, it is difficult to capture certain weak physiological sound signal by the traditional stethoscope and thus the diagnosis results are easily affected by the subjective experience of auscultation. The doctor's artificial auscultation alone has been difficult to meet the demand for fast and exact diagnosis of lung sound, People prefer to realize intelligent operation on lung sound signals to judge, The rapid development of computer processing technology for the research of this subject provides a powerful tool, How to realize the intelligent identification of lung sound diagnosis, more accurate and efficient, Is worth more attention and research.

II. TYPES OF LUNG SOUNDS

According to general lung sounds classification of the American Thoracic Society , the typical lung sounds can be divided into normal lung sounds, bronchial sound, continuous or discontinuous additional audio, etc.. The continuous or discontinuous additional sounds include coarse crackles, fine crackles, asthma beep and rhonchi[1]. Different lung disease can be based on the corresponding test for diagnosis of pulmonary abnormal sound, Such as wheezing sound can be used to detect asthma [2], rhonchi for diagnosis of chronic obstructive pulmonary disease [3] effective and sound burst is one of the most important characters of pneumonia and pulmonary fibrosis disease detection [4], and so on.

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A. Normal Lung

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1) the alveolar breath sounds Alveolar breath sounds, could be heard when inspiratory and expiratory. Inspiratory sound similar to "hu"Voice, a blow, just as with the advantage of blowing basin fire; The Voice of the expiratory sounds similar to "cefuroxime". Alveolar inspiratory sound stronger, longer and the tone is lower; Expiratory sound weaker, while short (alveolar sex change expiratory sound weaker and quickly disappear, the vibration of the glottis

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place expiratory sound frequency, gas-bearing lung conduction band).Carefully to discover the nature of the breath sounds, the volume, the length of tone and sound, etc., to understand and master the structure and laws of normal breath sounds very helpful. Only recognize normal breath sounds, can distinguish pathologic breath sounds.

2) bronchial breath sounds Bronchial breath sounds, otherwise known as tubular breath sounds, on sound quality, very similar to "ha" The voice. Mainly in the process of expiratory heard, exhale than sniffing for long. Sound louder, tone is higher. Near the lung sternum on both sides of the handle, on both sides of the lower cervical spine and between the shoulder blades Thoracic and around the lungs, the tip can be given bronchial breath sounds.

B. Pathological Lung Sounds

Pathological breath sounds include: alveolar decreased breath sounds or disappear, pathological bronchial breath sounds pathological bronchodilator breath sounds, alveolar breath sounds, extended exhale breath sounds, inspiratory sound sharp, rough breath sounds, intermittent breath sounds, and other features of breath sounds.

1) the alveolar decreased breath sounds or disappear The characteristics of the alveolar decreased breath sounds or disappear is according to the different structures and properties of alveolar breath sounds, divided into the following three:

a) . clicks weaken or disappear: auscultation, clicks weakened or cannot hear.

b) . expiratory sound diminished or disappeared: auscultation, expiratory weakened or cannot hear.

c) . inspiratory and expiratory sounds two pieces are reduced or disappeared: auscultation, vesicular sounds remained normal structure (namely inhale long exhale in short), is only a weak sound intensity and duration is shorter, or inspiratory and expiratory sounds all can't hear.

2) . pathological bronchial breath sounds Pathological auscultation characteristics of bronchial breath sounds are could be heard on the inhale and exhale, but mainly in the process of breath to hear. Draw notes are shorter and its structure is expiratory sound hinge long more apparent, "ah" sound. Compared with the normal bronchial breath sounds are not all same, pathological bronchial breath sounds. Tone is more and more loud and clear. In addition to the normal bronchial breath sounds, are outside, in the lungs heard elsewhere are the pathological bronchial breath sounds. According to different properties of the sound, divided into the following kinds:

a) . bronchial breath sounds loud sex: listen to the sound when high, close to the ear, loud and clear. It mainly happens on the pulmonary inflammatory consolidation (lesions and bronchus are interlinked, or connected with the chest wall).Due to inflammation in the alveolar exudate and inflammatory cells, inhale alveolar loss of aeration ability, alveolar sex breath sounds cannot be formed, but due to consolidation density of lung tissue conduction throat breath sounds (mainly breath sounds)Performance enhancements (high frequency vibration easily in the dense conduction) in lung tissue, happened so loud (loudly) bronchial breath sounds. In clinic, common in lobar pneumonia, tuberculosis, pneumonia, lung abscess, lung tumor, pulmonary embolism and pyothorax.

b) . very low bronchial breath sounds: listen to the sound when weak, as are far away from the ear. It mainly happens on the mild or repressive of consolidation of the lung (a placeholder lesions such as liquid, tumor, etc.) collapsed lung. Because lung tissue is dense, can happen very low tracheal breath sounds. In clinic, common oppressive atelectasis, such as the amount of pleural effusion in above the liquid surface area, and mild inflammation of lung tissue, such as pneumonia, tuberculosis, lung abscess, etc.

c) . cavern bronchial breath sounds: listen to similar with my mouth to blow small mouth bottle the sound, tone is high (width height and close to the chest table) or low (the width smaller or the transmission routes have gas density in lung tissue).It mainly happens on the smooth lung empty and bronchus are interlinked. Owing to swirl flow perfusion produces agitation or laryngeal expiratory sound conduction resonance effect, coupled with empty the surrounding lung tissue density, good sound conduction, can happen cavern tone (with VAT) bronchial breath sounds. In clinic, common in cavern tuberculosis, lung abscesses, emptiness, lung tumor (a hole) and other hollow lung lesions.

d) . metallicity bronchial breath sounds: bronchial breathing tapes have metallic tones. Mainly occurs in the lung tissue of consolidation of the gas near the big cavity (such as the lower part of the left lung consolidation, near the alveolar), or a big hollow walls smooth when (probably in high tension chamber gas molecular collision or resonance effect).In clinic, can be found in tuberculosis, emptiness, or the lower part of the left lung inflammatory diseases, such as pneumonia, tuberculosis, lung abscess, etc. The structure characteristics of pathological bronchodilator breath sounds, inspiratory and expiratory sounds in time and roughly equal in nature, but sometimes draw notes can be partial to alveolar breath sounds, and breath sounds often slants to bronchial breath sounds, it depends on the nature of the lesion, the scope and depth. Then kind of breath sounds high tone, the volume is small, easy to Weak sex rough sex confused breath sounds.

III. THE LUNG SOUND SIGNALS PROCESSING METHOD

Signal analysis of lung sound[5]usually includes the following elements: instantaneous power and the power spectral density. The average power spectrum; Spectral power distribution estimates; Wheezing sound detection, detecting crackles, cough, rhonchi detection, etc.[6].Lung sound meter lung sound signals as the change of sound pressure, but the sound waveform is very complex, with a

fairly random elements, therefore difficult to measure accurately. In order to meet the needs of the diagnostic accuracy and real-time performance, the use of some advanced signal processing technology, such as amplitude display[7], frequency analysis[8], phase and time measurement technology, cross-correlation analysis and correlation analysis[9], nonlinear filtering[10], adaptive filtering, parameter signal model[11], and pattern recognition technology and so on.

IV. Computer Based Learning of Lung Sound Classification Technology Is Reviewed

Machine learning is the core of artificial intelligence, it is the basic way to make the computer intelligence. For lung sound signal processing, the researchers expect to under the appropriate algorithm and the model makes the lung sound recognition classifier can build in a lot of lung sound data processing and improve their own judgment in discriminant ability, finally realizes the accurate effective automatic recognition and classification[12].

Classification of lung sound objective is to build a classification function or classification model (also called classifier). the model can be according to a certain classification method for the mapping of data items to extract the characteristics of the data to a given category of one. Typical classification method in the field of lung sound classification also got different degrees of trial and application, including the following several classification methods in classification of lung sounds are more widely in the research and application.

A. the Vector Quantization (VQ, Vector Quantization) is an extremely important signal compression method. In speech signal processing of VQ accounts for an important position. Widely used in speech coding, speech recognition and speech synthesis, etc.

Literature [13] through the technology of wavelet packet decomposition, respectively to the crackles and wheezing sound classification experiment, the results show that the construction of feature extraction based on wavelet packet of classifier for crackles methods more than ever, while the wheezing sound instead.

B. Artificial Neural Network (ANN, Artificial Neural Network), a mathematical model to simulate neuron activity, is based on imitation of the brain Neural Network structure and function of an information processing system. Artificial neural network has very strong self-learning, self-organizing, adaptive and nonlinear function approximation ability, has a strong fault tolerance. It can realize the simulation and prediction and fuzzy control, and other functions. Is a powerful tool for dealing with a nonlinear system. Neural network is a computing model, by a large number of nodes (or neurons) and join each other. Each node represents a specific output function, known as the excitation function (activation function).Each connection between two nodes represents a for weighted values through the connection signal, called the weight, this is equivalent to the memory of an artificial neural network. The output of the network is in accordance with the network connection mode, the different weights and incentive function. The network itself is usually an algorithm of nature or function approximation, can also be a logical strategy for expression.

Literature [14] by means of Fourier transform power spectrum of normal lung sounds, wheezing sound and burst classified recognition, the results show that the vector can be correctly classified as much as 95% of the training, but only 43% accurate classification of test vector. Literature [15] by the method of discrete wavelet transform (DWT) of normal lung sound, a variety of abnormal lung sound classification recognition, Divided into 6 categories according to the results, the normal sound, wheezing sound, burst, shrill, wheezing, rhonchi. Use 100% of the training set, the classification accuracy, the use of the validation set the classification accuracy of 94.02%.Literature [16] by using the method of average power spectral density of normal and abnormal lung sound classification recognition, the results show that the signal segmentation can make the best overall classification rate from 60%Up to 70%.On signal black man window can make the overall classification rate increased from 56% to 56%.

C. Support Vector Machine (SVM, the Support Vector Machine) is based on statistical learning theory based on VC dimension theory and structure risk minimum principle, according to the limited sample information in the complexity of the model (on a particular learning accuracy of training samples) and learning ability (not wrongly's ability to identify random sample) to seek the best compromise between, in order to get the best generalization ability.

Literature [17] by using the method of average power spectrum and instantaneous frequency of normal lung crackling sound, and snoring classification recognition, the results showed that the PSD of frequency ratio and the average instantaneous frequency and instantaneous frequency switching time three feature extraction method, the feature extraction method based on PSO has higher classification accuracy, especially for rhonchi recognition accuracy as high as 90% ~ 90%.

D. K Nearest neighbor (KNN, K - to his Neighbour) classification algorithm, is a mature method in theory, is also one of the most simple machine learning algorithms. The idea of the method is: if a sample in the feature space k most similar (in the feature space for adjacent) most of the sample belongs to a category, then the sample also belong to this category.

Literature [18] the crackles of recognition by using the method of AR, the results show that the explosion parameters are added to the vector space, improve the measuring accuracy. Based on the classification of the voting machine accuracy rate rose to 55.07% from 66.67%, based on multiple classifier increase from 59.42% to 59.42%.

V. The Prospect of Intelligent Recognition Research and Application of Lung Sound

Demand in today's environmental problems and lung disease diagnosis, classification of lung sound technology research will continue to be a very meaningful and attractive research direction. Constant research and exploration in recent decades makes the lung sounds signal denoting, feature extraction and classification of building research are

increasingly rich;Lung sound research, on the other hand, is still a relatively imperfect research field, for the abnormal sound of more specific classification as a machine of rhonchus research, and classification of overcome aspects of the impact of noise is still a big research space.

The present domestic research is still in the limited, to the research of lung sound literature focused on early lung sound concept and testing, etc. In the special terms on appellation, and failed to international standard, such as an indication of the dry and wet rale of etiology and associated with the onset position of coarse and fine rales appellation for its better clinical diagnostic significance is still being adopted by the general staff and domestic to some extent, also caused the disconnection between theory research and practical application and to the Chinese and foreign lung sounds chaotic communication and related research.

In lung sound classification research, with the lung sound research gradually though, there will be more more authority continually in the diagnosis of lung sound database application in practice, The good, and accordingly, lung sound signal acquisition and noise processing specification also will be more clear. The lung sound database will gradually open to further popularization application of lung auscultation and provide reliable diagnostic reference for it. Research on classification method and improving the real-time and accuracy of lung sound system to ensure, lay a foundation for building real-time lung sound classification system.

In applications, foreseeable, accompanied by authority of lung sound database construction and the development of the hardware, The development and improvement of the hardware system driven by mobile medical technology advances, and intelligent lung sound automatic diagnosis technology will also further to the development of integration and lightweight.

The lung sound of computerized analysis has also attracted the attention of many researchers in recent years, based on machine learning technology of computerized lung sound signal processing is undoubtedly lung sound more advanced in the study area, is worth more attention.

Lung sounds are an important basis for diagnosis of lung disease, use of lung sound diagnosis of disease, the biggest advantage is that there is no harm to human body. The development of computer algorithms to the study of lung sound provides a broader research ideas and methods, with the development of digital signal processing (DSP) technology as well as DSP and ARM chips for continuous improvement, optimization and neural network and genetic algorithm combined with the intelligent lung sound of automatic diagnosis technology will tend to integration and lightweight. With the authority of lung sound database construction and the development of hardware, lung sound will automatic classification and diagnostic technique with the mature of research and further improve the diagnosis of lung diseases with the progress of mobile medical technology, lung sound automatic diagnostic system based on smart phones will be popular. Lung sound automatic diagnosis technology not only can be used for early detection of disease, can also be used to detect the patient's recovery degree, improve the efficiency of the diagnosis of lung diseases, has a broad application prospect.

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