Separation and Classification of Crackles and Bronchial Breath Sounds from Normal Breath Sounds Using Gaussian Mixture Model

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Abstract. A computer aided diagnostic system capable of analyzing respiratory sounds can be very helpful in detection of pneumonia, asthma and tuberculosis as the Respiratory sound signal carries information about the underlying physiology of the lungs and is used to detect presence of adventitious lung sounds which are an indication of disease. Respiratory sound analysis helps in distinguishing normal respiratory sounds from abnormal respiratory sounds and this can be used to accurately diagnose respiratory diseases as is done by a medical specialist via auscultation. This process has subjective nature and that is why simple auscultation cannot be relied upon. In this paper we present a novel method for automated detection of crackles and bronchial breath sounds which when coupled together indicate presence and severity of Pneumonia. The proposed system consists of four modules i.e., pre-processing in which noise is filtered out, followed by feature extraction. The proposed system then performs classification to separate crackles and bronchial breath sounds from normal breath sounds.

1 Introduction

Respiratory sound analysis can be helpful in the diagnosis of respiratory diseases such as pneumonia as they are one of the major killers all over the world especially in the developing countries. Pneumonia is amongst the top 10 leading causes of death amongst asians living in the US [26]. According to the latest estimates it also accounts for 1.4 million deaths in children under-five years of age annually. This represents 18% of all annual under-five worldwide mortality [11] and about 98% of these deaths occur in developing countries. The economic cost of asthma, COPD, and pneumonia was $106 billion in 2009: $81 billion in direct health expenditures $25 billion in indirect cost of mortality [27]. Developed Countries can bear the such staggering costs but this is not the case for under developed countries and this lead to a high mortality rate of their citizens. Another reason for high mortality rate for people who acquire these diseases
is because of a lack of trained personnel as the ratio of doctors to patients is very low and another reason is late diagnosis of the disease. The medical specialist begins diagnosis of these diseases begins by recording history of the patient followed by a physical exam in which detection of adventitious lung sounds and abnormal lung sounds is undertaken with the help of a stethoscope; a process called auscultation. Adventitious lung sounds are additional respiratory sounds superimposed on breath sounds [3]. They are of two types 1) stationary and 2) non-stationary. The former category contains wheezes and rhonchi whereas the latter category contains crackles. Crackles are discontinuous explosive sounds which occur usually during inspiration [3]. Figure 1 shows the waveforms for normal breath, crackles and bronchial breaths.

![Fig. 1. Breath sound waveforms. From Left to right: Crackle sound waveform, Normal breath sound waveform; Bronchial sound waveform.](image)

The occurrence of crackles is an indication of the severity of the pulmonary disease [4] and combined with the presence of bronchial breaths they confirm the presence of pneumonia [23]. Bronchial Breath sounds are abnormal breath sounds detected at the posterior chest wall, containing higher frequency components and a higher intensity than that of normal breath sounds heard in the same region [3]. Therefore, simple auscultation cannot be relied upon as auscultation with a stethoscope is a subjective process since it depends on the individual’s own hearing, experience and ability to distinguish different sounds patterns[2]. Thus there is a need for a system which accurately detects the presence of crackles and bronchial breaths in the respiratory sound of patient so that it can help in the accurate diagnosis of pneumonia.

This article consists of five sections. Section 2 highlights existing methods and related work for respiratory sound analysis. Section 3 describes a brief overview and all steps of the proposed system. The results are presented in Section 4 followed by conclusions in Section 5.

2 Related Work

Respiratory Sound Analysis is a relatively new area of interest for researchers and though few methods for detection and classification of crackles have been formulated, methods for the detection of bronchial breath sounds have not yet