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Poster Abstract: A Comprehensive Approach for Cough Type Detection

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***Abstract*—Presence of sputum in pulmonary system is an important bio-marker, critical in determining the existence of many disease such as lung infection, pneumonia, cancer, etc. While there has been many reports of successful algorithms to automatically detect cough instances, there has been not much work in identifying the cough type, or equivalently detection of sputum presence. Cough type detection is traditionally done by physical examination through hearing patients coughs in a clinical visit which is subjective and costly. This work tries to provide an objective comprehensive approach for cough type detection using an extensive set of acoustic features applied to the recorded audio from a relatively large population of both healthy subjects and patient with various pulmonary diseases and healthy controls. A total number of 5971 coughs (5242 dry and 729 wet) were collected from 131 subjects using Smartphone. Annotation was done using a crowd-source platform. Classification sensitivity and specificity values of 86% and 84% was achieved respectively which is the highest in literature to the best of our knowledge.**

***Index Terms*—COPD, asthma, cough type detection, remote health monitoring**

I. Introduction

Among all these symptoms, cough is the single most common cause of outpatient clinical visit for pulmonary patients. Quantitative and qualitative tracking of cough and analyzing its features can open the window toward detection, management and prevention of many diseases [1].An important feature of cough is the cough type. Cough type can be categorized into two: wet (or productive) and dry (non-wet), where a wet cough is a cough that reveals the existence of sputum or mucus in the lung airways. Existence of sputum in the lung can be indicative of numerous conditions from a simple pulmonary infections to more serious diseases such as pneumonia and cancer. This work proposes a passive audio-based approach in detection of cough type using a comprehensive featureset. This work utilizes the biggest dataset for cough type classification in the literature. A series of a correlation and a wrapper-based feature selection algorithms was utilized to reduce the dimension of the dataset and to avoid overfitting.

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II. Related Works

One of the earliest efforts in cough type detection was done by Chatrzarrin et al. in 2011 [2]. For a limited number of coughs (47 instances), a very limited number of features (number of peaks in energy envelope and power ratio of two bands in the cough frequency spectrum) were utilized to find the optimal threshold to separate wet and dry coughs. Swankar et al. applied logistic regression on a more comprehensive set of features including MFCC, Formant Frequencies, non-Gaussianity, etc. on 178 cough instances from 46 subjects collected using a bed-side microphone [3]. Using a more colorful set of features and bigger dataset they were able to achieve 80% sensitivity and 73% specificity. Same group published a year later by including more cough instances (536 coughs from 78 subjects) and utilizing feature selection, removing features with p-value less than 0.06 [4]. They divided each cough into 3 phases and generated 22 features for each phase. Eventually 19 features out of 66 were selected for classification which led to 84% sensitivity and 76% specificity. The main limitations of these previous efforts are limited number of coughs from each type, limited set of features and limited set of classification algorithms. This work tackles these issues by providing a large dataset, a comprehensive featureset and utilizing different feature selection and machine learning algorithms.

III. Methodology and Results

The proposed system comprises five main building blocks: Sensing, Annotation, Pre-processing, Feature Engineering and Classification. The sensing module records the audio from the subjects using a smartphone. The collected audio is then extracted and sent to the crowd-source based annotation platform. There, the cough segments are separated from the rest of the audio. The separated coughs are then listened to by one level of trained and one level of expert annotators in that order to label the type. The labeled coughs are then passed through a pre-processing module which down-samples and normalizes the coughs. The appropriate features are then extracted from the pre-processed coughs and multiple feature

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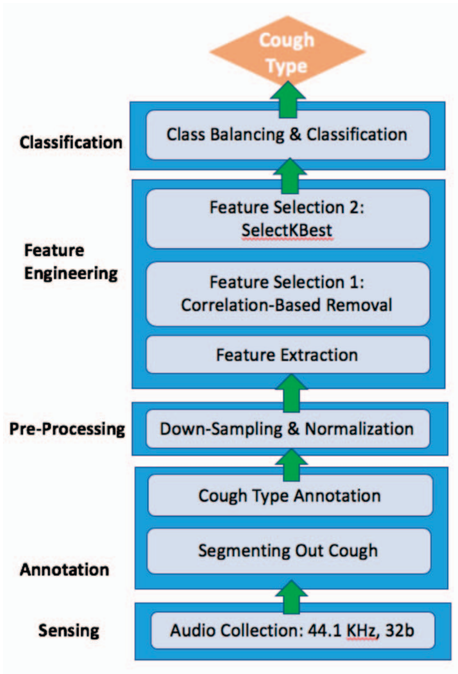

Fig. 1. System overview of the proposed method

selection algorithms are utilized to reduce the dimensionality of the data. Eventually class balancing is done through random down-sampling and classification is performed to determine the cough type. Figure 1 provides and overview of the proposed method.

After due approval from an institutional review board (IRB), in this study, we have collected data from 131 subjects (67 males and 64 female) including 91 COPD and Asthma patients and 40 healthy controls. Patients went through 2 minutes of voluntary cough session. After careful annotation, a total number of 5971 coughs from 131 subjects from which 5242 were annotated as dry and 729 as wet coughs.

The extracted slices of coughs were first pre-processed by low-pass filtering and amplitude normalization. Then, features are generated through a well-known toolbox called OpenSmile, which has been utilized heavily for acoustic analytics. Investigating the literature we found that the *"IS10 paraling"* feature package is the most suitable due to its comprehensiveness and due to its paralinguistic modalities. A total number of 1522 features are generated including both OpenSmile. Due to the limitation on number of cough samples, feature selection is necessary to avoid overfitting. Through two layers of a correlation-based feature removal and a wrapper-based feature ranker, a total number of 151 features were selected for classification. After feature value normalisation, we utilized three different classification algorithms: Logistic regression, Random Forest and SVM. Figure 2 depicts the classification results from a 10-fold cross-validation for both with and without feature selection. Figure 3 shows the importance of feature selection for this problem where a comprehensive

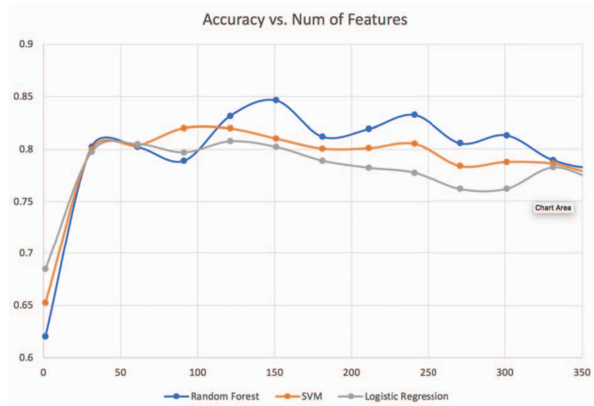

Fig. 2. Accuracy comparison for different algorithms vs. number of features

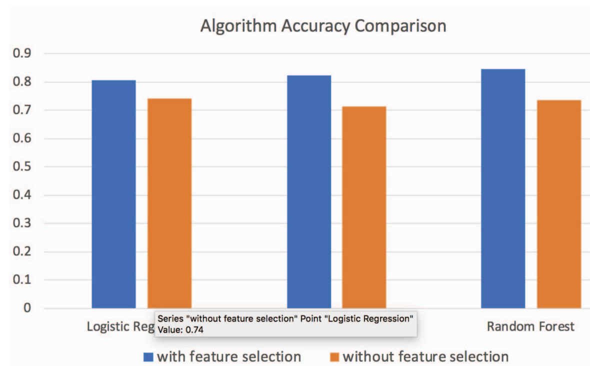

Fig. 3. Accuracy comparison with and without feature selection

approach is taken for feature generation.

Conclusion

In this paper, a cough type detection methodology is presented which comprises a comprehensive feature generation scheme. Correlation and wrapper-based feature selection algorithms were employed to reduce the dimensionality of the feature set. Multiple classification algorithms were tested, out of which, Random Forest scored the highest. The achieved sensitivity and specificity values are 86% and 84% respectively (highest in the literature to the best of our knowledge).

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