Fast Pulmonary Function Test Using Onboard Smartphone Equipment

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***Abstract*—The incidence of airway diseases and bronchial asthma appears to be increasing worldwide due to environmental change. Early diagnosis and appropriate treatment can slow the progress of these diseases significantly. By the present moment successes in lung sound spectra analysis and quality of sound-recording equipment provide a methods of automatic detection of lung function abnormalities. Widespread use of smartphones equipped with microphone gives an opportunity of using mobile technologies for early detection of respiratory disease cases. In this article, review of researches results in lung sound analysis and intermediate result of development of mobile app for lung function estimation are presented.**

I. Introduction

Chronic respiratory diseases are widespread all over the world. According to World Health Organization (WHO), the number of patients suffered from diseases that cause limitations in lung airflow (that are known under common term chronic obstructive pulmonary diseases, COPD), including chronic bronchitis and emphysema, in 2004 was about 64 millions and 235 million people suffered from asthma [5].

In the same survey, experts from WHO conclude that due to increasing value of underlying risk factors such as urban air pollution, dusts and chemicals, climate change, tobacco use (including second hand smoke) and common chronic disease risk factors, such as unhealthy diet and physical inactivity, the number of deaths from chronic airway diseases will increase by more than 30% in the next decade.

II. Lung function testing

Functionality of the lungs is examined my means of so-called pulmonary function tests (PFT). There is a variety of different tests include spirometry, peak flowmetry, body plethysmography, nitrogen washout, ergospirometry. Detailed description of these tests and necessary equipment can be found, for example, in [2].

Spirometry test is the simplest one and the purpose of this technique is to measure the amount and speed of inhaled or exhaled air. Tests with both forced expiration after complete inhalation, and slow breathing are used. Hence, spirometry provides fast and low cost way to diagnose type and extent of impairment.

During the test air volumes and flow rate are measured by sensor and a variety of parameters evaluated, the basic are forced vital capacity (FVC) and forced expiratory volume during first second (FEV_1). Results of the test are visualized either on volume-time spirogram, or flow-volume loop. All PFT are based on recording of flow rates against time with next integration to volume.

Interpretation procedure of recordings obtained during spirometry test described in details by standards and recommendations [4]. Availability of precise alogorithms gives an opportunity of implementation of fully automated systems for restrictive and obstructive abnormalities detection. Interpretation rules also rely on a value of lower limit of normal (LLN) values of FEV_1 / FVC, depending on age, height, gender and ethnic group.

Basic interpretation procedure allowing to separate normal cases from abnormalities is defined by Algorithm 1 [3], [4].

Algorithm 1 Diagnosing obstruction or restrictive/mixed abnormalities

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if FVC ≥ LLN then
  if FEV1 / FVC ≤ LLN &  then
    diagnose normal case
  else
    diagnose obstruction
  end if
  if FEV1 / FVC ≥ 0.55 & FVC < 85% then
    diagnose restrictive or mixed abnormalities
  else
    diagnose obstruction
  end if
end if
```

III. Lung Capacity Estimation

As it was shown above for the purposes of simple spirometry test method of FVC and FEV_1 estimation is needed. Fast (and dirty) method of obtaining Lung Capacity is shown in [1]. The approach is based on detecting breathing phases using the microphone to capture the flow rate. In [1] simple formulae for expiratory air volume estimation are provided depending on patient height, age, breath time and energy (amplitude of acoustic signal over time).

IV. Development of the Spirometry Test Software

Combining the algorithm of abnormalities detection with recent advances in breath sound analysis we can provide a service for fast detection of possibility of pulmonary restrictions or obstructions.

Currently we have developed a small app for Android platform to capture breathing signal and estimating the FVC. Wide experiments for estimating the quality of test procedure are planned in cooperation with colleagues from department of pulmonary deseases of Petrozavodsk hospital of emergency care.

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