Development of Smartphone Application for Pulmonary Function Testing

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Respiratory Diseases

Facts by WHO

- Approx. 64 million people suffered from COPD (and 235 million from asthma) worldwide in 2004
- Approx. 5% of deaths every year
- Not curable but treatment can slow the progress of the disease

Risk factors

- Air pollution
- Occupational dusts and chemicals
- Tobacco use
- Unhealthy diet
- Physical inactivity

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Algorithm of Abnormalities Detection

Algorithm 1 Diagnosing obstruction or restrictive/mixed abnormalities

if FVC $\geq$ LLN then
  if FEV_1 / FVC $\leq$ LLN & then
    diagnose normal case
  else
    diagnose obstruction
  end if
  if FEV_1 / FVC ≥ 0.55 & FVC $< 85\%$ then
    diagnose restrictive or mixed abnormalities
  else
    diagnose obstruction
  end if
end if

[1]

[1] from "Diagnostic Spirometry in Primary Care. Proposed standards for general practice...-by M. L. Levy et. al.

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General Algorithm Breath Analysis

Algorithm

- Writing breathing in WAV format.
- Detection phase of inhalation / exhalation.
- Clean signal from the unnecessary information.
- The calculation of time and energy between inhalation and exhalation.
- Calculation of lung volume, etc on the basis of the data obtained.
- Processing of results.

Look at Signals

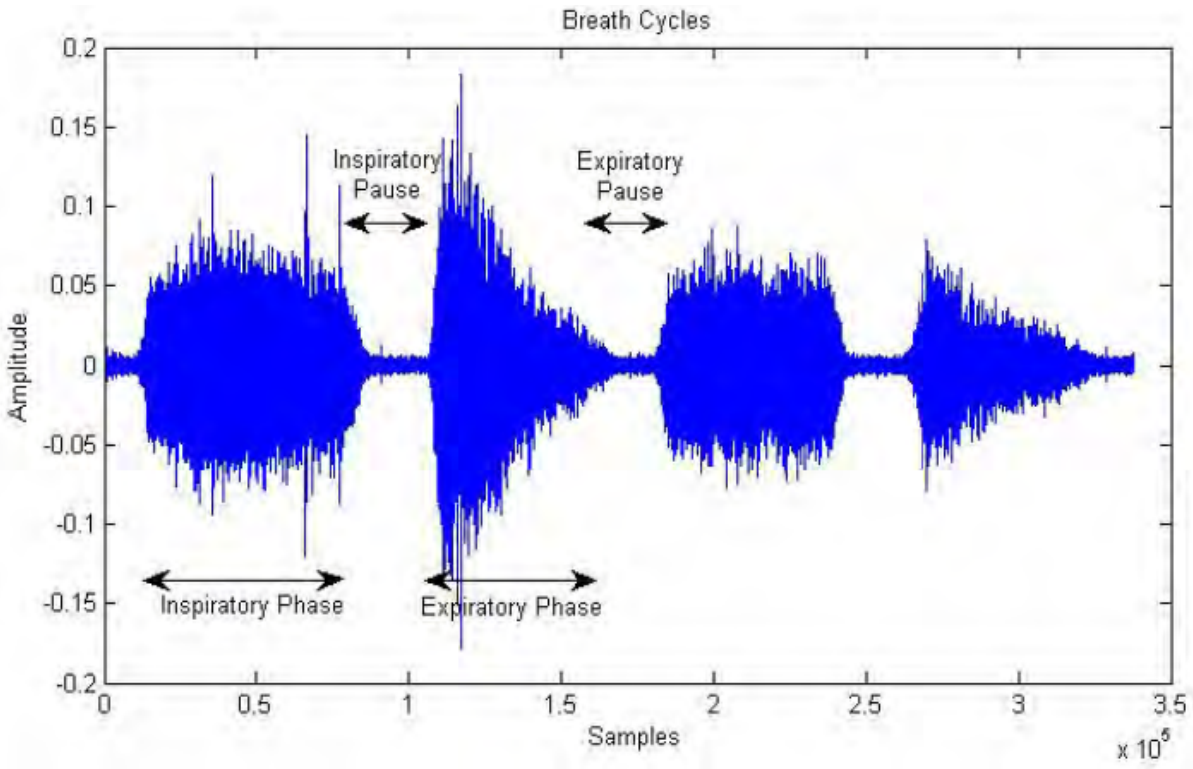

Рис.: Respiration signal obtained by the microphone

Look at Signals

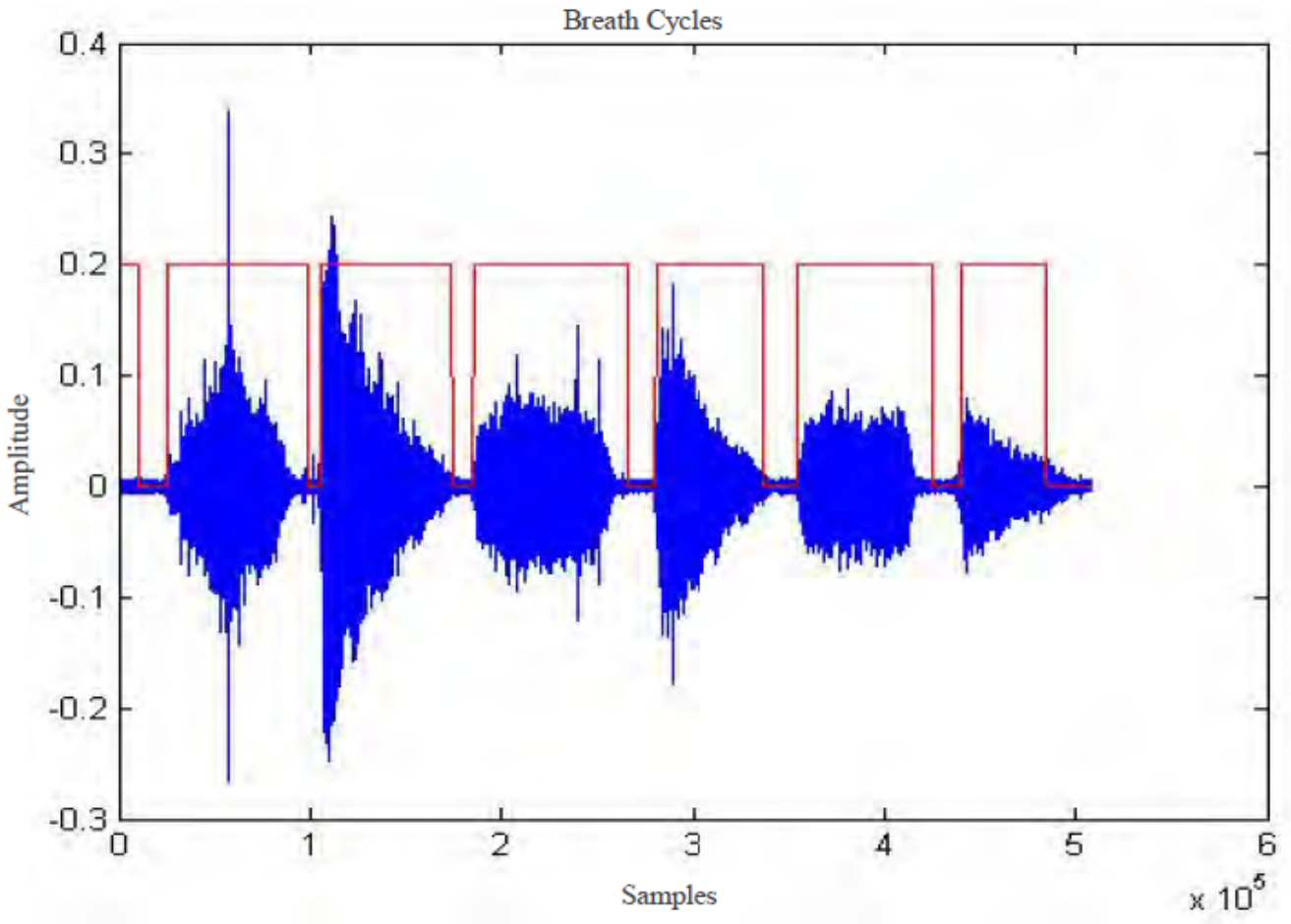

Рис.: Respiration signal after separation of phases of inhalation and exhalation.

Lung Capacity

Forced volume capacity[2]

$$FVC_m = 0.1524 \times height - 0.0214 \times age - 4.6500$$

$$FVC_f = 0.1247 \times height - 0.0216 \times age - 3.5900$$

Forced expiratory volume after one second

$$FEV1_m = 0.1052 \times height - 0.0244 \times a - 2.1900$$

$$FEV1_f = 0.0869 \times height - 0.0255 \times a - 1.5780$$

[2] from "Lung Capacity Estimation Through Acoustic Signal of Breath" by Ahmad Abushakra and Miad Faezipour

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Estimated Lung Capacity

Forced volume capacity assessment based on breath sound analysis[3]

$$FVC_m = \frac{15e}{100}(0.1524 \times height - 0.0214 \times age - 4.65) \times t$$

$$FVC_f = \frac{15e}{100}(0.1247 \times height - 0.0216 \times age - 3.5900) \times t$$

Here t is the average time duration of exhale and inhale and e is the signal energy. P.S These equations were derived using empirical data and estimation.

[3] from "Lung Capacity Estimation Through Acoustic Signal of Breath" by Ahmad Abushakra and Miad Faezipour

Some Results

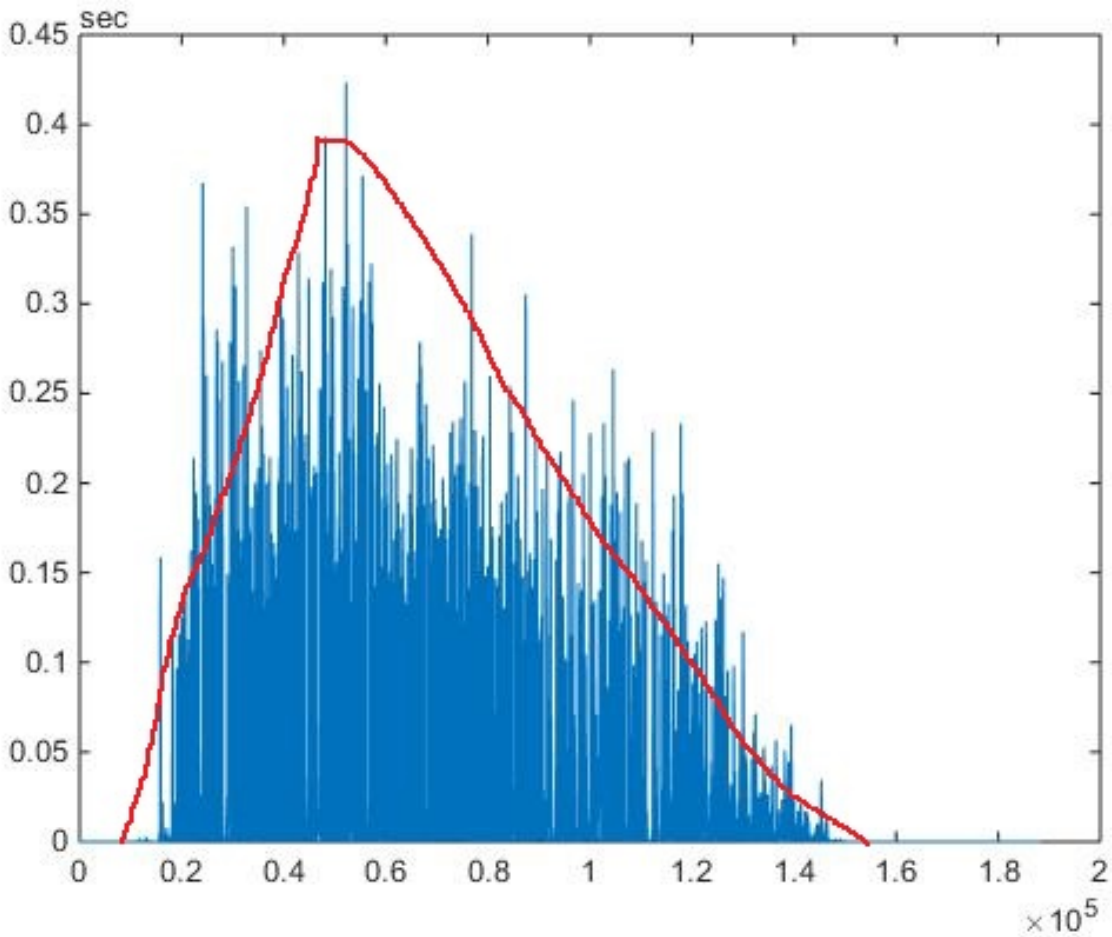

Рис.: My spirogram.

Some Results

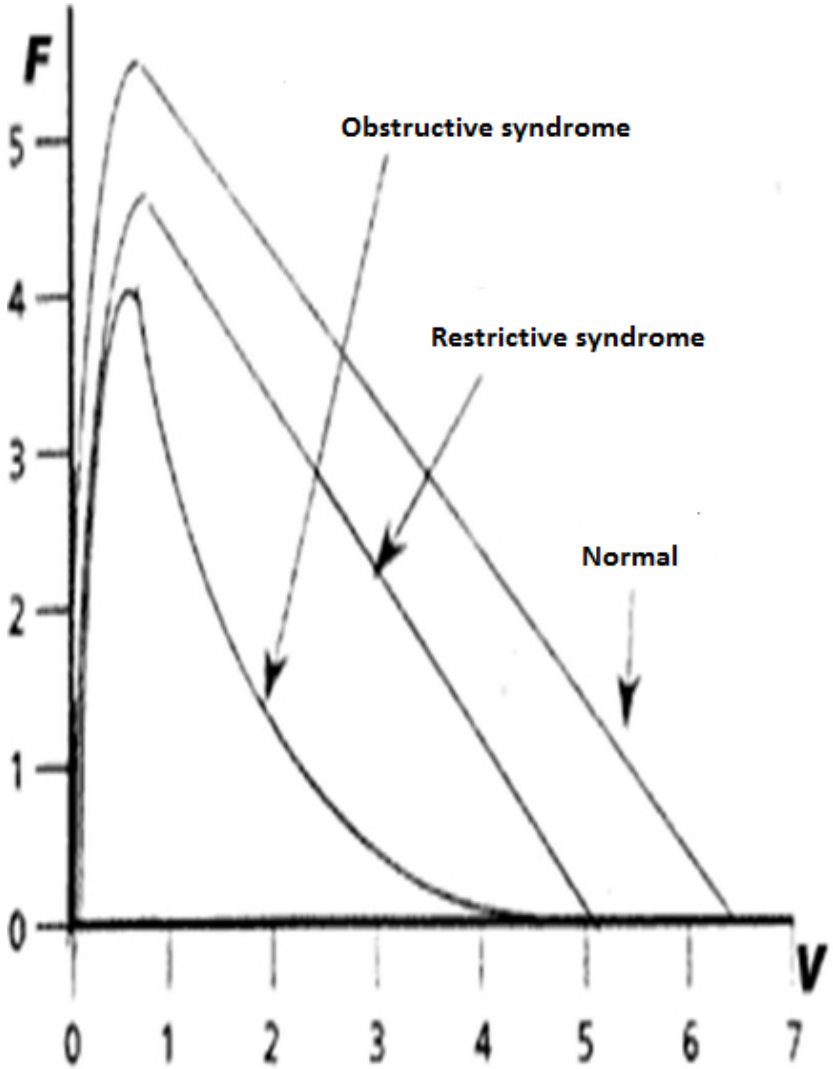

Рис.: Type of spirograms.

Data Processing Methods

- Calculating the results on the phone.
  - You don't need the Internet, but need a powerful phone.
- Calculating results in the cloud.
  - Any phone, but need internet.

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Future Plans

- Conduct experiments and to improve the results of the research.
- Modifying an application to work in the cloud.
- Modifying data analysis.