Assignment 1 - Respiration analysis

Assignment Description

Respiratory effort belts are widely used to monitor respiration noninvasively and continuously. They are used for example in monitoring the respiration in sleep, detecting the functional disorders of the respiratory system, detecting the respiratory muscle dysfunctions and moreover they are comfortable and an easy way to monitor the respiration of children and infants. Additional advantage is that respiratory effort belts do not require the use of a face mask or mouth piece which could change the breathing pattern.

Without calibration, respiratory belts give only qualitative information about the movement of the chest and abdomen. After calibration, they can be used quantitatively to measure continuous respiratory volume and airflow.

The respiratory system can be considered as a simple physical system with two moving parts: the chest and abdomen [1]. Consequently, the sum of the volume change of the chest and abdomen is equivalent to the volume measured at the mouth. This concept of two degrees forms the basis of the various techniques that can be used to calibrate the respiratory effort belts, for instance multiple linear regression.

A prediction of the respiratory airflow, Fest, is commonly calculated from the respiratory effort belt signals by using multiple linear regression [2] to a simultaneous spirometer recording. This baseline model can be established by fitting the following linear model to the time-synchronized signals:

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    F_est = β_1 s_ch + β_2 s_ab + ε
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where the regressor variables s_ch and s_ab are the respiratory effort belt signals from the chest and abdomen, respectively, and ε is the zero-mean and Gaussian error. β_1 and β_2 are regression coefficients. In this baseline model, one sample of each regressor variable is used at a time to predict the response variable. This model can be extended to include more regressor variables if necessary, for example second order terms (s_ch^2 and s_ab^2) and/or cross-product term (s_ch s_ab).

Your task in this assignment is to study and test different prediction models, to evaluate their performance, and to select the best one by completing all the given problems.

Data

Movements of the chest and abdomen were measured with the respiratory effort belts [au] (au = arbitrary unit). The spirometer was used to measure airflow signal [ml/s]. These signals were measured at the same time. The spirometer signal is already time-synchronized with the respiratory effort belt signals. The sampling frequencies were 50 Hz for the respiratory effort belt signals, and 100 Hz for the spirometer signal.

NOTE: In this first assignment, the signals are heavily filtered so that they would be smooth and algorithms would be easy to implement. In the real case, this kind of heavy filtering is usually not acceptable as it distorts signals too much.

Useful MATLAB commands:

load, resample, length, mean, sum, power, sqrt, corr, figure, subplot, plot, xlabel, ylabel, title, linspace, hold on, zeros

References

1. Konno K, Mead J (1967) Measurement of the separate changes of chest and abdomen during breathing. J Appl Physiol 22:407-422.

2. Montgomery DC, Peck EA, Vining GG (2001) Introduction to linear regression analysis. 3rd edition. John Wiley & Sons.