UNIVERSITÄT ZU LÜBECK
INSTITUTE FOR ELECTRICAL
ENGINEERING IN MEDICINE

Master's thesis

Real-Time Cardiac Artifact Removal from Surface Electromyographic Measurements of the Respiratory Muscles

Project Background

Electromyography (EMG) denotes the measurement of the electric potentials generated by muscles during their activation. Surface EMG measurements provide a non-invasive measure of muscle activity by means of electrodes located on the skin above the muscles of interest. Surface EMG measurements in general, and measurements of the respiratory muscles in particular, suffer from strong cardiac artifacts. Since the heart – itself representing a strong muscle – is close to the recording electrode site, it contributes markedly to the measured electrical potentials. This interferes with the detection of respiratory muscle activity, and hence methods for the automatic removal of cardiac contaminants from surface EMG measurements of the respiratory muscles are required.
For offline removal of cardiac artifacts, template subtraction [1] is the gold standard, which simply averages over past detected ECG beats and then removes this average ECG artifact from the signal once a new ECG beat is detected. With several straight-forward adjustments, the method seems to work reasonably well, but it appears difficult to extend it to real-time processing, although attempts have been made [2]. Another, more recent method for removal of cardiac contaminants is based on a dynamical model of the cardiac cycle and a classical estimation algorithm (the extended Kalman filter, EKF) for estimating the state and parameters of this model [3]. For this method as well, there are several challenges regarding the translation to real-time processing. Recently, Cuomo et al. [4] proposed a novel method for real-time denoising of ECG measurements, which could represent a promising candidate for real-time removal of ECG artifacts from EMG measurements as well. The method is based on a specifically optimized recursive filtering methodology.

Project Description

The aim of this thesis is to compare different algorithms for the real-time removal of cardiac artifacts in respiratory EMG measurements, and to develop novel approaches to solve this problem. The algorithms are first to be evaluated offline on already available trial data and in simulations. As a next step, a real-time implementation of the most successful algorithms in a laboratory setup will be of interest.

Keywords

Digital Signal Processing, Real-time Processing, Electromyography (EMG), Electrocardiography (ECG), State Estimation

References

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Supervisor: M. Sc. Eike Petersen
Examiner: Prof. Dr. Philipp Rostalski