

## B2 Inverse Problems and Biosignal Processing 2

Time: Thursday, 16.09.2010

Location: Humboldt-Building, Lecture Room 211

Chairman: P. Husar (DE-Ilmenau)

1:30 p.m.	M. Golz, D. Sommer, T. Schnupp, Ch. Heinze (DE-Schmalkalden)
<b>Technological Measures for Alertness Management</b> An introduction is given to the risk of fatigue during sustained operations and an overview is presented on different types of countermeasures to tackle this problem. Three different research activities in this area are considered with more attention, fatigue monitoring, fatigue testing, and modelling and simulation of the sleep-wake cycle. The first two approaches are at the short-term level, whereas the latter is operating in order to get long-term predictions. Afterwards, our special concern is directed to extreme central fatigue and microsleep events. Electroencephalography (EEG) was utilized to assess the underlying neurodynamic processes. During several test runs in the driving simulator a relatively large amount of biosignal and video material was recorded. Adaptive signal processing and pattern recognition techniques were applied. The resulting detection accuracy was validated by different random and fixed cross-validation schemes. This led to estimations of the inter- as well as intra-individual variability of the detection accuracy. It will be shown, that this variability is not mainly caused by methodology, like e.g. due to random initialization, or random computational order. Therefore, it is concluded that the EEG and possibly also the underlying processes offer a large inter-individual variability. This is indirectly confirmed by observations of behaviour and by investigations of microsleep density (MSD) across subjects. MSD was recently introduced by the authors as a measure of extreme fatigue and is a result of consecutive classification of a trained classifier in the recall mode to the total data set. MSD was estimated under the assumption that detectors adapted to selected doubtless examples of microsleep produce good estimations also for non-evident examples. Results show that MSD strongly correlates to other independent variables associated to fatigue, like e.g. the subjective self-rating of sleepiness, the standard deviation of the lateral position of the vehicle in lane, and to a simple measured variable of accident probability. Finally, several applications are highlighted and their properties are judged subjectively.	
1:50 p.m.	D. Sommer, T. Schnupp, M. Golz (DE-Schmalkalden), J. Krajewski (DE-Wuppertal)
<b>The Pupillographic Sleepiness Test Analyzed by Computational Intelligence Methods</b> Analyzed by Computational Intelligence Methods	

2:10 p.m.	T. Schnupp, C. Schenka (DE-Schnalkalden), J. Krajewski (DE-Wuppertal), M. Golz (DE-Schnalkalden)
<p><b>Data Analysis of the Compensatory Tracking Task Using Computational Intelligence</b></p> <p><b>Introduction</b> Several attempts had been made to assess vigilance by test procedures within short time. Short-term observations lead to increased uncertainty. On the other hand, methods of computational intelligence are known to deal with large variance and limited amount of data which prevents the application of parametric statistics. This contribution aims at improving vigilance estimation based on the compensatory tracking task (CTT) by the application and optimization of Support-Vector Machines (SVM). Experiments During the test duration of ten minutes subjects are instructed to maintain a minimum distance between a disk-shaped cursor and the annular target (screen-center). The cursor's motion is affected by forces unpredictable for the subject. Analysis of the visuomotoric performance presented here is restricted to cursor-target distances sampled at a rate of 12.75 Hz.</p> <p><b>Methods</b> Extracted time-domain feature set utilized methods specialized for posturography. The extracted spectral-domain feature set utilized spectral densities estimated using Weighted Overlapped Segment Averaging (Welch's method) and subsequent averaging in equidistant spectral bands. Seven binary classification problems were defined using class "vigilant" and seven classes of different levels of "hypovigilance". Data was assigned to classes according to subject's time-since-sleep (TSS). Different classifiers were applied and compared in terms of lowest test set error rates using 25-fold delete-d validation. Results &amp; Conclusions With rising TSS classification error rates reduce, indicating that the extracted features are sensitive to hypovigilance. The combination of SVM and spectral-domain features resulted in lowest error rates of <math>6.3 \pm 10.6</math> %. Extended experiments need to prove that these results are replicable with a larger group of subjects.</p>	

2:30 p.m.	Ch. Walther, R. Baumgart-Schmitt, Ch. Menz, D. Trommer, M. Krautwald, K.-P. Sturm (DE-Schmalkalden), U. Jäger (DE-Steinbach-Hallenberg)
<p><b>Multi-Criteria Model-driven Feature Selection using Fuzzy Ruled Classification of Stages of Anaesthesia</b></p> <p>The optimal feature selection to classify stages of anaesthesia by fuzzy rules should be identified. The one-channel frontal electroencephalogram (EEG) was measured on the forehead during operations and establishes the feature set for the classification task. No other vital data like heart rate or blood pressure is used. Data sets from 200 patients and operations were considered. Three different stages of anaesthesia are defined as light, normal and deep anaesthesia to estimate the optimisation. The Strength Pareto Evolutionary Algorithm (SPEA) was used to select the features used by the fuzzy rules. This algorithm was available in the advanced second version. The Receiver Operating Characteristic (ROC) is calculated based on the combination of features used to classify the stages of anaesthesia. The classification performance for each anaesthetic stage describes the true-positive (sensitivity) and the false-positive (specificity) recognition of the epochs of all EEG data sets. By using three different anaesthetic stages six different criteria are used to optimize the feature selection and the corresponding fuzzy rules. So a multi-criteria optimisation model is established. The analysis of the produced ROC-curves results into an optimal estimation of feature sets which can be used by the fuzzy rules to classify the stages anaesthesia. To reduce the dimensionality the parameters of the fuzzy sets and the general structures of the rules are invariable. The selection of the fuzzy sets is only optimized which corresponds to the selection of the features to classify the anaesthesia stages.</p>	
2:50 – 3:10 p.m. Coffee break	

3:10 p.m.	D. Trommer, M. Krautwald, R. Baumgart-Schmitt, Ch. Menz, Ch. Walther (DE-Schmalkalden)
<p data-bbox="352 315 1251 365"><b>The recursive ICA, a new recursive approach for separating one signal source from dominant noise</b></p> <p data-bbox="352 365 1251 954">In this approach a signal extraction algorithm for bioelectrical signals measured by a sensor array under low signal noise ratio will be conducted. As an example the algorithm can be used for signal pre-processing before a classification algorithm should work. A well known approach for blind source separation of a linear mixture of signals, which will be measured by a sensor array, is the Independent Component Analysis [ICA]. In our case only one source is relevant. We propose that the ICA can separate a single source from noise and artefacts. Therefore the quality of a downstream classification can be improved. Mostly by using several derivatives of ICA, the processing time depends on the dimensions of the mixture space and often no information about previous computations can be used to improve accuracy or processing time. In this new approach we have implemented a fixed-point ICA algorithm in a recursive way and extend it by a feedback to its results computed before. We are using an own window-function for splitting the complete dataset into several parts. Also we propose that the algorithm can be used for signal pre-processing in real time classification systems. For this purpose the input of the algorithm should be a dataset with the length of such a window. Thereby the initial value of the algorithm will be adapted and the result of the calculated ICA-window of the next dataset will separate the same source-signal as it has been done by the calculation before. The variation between the current and the previous windowed dataset will be calculated too. In our approach with the case of nearly permanent values of the linear mixture between the different sources the ICA has to run only once. If the variation between two datasets becomes too high, the mixed collected data will be corrected by the use of the former result of the ICA. By using our new approach the processing speed can be improved, because it is mostly depending on the variation between two datasets. This approach was validated with synthetic and real data.</p>	

3:30 p.m.	M. Krautwald, D. Trommer, R. Baumgart-Schmitt, Ch. Walther, Ch. Menz (DE-Schmalkalden)
<p><b>Parameter optimization for Support Vector Machines by using a multicriteria genetic algorithm for classification of sleep-stages</b></p> <p>For Support Vector Machines (SVM), like all methods of classification, the choosing parameters determine the quality of classification. Searching these parameters is an optimization problem. This can be solved with different methods. One approach for solving an optimization problem is the genetic algorithm, which has his background in the biological evolution. In this paper a multicriteria genetic algorithm should introduced. It base on the Non-dominated Sorting Genetic Algorithm (NSGA) II, published 2000 by Deb. The algorithm has been adapted for parameter optimization of SVM to classify sleep-stages. Therefore it includes all values of the confusion matrix for searching fronts. We separate sleep in maximum eight stages. That means the confusion matrix has up to 64 elements which are used as criteria. Further criteria are the total right classified data in percent, the diagonal and the geometrical mean of the confusion matrix and the accuracy of the poorest class. That means the pareto set is embedded in a up to 68-dimensional space. Each criterion to sort every result in a front can be weighted by the user to afford an optimal adaption on the given problem. Additionally to the original genetic methods the introduced algorithm generates every population some completely new individuals in a variable percentage rate. With it a single-edge development should be avoided. The sleep classification based on electroencephalogram (EEG)-data which were collected with a frontal one-channel electrode. Datasets of different test persons were used. How the genetic algorithm influence the classification quality will be demonstrated in this paper. Different experiments with the real sleep data, but also with synthetic data, show that classification quality of SVM increases by using the adapted genetic algorithm for parameter optimization.</p>	

3:50 p.m.	Ch. Heinze (DE-Schmalkalden), U. Trutschel (USA-Stoneham), D. Sommer, M. Golz (DE-Schmalkalden)
<p><b>Recurrence plots and their application to long-term heart rate recordings for the analysis of circadian rhythmicity</b></p> <p>The ECG, which requires merely the application of electrodes combined with a mobile recording device, provides an assessment of circadian rhythmicity. This is limited due to many influences, among them are the complex regulation by the autonomic nervous system and of the suprachiasmatic nucleus. Therefore, the heart rate (HR) time series is highly variable and irregular. It was investigated if methods of nonlinear signal analysis can reveal circadian characteristics of long-term HR signals. Analysis was based on ECG of three young adults who participated in an unsupervised 50-hour data recording protocol during their normal daily routine. In addition, subjectively rated sleepiness and motoric activity (via wrist actometry) were recorded simultaneously. State space trajectories of HR series were reconstructed by time delay embedding. Recurrence plots (RP) provide a 2-dimensional representation of all times when a trajectory revisits roughly the same area in state space. The interpretation of large- and small-scale patterns within RP reveals different qualities on the evolving trajectory, such as determinism, periodicity, fractal dimension, or intermittency; recurrence quantification analysis (RQA) quantifies number and duration of the different RP properties. A sliding window (width 60 minutes, step size 1 minute) was applied to all HR series; for each window, RPs (ca. 3000 per subject) were constructed and quantitative features were extracted. The occurrence of similar events, like peaks and troughs of sleepiness, peaks of physical activity, transitions from sleep to wake or vice versa, resulted in similar RP patterns. Extracted features from more traditional methods of nonlinear HR analysis, particularly Poincaré plots, contained stronger spectral components around circadian period length than RQA features. On the other hand, RQA features revealed a strong sensitivity to sleep initiation or to the wake-up time. In conclusion, RP features are sensitive to circadian variations and therefore provide means to adapt the free parameters of sleep-wake models for each individual. This will improve the technological basis of fatigue risk management.</p>	
<b>End of Lecture Session</b>	