

Ambulatory heartbeat-based psycho-mental strain monitoring

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Introduction

Currently only a small number of physiological measures have the potential for ambulatory/in-field stress detection and monitoring. Among them especially heart rate (HR) and its variability (HRV) are of the most preferred parameters due to their simple, robust, permanent and non-invasive acquisition. Nevertheless researchers still face a lot of challenges when estimating psycho-mental strain in an ambulatory setting. These challenges arise from the presence of multiple confounders like measurement artifacts, orthostatic and metabolic variances and individual response patterns as well as sometimes poor agreement of subjective reports and physiological states. We introduce a fuzzy-model based approach for mental strain estimation and validated the model output against subjective measurements.

Methods

Fifty healthy volunteers were monitored over a one-day period (average: 19 hours). Using a mobile sensor system and an electronic diary device, physiological data as well as subjective reports were collected. Subjective measures and heart-beat time series were combined within a fuzzy model approach (Kumar et al. 2010). Model was individually trained using the first seven subjective responses of each subject. The developed model was validated by a correlation analysis using the "unknown" subjective responses and the modeled psycho-mental strain.



Fig. 1: Combined assessment of physiological workload indicators, activity and subjective reports using an ambulatory monitoring system developed at celisca.

Results

There were only weak linear correlations between heart beat and subjective stress measures when analyzing a sub-sample (maximal correlation coefficients were 0.3 and below). Whereas the fuzzy-model values reached a promising accuracy ($R^2=0,672$).

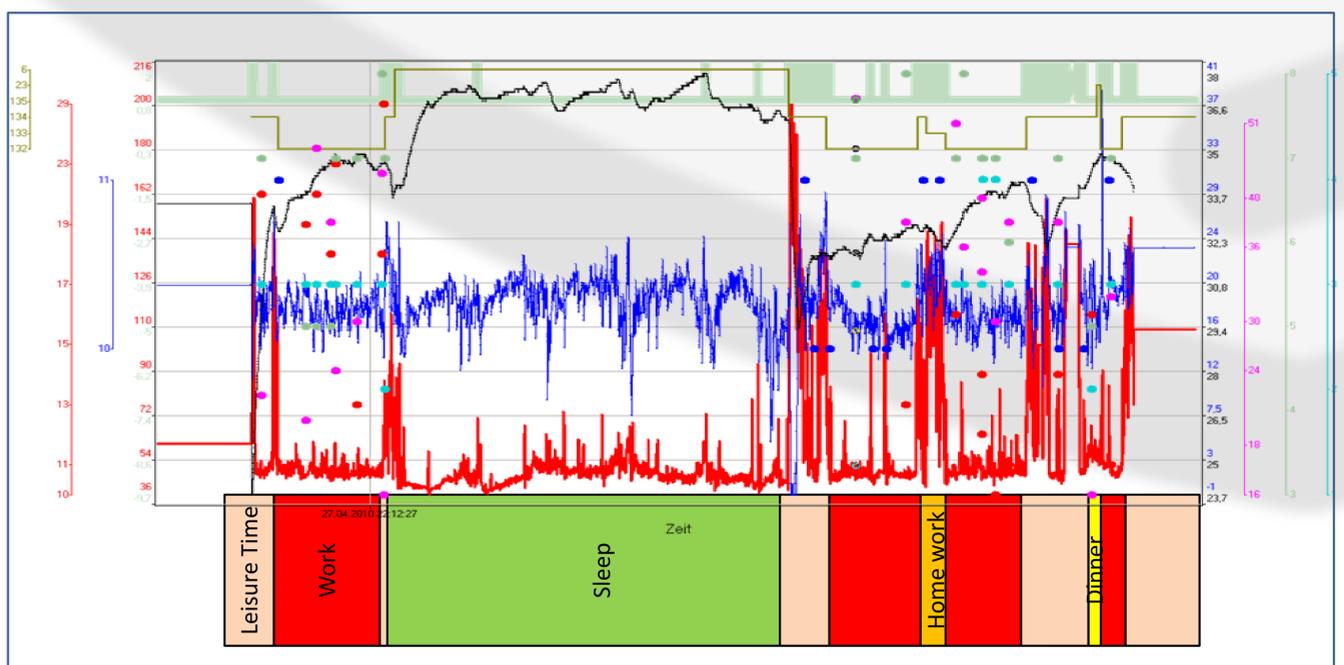


Figure 2: Multi parametric 24-hour data of an ambulatory subject

Discussion

Our study confirmed research results showing a weak linear relationship between physiological and subjective workload-/stress-measures in the ambulatory setting. Using a Fuzzy-logic approach increases stress detection accuracy significantly due to the consideration of individuality and confounders.

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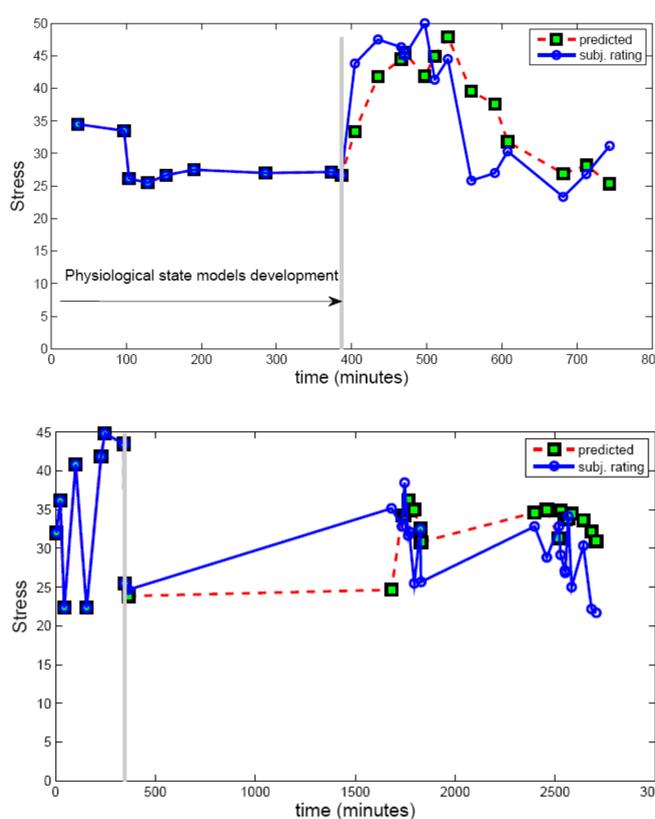


Figure 3 a/b: Fuzzy-based stress-estimation of two subjects using heartbeat-interval time series in comparison to their subjective reports across several hours