A movement-artefact-free heart-rate prediction system

Ying Wang[1,2,†,*], Maarten Thoonen[1,†], Frank Halfwerk[3,4], Robby van Delden[5], Peter Veltink[1]

[1] Biomedical Signals and Systems, EEMCS, University of Twente, the Netherlands.
[2] ZGT Academy, Ziekenhuisgroep Twente, the Netherlands.
[3] Thorax Centrum Twente, Medisch Spectrum Twente, the Netherlands.
[4] Biomechanical Engineering, ET, University of Twente, the Netherlands.
[4] Human Media Interaction, EEMCS, University of Twente, the Netherlands.
[†] The authors contributed to the abstract equally.
[*]Corresponding author with email ying.wang@utwente.nl

Clinical-adverse-event monitoring using continuous vital signs plays a crucial role in timely interventions for postoperative patients during their recovery period. However, patients' activities of daily living (ADL) have influence on physiological responses and contaminate the monitoring accuracy. An inaccurate monitoring system with reoccurring false alarms can lead to caretakers' alarm fatigue which may cause severe consequences. It is necessary to increase the monitoring performance by considering the influence of patients' ADL.

This explorative study aimed to develop a heart-rate prediction system to eliminate the effect of patients' ADL on the clinical-adverse-event monitoring performance. To build up this system, nine healthy subjects were asked to execute ADL, e.g., sitting, lying, walking, cycling, and stair climbing, at a simulated living environment (E-health house, University of Twente) with wearable IMUs (Inertial Measurement Units) attached to the chest and upper leg, and electrocardiography (ECG) sensors. We extracted 24 features from IMUs: the mean and standard deviation of linear acceleration along the x, y, and z axis and rotational velocity around the three axes. A support-vector-machine classifier with a radial basis function kernel was trained to recognize different ADL. The recognized ADL, activity duration, and activity intensity (the average of all standard deviation values) were treated as input variables of a K-Nearest Neighbor regressor which predicted heart rate. The heart rate extracted from ECG signals was treated as the golden standard. Five-fold cross-validation was used to evaluate the performance of the prediction system.

As preliminary results, an acceptable performance was obtained with R-squared of 0.78 ± 0.095 (mean ± SD) and the mean absolute error of 5.98 ± 0.529 bpm. Given the heterogeneity of different populations, the system will be further tested and developed using patient datasets in future towards clinical-practice applications.