Alignment of Multi-Sensored Data: Adjustment of Sampling Frequencies and Time Shifts

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Objectives: For a more comprehensive clinical picture measuring vital signs with multiple devices has its strength in sensor variety (ECG, body movement, temperature and respiration) and the compensation of signal loss. Our aim is to find a robust way in the necessary preprocessing steps for the correction of sampling frequencies and the alignment of non-synchronized sensors.

Methods: We used data from an experiment including five different devices which measured simultaneously the activity of the heart and other vital signs (Hexoskin Smart Shirt (H), SOMNOtouch NIBP (S), Polar RS800 Multi (Polar), eMotion Faros 360 (F), NeXus-10 MKII (N), see Figure). Our alignment procedure is based on pairwise comparisons of 300 consecutive RR intervals from a resting periods to the Hexoskin reference sequence by minimizing the overall absolute sum of differences. Robust linear regression fits were used to adjust general deviations in the sampling frequencies and for non-linear resampling in a sliding window.

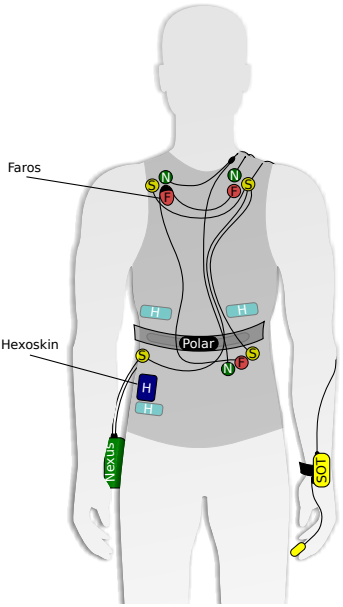

Illustration of sensor placement.
Body silhouette designed by Freepik.

Results: Altering sampling frequencies were identified in Faros and Polar devices in the course of experimental measurements in 13 subjects. NeXus, sampled at 8000 Hz, showed the most precise frequency transmitter resulting in a mean discrepancy of $+0.0041\%$ and having the lowest standard deviation among all subjects. In two identical Faros devices, the average discrepancy to Hexoskin was $+0.0293\%$ and $+0.0175\%$.

Conclusion: The integrity and accuracy of experimental data were increased by linear and non-linear transformations of non-synchronized signals.