Motivation

- **Long term goal**: Better health control due to monitoring at home
- **Short term goal**: Measurement of heart signal in any decubitus position

Concept

- Provide patient bed with several magnetic sensors
- Four commercially available Optically Pumped Magnetometers (OPMs) used [1]
- Selection of best sensor signal
- Heart Rate Variability (HRV) analysis in real-time

Preprocessing

- Non-linear and time-variant trend removal [2]
- Low pass filtering with cut-off frequency $f_c = 30$ Hz

Sensor selection and removal of turning distortions

- Ensure that heart signal is optimally measured independent of the decubitus position of the patient
- Selection of the "best" sensor signal
  - (Frame-based, index $k$) calculation of (smoothed) signal variance for every sensor $j$
    \[ \sigma^2_j(k) = \frac{1}{N_j - 1} \sum_{n=N_j}^{(k+1)N_j} (x_{m,n}(k) - m_j)^2 \]
- Use sensor with highest signal variance $m(k) = \arg\max_j \sigma^2_j(k)$

- Turning distortions are set to zero
- Peaks are not detected as R waves during HRV
- Time index of distortion segments forwarded to HRV
- Prohibit wrong calculation of distances between two R waves (before and after the distortion)

System overview

![Fig. 1: Patient bed in the shielded chamber equipped with four optically pumped magnetometers.](image)

![Fig. 2: Overview of the system for enhancement and selection of the magnetic sensor signals for calculation of a heart rate variability analysis.](image)

Heart rate variability analysis

- Comparison of HRV with and without sensor signal selection
- Preprocessing and removal of distortions identical for combined signal and for single sensor signals

![Fig. 6: Comparison of HRV (a) with and (b) without combination of the sensor signals. The HRV without combination is calculated for each sensor individually. The preprocessing steps as well as the removal of turning distortions is done in the same way for the combined signal and for each single signal.](image)

- Computation of HRV in real-time
- Poincare plot, Tachogram, Histogram, ...
- R-wave detection by edge detection
- Development of a graphical user interface for physicians
- Generation of a report at the end of the measurement

![Fig. 7: Graphical user interface of the real-time system for the HRV analysis.](image)

Conclusion and Outlook

- A robust heart rate variability analysis was implemented
- The heart signal could be measured in any decubitus position
- Turning distortions were removed and didn’t affect the results of the HRV
- Usage of different magnetic sensors (e.g. magnetoelastic sensors) operating in an unshielded environment
- Equip patient bed with more magnetic sensors in the future

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