Master thesis proposal
Cardiovascular cooperation failure during orthostatic stress

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The length of the normal heart contraction cycle, called the RR–interval, varies depending on the body's current needs for oxygen and other nutrients. There is a lot of evidence that a series of RR–intervals carry information about the complex interdependence of various physiological processes, reflex loops, complex mechanisms operating at different time scales and often spatially distant. It is believed that heart rate variability represents the organism's ability to respond to internal and external challenges, and therefore is an indirect (and also non–invasive and inexpensive) method of assessing the overall state of human health. In healthy people, this variability is mainly associated with the activity of the autonomic nervous system—a part of the central nervous systems which stays apart from a human conscious action. Interdisciplinary cooperation has been intensively developed aiming on reading the information contained in RR–intervals.

The thesis will be done in collaboration with the Institute of Theoretical Physics and Astrophysics, University of Gdańsk, who will provide support and data. They have access to long time series, consisting of ca 20000 observations of RR–intervals. They also have shorter (300–500 observations) of systolic blood pressure (SBP) measurements.

Thesis and goals

Aim: Quantification of the autonomic regulation between heart rate and blood pressure by multiscale asymmetry coefficients.

The head-up tilt (HUT) test is a procedure which elicits the so–called orthostatic stress in a subject by moving his/her body from a relaxed supine position to an upright position. The change in body position results in a transition in neural activity. The activation of the complex interacting network of neural systems maintaining the proper blood distribution during the HUT test affects and is reflected in both heart rate and systolic blood pressure variability.

- Recordings obtained in the HUT test of RR–intervals and systolic blood pressure will be studied in groups: the results of the HUT test (whether there was a faint or not) and the person's clinical qualification (the person is healthy or suffers from faints in ordinary life).

- The project consists of:
    1. overall statistical description of groups of signals,
    2. investigation of the dynamics of the response with the so–called multistructure index (MI) which quantifies the dominance of heart rate accelerations and blood pressure rises versus other events on different scales.
    3. Build a statistical or machine learning model that discriminates between healthy and inefficient reflex response should be extracted from the MI.

Data

The RR–intervals and blood pressure measurements will be provided by the Institute of Theoretical Physics and Astrophysics, University of Gdańsk. Further data is available in public databases (e.g. `https://physionet.org/physiobank/database/`).

References

[1] D. Makowiec, B. Graff, and Z. R. Struzik. Multistructure index characterization of heart rate and systolic blood pressure reveals precursory signs of syncope. *Scientific Reports*, 7:419, 2017.

[2] J. Wdowczyk, D. Makowiec, M. Gruchała, D. Wejer, and Z. R. Struzik. Dynamical landscape of heart rhythm in long–term heart transplant recipients: A way to discern erratic rhythms. *Frontiers in Physiology*, 9:274, 2018.