Master thesis proposal
Dynamical patterns of RR–intervals in aging humans

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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: Discovering respiratory patterns: accelerations while breathe in and decelerations while breath out, in RR–intervals.

- 192 series with RR–intervals recorded from healthy people, varying by age and sex, will be studied (20000 RR–intervals of nocturnal rest)
- Investigations will focus on properties of sets of RR–increments, called dynamical patterns, i.e.,

$$\{\Delta RR(k,i)\} = \{RR(i) - RR(i-k)\} \quad \text{for} \quad k = 1, 2, ..., 6$$

  when i is coming from either the diurnal or the nocturnal part of the signal.
- The thesis work would involve modelling and studying the data through time series approaches, e.g.:

1. quantification of distributions of dynamical patterns and their estimates by entropic measures
2. estimates of correlation and/or autocorrelation between dynamical patterns
3. studying dependencies of these characteristics on age and sex

Data

The RR–intervals 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.