Machine Learning and Network Physiology for Medical Diagnosis with an Application to Dysfunctional Breathing

Abstract for the general public

In this project, we will propose advanced computational methods for the analysis of biological oscillators in order to tackle important medical conditions and diseases. In particular, we will use a machine learning methodology for the analysis of biological oscillatory signals. In terms of methodology, we propose to use methods for automated modelling of dynamical systems from the area of computational scientific discovery. In this way, we will model the individual oscillators, as well as their interconnections, i.e., couplings. We also propose to use computational methods for predictive clustering with the task of grouping subjects in such a way that subjects in the same group (cluster) are more similar (in some sense) to each other than to those in other groups (clusters). We will use also multitarget regression, which estimates the relationships between several dependent variables and one or more independent variables. These methods will be used to identify clinical properties of interest, as well as to relate properties/ features of the oscillators and their couplings to these clinical properties and states. All machine learning methods considered will belong to the category of explainable machine learning methods that produce interpretable models.

The proposed methodology will be applied to the task of medical diagnosis and physiological assessment in the context of Dysfunctional Breathing. Data will be collected from patients and healthy subjects that will include, on one hand, physiological assessments through a range of tests (e.g., cardiopulmonary test, pulmonary function test, stress test), and, on the other hand, measurements of cardiac (ECG), cardiovascular (blood pressure, BP) and respiration activity (RES) signals. Higher-level descriptions of the oscillators and their couplings will be extracted from the signals using time-frequency analysis and system dynamics modelling. Predictive clustering will be used to identify groups of subjects with similar health outcomes, i.e., Dysfunctional Breathing phenotypes, on one hand. Multi-target regression will be used to relate these phenotypes to the higher-level descriptions of the signals, on the other hand. We expect that novel insights will be generated, through the use of explainable machine learning, that will be of interest to medical domain experts and relevant to diagnosing and treating Dysfunctional Breathing.