CMUP- WORKSHOP on Signal Processing and Data Analysis

Continuous estimation methods for cardiovascular dynamics

6 - 7 December 2018

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Thursday, 6 December, 16h30, FCUP, FC1 (DM)

Scientific Framework - Theory I - Gaetano Valenza, 16h30-18h30, FC1 Room 0.31

Friday, 7 December, 9h, FCUP, FC1 (DM)

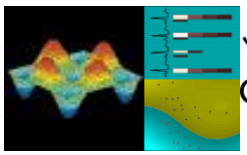
Scientific Framework - Theory II - Gaetano Valenza, 9h -11h, FC1 Room 0.31
Hands-on application I - Riccardo Barbieri , 11h30 -13h30, FC1 Room 1.19
Hands-on application II - Riccardo Barbieri - 14h30 -16h30, FC1 Room 1.19

FREE but subject to REGISTRATION on the link **https://goo.gl/forms/2gUjYwY1Kza9nOcS2**
Registration Deadline: 20 November 2018 – 12h (subject to availability, detailed programs and outline next 2 pages)

GENERAL DESCRIPTION: This WORKSHOP will introduce interested faculty and students to effective estimation methods for cardiovascular dynamics, with a special emphasis on the point process mathematical framework endowed with orthonormal expansion of model kernels. It will guide them throughout examples of analytical derivation and algorithmic development, from programming steps to hands-on application to experimental data.

Riccardo Barbieri, received the M.S. in Electrical Engineering from the University of Rome "La Sapienza", Rome, Italy, in 1992, and the Ph.D. in Biomedical Engineering from Boston University, Boston, MA, in 1998. He is Associate Professor of Bioengineering at Politecnico di Milano (Italy) and Research Affiliate at Massachusetts General Hospital and at the Massachusetts Institute of Technology. His broad research interests are in the development of signal processing algorithms for the analysis of biological systems. He is currently focusing his studies on computational modeling of neural information encoding, and on application of nonlinear and multivariate statistical models to characterize heart rate variability and cardiovascular control dynamics. He is author of more than 150 peer-reviewed publications in these fields since 1994. Dr. Barbieri is a Member of the American Association for the Advancement of Science, the European Society of Hypertension, the Society for Neuroscience, and Senior Member of IEEE and the Engineering in Medicine and Biology Society.

Gaetano Valenza, M.Eng., Ph.D., is currently Assistant Professor of Bioengineering at the University of Pisa, Pisa, Italy, and Principal Investigator of the Computational Physiology and Biomedical Instruments group of the University of Pisa. His research interests include statistical and nonlinear biomedical signal and image processing, cardiovascular and neural modeling, and wearable systems for physiological monitoring. Applications of his research include the assessment of autonomic nervous system activity on cardiovascular control, brain-heart interactions, affective computing, assessment of mood and mental/neurological disorders. He is author of more than 150 international scientific contributions in these fields and is official reviewer of more than 60 international scientific journals and research funding agencies. He has been involved in several international research projects, and currently is the scientific co-coordinator of the European collaborative project H2020-PHC-2015-689691-NEVERMIND. Dr. Valenza is Senior Member of the IEEE, a Member of the IEEE Technical Committees on Cardiopulmonary Systems and on Biomedical Signal Processing, and has been guest editor of several international scientific journals.



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Workshop info: aprocha@fc.up.pt

CMUP, FCUP – Dep.Matemática (R Campo Alegre, 687)

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DETAILED PROGRAM

Part I – Theory (FC1, Room 0.31)

Heart rate variability (HRV), generally defined as the variations of heart rate (HR) around its mean, is an important quantitative marker of cardiovascular regulation by the autonomic nervous system. HRV results from the multiple nonlinear interactions between sympathetic and parasympathetic nervous systems, whose activity can be quantified through effective metrics. To date, HRV has been evaluated in thousands of studies, to characterize and diagnose diseases that affect the autonomic nervous system, follow their progression, and measure efficacy of therapy.

This presentation focuses on our recently derived definitions of HR and HRV based on explicit point process Bayesian probability models. Point process models give a physiologically sound representation of the stochastic structure generating the heartbeat and they allow for instantaneous assessment of fast, non-stationary dynamics. Our current work is focusing on incorporating the point process framework into nonlinear models of cardiovascular control and autonomic regulation, with inclusion of other cardiovascular variables such as arterial blood pressure and respiration. We exploit the use of orthonormal Laguerre functions to improve on kernel estimations, as well as derive novel effective markers of autonomic outflow. The presented dynamic statistical measures yield important implications for research studies of cardiovascular and autonomic regulation, and they provide the basis for potential real-time indicators for ambulatory monitoring and instantaneous assessment of autonomic control in clinical setting.

General Outline:

Background on estimation methods for cardiovascular dynamics
- Autonomic nervous system and cardiovascular physiology at a glance
- Inhomogeneous point-process vs. interpolation
- Inhomogeneous point-process and heartbeat linear dynamics
- Heartbeat dynamics: spectral paradigm and related limitations

Orthonormal expansions of heartbeat series to retrieve effective markers of autonomic outflow
- Orthonormal Laguerre functions
- Inhomogeneous point-process and heartbeat nonlinear dynamics: instantaneous high-order spectra and instantaneous complexity
- Multivariate nonlinear point-process models for cardiovascular and cardiorespiratory dynamics
- Estimation of sympathetic and vagal autonomic outflow from heartbeat dynamics

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DETAILED PROGRAM

Part II – Hands-on application (FC1 Room 1.19, Computer Lab)

Guided examples and hands-on application to experimental data (under registration availability)

Hands-on application I

The first session of the Hands-On Application seminar will invite participants to work directly on the computer and follow a tutorial for application of a basic point process framework on real RR series. To this extent, from the webpage they can download software and documentation related to the point process algorithms for estimation of instantaneous measures of Heart Rate Variability (HRV). Only a limited set of algorithms are presented here. The programs are fully functional in Matlab or Octave, and they are primarily aimed at demonstrating the efficacy of the models, and guiding the user along the kind of results that the frameworks can achieve. (See Point Process Models of Human Heart Beat Interval Dynamics - Provision and Dissemination of Software – Webpage: http://users.neurostat.mit.edu/barbieri/pphrv)

Topics including:

- From ECG to Heartbeat Dynamics: Discerning physiological and algorithmic artifacts
- Inhomogeneous point-process and heartbeat linear dynamics
- Quantifying heartbeat modeling goodness of fit through Kolmogorov-Smirnov statistics (Time Rescaling Theorem)

Hands-on application II

The second session of the Hands-On seminar will incorporate effective links with cardiovascular physiology related to postural changes and baroreflex control of heart rate. Specific application will be implemented through a library of executables paired with data specifically tailored along the following outline.

Outline:

- Instantaneous spectral analysis of heartbeat dynamics and time-frequency analysis
- Instantaneous nonlinear analysis of heartbeat dynamics
- Instantaneous complexity analysis of heartbeat dynamics
- Effective estimation of sympathetic and vagal activity from heartbeat dynamics through orthonormal Laguerre functions