IASC-ERS Course

An Introduction to Functional Data Analysis for Density Functions in Bayes spaces

Alessandra Menafoglio
Karel Hron
Jitka Machalova

Virtual location, April 29-30, 2021

INTERNATIONAL ORGANIZING COMMITTEE:

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The European Regional Section of the International Association for Statistical Computing (IASC-ERS), the International Association for Statistical Computing (IASC), and the International Statistical Institute (ISI) are pleased to invite PhD students, Master students and also researchers in statistics and data analysis to attend the IASC-ERS Webinar Course "*An Introduction to Functional Data Analysis for Density Functions in Bayes spaces*". The course will be team-taught by Alessandra Menafoglio (Politecnico di Milano, Italy), Karel Hron and Jitka Machalová (Palacký University, Olomouc, Czech Republic). It will take plase online on April 29-30, 2021, from 14h00 to 17h00 GMT+2.

The IASC-ERS Courses aim to spread the knowledge base and advances in Statistical Computing in Europe and the wide world, to provide an overview of the state-of-the-art of the ongoing research in computational statistics, to provide an overall perspective of the application of computational statistics in data science problems, to present applications where computational statistics have been crucial to solve problems in real-life applications, and to increase the number of researchers and practitioners in computational statistics and data science.

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The analysis of distributional data (probability density functions or histogram data) has recently gained increasing attention in the applications. Distributional data are often observed by themselves, or as result of aggregation of large streams of data. The course will provide an introduction to the analysis of these data using a Functional Data Analysis (FDA) approach, grounded on the perspective of Bayes spaces. These spaces are mathematical spaces whose points are densities (or, more generally, measures), which generalize to the FDA setting the Aitchison simplex for multivariate compositional data. The course will give an overview of the theory of Bayes spaces, as well as of statistical methods developed in this setting. All the methods will be illustrated through examples from real case studies.

Instructors:

- Alessandra Menafoglio (Politecnico di Milano, Italy)
- Karel Hron (Palacký University, Olomouc, Czech Republic)
- Jitka Machalova (Palacký University, Olomouc, Czech Republic)

Topics:

- The geometry of Bayes spaces
- Smoothing splines for densities
- Dimensionality reduction in Bayes spaces: Simplicial Functional Principal Component Analysis
- Anomaly detection for density data based on control charts
- Density-on-scalar, scalar-on-density and density-on-density functional regression
- Spatial statistics for distributional observations: spatial modeling & kriging

AGENDA

(Local time: Rome-Prague, GMT+2)

Thursday, April 29th 2021:

- Opening: 14h00 – 14h15
- Session 1: 14h15 – 15h00 (The geometry of Bayes spaces)
- Session 2: 15h10 – 15h55 (Smoothing splines for densities)
- Session 3: 16h05 – 16h50 (Dimensionality reduction in Bayes spaces: Simplicial Functional Principal Component Analysis)

Friday, April 30th 2021:

- Session 1: 14h00 – 14h45 (Anomaly detection for density data based on control charts)
- Session 2: 14h55 – 15h40 (Density-on-scalar, scalar-on-density and density-on-density functional regression)
- Session 3: 15h50 – 16h35 (Spatial statistics for distributional observations: spatial modeling & kriging)
- Closing: 16h35 – 16h45

Biographic notes on the teachers

Alessandra Menafoglio is a Senior Assistant Professor in Statistics at the Department of Mathematics of the Politecnico di Milano, within the laboratory for modeling and scientific computing (MOX). Her research interests focus on the study of innovative statistical models and methods for the analysis of complex and large data (such as functional data, distributional data and images), with particular emphasis on the applications to Earth and Environmental Sciences. Recently, she was awarded the 2019 Andrei Borisovich Vistelius Research Award by the IAMG (International Association for Mathematical Geosciences). She is Associate Editor of the journals *Stochastic Environmental Research and Risk Assessment* and *Applied Computing and Geosciences*, and she is part of the Editorial Board of the journal *Mathematical Geosciences*. She teaches basic and advanced courses of Statistics at the School of Industrial and Information Engineering of Politecnico di Milano. She also collaborates as teacher of Statistics with the School of Management of Politecnico di Milano (MIP).

Karel Hron is a Professor of Applied Mathematics at the Palacký University, Czech Republic, His research interests focus on analyzing compositional data in both their multivariate and functional forms, He is active in both developing the methodology for compositional data analysis as well in its promoting in a wide range of applications including geochemistry, chemometrics, omics sciences and time use epidemiology. He is co-author of cca. 90 papers in peer-reviewed journals and book chapters about the topic, and recently (2018) also a book *Applied Compositional Data Analysis* (Springer Series in Statistics). He also hold several short courses on compositional data analysis. He teaches basic and advanced courses of Probability and Statistics at the Faculty of Science, Palacký University, and is also active in promoting mathematics and statistics among high-school students.

Jitka Machalova is an Associate Professor of Applied Mathematics at the Palacký University, Czech Republic. Her research interests focus on numerical mathematics and optimization, in particular on approximation of data by using spline functions. She teaches basic and advanced course of Numerical Methods and Optimization and a course of Approximation of Data at the Faculty of Science, Palacký University.

References:

1. Egozcue JJ, Díaz-Barrero JL, Pawlowsky-Glahn V (2006) *Hilbert space of probability density functions based on Aitchison geometry*. Acta Mathematica Sinica 22(4):1175–1182
2. Hron K, Menafoglio A, Templ M, Hrůzová K, Filzmoser P (2016) *Simplicial principal component analysis for density functions in Bayes spaces*. Computational Statistics & Data Analysis 94:330–350
3. Machalová J, Talská R, Hron K, Gába A (2021) *Compositional splines for representation of density functions*. Computational Statistics DOI: 10.1007/s00180-020-01042-7
4. Menafoglio A, Guadagnini A, Secchi P (2014) *A kriging approach based on Aitchison geometry for the characterization of particle-size curves in heterogeneous aquifers*. Stochastic Environmental Reserch and Risk Assessment 28(7):1835-1851
5. Menafoglio A, Secchi P, Guadagnini A (2016) *A class-kriging predictor for functional compositions with application to particle-size curves in heterogeneous aquifers*. Mathematical Geosciences 48(4):463–485

6. Menafoglio A, Gaetani G, Secchi P (2018) *Random domain decompositions for object-oriented Kriging over complex domains*. Stochastic Environmental Reserch and Risk Assessment 32(12):3421-3437
7. Menafoglio A, Guadagnini L, Guadagnini A, Secchi P (2021) *Object oriented spatial analysis of natural concentration levels of chemical species in regional-scale aquifers*. Spatial Statistics 43:100494
8. Talská R, Menafoglio A, Hron K, Egozcue JJ, Palarea-Albaladejo J (2020) *Weighting the domain of probability densities in functional data analysis*. Stat DOI: 10.1002/sta4.283
9. Talská R, Menafoglio A, Machalová J, Hron K, Fišerová E (2018) *Compositional regression with functional response*. Computational Statistics & Data Analysis 123:66–85
10. van den Boogaart KG, Egozcue JJ, Pawlowsky-Glahn V (2014) *Bayes Hilbert spaces*. Australian & New Zealand Journal of Statistics 56(2):171–194

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REGISTRATION PROCEDURE

The IASC-ERS Webinar "*An Introduction to Functional Data Analysis for Density Functions in Bayes spaces*" will be held virtually using the platform GoToWebinar from April 29-30, 2021. The official language is English. The registration deadline is **Tuesday, April 27th 2021**. The course is free of charge.

Please complete the IASC-ERS Webinar Registration Form at
https://attendee.gotowebinar.com/register/8667082239416059148.
If you have any questions or you need any help, please do not hesitate to contact us at iasc.ers.21@gmail.com.

To become an IASC-ERS member, please complete the Membership Application Form at
https://www.isi-web.org/index.php/membership/individual-membership/iasc.

All participants are expected to adhere to the ISI Community Principles and Conduct Policy (https://www.isi-web.org/index.php/about-isi/policies/community-conduct).

More information about GoToWebinar please visit https://www.gotomeeting.com/webinar.
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https://support.goto.com/webinar/help/gotowebinar-for-mobile-devices-g2w050033.

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GoToWebinar Platform

To attend this virtual course:

1. Please complete the IASC-ERS GoToWebinar Registration Form at
https://attendee.gotowebinar.com/register/8667082239416059148
as soon as you decide to attend the course. Please, provide all the requested information.

2. Following the registration on the GoToWebinar platform you will receive by email an invitation link and a webinar's ID to join the course by GoToWebinar.

3. You can also go to https://www.gotomeeting.com/webinar/join-webinar and join the webinar entering the 9-digit Webinar ID and your email in the Join a Webinar window.

4. Please, try to connect about 30 minutes before the course stars.

5. We recommend joining via a high speed and wired connection and to use a USB headset for best sound quality.

6. Before to attend the course, please visit the webpage
https://www.gotomeeting.com/webinar/join-webinar and see the video "GoToWebinar Attendee Quick Start". For more information, you can also visit the YouTube channel
https://www.youtube.com/user/gotowebinar.

7. If you have any questions or you need any help, please do not hesitate to contact us at iasc.ers.21@gmail.com.