A MESSAGE FROM THE PRESIDENT

- Sonia Petrone -
ISBA President, 2014
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Summer greetings from the ISBA Presidents, Merlise Clyde (**Past President**) , Sonia Petrone (President) and Alexandra Schmidt (President Elect). Three women, yes. Suprised? Ah! would you be surprised by three men? Yet puzzled? Ay-ay, gender equality still has way to go! Trying to find some explanation? Agh! you are an even more serious case!

That's a joke, sure. But just to capture your attention. Gender equality is far from being achieved in academic life. As a scientific society, we are called to care about this. Gender equality is an issue that has been raised in the past and is again being discussed inside many scientific statistical societies, another sign that it is not at all solved. I stress once more that ISBA does care about gender equality, as well as geographical diversity and respect of minorities. Just a few, yet relevant signs: the ISBA Board, including the Executive, has seven women and ten men; 3 Board members are from the US, 6 from Europe, 2 from Latin America, 1 from East Asia. Among the invited speakers at Cancun for the keynote and Foundational Lectures there are 3 women and 6 men. I do not have data yet about the composition of ISBA membership but I hope to inform you in the next ISBA newsletter. And I'd like to encourage you to bring experiences and data about gender equality in your institutions to our attention. ISBA is keen to discuss about these issues with other statistical societies.

Now we all, women and men, young and doub-

ly young, are looking forward to the **ISBA 2014 World Meeting** that is soon coming at Cancun!

Let me first draw your attention to a satellite event that precedes the world meeting, the **II Escuela Latinoamericana de Estadística Bayesiana** (II Latin American School In Bayesian Statistics) on 1 and 12 July 2014, Chetumal, Quintana Roo, Mexico: (http://www.est.colpos.mx/bayes/). Right after, the ISBA World Meeting (http://isba2014.eventos.cimat.mx) opens with short courses on July 13th and 14th, followed by the Foundational Lectures, a core part of the meeting, on Monday afternoon. The highlight of the welcome reception on Monday evening is the ISBA Fellows Ceremony, chaired by Jim Berger. You don't want to miss it, we are honoring people that marked the story of Bayesian thinking and Bayesian Statistics! ISBA Fellows are elected by the Committee on Fellows upon nominations. I greatly thank the 2014 Committee: Jim Berger (chair), Jose Bernardo, Sid Chib, Jayanta Ghosh, John Geweke, Luis Pericchi, Dale Poirer and Mike West, for their work and advise.

MESSAGE FROM THE PRESIDENT, *Continued from page 1. . . .*

The scientific program at the world meeting also includes a special session from the ISBA official publication, ***Bayesian Analysis***. I take the opportunity to remind you of the invitation from Editor-in-Chief Marina Vannucci to contribute written discussions to the special invited paper "Robust Bayesian Graphical Modeling Using Dirichlet t-Distributions" by Michael Finegold and Mathias Drton (http://ba.stat.cmu.edu/abstracts/Finegold.php), which will be presented during the Bayesian Analysis session in Cancun. Contributed written discussions can be submitted online by July 25th at (http://www.e-publications.org/ims/submission/).

Open Discussion: this was one of the inspiring motives, and a wonderful peculiar trait, of the Valencia Meetings that are at the origin of the ISBA world meetings. The idea of the first Valencia meetings, as we know, was to have an informal and friendly environment for discussing and exchanging thoughts and ideas about Bayesian probability and statistics. Those were small workshops; now the world meeting has more than 400 participants. But I hope to see the same friendly but also lively, deep, hard-working spirit - ah! I never saw, at any conference, so many people passionately discussing in front of posters - posters presented by young as well as by senior people - as at the Valencia and ISBA meetings! - I wish that this wonderful spirit continues to pervade the ISBA world meetings. It will be so in Cancun, I am sure! Looking forward to seeing you there! Looking forward, too, to discussing with you about several projects and future plans that have been boiling for the last months - ISBA sponsorship of meetings, travel awards, common initiatives with other scientific societies and with the ISBA Chapters, enhancing Bayesian research... The world meeting is the opportunity to discuss not only among ISBA officers but with you all about our projects and your projects, your needs, your ideas. See you soon in Cancun!

Administrative manager. ISBA has been happily growing in membership and recognition, and the number of initiatives and activities is enjoying the same explosion. This arises the need for a staff person that can provide general assistance to ISBA officers and members and be a permanent presence inside ISBA for executive work and procedures. We are happy to welcome Gabriella Bonfanti, who will offer this service to ISBA in the role of Administrative Manager. Gabriella can be contacted at bonfanti.ga@gmail.com.

ISBA at NIPS? In my note for the ISBA bulletin last March, I encouraged discussions "from the floor" about a hot issue, Bayesian computations with big data. Contributions are coming, hold on! But let me insist with a somehow related idea, having some "ISBA at NIPS" initiative. NIPS (Neural Information Processing Systems Conference) already includes substantial contributions on Bayesian methods and applications, but I think that making the presence of ISBA more visible would enhance the Bayesian research in these areas and lead to fruitful interchange. NIPS has satellite workshops but the idea would be having autonomous ISBA events, co-located with NIPS in an appropriate format. You are very welcome to email me at sonia.petrone@unibocconi.it with comments and suggestions.

Finally, let me share with you, with thanks to Ron Wasserstein , Kerrie Mengersen and the all World of Statistics Steering Committee, the latest News from the World of Statistics, (http://www.worldofstatistics.org/files/2014/06/June-23-2014.pdf), and bring to your attention Statistics and Science: A Report of the London Workshop on the Future of the Statistical Sciences, http://bit.ly/londonreport, which is the product of a high-level meeting in London last November attended by 100 prominent statisticians from around the world. This invitation-only summit was the capstone event of the International Year of Statistics, a year-long celebration during 2013 that drew as participants more than 2,300 organizations from 128 countries. The report is written in an accessible style so people who are not experts in statistics can understand its messages and the field's impact on society. It can be used as a resource by students interested in studying statistics at university, by policymakers who want to better understand the value statistics provides society and by the general public to learn more about the misunderstood field of statistical science. ▲

A Message from the Editor

- Feng Liang -
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Summer is here! Maybe you are enjoying a relaxing vacation with your loved ones, or finishing up papers you put off during the school year, or on your way to Cancun. No matter what you are doing, I hope you could take a break and catch up with some latest news and upcoming events in our society presented in this issue of the Bulletin: II Latin American School in Bayesian Statistics, ISBA fellow cermony, new discussion papers at Bayesian Aanalysis, a fresh report for the recent workshop on Frontiers of Statistics, disseraton abstracts of the 2013 Savage Award finalists, etc.

In addition to the call for discussion on Bayesian computations and big data, our president just sent another call for ideas and suggestions for possible ISBA events co-located with NIPS. Look forward to your suggestions/contributions!   ▲

WORKSHOP ON FRONTIERS OF STATISTICS

2014 ISBA-GEORGE BOX RESEARCH WORKSHOP ON FRONTIERS OF STATISTICS

- Refik Soyer -
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This unique worskhop, co-organized by the ISBA Sections on Economics, Finance & Business (EFaB), Industrial Statistics (IS), and Objective Bayes (OB), was held at the George Washington University on May 21-22, 2014.

This was a terrific research workshop, as well as a memorable event in terms of a forum for sharing and commemorating connections and links to areas Box worked in– and in most cases defined seminal contributions to– with current research frontiers. The 2014 ISBA-Box Research Workshop

ISBA-Box 2014 Banquet Speaker George C Tiao.

was held on May 20th-22nd, 2014 at the George Washington University, in Washington DC. Initiated and led by Refik Soyer, (inaugural) chair of the ISBA Section on Industrial Statistics, this was a unique research workshop that recognized and reflected on the contributions of one of the founding fathers of modern Bayesian statistics, and his legacy in terms of impact and connections with many current scientific research frontiers in EFaB areas and more broadly. Overlaying this important historical perspective, this was an aggressively active frontier research workshop, with talks, posters and participation of a substantial number of current leading innovators in the Bayesian world, as well as a rich and diverse junior participant group.

This 2-day meeting featured presentations and discussions of topical, frontier research in the methodology and applications of Bayesian statistics, and related areas. The focus areas included those pioneered by George Box through his career as a path-breaking innovator in concepts, theory, methods and applications across a broad sweep of areas, and defined substantive contexts to reflect on Box's legacy, coupled with the vibrancy of our discipline– especially in its interfaces with challenging areas of application. The research areas represented key and challenging research arenas for modern, stochastic model-based and computationally-oriented research statisticians in academia, business and industrial environments. In addition to helping to maintain and promote historical connections, the Workshop defined

a wonderfully productive event for exchange of ideas and advances, identification and confrontation of challenges to statistical science and Bayesian methodology, and definition of new research directions.

Highlighted areas of Bayesian R&D included dynamics and control; time series and forecasting; design and experimentation; model assessment and criticism; objective Bayes; Bayes:frequentist interfaces; applications in industry, business, and economics; and linkages to Box's influences on current research frontiers. A range of challenging, diverse and important application contexts very naturally underlay most of the talks and posters.

The full program will be maintained at 2014 ISBA-George Box Research Workshop on Frontiers of Statistics for access by all ISBA members.

The Workshop, attended by over 75 participants, was an ISBA sponsored meeting. The ISBA Program Council and the EFaB, IS and OB Sections contributed financial support for graduate students and junior researchers. Generous financial support was provided by the George Washington University through the Institute for Integrating Statistics in Decision Sciences and the office of the Provost.

ISBA-Box 2014 Organizers and Colleagues. *Left to right:* Rob McCulloch, Ed George (co-organiser, and past chair of the Objective Bayes Section, Mike West (co-organiser, and past chair of the EFaB Section), Raquel Prado (co-organiser, and past chair of the ISBA Program Council), Refik Soyer (chair of the organising committee, and chair of the Industrial Statistics Section), Ehsan Soofi, & Hedibert Lopes, In the background, the Washington DC *spike-and-slab*. ▲

BAYESIAN ANALYSIS - A MESSAGE FROM THE EDITOR

UPDATE FROM BA

- Marina Vannucci -
Editor-in-Chief
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The 2014 June issue of Bayesian Analysis is now available online. The issue contains fine articles on various topics of Bayesian statistics. I am very pleased to announce that the special invited discussion paper to be presented in the "BA invited session" at ISBA 2014, in Cancun, has now been chosen. The selected paper is "Robust Bayesian Graphical Modeling Using Dirichlet t-Distributions", by Michael Finegold and Mathias Drton. The paper will be published in the Sept issue of BA, with invited and contributed discussions, and can be downloaded at
http://ba.stat.cmu.edu/abstracts/
Finegold.php

If you are interested in contributing a written discussion please submit it at EJMS as "contributed discussion" any time before July 25th. Please provide the title of the paper under discussion and your name and affiliation at the beginning of the contribution. Contributed discussions will be selected for publication by the Editor-in-Chief.

We remind readers that at BA it is now possible for individual authors to submit manuscripts for consideration as discussion papers. Such submissions will first go through our regular review process and, if accepted, the Editor in charge and the EiC will make a decision as to whether the manuscript can make a good discussion paper. If you wish to submit your work for consideration, please select "Article with Discussion" when submitting at EJMS. ▲

ISBA - SECTIONS

HIGHLIGHTS FROM THE ISBA SECTIONS

- Sonia Petrone -
ISBA President, 2014
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Here are some news, just a few highlights, of the activity of the ISBA Sections. Sections reflect important research areas for us; of course, without being by any means exhaustive of the rich research activities and problems for Bayesian statistics. Remember the ISBA website for conferences (http://bayesian.org/forums/conferences).

The **Bayesian Computation** (BayesComp) Section is organizing its flagship meeting, Bayesian Computing at MCMSki, that will likely take place in Lenzerheide, Switzerland in January 2016. This meeting will be the next incarnation of the popular MCMSki series that addresses recent advances in the theory and application of Bayesian computational methods such as MCMC. A three-day meeting is planned, perhaps with an additional day or two of satellite meetings and/or short courses. The Scientific Organizing Committee will be chaired by Mark Girolami, and the Local Organizing Committee by Antonietta Mira.

The **Bayesian Nonparametrics** (BNP) Section is actively involved in the organization of the official section conference that is organized every two years. The next one will be the 10th Conference on Bayesian Nonparametrics and it will take place in Raleigh, North Carolina, June 21-26, 2015. The local committee is formed by Subhashis Ghosal, Brian Reich (NC State), Hongtu Zhao (UNC-CH), Li Ma, Katherine Heller, David Dunson, Surya Tokdar (Duke). The conference will include plenary lectures, invited, contributed and poster sessions.

The ISBA Section on **Environmental Sciences** announces the 4th International Conference on Data Analysis and Modeling in Earth Sciences (DAMES 2014), which is to be held from 6-8 October 2014 in Milan, Italy (http://dames.pik-potsdam.de/index.php?a=conference) and will include sessions on Bayesian sismology. Risk evaluation is a problem where the Bayesian approach can really make a difference, we should be strongly present in these areas!

Soon upcoming, July 2-5, 2014, is the University of Zurich-sponsored and ISBA-endorsed workshop **Bayesian Biostatistics**, (http://www.biostat.uzh.ch/bb2014_en.html), a satellite conference of the International Biometric Conference 2014. The Bayesian Biostatistics workshop will focus on recent developments in clinical, epidemiological and biological applications of Bayesian methods.

In 2014, the ISBA Section on **Economics, Finance and Business** (EFaB) has organized, together with the ISBA Sections on Industrial Statistics and Objective Bayes, the ISBA-George Box Research Workshop on Frontiers of Statistics, (http://business.gwu.edu/decisionsciences/i2sds/conferences.cfm), which was held in Washington DC, May 20-22, 2014. I would like to thank Mike West and Refik Soyer for offering to make the recorded videos of the conference available to the Bayesian community. The videos still need some editing but will be soon available on the ISBA-CE website (http://bayesian.org/continuing-education), which we are also planning to enrich with new contents on foundational and historical material.

Last but not least, some news from our lively and enthusiastic **j-ISBA** Section, open to students and researchers within 5 years of having completed their degree. Their enthusiasm is contagious, the section is up to over 120 members and growing, with the j-ISBA community online, in social networks, web events, and more. The second BAYSM 2014 workshop will be held in Vienna, September 18-19, 2014, (http://baysm2014.wu.ac.at). Great to have such enthusiastic new generation inside ISBA!   ▲

STUDENTS' CORNER

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As you can read in the ISBA website, the Savage Award, named in honor of Leonard J. "Jimmie" Savage, is bestowed each year (along with a monetary prize) to two outstanding doctoral dissertations in Bayesian econometrics and statistics: One in **Theory and Methods**, for a dissertation that makes important original contributions to the foundations, theoretical developments, and/or general methodology of Bayesian analysis; the other in **Applied Methodology**, for a dissertation that makes outstanding contributions with novel Bayesian analysis of a substantive problem that has potential to impact statistical practice in a field of application.

Every two years, when the award coincides with the ISBA world meeting, the four finalists, two for each area, present their work at a special session of the meeting, before the winners are finally announced. This year, however, the high quality of the submitted theses made it impossible for the award committee to select four finalists, and so we have eight. It is exciting to know that research of such level is being produced! Unfortunately, twice the finalists means twice the time required for dedicated sessions in an already intense ISBA meeting program. The result is that those of us going to Cancún this July will only have the chance to see four of the finalists presenting their theses. We therefore thought it a good idea to present to you all eight works together in once place and, since this section usually contains a thesis abstract anyway, what better place to print all eight?

Following, you will find the dissertation abstracts of the eight 2013 Savage Award finalists. We invite you to read them, pick your favorites if you like, but be sure to support them all, as they represent a young promise for the future of Bayesian statistics. And those of you who haven't met the finalists, we asked them to tell us something about themselves.

Theory and Methods

Andres Felipe Barrientos is currently a Postdoctoral researcher at the Department of Statistics of the Pontificia Universidad Católica de Chile, in Santiago de Chile, where he has been developing Bayesian Nonparametric models and methods over the last few years. His research mainly focuses on semi(non)-parametric single density estimation and regression models; in particular, theoretical properties such as the support of prior distributions and the consistency of the posterior distributions. He is also interested in applications and computational aspects related to inference for these kinds of models. In addition, he tells us he is always open to exploring new ideas and taking on new challenges. I hope one of our readers will take up the opportunity and present Andres with a challenge, so we can all see what interesting results a collaboration with him can lead to.

Debdeep Pati was born on March 12, 1985 in Kolkata, India. He received his Bachelor's degree in Statistics from the Indian Statistical Institute in 2006. He continued there for a Master's degree and graduated in 2008 specializing in Mathematical Statistics and Probability. In August 2008, Debdeep moved to the United States to pursue a Ph.D. in Statistical Science at Duke University, Durham, NC,. In 2010, he earned a second Master's and finally the Ph.D. under the supervision of Professor David B. Dunson in May 2012. Since Fall 2012, he has been an Assistant Professor at the Department of Statistics of the Florida State University. His research interests center around nonparametric Bayesian foundational theory and methodology in a broad range of areas including density estimation, high-dimensional density regression and variable selection, shape reconstruction, imaging and hierarchical modelling of shapes. He will be presenting his thesis at the Savage Award session of ISBA 2014.

Weining Shen received his PhD in statistics from North Carolina State University in 2013 and is currently a postdoc at the Univeristy of Texas MD Anderson cancer center. His research interests include Bayesian nonparametric and semiparametric modelling, Bayesian asymptotics, machine learning, biomarker evaluation and clinical trial designs. He will also be presenting at the Savage Award session in Cancún so, if you're plan-

ning to be there, you'll have a chance to meet him.

Sara Wade received a B.Sc. in Mathematics at the University of Maryland, College Park. In January 2013, she earned her PhD in Statistics from Bocconi University in Milan, where she worked on Bayesian nonparametric regression with Professor Sonia Petrone. in November 2012, she joined the Machine Learning group at the University of Cambridge, as a Research Associate (Postdoc) . Her research interests include regression; density estimation; conditional density estimation; mixture models; clustering; feature allocation; (dependent) random measures; Markov Chain Monte Carlo methods; and Bayesian nonparametrics, machine learning, and statistics in general. Applications of interest include the prediction and assessment of Alzheimer's disease based on neuroimaging data.

Theory and Applications of Dependent Nonparametric Bayesian Models for Bounded and Unbounded Responses

by Andres Felipe Barrientos
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Advisors:
Fernando Quintana and Alejandro Jara

As the complexity of many scientific problems grows, the modelling and analysis of data coming from these problems requires of increasingly sophisticated statistical models. The constant search of such models has been one of the major stimulus for research in Bayesian nonparametric (BNP) methods. This dissertation presents advances in BNP models for predictor–dependent distributions (or density regression) by studying one of their most important properties (support) and proposing a novel class of these models. In order to contextualize the dissertation, an initial chapter is included presenting a literature review and some basic concepts which are useful to understand the main reasons that motivated this work. Those reasons are also included in this chapter. Because this project is based on two different works, the dissertation has been divided in two pieces that are self-contained and included in two different chapters, 2 and 3.

In the first part, Chapter 2, we study the support properties of Dirichlet process-based models for sets of predictor-dependent probability distributions. Exploiting the connection between copulas and stochastic processes, we provide an alternative definition of MacEachern's dependent Dirichlet processes. Based on this definition, we provide sufficient conditions for the full weak support of different versions of the process. In particular, we show that under mild conditions on the copula functions, the version where only the support points or the weights are dependent on predictors have full weak support. In addition, we also characterize the Hellinger and Kullback-Leibler support of mixtures induced by the different versions of the dependent Dirichlet process. A generalization of the results for the general class of dependent stick-breaking processes is also provided.

In the second part, Chapter 3, we propose a novel probability model for sets of predictor–dependent probability distributions with bounded domain. The proposal corresponds to an extension of the Dirichlet-Bernstein prior by using dependent stick-breaking processes. Appealing theoretical properties such as full support, continuity, marginal distribution, correlation structure, and consistency of the posterior distribution are studied. Practicable special cases of the general model are discussed and illustrated using simulated and real–life data. The simulated data is also used to compare the proposed methodology to existing methods.

Finally, Chapter 4 summarizes the dissertation and discusses possible generalizations and future work.

Bayesian Nonparametric Modeling and Theory for Complex Data

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Comitee:
Dr. Alan E. Gelfand, Dr. Surya T. Tokdar and Dr. Lawrence Carin

The dissertation focuses on solving some important theoretical and methodological problems associated with Bayesian modeling of infinite dimensional 'objects', popularly called nonparametric Bayes. The term 'infinite dimensional object' can refer to a density, a conditional density, a

regression surface or even a manifold. Although Bayesian density estimation as well as function estimation are well-justified in the existing literature, there has been little or no theory justifying the estimation of more complex objects (e.g. conditional density, manifold, etc.). Part of this dissertation focuses on exploring the structure of the spaces on which the priors for conditional densities and manifolds are supported while studying how the posterior concentrates as increasing amounts of data are collected.

With the advent of new acquisition devices, there has been a need to model complex objects associated with complex data-types e.g. millions of genes affecting a bio-marker, 2D pixelated images, a cloud of points in the 3D space, etc. A significant portion of this dissertation has been devoted to developing adaptive nonparametric Bayes approaches for learning low-dimensional structures underlying higher-dimensional objects e.g. a high-dimensional regression function supported on a lower dimensional space, closed curves representing the boundaries of shapes in 2D images and closed surfaces located on or near the point cloud data. Characterizing the distribution of these objects has a tremendous impact in several application areas ranging from tumor tracking for targeted radiation therapy, to classifying cells in the brain, to model based methods for 3D animation and so on.

The first three chapters are devoted to Bayesian nonparametric theory and modeling in unconstrained Euclidean spaces e.g. mean regression and density regression, the next two focus on Bayesian modeling of manifolds e.g. closed curves and surfaces, and the final one on nonparametric Bayes spatial point pattern data modeling when the sampling locations are informative of the outcomes.

Adaptive Bayesian Function Estimation

by Weining Shen
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Advisors:
Prof. Subhashis Ghosal
Comitee:
Dr. Eric Laber, Dr. Huixia Wang and Dr. Surya Tokdar

This dissertation focuses on developing some new Bayesian methodologies for function estimation and studying their theoretical properties. In particular, we investigate conditions under which such methods achieve the optimal posterior rate of convergence even when the smoothness of the underlying function is unknown. Some examples of functions of interest include density function, conditional density function, regression function, and classification function. Although several nonparametric Bayesian models have been developed for many applications, their theoretical properties, such as large-sample convergence properties are often not fully understood. Part of the dissertation focuses on exploring the posterior convergence rates of certain nonparametric Bayesian procedures. We establish rate-adaptive Bayesian procedures in the sense that the optimal minimax rate of estimation can be achieved by using one single prior for the entire smoothness class that the underlying true function belongs to. Such results can be viewed as frequentist large-sample justification, which suggests that by carefully selecting priors, the posterior distribution of the estimator concentrates around the truth at an optimal rate.

In Chapter 2, we consider a multivariate density estimation problem. We show that rateadaptive Bayesian procedures can be obtained using Dirichlet mixtures of multivariate normal kernels with a prior distribution on the kernels covariance matrix parameter. Locally Hölder smoothness classes and their anisotropic extensions are considered. Our study involves several technical novelties, including a sharp approximation of finitely differentiable multivariate densities by normal mixtures and a new sieve on the space of such densities.

In Chapter 3, we consider a class of finite random series priors for univariate function estimation problems. The prior is constructed through distributions on the number of basis functions and the associated coefficients. We derive a general result on the construction of an appropriate sieve and obtain adaptive posterior contraction rates. This general result is applied on several statistical problems such as signal processing, density estimation, nonparametric regression, classification, spectral density estimation, functional regression etc. The random series prior can be viewed as an alternative to the commonly used Gaussian process prior, but can be analyzed by relatively simpler techniques and in many cases allows a simpler approach to computation without using Markov

chain Monte-Carlo (MCMC) methods.

In Chapter 4, we extend the random series prior to a multivariate setting. In particular, we consider a density regression problem (i.e., estimation of a conditional density function) in a high-dimensional situation, in which the number of covariates is possibly much larger than the sample size. We develop a MCMC-free computing technique to calculate the posterior moments of the conditional density. Adaptive convergence rate is obtained under sparsity conditions that adapts to both the smoothness level and the actual number of covariates that influence the conditional density.

Estimation of derivatives of density functions is another interesting topic as it directly connects to many important statistical quantities such as score functions, Fisher information and hypothesis testing in semiparametric location models. In Chapter 5, we focus on estimating derivatives of a univariate density function using Bayesian kernel methods and B-spline functions. Convergence rates are obtained using new techniques on constructing testing inequalities under Lr-norms, $1 \leq r \leq \infty$.

Bayesian Nonparametric Regression through Mixture Models

by Sara Wade
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sara-wade-2
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This thesis studies Bayesian nonparametric regression, where the aim is to flexibly model not only the regression function but also the error distribution around this function. For independent and identically distributed data, mixture models are a useful tool for density estimation. Our problem of interest can be seen as a *conditional density estimation* problem, and thus, a natural solution is to extend mixture models appropriately. Indeed, this is approach we follow.

There are two main ways to extend Bayesian mixture models for nonparametric regression; the first involves modelling the joint density of the response and covariates through a nonparametric mixture with conditional density estimates obtained as a by-product, and the second directly models the conditional density with a covariate dependent mixture. In the literature, there exist many models proposals which fall within these two general classes. Our first contribution is to provide a unifying framework and review of such models.

These models are highly flexible, yet also numerous, which raises the question of how to choose among the models for the application at hand. In answer to this question, we derive predictive equations for the conditional mean and density and carefully analyse the quantities involved. Our main contributions to the subject are a detailed study of the predictive performance of existing models, the identification of potential sources of improvement in prediction, and the development of novel procedures to improve prediction. In particular, we propose a novel nonparametric prior developed from the idea of extending the class of enriched conjugate priors to a nonparametric setting and use this prior to improve the predictive performance of the models based on the joint approach, specifically for multivariate covariates. In addition, we propose strictly incorporating covariate information in the latent partition function of the models and show that this can improve predictive performance, and for models with covariate dependent weights, we propose a natural and interpretable construction for the weights. For all proposals, appropriate Markov chain Monte Carlo algorithms for inference have been developed.

Finally, we apply the proposed models in three case studies of Alzheimer's disease. The three studies explore diagnosis of the disease based on various AD biomarkers, the relationship between the disease and asymmetry in the hippocampus, and the evolution of hippocampal volume with disease status and increasing age.

Applied Methodology

Osvaldo Anacleto completed his PhD in Statistics in 2012 at the Open University (UK). He also holds a B.Sc. and M.Sc. in Statistics, both obtained from the Universidade Federal de São Carlos (UFSCar, Brazil). Prior to his arrival to the UK in 2009, he worked as a temporary lecturer in Statistics at UFSCar and also for a Brazilian leading bank, where he analyzed large financial data sets and provided statistical support as a research and development specialist. He is currently a Research Fellow at the Roslin Institute, University of Edinburgh, working on the development of statistical methods for understanding the genetic

basis of infectious diseases. Don't miss the chance to follow his talk at the Savage award session in Cancún.

Antonio Canale obtained a B.S. in Statistics and Management in 2006, followed by a M.S. in Statistics and Computer Science in 2008, both from the University of Padua, Italy. From 2007 to 2009 he worked as a freelance business statistics consultant. During his Ph.D. at the University of Padua, he developed novel Bayesian nonparametric methodologies motivated by the concrete problem of telecommunications customer base data modeling. After completion of his Ph.D. in 2012 he worked as a Post doctoral fellow at the University of Turin where he is now an Assistant Professor in Statistics. He is also a Research Affiliate of the "de Castro Statistics Initiative" at Collegio Carlo Alberto in Moncalieri, Italy. His research interests include Bayesian Nonparametrics, flexible distributions, and data mining methods motivated by challenging applied problems.

Joseph Dureau obtained, in 2006 a B.Sc. Degree in mathematics applied to social sciences from the University of Paris 1 - Sorbonne, as well as a B.Sc. Degree in engineering from the Ecole Centrale Paris, where he also got, in 2009, a M.Sc. in applied mathematics. In 2013 he graduated from the Ph.D. in Statistics at the London School of Economics. He has worked as a research assistant for relatively short periods at the Jet Propulsion Laboratory of NASA in Los Angeles, the French commission for nuclear energy and the Ecology and Evolution Department of the Ecole Normale Supérieure in Paris and, after graduation, as a research officer at the Statistics department of the London School of Economics. He has recently left the academic world, deciding to apply his statistical knowledge as a co-founder of Standard Analytics, a venture for which I hope you will join me in wishing him success.

Ole Maneesoonthorn received a Ph.D. in Econometrics from Monash University. Her research, in the fields of financial econometrics and Bayesian econometrics, earned her the Molly Holman Doctoral Medal 2013 from Monash University. Ole has published in the top journal in econometrics, as well as being recognized on many occasions for her research content and presentation skills. Such recognitions include winning the prize for best Ph.D. paper at both the inaugural Peter C.B. Phillip Ph.D. Camp in 2012 (held at the National University of Singapore) and the 2010 Financial Integrated Research Network (FIRN) Doctoral Tutorial (hosted by the RMIT University); and an honourable mention at the 2013 New Zealand Econometrics Study Group. Ole is currently an Assistant Professor at the Melbourne Business School, the University of Melbourne. She will be present at the Savage award session of our closely approaching world ISBA meeting.

BAYESIAN DYNAMIC GRAPHICAL MODELS FOR HIGH-DIMENSIONAL FLOW FORECASTING IN ROAD TRAFFIC NETWORKS

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Congestion on roads is a crucial problem which affects our lives in many ways. As a consequence, there is a strong effort to improve road networks in order to keep the traffic flowing. Flow forecasting models based on the large amount of traffic data, which are now available, can be a very useful tool to support decisions and actions when managing traffic networks. Although many forecasting models have been developed to this end, very few of them capture important features of high-dimensional traffic data and, moreover, operating most of these models is a hard task when considering on-line traffic management environments.

Dynamic graphical models can be a suitable choice to address the challenge of forecasting high-dimensional traffic flows in real-time. These models represent network flows by a graph, which not only is a useful pictorial representation of multivariate time series of traffic flow data, but it also ensures that model computation is always simple, even for very complex road networks. One example of such a model is the multiregression dynamic model (MDM).

This thesis focuses on the development of two classes of dynamic graphical models to forecast traffic flows. Firstly, the linear multiregression dynamic model (LMDM), which is an MDM particular case, is extended to allow important traffic characteristics in its structure, such as the hetero-

cedasticity of daily traffic flows, measurement errors due to malfunctions in data collection devices, and the use of extra traffic variables as predictors to forecast flows. Due to its graphical structure, the MDM assumes independence of flows at the entrances of a road network. This thesis therefore introduces a new class of dynamic graphical models where the correlation across road network entrances is accommodated, resulting in better forecasts when compared to the LMDM.

All the methodology proposed in this thesis is illustrated using data collected at the intersection of three busy motorways near Manchester, UK.

BAYESIAN NONPARAMETRIC MODELS FOR COUNT DATA WITH APPLICATIONS TO CUSTOMER BASE MANAGEMENT

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Motivated by the analysis of telecommunications marketing data, which are multidimensional, longitudinal and mostly consisting in counts, this thesis introduces novel Bayesian nonparametric techniques for the estimation of probability mass functions and count stochastic processes. In addition, the theoretical basis of nonparametric mixture models for mixed-scale density estimation are provided. Mixed-scale data consists in joint continuous, count and categorical variables. Although Bayesian nonparametric models for continuous variables are well developed, the literature on related approaches for counts is limited and that for mixed-scale variables is close to none. The leading idea of this work is to induce prior distributions on the spaces of interest via priors on suitable latent spaces and mapping functions. Precisely a class of priors on the space of the probability mass functions and of the mixed-scale densities is induced through priors on the space of continuous densities and another class of priors on count stochastic process is induced through priors on the space of continuous stochastic processes. Asymptotic properties of these procedures are studied and results in terms of large support

and posterior consistency are obtained under suitable assumptions. Efficient Gibbs samplers are developed for posterior computation, and the performance of the proposed methods is assessed in simulation studies and real data applications.

BAYESIAN INFERENCE FOR INDIRECTLY OBSERVED STOCHASTIC PROCESSES, APPLICATIONS TO EPIDEMIC MODELLING

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Stochastic processes are mathematical objects that offer a probabilistic representation of how some quantities evolve in time. In this thesis we focus on estimating the trajectory and parameters of dynamical systems in cases where only indirect observations of the driving stochastic process are available. We have first explored means to use weekly recorded numbers of cases of Influenza to capture how the frequency and nature of contacts made with infected individuals evolved in time. The latter was modelled with diffusions and can be used to quantify the impact of varying drivers of epidemics as holidays, climate, or prevention interventions. Following this idea, we have estimated how the frequency of condom use has evolved during the intervention of the Gates Foundation against HIV in India. In this setting, the available estimates of the proportion of individuals infected with HIV were not only indirect but also very scarce observations, leading to specific difficulties. At last, we developed a methodology for fractional Brownian motions (fBM), here a fractional stochastic volatility model, indirectly observed through market prices.

The intractability of the likelihood function, requiring augmentation of the parameter space with the diffusion path, is ubiquitous in this thesis. We aimed for inference methods robust to refinements in time discretisations, made necessary to enforce accuracy of Euler schemes. The particle Marginal Metropolis Hastings (PMMH) algorithm exhibits this mesh free property. We propose the use of fast approximate filters as a pre-exploration tool to estimate the shape of the target density, for

a quicker and more robust adaptation phase of the asymptotically exact algorithm. The fBM problem could not be treated with the PMMH, which required an alternative methodology based on reparameterisation and advanced Hamiltonian Monte Carlo techniques on the diffusion pathspace, that would also be applicable in the Markovian setting.

STOCHASTIC VOLATILITY, JUMPS AND VARIANCE RISK PREMIA: A BAYESIAN STATE SPACE APPROACH

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Planning for future movements in asset prices and understanding the variation in the return on assets are key to the successful management of investment portfolios. This thesis investigates issues related to modelling both asset return volatility and the large movements in asset prices that may be induced by the events in the general economy, as random processes, with the implications for risk compensation and the prediction thereof being a particular focus.

Exploiting modern numerical Bayesian tools, a state space framework is used to conduct all inference, with the thesis making three novel contributions to the empirical finance literature. First, observable measures of physical and option-implied volatility on the S&P 500 market index are combined to conduct inference about the latent spot market volatility, with a dynamic structure specified for the variance risk premia factored into option prices. The pooling of dual sources of information, along with the use of a dynamic model for the risk premia, produces insights into the workings of the U.S. markets, plus yields accurate forecasts of several key variables, including over the recent period of stock market turmoil.

Second, a new continuous time asset pricing model allowing for dynamics in, and interactions between, the occurrences of price and volatility jumps is proposed. Various hypotheses about the nature of extreme movements in both S&P 500 returns and the volatility of the index are analyzed, within a state space model in which the usual returns measure is supplemented by direct measures of physical volatility and price jumps. The empirical results emphasize the importance of modelling both types of jumps, with the link between the intensity of volatility jumps and certain key extreme events in the economy being drawn.

Finally, an empirical exploration of an alternative framework for the statistical evaluation of price jumps is conducted, with the aim of comparing the resultant measures of return variance and jumps with those induced by more conventional methods. The empirical analysis sheds light on the potential impact of the method of measurement construction on inference about the asset pricing process, and ultimately any financial decisions based on such inference.