THE ISBA BULLETIN

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The official bulletin of the International Society for Bayesian Analysis

A MESSAGE FROM THE PRESIDENT

- Mike West -

ISBA President, 2009

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The ISBA Board met earlier this summer at two sub-board meetings: one in Bressanone, Italy, in June and a second in Washington DC, USA, in August. Among the discussion topics that I can now report to the full membership are progress on the ISBA office developments of membership services that were mentioned in the June Bulletin, questions of ISBA meeting organisation and the role of the Society in supporting and sponsoring other meetings, and activities of several of our volunteer committees that do much of the work needed to run and develop the Society.

ISBA IT & VIRTUAL OFFICE.
The development of the ISBA membership and event management system is effectively complete; the system is operational.

One aspect of the new system is automated email. You received the announcement of the publication of this issue of the Bulletin via the system, as well as some other recent emails. Members wishing to email the full membership can send a note to any one of the members of the Executive Committee for consideration and forwarding to the new list. Over the coming weeks we will also finalise upload of additional lists of past and potentially future members, to begin to connect more broadly with the Bayesian community.

The membership management component of the system is . . . *Continued on page* 2.

A MESSAGE FROM THE EDITOR

by Raphael Gottardo

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Well, here we are again, one more academic year has passed and a new one is starting. I hope that you enjoyed the long break and had time to recharge your batteries. I wish you the very best for this new academic year, and I hope it will be very fruitful in terms of academic achievements.

I would like to start by saying that my term as editor of the bulletin is ending very soon, January 1st 2010, to be precise. This means that you will soon have a new editor in charge of the bulletin, as well as new editors for BA and the ISBA website. Since the start of my term, I have tried to do my very best to improve the quality of the bulletin by, for example improving the latex template and the overall presentation of the bulletin. Of course, time has gone by very quickly, and I did not manage to do everything I wanted to do. Even though I would have been happy to continue as editor, . . . *Continue on page* 4. ▲

In this issue

MESSAGE FROM THE PRESIDENT, *Continued from page 1.*
now open for access by all members. You will shortly receive an email with details so that you can log in and formally register, and make changes and updates to your membership account and access details. If you need to renew membership at the end of 2009, you will be advised to do so by the automated system and will find a new link on the ISBA home page.

The third major facility offered by the system is event management. As noted above, the first use of this will be for a March 2010 meeting, for which ISBA will be the portal for registrations. On clicking the registration link at the conference web site, delegates will be sent to the ISBA site for input and payment. The registrations will be processed via the ISBA system and reconciled with the workshop organising committee. This provides a service to the broader Bayesian community as well as an additional element of PR for ISBA at meetings with some participants that are not currently members (they do exist!).

The operation of the IT system is an excellent step for the Society. The development has been effective and efficient, as well as very modest in terms of cost to ISBA. We are just starting to use it, but it is an appropriate time to acknowledge the work and contributions of Yi Zhang (data base development and support) and Lance Brown (systems support) in getting us to the threshold of having a fully functional ISBA virtual office, as well as financial and personnel contributions from the Department of Statistical Science at Duke University.

MEMBERSHIP.
Following the report from the ISBA Membership Committee in June, that committee continues its work and idea-generation for broadening awareness of the benefits of ISBA membership. One action item proposed in the June report – an ISBA flyer – was, well, acted upon and the flyer produced in July, for initial distribution at meetings and through email communications. You can see the flyer in this issue of the Bulletin. If you care to help, please feel free to contact Hedibert Lopes, chair of the committee, to get a pdf version of the flyer, or to request hard copies, and help us to promote ISBA in your departments and among colleagues and students.

At its summer meetings, the Board resolved to make an important change to the membership sign-up terms for *new* members. From this year on, anyone joining ISBA for the very first time at some point after September 1st of a "current" year will be paying for full membership for the next year, but also granted membership for the balance of the current year. This has a number of implications, among which is the fact that new members joining after September 1st will be eligible to vote in the end of year elections, and so have a voice in the election of the Board and ISBA leadership for the following year – the first of their full membership.

COMMITTEES.
Several of our committees, including the Membership committee mentioned above, are active and working diligently on matters of interest and benefit to the members. We have new appointees to mention in addition to advising you of the outcomes of some recent committee work. Some of the current and recent committee efforts, on your behalf, are as follows.

Nominations: The 2009 Nominating Committee has completed its work, and delivered the following slate of candidates for the upcoming elections:

For President-Elect in 2010, President in 2011:
- Michael Jordan
- Kerrie Mengersen

For Executive Secretary in 2010-2012:
- Merlise Clyde
- Marina Vannucci

For the Board in 2010-2012:
- Siddhartha Chib
- Andres Christén
- Arnaud Doucet
- Paul Fearnhead
- Marco Ferreira
- Peter Hoff
- Raquel Prado
- David Rios Insua

You can see below biographical details, statements and information on the upcoming elections. Thanks are due to all for their willingness to serve if elected. Thanks are also due to the committee for their work on this important societal matter: Christian Robert (chair), Marilena Barbieri, Carlos Carvalho, Simon French, David Higdon, Eduardo Gutiérrez-Peña and Judith Rousseau.

Editors: Fabrizio Ruggeri (chair), Ed George, Rosangela Loschi and Peter Müller are close to completion of their work on ISBA Editors Search Committee, established to identify and nominate candidates for the three ISBA Editorships: the Editor in Chief of our journal, *Bayesian Analysis*, the Editor of our quarterly *Bulletin*, and the ISBA

Webmaster. These three editorial positions are for (potentially renewable) three year terms, and each becomes vacant on January 1st, 2010. This committee will soon conclude its business and report to the Board, so that new Editors can be appointed and up-and-running in good time to ensure smooth transitions in each of these three, purely volunteer positions that are so critical to our Society.

Parlimentary matters: The Constitution and Bylaws Committee works – quietly but effectively – on reviewing existing parlimentary matters, responding to Board requests to consider changes and submitting draft changes to the Board. A change to the Bylaws was recently finalised and approved by the Board: a change to formalise the terms and process of appointment of the ISBA Editors (mentioned above). Be reminded that the Constitution and Bylaws are on public display at the ISBA web site. Thanks to our parlimentarians, Jay Kadane (Chair), Herman Van Dijk, Merlise Clyde, Tony O'Hagan and David Madigan for their continued work and effectiveness.

Prizes: Thanks are also due to the members of the Prize Committee, Fernando Quintana, Marina Vannucci (outgoing chair), Judith Rousseau (incoming chair), Dani Gamerman, Michael Jordan and Dongchu Sun, for their work running the processes related to the several ISBA administered and supported awards. You can read elsewhere in this Bulletin the details of the latest two competitions: those for the annual Savage Award and Mitchell Prize that were announced and awarded in Washington DC, in August.

CONFERENCES AND WORKSHOPS.

Following Board discussion and a report from the Program Council, and aligned with the recent experiences and expectations of ISBA roles in meetings in the coming years, ISBA now has a revised set of guidelines on conference support and organisation. This updates and supercedes guidelines and recommendations under which we have been operating since the 1990s, and now defines operating procedures for the current and future Program Council and Board.

The guidelines place ISBA organised, co-organised or supported meetings into four categories: (A) ISBA World Meetings; (B) regional meetings of ISBA local chapters; (C) meetings originating from or organized with ISBA involvement as a co-organizing society, and (D) other meetings primarily sponsored by other groups.

(A) World Meetings: The biennial ISBA World Meetings are held in even-numbered years. Formal proposals to site and organize World Meetings are requested from the ISBA membership well in advance. Criteria guiding the decision to award a World Meeting to a proposing group include accessibility of the proposed location, nature and experience of the local organising committee, and expectations and opportunities for fund raising by the local organising committee. ISBA's Program Council, including any organizing committees created by the Council for a World Meeting, has the responsibility for generating travel grant funding proposals, the scientific program, and the overall management of the World Meeting. The Program Council communicates procedures and practices from one World Meeting to the next.

World Meetings are the first priority for ISBA funding. ISBA commits a budget to ensure junior participant travel awards via the dedicated categorized awards (Graduate Travel Award Fund, ISBA Lifetime Members Junior Researcher Award, Pilar Iglesias Fund) and with supplemental finance from core ISBA funds. Modest funding may be committed to organization and administration of World Meetings, although the main source of such funding must generally come from local organizers following the international competition to site and host/run the World Meeting.

As previously indicated, the call for proposals for ISBA 11, to be held in 2012, will be forthcoming over the next few months.

(B) Regional meetings of ISBA Local Chapters: Regional meetings of ISBA Local Chapters around the world serve important functions for ISBA. Although the ISBA Program Council has no responsibility for organizing such meetings, it coordinates discussion about such meetings between Chapters and the Board. ISBA assists organizing committees by officially endorsing proposals for funds where necessary, and providing other advice and publicity to the broader membership. ISBA Local Chapters may receive modest funding from ISBA for regional meetings in the country of the chapter, and the meeting will then be designated an ISBA Regional Meeting. Any such support will be predominantly or wholly committed to support student and junior researcher participants.

As an example, ISBA is supporting the upcoming meeting of the Brazilian Local Chapter, ISBrA 10, in March 2010, in Rio de Janeiro. This is therefore the next ISBA Regional Meeting on our calendar.

(C) Meetings co-organized or initiated in part by ISBA: ISBA selectively co-sponsors other meetings, typically smaller research workshops strongly related to ISBA's mission or explicitly co-organized by ISBA, and meetings related to ISBA scientific and international outreach. Any financial support for such meetings will be predominantly or wholly committed to support student and junior researcher participants.

As an example, ISBA is supporting MCMSki III (http://madison.byu.edu/mcmski/) to be held in January 2011, in Utah. MCMSki is a focussed research workshop and ISBA has been strongly involved in its organisation and support to date, and this continues with the third meeting in 2011.

(D) Other meetings: ISBA supports and endorses other meetings to encourage Bayesian activity at workshops of other groups and societies, and to aid in developing relationships with other societies and professional communities. This rarely involves financial support, though some contribution may be considered in cases of very strong involvement of ISBA in initiation, organization, and programming. The decision to support other meetings in this category is based on consideration of the quality and appropriateness of the meeting to ISBA's mission, the conference themes and foci, timing, location and potential conflicts, and who the other co-sponsoring organizations are, among others.

Two examples are the *Eighth ICSA (International Chinese Statistical Association) International Conference: Frontiers of Interdisciplinary and Methodological Statistical Research*, in December 2010, in Guangzhou, China, at which ISBA will organise sessions and have a strong invited presence on the program, and the *International Research Conference on Bayesian Learning* (http://marc.yeditepe.edu.tr/yircobl11.htm) in June 2011, in Yeditepe, Turkey.

ISBA meeting registration support: As part of ISBA support for meetings not organized by ISBA, the Society may agree to provide registration services using the ISBA membership and event management data base system and personnel support. As one example, ISBA is supporting the *Frontiers of Statistical Decision Making and Bayesian Analysis* meeting in honor of Jim Berger (http://bergerconference2010.utsa.edu) in March 2010, in Austin, TX. This is the first meeting for which ISBA will "run the registrations" to pilot the new member services/event management facilities of the new ISBA membership IT system detailed above.

Other benefits to ISBA Members: The procedures guiding Program Council decisions now explicitly recommend that ISBA support for non-ISBA organised meetings provide ISBA members with discounted registration fees, and in some cases invitations to organize a session or sessions at the meeting and participate in other aspects of programming. When ISBA funds are provided in support of the meeting, they will be used primarily for junior participant support, duly emphasising student and new researcher participants, maximising participation, and with consideration of junior delegates from economically disadvantaged countries.

It has been a busy few months for ISBA; and, I believe, productive months. As usual, I invite and encourage all ISBA members to contact any member of the elected Board or Executive committee on any societal matters, and to consider playing active roles to further grow and enrich the existing activities of ISBA on behalf of Bayesians worldwide.

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WORDS FROM THE EDITOR, *Continued from page 1.* . . . I feel that it is important for the quality of the bulletin to get a new editor with brand new ideas. Fabrizio Ruggeri is currently chairing the ISBA Editors Search Committee, and I am sure that we will soon know the identity of our new editors. Speaking of changes, you will soon have the opportunity to elect a new president, as well as other board members. ISBA members should receive an email with all necessary information regarding the voting process. This is your chance to make a difference and speak up, so please remember to do it! If you are not currently an ISBA members but would like to be involved, please make sure to become a member, it's never too late.

In this issue of the bulletin, you will find all regular sections but the interview section. The AE in charge of the interview section, Donatello Telesca, obtained a contribution from Marina Vannucci, but because Marina is running as Exec Secretary, she felt that it would be better (fairer) to wait until the elections are over to publish her interview. So make sure to look out for Marina's interview in the December issue of the bulletin. Speaking of elections, you will also find a list of all candidates along with their statements. I hope that this will help you in making the right decision. Happy reading! ▲

ISBA ELECTIONS

2009 ISBA Elections

by Robert Wolpert
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Biographical information for each of the candidates appears below. The candidates for president have also included statements about what they intent to accomplish. This information is also currently accessible on the ISBA web-site. The 2009 elections of future ISBA officers will take place electronically at the ISBA web-site from 15 October through 15 November. Instructions for voting will be emailed to all current ISBA members prior to the election.

President 2011 (President Elect 2010, Past President 2012)

Kerrie L. Mengersen (QUT, Brisbane, AU)
Statement Pending. Please see ISBA website for up-to-date information.

Michael I. Jordan (UC Berkeley, CA, US)
I am honored to be nominated to serve as ISBA President. In this brief statement I'd like to focus on the external interface of ISBA. My own (somewhat unusual) intellectual history makes me particularly sensitive to this interface; while my first postgraduate degree was in statistics, and statistics has always been my primary interest, I have also aimed at developing a broad appreciation of the problem of statistical inference via exposure to the perspectives of nearby fields. Indeed, while I've published in statistical journals (Bayesian Analysis, Annals of Statistics, JASA, and Statistical Science), I've also published statistical work in the primary journals of numerous other fields; e.g., in Nature Genetics, SIAM Review, Journal of the ACM, Nature Neuroscience, Genome Research, IEEE Transactions on Information Theory, and Cognitive Science. I believe strongly that it is important to take statistics to other fields, not to wait for them to come to us.

This ongoing exposure to the "outside world" has made it clear to me that we are in the early days of what will be an explosive growth in interest in statistics, in particular Bayesian statistics, and that our institutions should be prepared. Inferential problems are everywhere and the next generation of scientists and engineers will not fail to notice this. ISBA is uniquely positioned to channel this growth, and in particular to guide people whose formal training is outside of statistics. We should provide Bayesian courses, videos of lectures of great Bayesian statisticians, online textbooks, software, high-quality links, etc. ISBA should be the first stop for all kinds of queries about statistics.

On a related note, I view the international aspect of ISBA as an essential strength (in part because of a love of languages; the French, Italian and Spanish members of ISBA might be interested to know that I can lecture on Bayesian statistics in their native tongues). I was recently in China, and my general sense of an imminent explosion of interest in statistics was only heightened. Can we insure that young (e.g.) Chinese scholars will be guided to ISBA and that ISBA will provide them with what they need?
Recent Examples of Service include:

- Advisory Board, Bayesian Analysis
- Editor, Bayesian Analysis
- ISBA Awards Committee
- Executive Editor, Foundations and Trends in Machine Learning
- Associate Editor, (JASA, SADM and JMLR)
- Series Editor, Springer

Executive Secretary 2010-2012

Merlise Clyde (Duke U, Durham, NC, US)
I am delighted to be nominated for the Executive Secretary of ISBA. I have served ISBA in a number of capacities: as a Board Member (2004-2006); as a member of the Savage Committee (member 2004-2007, chair 2004-2006); and as a member of the Bylaws and Constitution Committee (1999-2012).

The current executive committee of ISBA has done an outstanding job over the past year to "modernize" the way ISBA keeps in touch with its members – as Executive Secretary and a member of the executive committee, I would continue this progress so that we may grow as a society. Having served on the Bylaw and Constitution Committee, as well as the Savage Committee, I realize that "institutional" memory is often lost as committees change in composition. One of my goals as Executive Secretary, would be to create and help maintain an internal "Wiki" Handbook of Procedures to aid ISBA committees in passing on their wisdom.

I am currently Associate Professor in the Department of Statistical Science at Duke University. My research interests span a range of topics – although my favorite area is model choice and model uncertainty in linear and generalized linear models and nonparametric models (wavelets, kernels, and continuous dictionaries). My research is driven by problems that arise in applications and collaborations, which currently include astrostatistics, environmental statistics, genetics and neuroscience. My articles have been published in JASA, Biometrika, JRSS(B), Statistical Science, Annals of Applied Statistics, and Bayesian Analysis, among others. For more information please visit my website at `http://www.stat.duke.edu`.

Marina Vannucci (Rice U, Houston, TX, US)
I am currently Full Professor in the Department of Statistics at Rice University, USA. I received my Ph.D. degree in Statistics in 1996 from the University of Florence, Italy. Prior to joining Rice in 2007 I was in the faculty at Texas A&M University, USA. My research focuses on the theory and practice of Bayesian variable selection techniques and on the development of wavelet-based statistical models and their application. I have published papers in JRSS(B), JASA, Biometrika, Biometrics, Statistica Sinica, JCGS and JSPI. Currently I serve as the Deputy Editor for the journal Bayesian Analysis and as a member of the ISBA Prize Committee (which I chaired in 2008). I was an elected Board Member of ISBA in 2003-2005, an Associate Editor for the Annotated Bibliography section of the ISBA Bulletin in 2005-2007, a member of the Savage Awards Committee in 2005-2006 and of the Mitchell Prize Committee in 2005-2007. See more about me at `http://www.stat.rice.edu/~marina/`.

Board of Directors 20010-2012 (4 openings, listed randomly)

Paul Fearnhead (Lancaster U, UK)
I am professor of statistics at Lancaster University. My main research areas are within computational statistical methods, and in particular sequential Monte Carlo methods. My work has included applications within population genetics, inference for changepoint models, and inference for partially observed diffusions. I have published papers in wide-range of statistics and application-oriented journals, such as JRSS(B) (including two read papers), JASA and Nature Genetics. I am currently associate editor for RSS(B), and serve on the RSS research committee.

David Ríos Insua (U Rey Juan Carlos & Roy Acad Sci, ES)
I am a Professor of Stats and Operations Research at Rey Juan Carlos University in Madrid and a Member of the Royal Academy of Sciences (Spain). My interests are in Decision Theory, Decision Analysis, Negotiation Analysis and Risk Analysis, and their applications. I've published in JASA, Mgt. Science, J. Operational Research Society and many others. Some of my books are: Statistical Decision Theory (Kendall's, with Simon French), Robust Bayesian Analysis (Springer, with Fabrizio Ruggeri) and Bayesian Analysis of Stochastic Processes (Wiley forthcoming, with Mike Wiper and Ruggeri). I hope to contribute to ISBA with my long experience in administration (seven years as uni vicerector for IT) and my entrepreneurial skills (two recent startups in intelligent toys and web based innovation management). I'll try to push promotion of teaching Bayesian analysis, the use of Bayesian thinking in technology and decision analysis within and outside ISBA.

Sid Chib (Washington U, St. Louis, MO, US)
I am delighted to be a candidate for ISBA's board of directors. I am the Harry Hartkopf Professor of Econometrics and Statistics at Washington University in St. Louis. Over the past two decades and more I have been working on various aspects of Bayesian statistics, including the analysis of binary and categorical data, Metropolis-Hastings and MCMC methods, the computation of marginal likelihoods and Bayes factors, hidden Markov and change-point models, stochastic volatility and diffusions, splines and Dirichlet process mixtures, and the problem of causal inference. I have served or serve as an AE of, for example, JASA, JCGS, and Statistics and Computing. For ISBA, I was a member of the Savage

Committee from 1997-2000 and its Chair from 2001-2003. I was also a member of the Publication Committee from 2000-2002 and its Chair from 2003-2005. I am also the Director of the NBER-NSF SBIES conference series. If elected, I would help increase the membership in the Society, and help promote the value of Bayesian thinking in statistics and the applied areas.

Arnaud Doucet (UBC, Vancouver, CA and ISM, Tokyo, JP)
I am currently Associate Professor in the Departments of Computer Science and Statistics of the University of British Columbia. I am especially interested in Bayesian computational methods and have been working extensively on Markov chain Monte Carlo and Sequential Monte Carlo methods. I have been active in organizing workshops and invited sessions on Bayesian statistics and their applications. I have published papers in mainstream statistics journals but also in machine learning, information engineering and applied probability. I would really enjoy supporting ISBA as a member of the Board.

J. Andrés Christen (CIMAT, Guanajuato, MX)
I'm currently a full researcher/professor at CIMAT (Centro de Investigación en Matemáticas, the centre for mathematical research) in Guanajuato, Mexico. My research interests in Bayesian Statistics include applications in radiocarbon dating, clinical trials and ecology, and in the last 14 years I have published articles in main stream Statistical Journals as well as some specialized Journals in the mentioned application areas. Also, I have a research interest in theoretical aspects of MCMC, including MCMC for computationally demanding likelihoods and adaptive algorithms. Regarding my contributions to ISBA, I am the past Editor of the Bulletin and currently part of the organizing committee of ISBA 10. I am very excited to participate as a member of the Board of Directors for the important period of 2010-2012, when we will see the final transition of the traditional Valencia meetings to become the full responsibility of ISBA.

Marco Ferreira (U Missouri, Columbia, MO, US)
I'm an Assistant Professor of Statistics at the University of Missouri, Columbia. My research interests include time series, spatial, spatio-temporal, and multiscale modeling. I co-wrote a Springer book on Bayesian Multiscale Modeling. I have published papers in Biometrika, Bayesian Analysis, Canadian Journal of Statistics, and Journal of Multivariate Analysis. I'm currently an Associate Editor for Bayesian Analysis. I am very excited about the possibility of contributing to the Bayesian community as a member of the Board of ISBA.

Peter Hoff (U Washington, Seattle, WA, US)
I am an Associate Professor of Statistics at the University of Washington in Seattle. My research has recently focused on developing Bayesian methods for multivariate data, including covariance and copula estimation, cluster analysis and the analysis of relational data.

I have just completed an introductory textbook on Bayesian statistical methods, for which the primary target audience includes graduate students in the social, biological and health sciences. I believe that the future of Bayesian inference will be determined in large part by our ability to make basic Bayesian principles and methods accessible and understandable to such an audience.

I have organized several conference sessions, have served on the committees of several workshops, and have been an organizer of the the IMS New Researchers Conference. I am an Associate Editor of the Annals of Applied Statistics and JRSS(B). I have also served on the Lindley and Savage prize committees, as well as been a judge for the ASA's Section on Bayesian Statistical Science's paper competition. I look forward to the possibility of serving on the ISBA Board of Directors.

Raquel Prado (U California, Santa Cruz, CA, US)
I am an Associate Professor in the Department of Applied Mathematics and Statistics at UC Santa Cruz, USA. My research interests include Bayesian nonstationary time series, multivariate time series and statistical genetics. My focus is on developing models and related statistical methodology for the analysis of data in the areas of neuroscience and biology. I have published papers in mainstream statistical journals (e.g., JASA, Series C, Journal of Time Series Analysis, and JSPI) and in neuroscience journals. I am an Associate Editor for JASA and TAS Reviews. I was an Associate Editor of the ISBA Bulletin from 1999 until 2001. I have been a member of the Savage Award Committee and a member of the ISBA Prize Committee. I also served as a member of the Board of ISBA from 2001 to 2003.

ANNOTATED BIBLIOGRAPHY

SOME INTERESTING FACETS OF SPECTRAL ANALYSIS

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Spectral analysis is used to explore the features of a stochastic process in the frequency domain typically via a Fourier transform. Spectral analysis is ideally suited to analyzing periodicities. It is also used for the analysis of dependence inherent in stationary or certain non-stationary processes. For many processes modeling spectra is simpler than modeling, for example, the (auto) covariance function. One application of this is to the study of long memory processes.

In this annotation, after giving some background, I provide some interesting developments of the spectral analysis of stochastic processes. Whenever possible I focus on the Bayesian developments. This is certainly not an exhaustive exploration of the literature.

Background

There are numerous books on spectral analysis. Here is a list that provides both practical and theoretical viewpoints on the topic. Most of these books focus on the spectral analysis of time series. All books introduce the important ideas of tapering (premultiplying the data by certain constants before taking a Fourier transform to reduce the bias in estimating the spectrum) and averaging or smoothing to obtain consistent estimates. Only Percival and Walden introduce the multiple taper method, where the spectral estimates obtained from multiple orthonormal tapers are averaged to yield consistent estimates.

1. Bloomfield, P. (1976), *Fourier Analysis of Time Series: An Introduction*. John Wiley & Sons.

2. Brillinger, D. (1981), *Time Series: Data Analysis and Theory*. Holt, New York.

3. Priestley, M. B. (1981a), *Spectral Analysis and Time Series. (Vol. 1): Univariate Series*. Academic Press, London.

4. Priestley, M. B. (1981b), *Spectral Analysis and Time Series. (Vol. 2): Multivariate Series, Prediction and Control*. Academic Press, London.

5. Bretthorst, G. L. (1988), *Bayesian spectrum analysis and parameter estimation*. Springer-Verlag, New York.

   This book is out of print, but available legally for download from http://bayes.wustl.edu/glb/bib.html.

6. Percival, D. & Walden, A. (1993), *Spectral Analysis for Physical Applications*. Cambridge University Press, Cambridge.

Methods for stationary time series

The foundation stone of time series modeling involves the analysis of stationary processes. While the trend has been to move away from stationary processes, there are plenty of interesting papers in this area. Here follows a sampling.

7. Wahba, G. (1980), "Automatic smoothing of the log periodogram", *Journal of the American Statistical Association*, **75**:122–132.

   This article popularized the standard spectral-based model used for estimating the spectral density. Building on the literature at the time, the key idea is to form a regression model, smoothing some estimate of the logarithm of the spectral density function, assuming independence of the log chisquared errors.

8. Dahlhaus, R. (1987), "Nonparametric spectral analysis with missing observations", *Sankhyā, Series A*, **49**:347–367.

   Indicates how customized tapering can be used for the spectral analysis of time series observed in presence of missing values. It would interesting to contrast this simple approach with Bayesian methodologies.

9. Demoment, G., Houacine, A., & Herment, A. (1988), "Adaptive Bayesian spectrum estimation", In *Proceedings of the Fourth An-*

nual ASSP Workshop on Spectrum Estimation and Modeling, 1988, pages 33–38.

Demonstrates methods of parametric spectral estimation for autoregressive processes, in which smoothness priors are assumed on the Fourier transform of the autoregressive parameters (not on the parameters directly). The autoregressive order is known. This model needs to be contrasted with Huerta and West below.

10. Huerta, G. & West, M. (1999), "Bayesian inference on periodicities and component spectral structure in time series", *Journal of Time Series Analysis*, **20**:401–416.

    Develops Bayesian methods of parametric spectral analysis for high order autoregressive processes. The key idea, building on previous papers, is to decompose the process into latent processes corresponding to the complex and real roots of the characteristic polynomial defining the autoregressive process. The hierarchical prior structure guards against over-fitting, while encompassing certain stationary and nonstationary time series structures. MCMC methods (allowing for missing data) are outlined for posterior inference.

11. Daniels, M. & Cressie, C. (2001), "A hierarchical approach to covariance function estimation for time series", *Journal of Time Series Analysis*, **22**:253–266.

    Starting with a naive estimate, the periodogram, the spectrum is estimated via a Bayesian hierarchical model. An interesting difference from many models is to assume a truncated normal distribution for the fourth root of the estimated spectrum. A true parametric spectrum is assumed (although there is mention of the use of a possible Dirichlet-process prior). They discuss exact Bayesian inference via MCMC, as well as empirical Bayes schemes. The covariance is obtained from a Fourier transform of the spectrum.

12. Denison, D., Mallick, B., & Gangopadhyay, A. (2002), "A Bayesian curve fitting approach to power spectrum estimation", *Journal of Nonparametric Statistics*, **14**:141–153.

    This article blends multiple taper spectral estimation with Bayesian spline models, in order to estimate spectral density function. A reversible jump MCMC scheme is used to move between different numbers of knots and knot placements.

13. Wang, Y., Stoica, P., Li, J., & Marzetta, T. (2005), "Nonparametric spectral analysis with missing data via the EM algorithm", *Digital Signal Processing*, **15**:191–206.

    This article surveys and develops non-Bayesian methods for spectral analysis in the presence of missing data.

14. Botts, C. & Daniels, M. (2006), "A shrinkage estimator for spectral densities", *Biometrika*, **93**:179–195.

    Alters the Cressie and Daniels model above to include more general prior structures, but more importantly averages over different classes of parametric spectra to embrace model uncertainty (autoregressive moving average processes are used). Consistency results are given.

15. Kakizawa, Y. (2006), "Bernstein polynomial estimation of a spectral density", *Journal of Time Series Analysis*, **27**:253–287.

    Kakizawa applies Bernstein polynomial estimation (commonly used for density estimation) to estimating the spectrum. This has obvious Bayesian extensions.

16. Tanaka, F. & Komaki, F. (2008), "A superharmonic prior for the autoregressive process of the second-order", *Journal of Time Series Analysis*, **29**:444–452.

    This article proposes the superharmonic prior as a non-informative prior for spectral estimation of an autoregressive process of order two. It outperforms the Jeffrey's prior in terms of risk. Earlier work by the authors investigate this prior for IID and autoregressive moving average models.

17. Holan, S., McElroy, T., and Chakraborty, S. (2009), "A Bayesian approach to estimating the long memory parameter", *Bayesian Analysis*, **4**:159–190.

    Uses a spectral-based semiparametric Bayesian model for estimating the parameters of a long memory process. The model captures model uncertainty by assuming a prior on the number of components in the parametric spectral density function for a fractional exponential process.

Local spectral analyses

Traditionally spectral analysis is carried out on stationary processes. Steady movement has been made to analyzing processes that are locally stationary, usually in time (for spatial extensions see the "Spatial and spatio-temporal methods" sections below). Here are some interesting developments in this field. I have restricted this study to Fourier methods – wavelet methods are also commonplace.

18. Priestley, M. B. (1965), "Evolutionary spectra and non-stationary processes", *Journal of the Royal Statistical Society. Series B*, **27**:204–237.

    Introduces the important idea of a spectrum that varies in time (the evolutionary spectrum).

19. Huang, N., Shen, Z., Long, S., Wu, M., Shih, H., Zheng, Q., Yen, N., Tung, C., and Liu, H. (1998), "The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis", *Proceedings of the Royal Society of London. Series A*, **454**:903–995.

    The Hilbert spectrum outlined in this paper is a generalized Fourier expansion, indexed in time and frequency. This methodology is commonly used in many areas for the analysis of non-stationary processes.

20. Qi, Y., Minka, T., & Picard, R. (2002), "Bayesian spectrum estimation of unevenly sampled nonstationary data", *IEEE International Conference On Acoustics Speech And Signal Processing*, **2**:100–122.

    A time-varying sine/cosine basis forms the model used to investigate time-varying amplitudes and phases. The Bayesian hierarchical model assumes that the latent regression coefficients follow a Gaussian random walk. Inference proceeds using Kalman filtering. The number of basis functions and frequencies are assumed known. (This may be hard to know in advance).

21. Guo, W., Dai, M., Ombao, H., and Sachs, R. V. (2003), "Smoothing spline ANOVA for time-dependent spectral analysis", *Journal of the American Statistical Association*, **98**:643–652.

    Defines the SLEX basis that can be used for constructing time-frequency SLEX periodograms of locally stationary processes. Theory and methods are given for the estimation of smoothed time-frequency spectra.

22. Rosen, O., Stoffer, D. S., and Wood, S. (2009), "Local spectral analysis via a Bayesian mixture of smoothing splines", *Journal of the American Statistical Association*, **104**:249–262.

    Starting with a clear review of the use of Bayesian smoothing methods for the estimation of the logarithm spectral density function for stationary processes, the authors extend the methodology to the analysis of locally stationary processes. The logarithm of the local spectral density function in defined in terms of a countable mixture of common spectral components. The sampling scheme is carefully detailed.

23. Dahlhaus, R. and Polonik, W. (2009). "Empirical spectral processes for locally stationary time series", *Bernoulli*, **15**:1–39.

    This highly theoretical paper provides empirical process theory for the spectra of locally stationary processes. The functional central limit theorem provided in this paper has ramifications for moving away from the approximate independent models that are commonly assumed when modeling (locally) spectral densities.

Spatial and spatio-temporal methods

The spectral analysis of spatial and spatio-temporal datasets has had a rather stunted history. This is possibly due to lack of densely sampled data that is required for spectral analysis. This type of data is now commonplace. Here are some of the interesting (however non-Bayesian) developments in this area.

24. Priestley, M. B. (1964), "The analysis of two-dimensional stationary processes with discontinuous spectra", *Biometrika*, **51**:195–217.

    This paper advances spectral analysis for a two-dimensional discrete-indexed stationary process. The key development over earlier papers is to consider inference for mixed spectra; i.e., possible unknown harmonic components observed in the presence of stationary noise.

25. Bartlett, M. S. (1964), "The spectral analysis of two-dimensional point processes", *Biometrika*, **51**:299–311.

    Bartlett extends his previous work on the spectral analysis of stationary univariate point processes to stationary bivariate processes. He applies the methodology to studying the spatial patterns of pine saplings.

26. Renshaw, E. & Ford, E. D. (1983), "The interpretation of process from pattern using two-dimensional spectral analysis: Methods and problems of interpretation", *Applied Statistics*, **32**:51–63.

    This article discusses more of the practicalities of spectral analysis of two-dimensional discrete-indexed stationary processes. They demonstrate that a spectral analysis expressed in terms of polar components may be more useful in some applications.

27. Mugglestone, M. & Renshaw, E. (1996), "A practical guide to the spectral analysis of spatial point processes", *Computational Statistics and Data Analysis*, **21**:43–65.

    This article mimics the Renshaw and Ford paper, applied to point processes.

28. Stein, M. (1995), "Fixed-domain asymptotics for spatial periodograms", *Journal of the American Statistical Association*, **90**:1277–1288.

    Provides theory for estimating spectra using the spatial periodogram in the fixed domain (infill) asymptotic case of a stationary process observed on two-dimensional grids. Some results require the extra assumption of a Gaussian process.

29. Kim, H.-J. & Fuentes, M. (2000), "Spectral analysis with spatial periodogram and data tapers", In *Proceedings of the Joint Statistical Meeting 2000, American Statistical Association*, pages 88–92.

    Develops the spectral analysis of a stationary Gaussian random field observed in $\mathbb{R}^2$. Introduces tapered spectral estimators in this setting. The theory is given for data observed on a grid.

30. Fuentes, M. (2002), "Spectral methods for nonstationary spatial processes", *Biometrika*, **89**:197–210.

    Extends Kim and Fuentes to the analysis of nonstationary spatial processes observed on $\mathbb{R}^2$. Via infill arguments, develops theory for nonparametric and parametric spectral analysis.

31. Fuentes, M., Guttorp, P. & Sampson, P. (2007), "Using transforms to analyze space-time processes", In B. Finkenstadt, L. Held, and V. Isham (Eds.), *Statistical Methods for Spatio-Temporal Systems*, 77–150. Boca Raton, FL.: Chapman & Hall/CRC.

    In addition to a discussion of wavelet-based methods, this article lays out spectral analysis for space-time processes. The models introduced do not treat space and time differently.

32. Ombao, H., Shao, X., Rykhlevskaia, E., Fabiani, M., & Gratton, G. (2008), "Spatio-spectral analysis of brain signals", *Statistica Sinica*, **18**:1465–1482.

    Delivers the theory for spatially-varying spectra of space-time processes. In particular considers estimating the spectra of spatially-varying temporal linear processes via time-lag window plus spatial smoothing. (This can lead to interesting tradeoffs in practice).

BAYESIAN HISTORY

THE BAYESIAN SUCCESS HISTORY IN RADIOCARBON DATING

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Radiocarbon dating is a technique for dating organic matter. Upon entering the atmosphere, cosmic radiation breaks nitrogen atoms forming carbon-14 (^{14}C). Through photosynthesis, ^{14}C is then mixed into the biosphere and into all living organisms. ^{14}C is a radioactive isotope of C and decays at a constant rate; a constant decay and a constant production rates lead to a theoretically constant $^{14}C/C$ ratio in the biosphere. However, when a living organism stops metabolizing (i.e. it dies), no more ^{14}C is added and its $^{14}C/C$ ratio begins to decrease. By measuring the $^{14}C/C$ ratio of a sample, and comparing it with the current atmosphere's $^{14}C/C$ ratio, one can estimate (by the law of exponential decay) the time elapsed since the sample died. With a half life of 5730 years, ^{14}C is especially suited as a dating technique for ages of up to 20,000 years (in fact, dates can be obtained up to 50,000 years of age), and therefore is ideal for archaeology or palaeoecology studies: the near geological past, after the last glaciation (see Bowman, 1990, for a better explanation of radiocarbon dating).

The first difficulty in radiocarbon dating is that the atmosphere's $^{14}C/C$ ratio has not remained constant through time: cosmic radiation has varied due to a multitude of factors, and a "Modern Standard" ratio is used to estimate a rough approximate date only. Since the 1970s a great deal of effort has been directed at radiocarbon dating long series of dendrochronologically dated samples (ie. tree-ring dated wood samples) to obtain a "calibration curve". The second difficulty inherent in radiocarbon dating is measuring the sample's $^{14}C/C$ ratio. A (direct or indirect) counting process is involved and therefore it is measured with error. The third difficulty, only recently acknowledged, is that in achaeology or palaeoecology, individual dates of fossil organic samples (eg. seeds, plants, insects, etc.) are only of marginal interest. Rather, the main interest is dating the context in which these samples belong and indeed a further statistical analysis is required.

The involvement of Bayesians in radiocarbon dating actively began in the late 1980s and early 1990s (Naylor and Smith, 1988; Litton and Leese, 1991). In the early 1990's, pioneer usage of MCMC (Gibbs sampling) permitted the consideration of far more sophisticated analysis than with other alternatives (Buck, Litton and Smith, 1992; submitted in May 1991). At the same time, user friendly software for the Bayesian analyses of radiocarbon determinations became available, allowing users to define complex models and to tackle the problem of dating the underlying context of interest instead of simply "calibrating" individual ^{14}C measurements. Today, most statistical analysis of radiocarbon dates is essentially Bayesian, most of those analyses done by non-experts through user friendly software (see for example, Stuiver and Reimer, 1993; Buck, Christen, and James, 1999; Christen, 2003; Blaauw and Christen, 2005; Haslett and Parnell, 2008; http://c14.arch.ox.ac.uk/oxcal.html, http://bcal.shef.ac.uk/, http://cran.r-project.org/web/packages/Bchron/index.html).

Regarding the calibration curve, formerly it was basically the raw data and people used to "join the points" to obtain interpolated values. In 2004 a calibration curve was created (Buck and Blackwell, 2008) using a random walk type model which is basically a representation of the posterior distribution of the calibration model used. This resulted in the internationally agreed radiocarbon calibration curve or INTCAL04 (http://www.radiocarbon.org/IntCal04.htm; Reimer et al., 2004).

With respect to the measuring errors in the dating process, radiocarbon laboratories use simple techniques to produce the reported error. It is common that contamination of samples, and/or problems in other parts of the chemical and physical aspects of the radiocarbon dating process, result in the production of outliers. Bayesian methods have been developed to help laboratories more systematically assess their dating errors. Also, an integrated approach to outlier detection is in common use, where the posterior probability for each determination to be an outlier is calculated (using MCMC), conditional on the current data set used and on the prior information provided (Christen, 1994; Bronk Ramsey, 2009). Moreover, using a Bayesian approach an alternative, more robust, model for radiocarbon data has been proposed that might be capable of accommodating the long standing "unexplained scatter" seen in inter–laboratory comparisons (Christen and Pérez E., 2009).

The third and statistically most fertile part in the analysis of radiocarbon determinations is inferring the relevant context ages from dates of individual objects or samples. The link needed in relating samples to contexts comes in naturally as a prior distribution, commonly in terms of a hierarchical model or a complex non-linear regression. Creating user friendly software to define such complex models by non-experts has been a great challenge. Also, designing robust MCMC algorithms and automatic convergence tests have been critical and, up to some extent, show that MCMC applications may be coded and distributed to be used by non-specialists. For example, let's imagine that samples such as seeds, bones, etc. are extracted from various layers of a pyramid. It is known that inner layers belong to earlier periods than outer layers and therefore samples should conform to a chronological order. In turn, the pyramid may be related to other structures or sites in various ways. A complex hierarchical model needs to be defined to perform an analysis of the radiocarbon data in accordance with the known archaeological context. The software needs to able to handle this, automatically define the MCMC algorithm to be used and analyze its output. There are a large number of applications using Bayesian analysis of radiocarbon dating in world archaeology (see Beramendi-Orosco *et al.*, 2009, just to mention one recent representative example).

Another very active field that uses radiocarbon dating is palaeoecology, the ecology and climate of the near past. Peat and lake core samples are radiocarbon dated and an age–depth model is needed to infer the core ages at every depth (Blaauw and Christen, 2005; Haslett and Parnell, 2008). This in turn is used to estimate (among other things) the time elapsed between recorded events in the peat or lake cores. For example, the disappearance of a species of pollen at certain depth ranges might be related to (local, regional, or global?) wetter or drier periods. Establishing how fast these natural climate changes occurred is a very relevant question in today's climate change research. Again, Bayesian analyses in this area are gaining a lot of popularity and specialized software is also available. Of particular impact in this case is assessing and formally integrating all sources of error. Representing and dealing with the whole posterior distribution, instead of point estimates only, have suggested the potential limits and resolution of radiocarbon studies in this field (Blaauw *et al.*, 2007).

As opposed to some other application areas, Bayesian approaches are welcome in the analysis of radiocarbon dates and the amount of end users might range in the several hundreds. Nevertheless, only a handful (literary) of statisticians are actively working in this field. There is indeed considerable space for many more Bayesian statisticians to benefit from this fruitful field and help further the impact Bayesian statistics has had on radiocarbon dating.

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APPLICATIONS

Statistics for Computational Advertising

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As users continue to spend more time on the web, advertisers are shifting a large fraction of their campaign budgets to online advertising. There are three main players in an online advertising marketplace - publishers who own the content consumed by users, advertisers who promote their products to users, and ad-networks who are commercial intermediaries in charge of *matching* ads to user visits on publisher sites, with the twin goal of increasing revenue (shared between publisher and ad-network) and improving user experience. Large ad-networks like Yahoo!, Google, MSN typically perform billions of ad matches on a daily basis, these are done algorithmically in an automated fashion for scalability and profitability. The algorithmic match-making process is a highly complex one and has given rise to a new scientific discipline called "Computational Advertising", an inter-disciplinary area at the intersection of large scale search and text analysis, information retrieval, statistical modeling, machine learning, optimization and microeconomics. In this article, I provide a brief introduction to computational advertising and discuss some challenging statistical problems that are crucial to the success of an online advertising system.

Online advertising is practiced under different revenue models, advertisers choose the appropriate one depending on the goal of their campaign. Broadly speaking, there are three important revenue models. a) Pay-per-Click (PPC) where an advertiser pays only if the user clicks on its ad. b)Pay-per-Action (PPA) where payment is made only if the user after being redirected to the advertiser site registers a sale in some form (called conversion). c) Cost-per-Millie (CPM) where an advertiser pays if an ad is merely displayed to a user belonging to a certain demographic group that is specified a-priori. Note that both PPC and PPA models are based on ad performance and transfers the risk to the publisher while in the CPM model, the risk is entirely owned by the advertiser. Several ad-networks also use other revenue models where the risk is shared by both publisher and advertiser (e.g. CPM with guarantees of a certain number of clicks/conversions during campaign lifetime), this is a rapidly evolving area in the advertising marketplace.

Typically, PPC and PPA are commonly associated with small textual ads either displayed in response to a query issued by a user to a search engine (Sponsored Search) or on a peripheral location of a webpage when a user is browsing (Contextual Advertising). The CPM model is typically associated with graphical ads targeted to some user population where the main goal is to create "brand awareness" and increase customer "reach". Typically, display advertising comes in two flavors - Guaranteed and Non-guaranteed. In Guaranteed delivery, advertiser and the ad-network enters into a contract that specifies the target population, time interval, content site and number of visits that has to be delivered by the ad-network at the agreed price; no such guarantee is provided for Non-guaranteed contracts where visits are typically sold instantaneously on the spot market. For instance, Netflix may want to make an advance booking for an ad slot of 10M visits on Yahoo! finance by young males in California at CPM of 2 dollars. Depending on the demand, the ad-network may or may not accept the request at the proposed price. In general, CPM's paid for Guaranteed delivery are substantially higher, it is also important for ad-networks to deliver high quality inventory for these contracts to preserve the premium quality of the Guaranteed delivery product. Another method that has become popular for selling Non-guaranteed display ads is the Exchange model, an open marketplace where publishers and advertisers are connected through a large set of ad-networks (example of such an exchange is RightMedia). Since a proper discussion of every aspect of Computational Advertising is not possible in a short article, I will primarily focus on Sponsored Search and Contextual advertising and discuss the statistical problem of estimating click-rates of ads when displayed for a given *opportunity* (a user visit for which an ad call is made to the online advertising system).

Sponsored Search: This form of advertising is used when a user issues a query to a search engine. Along with search results (set of documents that are relevant to the query), several sponsored links that are typically small textual ads appear at a few positions on the page (e.g. North, East). For popular search engines like Google and Yahoo!, the set of candidate ads that are potentially relevant for a given query far exceed the available slots on the search results page, hence it is imperative to have a selection criterion to pick the top-k from a large pool of ad inventory. A first stage pruning criteria is facilitated by the advertiser who associates a set of "keywords" with each ad (e.g. coffee, Columbian, Mountain View) along with a *bid* amount. For a given opportunity that comes with an user-specified query, the ad-network finds a match against the specified keywords to obtain a relevant set of candidate ads. The matching process is conducted using several methods that are commonly referred to as exact matches, broad matches [10]. The selected ads for a given opportunity are ranked through an online auction that is based on some function of click-rates (CTR) and bids. For instance, expected revenue (CTR*bid) is a commonly used function. Other considerations (like ad quality) can also be factored into this formula to ensure quality ads get selected (e.g. an ad promising a 20 dollar coupon may click well but install spyware on the user's computer). The payout that accrues when an ad is clicked is typically determined through a generalized second price auction[7] to ensure stability. In earlier versions of Sponsored Search, the ranking of ads was based only on bids and payout was through a first price auction, this lead to several problems. For a detailed historical account on Sponsored Search, I refer readers to [8].

Contextual Advertising: Here, ads are displayed when a user is browsing through a webpage and does not directly specify a query (e.g. reading a New York Times article). This is a harder problem since one has to infer user's query intent indirectly through the page content and other related information (e.g. browse history). Matching ads based on relevance is more involved in this case compared to Sponsored

Search and is typically approached through several information retrieval techniques[5].

Several statistical problems arise in the context of both Sponsored Search and Contextual Advertising, instead of listing them all we only discuss the key problem of estimating click-rates when an ad is displayed at a particular position on a page for a given opportunity. Let y_{ijp} denote the binary response (click or no-click) when ad j is served to opportunity i at position p of the page. Exposure to an ad vary substantially by position, everything else being equal an ad placed on a high exposure position has higher click-rates (e.g North position in Sponsored Search has higher click-rates than East). Let $y_{ijp}|P_{ijp} \sim$ Bernoulli(P_{ijp}). The goal is to estimate the click-rates P_{ijp} from large amounts of data obtained continuously from the system. One can further decompose the opportunity i as u, q, where u and q denote the user and query respectively. A rich set of covariates $\mathbf{x}_u$, $\mathbf{x}_q$ and $\mathbf{x}_j$ are generally available. For instance, $\mathbf{x}_u$ may include user demographics and browse history,$\mathbf{x}_q$ are predictors extracted from the query through text mining techniques and $\mathbf{x}_j$ includes advertiser keywords, title, description along with predictors extracted from the landing page of the ad url. Moreover, distribution of opportunities and ads typically have a power law form, i.e., a small fraction (head and torso queries) account for a large fraction of data while the remaining (tail queries) accounts for the rest[15]. Furthermore, the system is dynamic both in that click-rates change over time and there is a constant churn of opportunities and ads. An ideal model would estimate click-rates using MLE in data rich regions but fall back on a covariate-based regression in regions of data sparseness. Hence, multi-level hierarchical models form an attractive class of methods. However, the scale of the problem (billions of observations with potentially millions of predictors to choose from, extreme heterogeneity, dynamic systems) makes model fitting challenging. In fact, the usual paradigm of computation that assumes all data can fit into memory is not applicable, distributed programming in a Map-Reduce paradigm [9] that parallelizes computations across a large set of commodity PC's provides a scalable approach. This requires new statistical model fitting approaches that can be used in a Map-Reduce paradigm. Other than issues related to scalability and low signal-to-noise ratio, there are several other aspects that make the aforementioned problem challenging, described below.

Displaying ads to opportunities is a sequential process, the click-rate estimate is one of the inputs that decides what gets displayed. Ideally, one would like to obtain unbiased estimates of ad-quality at a particular position for a given opportunity, this is however difficult since models are built through retrospective data where high exposure positions tend to get better ads. Strategies pursued to mitigate this positional bias typically assume a multiplicative model, i.e., $P_{ijp} = a_p.Q_{ij}$ and the global constants are estimated from data [14, 6]. In Sponsored Search, it is also customary to estimate the positional constant in an unbiased way through eye-tracking studies [14]. However, such a model is not appropriate for contextual advertising where ad layout on a webpage may have substantial variance (see [3] for more discussion). The interpretation of negatives is also noisy, a user reading a webpage may have not clicked either because he/she was not interested in looking at ads at all or perhaps the ad was not relevant. Another problem that adds to the noise is low click-rates (especially for contextual advertising).

Evaluating model performance is non-trivial. Usual statistical measures that quantify out-of-sample prediction error are not entirely reflective of quality since the goal is to converge to high click-rate ads, a large error in predicting a low CTR ad for an opportunity where a high quality ad is available may not hurt performance. Variation in advertiser bids further complicate the issue. In general, running side-by-side experiments comparing a new model with the control helps in reliably selecting a new method. Existence of such an experimental infrastructure also enables conducting experiments on small fraction of opportunities to expedite the convergence to best ads. For instance, [13, 12] describe Bayesian sequential designs conducted in a multi-armed bandit framework. An experimental design infrastructure used at Google is described in [11]. The ability to conduct experiments on a small fraction of opportunities to maximize overall system revenue provides a new research problem of optimally blending sequential designs with modern statistical models.

On the modeling side, logistic regression has become popular [14, 6]. In [1, 16], a scalable nested random-effects model fitted through a multi-scale Kalman filter exploits the hierarchical structure on the query and ads. Another class of models that are increasingly becoming popular [4, 2] are based on latent factors where

$$log(Q_{ij}) = X'_{ij}\beta + \mathbf{u}'_i A \mathbf{v}_j,$$

and the random effects $\mathbf{u}_i$'s and $\mathbf{v}_j$'s are assumed to be drawn from a Gaussian prior with mean given by some function of covariates. Here, β correspond to fixed effects for covariates X_{ij}. This is still a relatively new area with a rich set of difficult statistical modeling problems. Modern techniques based on Bayesian non-parametrics are germane in this context but the scale of the problem makes it challenging to apply, scalable approximations that work in a Map-Reduce paradigm are key.

To summarize, online advertising is already a multi-billion dollar industry that is likely to grow rapidly with users spending more time on the web. It has given rise to an exciting and highly interdisciplinary scientific discipline of Computational Advertising that can benefit immensely from state-of-the-art statistical methods. In this article, I have provided only a glimpse of some of the challenges. A NISS workshop on this topic will be held in November 2009.

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SOFTWARE HIGHLIGHT

tgp: AN R PACKAGE FOR NONLINEAR REGRESSION BY TREED GAUSSIAN PROCESSES

by Robert B. Gramacy

The tgp package [6] contains implementations of seven related Bayesian multivariate regression models, with hooks for sequential design, optimization, and the analysis of sensitivity to inputs. The regression models combine treed partition models, linear models (LM), and stationary Gaussian process (GP) models. GPs are flexible (phenomenological) priors over functions which, for computational reasons, are usually relegated to smaller applications. Whereas trees are a crude but thrifty divide–and–conquer approach to nonstationary regression with interpretive strengths. When combined they are quite powerful.

The GP is a prior over functions $Z : \Re^p \rightarrow \Re$ such that the function values at any finite set of points has a multivariate normal (MVN) distribution. As such, a particular GP is characterized by its mean function $\mu(x)$ and its covariance function $C(x, x')$, the parameterizations of which define the GP. Common choices for the correlation component of the covariance, such as the exponential and Matérn families, lead to stationary processes. This means that the nature of the correlation structure cannot vary over the input space. Another drawback to the GP is that it requires the inverse of an $N \times N$ covariance matrix—a serious computational burden.

Partitioning the predictor space can address both drawbacks. Fitting independent models in different parts of the input space facilitates nonstationarity and leads to smaller local covariance matrices. The treed Gaussian process (TGP) results [4] when the partitioning is accomplished by recursive axis–aligned splits, i.e., by trees. In this sense, TGP extends the treed constant and linear models of Chipman et al. [1, 2]—special cases of a GP—by specifying a prior over a tree process, and performing posterior inference on the joint tree and (leaf) models. The tgp package supports all special cases of the GP leaf model, with and without the tree. To illustrate, consider Figure 1 (a), which was generated in R as follows.

```
R> library(tgp)
R> library(MASS)
R> x <- mcycle[,1]; y <- mcycle[,2]
R> plot(x, y)
R> flm <- blm(x, y)
R> lines(x, flm$Zp.mean)
R> fgp <- bgp(x, y)
R> lines(x, fgp$Zp.mean, lty=2, col=2)
R> fcart <- bcart(x, y)
R> lines(x, fcart$Zp.mean, lty=3, col=3)
R> ftlm <- btlm(x, y)
R> lines(x, ftlm$Zp.mean, lty=4, col=4)
R> ftgp <- btgp(x, y)
R> lines(x, ftgp$Zp.mean, lty=5, col=5)
R> legend("bottomright", c("lm", "gp",
 +         "cart", "tlm", "tgp"),
 +         lty=1:5, col=1:5)
```

The mean predictive surfaces for the GP and TGP models look similar. However the full predictive distributions are indeed quite different. Consider the predictive variances in Figure 1 (b), generated by:

```
R> plot(x, ftgp$Zp.s2, type="l",
 +       lty=5, col=5)
R> lines(x, fgp$Zp.s2, lty=2, col=2)
R> tgp.trees(ftgp, height=3)
```

The (two) regime changes from the treed partition are clear in the figure.. The MAP tree under the TGP model is shown in Figure 1 (c).

The ability to infer a spatially varying predictive variance makes the TGP model perfect for sequential design. The predictive variance, and expected reduction in predicted variance (called ALC) can be assessed at a set of candidate locations, with the largest (of the respective statistics) used to select the next design point. Both statistics are available in closed form for the GP. The code below shows how the latter can be extracted in tgp, with a plot in Figure 1 (d).

```
R> r <- range(x)
R> XX <- seq(r[1], r[2]), length=1000)
R> ftgp <- btgp(x, y, XX=XX, Ds2x=T)
R> plot(ftgp, layout="as", as="alc",
 +       pparts=F)
```

We can see from the figure that the two different approaches can lead to different sequential designs. Repeated applications lead to designs which focus input locations where the model is least able to predict accurately. This approach was used to design a computer experiment for a rocket booster [5].

It is also possible to use `tgp` for optimization, i.e., to find the minimum of a noisy function. This may be facilitated by the expected improvement statistic using the argument `improv=TRUE` similar to ALC, above. This approach was used to determine the optimal robust configuration of a circuit device [7].

The `tgp` package contains many other features including the ability to detect linearity in regions and/or dimensions of the input space through the limiting linear model, hooks to create maximum entropy designs, perform sensitivity analyses, use categorical inputs, and compile the code for parallel execution via `pthreads`. In addition to the usual R documentation, the package is supported by two detailed tutorials as vignettes, authored in `Sweave`, with extensive code examples. `vignette("tgp")` covers all of the basics [3]; `vignette("tgp2")` covers some fancy extensions.

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[3] Robert B. Gramacy. `tgp`: An R package for Bayesian nonstationary, semiparametric nonlinear regression and design by treed gaussian process models. *J. of Stat. Soft.*, 19(9), 2007.

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[6] Robert B. Gramacy and Matt A. Taddy. `tgp`*: Bayesian treed Gaussian process models*, 2008. R package version 2.1-2.

[7] Matthew Taddy, Herbert K. H. Lee, Genetha A. Gray, and Joshua D. Griffin. Bayesian guided pattern search for robust local optimization. *Technometrics*, 2009. to appear.

STUDENTS' CORNER

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This Students' Corner features the dissertation abstract of recent Telecom ParisTech and University Pierre and Marie Curie graduate Julien Cornebise. If you are newly graduated and would like to publish your thesis abstract, don't hesitate to contact me.

Dissertation Abstracts

ADAPTIVE SEQUENTIAL MONTE CARLO METHODS

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This dissertation focuses on the study and development of sequential Monte Carlo algorithms (*SMC*), also known as *particle algorithms*. We center on the conception and design of adaptive algorithms that are able to automatically tune key parameters such as the *adjustment multiplier weights* (or "first stage weights") or the *proposal kernel* of the auxiliary particle filter's (APF). We aim for the optimal choice in terms of computational efficiency and accuracy of the resulting estimates; this optimality is mathematically formalized by criteria whose study is also discussed in this work.

We first bring a theoretical study of existing

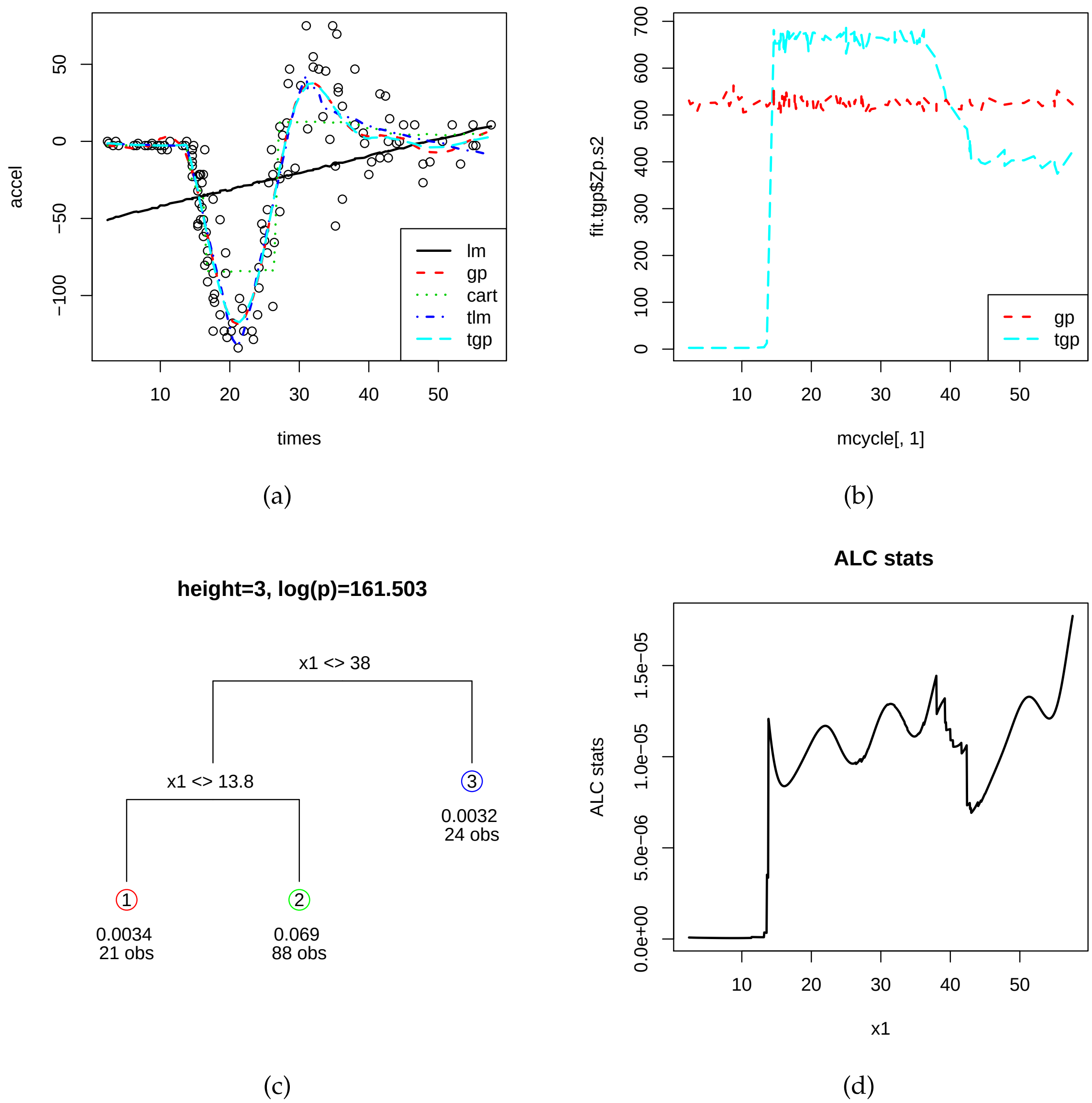


Figure 1: (a) Comparing mean predictive surfaces; (b) Predictive variance under the T/GP; (c) MAP under the TGP model; (d) Expected reduction in predictive variance

practices, most notably through an asymptotic analysis of criteria such as the *coefficient of variation* and the *entropy* of the importance weights, which have been so far mostly used on an empirical basis. We show their link to χ^2 and Kullback-Leibler divergences, respectively, between two distributions that we make explicit. We also develop new criteria with properties better suited to the purpose, specifically decoupling the adaptation of the adjustment multiplier weights and of the proposal kernel and allowing for more efficient optimization.

Based on this theoretical ground, we establish new algorithms likely to be used on today's most intricate models, keeping in mind the mandatory computational efficiency of the fundamentally iterative SMC methods. Regarding the adaptation of the adjustment multiplier weights, we propose and analyze a *refueling* algorithm combined with a *pilot sample*. To achieve the theoretical analysis of these algorithms, we first establish the convergence of the APF with random adjustment multiplier weights.

Finally, we adapt the proposal kernel by fitting a parametric mixture of kernels, closely connected to the *mixture of experts* from machine-learning. The components' kernels belong to the broad class of *integrated* curved exponential family, richer than the more classical exponential family. The weights of the mixture stem from a logistic regression, that partitions the space of the original particles into subregions to which are assigned a few specialized kernels. The flexibility of this family allows for fitting highly nonlinear and multi-modal distributions. The optimization algorithm presented is inspired by Stochastic Approximation EM, Monte Carlo EM, and Cross-Entropy method. We illustrate its performance, in terms of KLD reduction and impact on the importance weights, on several thoroughly examined numerical examples.

NEWS FROM THE WORLD

Announcements

I would like to encourage those who have any announcements or would like to draw attention to an up-coming conference, to get in touch with me and I would be happy to place them here.

2010 Valencia Conference

This is to announce that the Ninth Valencia International Meeting on Bayesian Statistics and the 2010 ISBA World Meeting will jointly be held in Benidorm (Alicante, Spain), June 3rd to June 8th, 2010. As already announced in Valencia 8, this will be the last Valencia meeting personally organized by José M. Bernardo (who will be 60 when the conference takes place). After Valencia 9, the Valencia meetings will become regular ISBA World Meetings (which will not necessarily take place in the State of Valencia). ISBA world meetings will therefore take place every two years.

For more information visit the website, http://www.uv.es/valenciameeting

Events

2010 Bayesian Biostatistics Conference, Houston, Texas. 27-29th January, 2010.

Current and prospective users of Bayesian biostatistics are invited to join experts in the field for a three-day conference sponsored by the Department of Biostatistics at The University of Texas M. D. Anderson Cancer Center in Houston, Texas, USA. Attendees will have the opportunity to attend two courses on the first day of the conference (Wednesday): The Use of Bayesian Statistics in Clinical Trials, and Applications of Bayesian Methods to Drug and Medical Device Development. On Thursday and Friday, invited presentations will cover a variety of topics, possibly including comprehensive decision modeling; using predictive probabilities in clinical studies and drug development; roles for hierarchical modeling; how Bayesian methods can be used to augment traditional methods; Bayesian methods in epidemiology; the Bayesian approach and medical ethics; how to assure good quality and scientific rigor in taking a Bayesian approach; and guidelines for publishing Bayesian analyses. Registration fees will be modest. Program co-chairs: Donald A. Berry, Ph.D., The University of Texas M. D. Anderson Cancer Center, and Telba Z. Irony, Ph.D., Center for Devices and Radiological Health, U.S. Food and Drug Administration.

Information will be available at http://biostatistics.mdanderson.org/BBC2010/

Frontiers of Statistical Decision Making and Bayesian Analysis, San Antonio, Texas. 17-20th March, 2010.

This conference consists of plenary, invited and poster sessions. Plenary speakers include Donald Berry, Lawrence Brown, Persi Diaconis, Stephen Fienberg, and Alan Gelfand. The conference will provide an overview of past, present and future developments of statistical decision making and Bayesian analysis. Prior to the conference, short courses on various statistical topics will be offered.

For more information visit the website, http://bergerconference2010.utsa.edu/.

10th Bayesian Statistics Brazilian Meeting, Green Coast, Brazil. 21-24th March, 2010.

The 10th EBEB will take place at Portogalo Suites Hotel, located in the pleasant Green Coast area of the State of Rio de Janeiro, Brazil. It is about 150km far from the city of Rio de Janeiro. In this 10th edition, we aim to discuss recent developments in the area both from the methodological and computational points of view. These developments will be presented and discussed by leading researchers in the world with a short course, 13 plenary talks, 8 oral presentations and 2 poster sessions. Since its 6th edition, EBEB is organized by ISBrA, the Brazilian chapter of ISBA, EBEB X is supported by ISBA.

Submissions and registration can be made at www.dme.ufrj.br/ebebx.

ISBA

INTERNATIONAL SOCIETY FOR BAYESIAN ANALYSIS

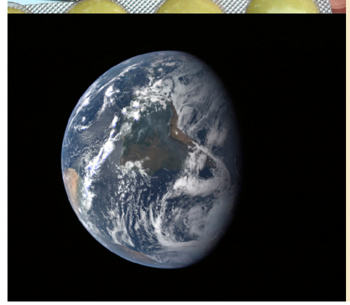
The International Society for Bayesian Analysis (ISBA) was founded in 1992 to promote the development and application of Bayesian analysis useful in the solution of theoretical and applied problems in science, industry and government. By sponsoring and organizing meetings worldwide, publishing the electronic journal of Bayesian statistics "Bayesian Analysis", administering professional prizes and travel awards as well as other activities, ISBA provides a focal point for those interested in Bayesian analysis and its applications.

2010 ISBA World Meeting & Ninth Valencia Conference Announcement

This is to announce that the 2010 ISBA World Meeting and the Ninth Valencia International Meeting on Bayesian Statistics will be held jointly in Benidorm (Alicante, Spain), June 3rd to June 8th, 2010.

This will be the last meeting in the Valencia series, and from 2010 on the ISBA World Meetings will be held every two years. The venue of the 2012 World Meeting will be decided based on proposals from members worldwide; a call for proposals will appear later in 2009.

Visit the ISBA website at www.bayesian.org



ISBA Publications:

Bayesian Analysis, the online journal sponsored by ISBA, and fast becoming the premier outlet for leading contributions to Bayesian research. A hard-copy version of the journal is anticipated soon.

ISBA Bulletin, the quarterly newsletter emailed to ISBA members, containing a wealth of information about statistics, meetings, prizes, networking, opportunities, and other areas of interest.

ISBA Website, the primary source of information on ISBA and all things Bayesian.

ISBA International Local Chapters:

ISBA promotes and supports the development and activities of local chapters of Bayesian statisticians around the world.

ISBA Prizes:

ISBA co-sponsors and administers the premier international prizes for achievements in the field of Bayesian statistics broadly. These include:

The DeGroot Prize (for a book in statistical science)
The Lindley Prize (for a contributed paper at an ISBA world meeting)
The Mitchell Prize (for a Bayesian analysis of an important applied problem)
The Savage Award (for outstanding doctoral dissertations).

ISBA Awards:

ISBA maintains a number of funds to offer travel awards, including the ISBA Student and New Researcher award, the ISBA Lifetime Members Junior Researcher award, and the Pilar Iglesias award for young researchers from developing countries. These awards provide financial support for many new and junior researchers to travel to ISBA World Meetings.