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Case Studies in Bayesian Statistics

Volume IV

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Preface

The 4th Workshop on Case Studies in Bayesian Statistics was held at the Carnegie Mellon University campus on September 27-28, 1997. As in the past, the workshop featured both invited and contributed case studies. The former were presented and discussed in detail while the latter were presented in poster format. This volume contains the four invited case studies with the accompanying discussion as well as nine contributed papers selected by a refereeing process. While most of the case studies in the volume come from biomedical research the reader will also find studies in environmental science and marketing research.

INVITED PAPERS

In *Modeling Customer Survey Data*, **Linda A. Clark, William S. Cleveland, Lorraine Denby,** and **Chuanhai Liu** use hierarchical modeling with time series components in for customer value analysis (CVA) data from Lucent Technologies. The data were derived from surveys of customers of the company and its competitors, designed to assess relative performance on a spectrum of issues including product and service quality and pricing. The model provides a full description of the CVA data, with random location and scale effects for survey respondents and longitudinal company effects for each attribute. In addition to assessing the performance of specific companies, the model allows the empirical exploration of the conceptual basis of consumer value analysis. The authors place special emphasis on graphical displays for this complex, multivariate set of data and include a wealth of such plots in the paper.

The advent of functional neuroimaging has revolutionized the study of the brain in recent years. The new technology generates enormous sets of data with intricate spatio-temporal patterns. The significant statistical challenges presented by such data are discussed in *Functional Connectivity in the Cortical Circuits Subserving Eye Movements* by **Chris Genovese** and **John Sweeney**. Since eye movement abnormalities provide a commonly used marker for several neurologic and psychiatric disorders, the study of how the brain controls eye movements is important for acquiring an understanding of brain abnormalities related to these disorders. The authors analyze functional Magnetic Resonance Imaging (fMRI) data to study the human eye-movement system. Through the use of hierarchical modeling, they examine the functional relationship between subserving rapid eye repositioning movements and smooth visual pursuit of a target. The discussion of the specific analysis of the eye movement data is used to showcase a broad spectrum of modeling and computational issues confronting investigators in functional imaging.

The recent explosive growth in genetic research and in our understanding of the genetic susceptibility to various diseases provides the background for the next in-

vited case study in this volume. In *Modeling Risk of Breast Cancer and Decisions about Genetic Testing*, **Giovanni Parmigiani, Donald A. Berry, Edwin Iversen, Jr., Peter Müller, Joellen Schildkraut** and **Eric P. Winer** make use of the extensive capabilities of modern Bayesian modeling and computing to study clinical and health policy issues related to genetic testing for susceptibility to breast cancer. Their paper discusses aspects of an integrated set of research projects on breast cancer at Duke University. The main questions include the prediction of genetic susceptibility to breast cancer (presence of BRCA1 and BRCA2 mutations), the assessment of the risk for developing breast cancer, and the incorporation of this knowledge in the construction of decision models for breast cancer prevention and treatment.

The last of the invited case studies discusses the use of Bayesian methods in another key area of biomedical research, drug development. In *The Bayesian approach to population pharmacokinetic/pharmacodynamic modeling*, **Jon Wakefield, Leon Aarons** and **Amy Racine-Poon** take a population perspective of drug development, aiming at characterizing the variability in drug absorption, distribution and elimination, and drug efficacy and toxicity across individuals. The analysis incorporates informative prior distributions to capture information from previous studies or from biological and clinical considerations. The authors emphasize the strengths of Bayesian methods for problems in pharmacokinetics and pharmacodynamics, particularly with respect to the ability of these methods to handle large numbers of parameters and non-linear, subject-specific models.

CONTRIBUTED PAPERS

The study of toxicity resulting from radiation treatment for cancer is addressed in *Longitudinal Modeling of the Side Effects of Radiation Therapy* by **Sudeshna Adak** and **Abhinanda Sarkar**. The authors analyze data from a recent study of lung cancer patients who were observed over a four week period. The focus of the paper is on Bayesian modeling for the prediction of the longitudinal course of toxicity in these patients using pre-treatment patient data, such as age and stage of the disease.

In *Analysis of hospital quality monitors using hierarchical time series models*, **Omar Aguilar** and**Mike West** analyze longitudinal quality of care measures from Veterans Administration hospitals. Their approach is designed to assess the relationship among monitors of the various aspect of quality of care and to examine the variability of quality indicators across hospitals both cross-sectionally and over time.

The link between ambient ozone and pediatric Emergency Room visits for asthma attacks is the the focus of *Spatio-Temporal Hierarchical Models for Analyzing Atlanta Pediatric Asthma ER Visit Rates* by **Bradley P. Carlin, Hong Xia, Owen Devine, Paige Tolbert,** and **James Mulholland**. The models include demographic and meteorologic covariates, and allow for spatial and spatio-temporal autocorrelation, errors in the ozone estimates. In addition to deriving numerical estimates of the risk of asthma attacks due to ozone exposure, the authors discuss

methods for drawing smoothed maps for relative risks, which can be used in a variety of epidemiologic studies.

The topic of *Validating Bayesian Prediction Models: a Case Study in Genetic Susceptibility to Breast Cancer* by **Edwin Iversen Jr, Giovanni Parmigiani**, and **Donald Berry** is closely linked to the work presented earlier in this volume by Parmigiani et al. This paper is focused on the validation of a probability model for risk of BRCA1 and BRCA2 mutations. The approach allows joint assessment of test sensitivity and specificity and carrier score error and treats genetic status as a latent variable. Receiver operating characteristic (ROC) curves are used to assess diagnostic performance of the model for a range of thresholds.

In *Population Models for Hematologic Data*, **J.Lynn Palmer** and **Peter Müller** study the distribution of blood stem cells collected longitudinally from cancer patients during the time period prior to undergoing high-dose therapy. The resulting models are used as the basis for designing optimal blood cell collection schedules for patients scheduled for intensive therapy.

The application of Bayesian structured mixture models in the process of drug screening is discussed by **Susan Paddock, Mike West, S. Stanley Young** and **Merlise Clyde** in *Mixture Models in the Exploration of Structure-Activity Relationships in Drug Design*. The authors use mixture models to handle missing information on binding configurations in drug screening experiments. They report their experience with both simulated and real data sets and discuss ways in which the analysis of the latter led them to enhancements of their their original model.

The next two contributed case studies come from research in environmental science. In *A Hierarchical Spatial Model for Constructing Wind Fields from Scatterometer Data in the Labrador Sea*, **J. A. Royle, L. M. Berliner, C. K. Wikle**and **R. Milliff** discuss the analysis of high resolution wind data using a model incorporating spatial structure components. The model leads to realistic reproductions of both wind and pressure fields, holding promise of generalizability outside the domain of the original data collection.

In *Redesigning a Network of Rainfall Stations*, **Bruno Sansó** and **Peter Müller** use a decision model to evaluate alternative designs for a system of rainfall monitoring stations in Venezuela. The goal of their analysis is to reduce the overall number of stations with minimal loss of information about local rainfall.

The final paper in the volume discusses the use of change-point modeling to screening for prostate cancer. In *Using PSA to detect prostate cancer onset: An application of Bayesian retrospective and prospective change-point identification*, **Elizabeth H. Slate** and **Larry C. Clark** analyze an extensive set of longitudinal prostate-specific antigen (PSA) measurements on participants in the Nutritional Prevention of Cancer Trial. Through the use of hierarchical modeling the authors study the natural history of PSA levels and assess the diagnostic performance of rules based on PSA data.

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