FOREWORD

The volume results from an AMS-IMS-SIAM Joint Summer Research Conference in the Mathematical Sciences. The meetings were held at the University of Washington from June 28th to July 3rd, 1997. For such a special occasion, Seattle contributed its beautiful surroundings along with its usual picturesque early summer weather.

The focus of the conference was the design of experiments. The proposal for it emphasized nonlinear models, Bayesian techniques and sequential methods, and applications to clinical trials and computer codes.

Of the 26 talks presented at the conference, 18 have resulted in contributions to this publication. Papers are in four groupings: Computer and High-Dimensional Experiments; Clinical Trials; Adaptive Designs; Regression Models, Response Surfaces and Factorial Designs. Of these, the first and last are more wide-ranging and perhaps closer to the line of research that comes to mind when optimal design, or the earlier notion of sensible design, is mentioned; the middle two are more directed toward sequential design. Coincidentally, the foundations for both optimal and sequential design were laid down in the late 1950's.

The design of experiments continues to hold something of a unique position in statistics - it is an active field, but perhaps never commensurate with the fact that all who do research are obliged to think about it. Still the subject fascinates, and those who are committed to it as their research area have little trouble recognizing others of similar stripe.

What commonalities do we find in this collection? How do they come down to us? The concept of D-optimality is mentioned specifically in more than half the papers, running across all groupings, and other allusions to letter optimality come in as well. This is Kiefer's legacy - design from the perspective of decision theory. Likewise, sequential design shows up in the majority of these works, often indebted to Chernoff's 1953 paper on locally optimum designs or to his 1972 book in another SIAM series.

A third item of note is the increasing use of Bayesian models and techniques over time. At one end, the computer model set-up in the paper of Schonlau, Welch and Jones is brought on in large part by the sheer size of the design space. In the middle ground one has priors on model parameters, as in the dose-response curves of Zhu and Wong, for instance. Then there is the use of explicit or empirical Bayes-type procedures in the context of adaptive allocation to treatments, as in Hardwick and Stout or Melfi and Page, where substantial prior information seems likely to be available. Finally one should mention the natural development of theory to acknowledge the importance of nonlinear models in a variety of fields. This is on prominent display in the papers of Atkinson, of Gautier and Pronzato, and of Haines.

And what has come of the call for applications? What one thinks of as industrial matters arise in the form of fractional factorial designs, response surface methodology, and a latter-day example of engineering design based on a computer model. Designs for estimating parameters of chemical kinetics models are mentioned in various papers. Calibration of test items in psychometrics, estimation of thresholds in psychophysics, and neural network models are considered for the presence of design efficiencies. The design aspects of clinical trials and of dose-response curve estimation are a staple of the central portion of the book. Space limitations leave us mostly with outlines of applications rather than serious detail or hard data, but this kind of depravation is easily remedied these days should one be willing to express interest.

A conference proceedings seems a decent place to reflect on where we have been and where we might be heading. As a reference point, consider the International Symposium on Statistical Design and Linear Models held 25 years ago at Colorado State University. It featured contributions from an impressive collection of notables, Chernoff and Kiefer among them.

Computation. At the Colorado meeting, the optimum design algorithms of Fedorov, Mitchell and Wynn were recent developments - Mitchell's DETMAX algorithm was announced in an abstract of a contributed paper to those proceedings for example, while papers by Fedorov and Wynn could provide more detailed algorithmic descriptions. Evidently construction had lagged behind theory by about 10 years. Procedures derived today are implemented tomorrow, roughly. In another direction, setting aside the theoretical developments of Chen and Hedayat, inspect the catalogue of minimum aberration designs at the end of that paper. Or, again, consider the simulations in the works of Atkinson, Melfi and Page, and Buyske. Such a list hardly does justice to how far we have come, and can do little more than hint at how far we might go.

Computers. That design could prove useful in connection with the understanding of computer models is a development of the past 15 to 20 years. The paper of Schonlau, Welch and Jones is a good illustration of this line of thought. The design of computer algorithms with optimum properties has been heavily researched since the early 1980's as well. Fedorov and Flanagan look to the monitoring of computer networks as a design problem and more will come of this. An emerging problem is one of design for the testing of computer software. What is clear is that computers evolve rapidly, networks grow, the complexity of computer models and algorithms increases. It is nearly as evident that the role of design does not diminish in the process.

Mathematics. Note that the papers of Bates, Riccomagno, Schwabe and Wynn and of Dette individually emphasize linear Fourier regression models. Their outlooks differ, parameter estimation on the one hand and model discrimination on the other, and this to the extent that the first paper touts uniformly distributed points in space and downplays product designs, while the second relies on product designs and suggests that some nonuniformity might be useful. What impresses the reader is rather this: classical models retain interest for a variety of reasons, and the mathematics by which one addresses such basic problems has become very sophisticated, even by 1973 standards. The work of Draper and Pukelsheim is another good case in point.

Perhaps what such comparisons to the past bespeak is carried by the notion of size. Data proliferate as measurements become automated and automatic, while our ability to handle these data seems always (at least) one step behind. Which data to collect? Which data to analyze? Design problems anyone?

Sequential methods are slighted in the last remarks. A reasonable case can be made that they are always slighted, the inherent difficulty of the associated problems is hard to ignore. In these pages one sees that more can be done with sequential design when there are relatively few choices to be made - choice of treatments versus points in space, say. No matter, research into sequential procedures should be listed near the top of any list of priorities for work in design theory.

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