7th Workshop on Quality Improvement Methods
at the Universitätskolleg Bommerholz

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ABSTRACTS

Session 1: DOE / Kriging

Sequential design of experiments for generalized linear models

David Steinberg (Tel Aviv University)
Dr. Hovav Dror

We consider the problem of experimental design when the response is modeled by a generalized linear model (GLM) and the experimental plan can be determined sequentially. Most prior research on this problem has been limited to the case of one-factor, binary response experiments, which are encountered in dose-response studies and sensitivity testing. We suggest a new procedure for the sequential choice of observations that improves on existing methods in four important ways: (1) it can be applied to multi-factor experiments and is not limited to the one-factor setting; (2) it can be used with any GLM, not just binary responses; (3) both fully sequential and group sequential settings are treated; and (4) the experimenter is not constrained to specify a single model and can use the prior to reflect uncertainty as to the link function and the form of the linear predictor.

Our procedure is based on a D-optimality criterion, and on a Bayesian analysis that exploits a discretization of the parameter space to efficiently represent the posterior distribution. In the one-factor setting, a simulation study shows that our method is superior in efficiency to commonly used procedures, such as the "Bruceton" test (Dixon and Mood, 1948), the Langlie (1965) test or Neyer's (1994) procedure. We also present a comparison of results obtained with the new algorithm versus the "Bruceton" method on an actual sensitivity test conducted recently at an industrial plant.

Discrete Mixtures of Kernels for Kriging-based Optimization

David Ginsbourger (École Nationale Supérieure des Mines de Saint-Étienne)
(joint work with C. Helbert and L. Carraro)

Over the last 5-10 years, numerical simulations of stochastic and deterministic systems have become more accurate, but also more time consuming. This makes it impossible to study simulators exhaustively, especially when the number of parameters is large. Consequently, Computer Experiments is a field of study in expansion; application areas include crash-test studies, reservoir forecasting, nuclear criticity, etc. We focus on surrogate-based global optimization techniques for this kind of complex models.

Surrogate modeling consists of building mathematical approximations of the studied function (here the numerical simulator) on the basis of a set of observations made at a some experimental design. Classical surrogates range from plain linear regression to non-linear approximators like neural networks, splines, or Kriging. Kriging is very convenient for sequential learning since it delivers at the same time an interpolating mean predictor and a prediction variance quantifying the accuracy of the prediction at each unobserved location. One of the main issues when using an Ordinary Kriging model is to select a parametric covariance kernel and to estimate its associated parameters.

Kriging-based exploration strategies often rely on a single Ordinary Kriging model which parametric covariance kernel is selected a priori or on the basis of an initial data set. Since choosing an unadapted kernel can radically harm the results, we wish to reduce the risk of model misspecification. We consider here the simultaneous use of multiple kernels within Kriging. We give the equations of discrete mixtures of Ordinary Krigings, and derive a multikernel version of the expected improvement optimization criterion. We finally provide an illustration of the Efficient Global Optimization algorithm with mixed exponential and Gaussian kernels, where the parameters are estimated by Maximum Likelihood and the mixing weights are likelihood ratios.

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Session 2: Statistics / Robust Optimization

Statistics Development: Statistical Methods Meeting the User's Needs

Jan Engel (Centre for Quantitative Methods CQM BV Eindhoven)
Henriette (Jettie) C.M. Hoonhout (Philips Research Europe, Eindhoven)

Statistical methods have a large potential to be effectively used by industrial practitioners if they would satisfy two criteria: functionality and usability. Statistical methods are usually the product of statistical research activities of universities and other research organizations. Some already satisfy these criteria; however, many do not. The effect is that potentially relevant methods are not used in practice as often as they could. In this paper we will present an approach regarding "statistics development", in which the end-user is given a central position, promoting that the results from statistical

research aim to meet the needs and requirements of the practitioner. Examples of known and new methods will be presented to illustrate our statements. In addition, we will discuss issues such as education in statistics, the link with statistical consultancy and publication of methods in various channels.

Quality Assurance for Statistical Consulting

Claus Weihs (Technische Universität Dortmund)

Can statistical consulting be quality designed? This paper develops ideas on quality assurance of statistical consulting. An example of a quality assuring structure of statistical consulting is discussed. A measurement system for quality indicators is derived, and ideas for joint optimisation of such indicators are given.

A case study: Process Improvement Using Mixture-Process Variable Designs and Robust Optimization Techniques

N. S. Sahni, N.S. (Jawaharlal Nehru University of New Delhi, India)
G. Piepel (Pacific Northwest National Laboratory, USA)
Tormod Naes (University of Oslo)

A process for producing low-fat mayonnaise was investigated with the goal of optimizing the raw material (RM) recipe and process variable (PV) levels. The investigations included: (1) optimizing the recipe for discrete combinations of the PVs, (2) optimizing the recipe to be robust to variations in the PVs, (3) optimizing the PV settings to be robust to variations in the recipe, (4) accounting for a cost constraint, and (5) quantifying the uncertainty in the robust, optimal settings resulting from model estimation and model selection uncertainties. A mixture-process variable (MPV) design was constructed and run as a split-plot experiment. Separate models involving the RM proportions and PV levels were fit and used to develop combined MPV models. Squared error loss, mean-squared error, and bootstrap methods were applied to develop optimal and robust solutions. Optimal settings of RM proportions and/or PV levels were developed that were less costly and more robust than the reference recipe and PV settings that had been tentatively identified by a non-statistical approach.

Session 3: Audio Signal Analysis

Unsupervised Learning Methods for Audio Signal Analysis and Sound Source Separation

Tuomas Virtanen (Tampere University of Technology)

This presentation gives an overview of unsupervised learning methods which have recently been proposed for audio signal analysis and sound source separation, and produced promising results in many applications. The learning algorithms discussed here include independent component analysis, non-negative matrix factorization, sparse coding, and their extensions. We present linear signal models which can be used for monaural or multi-channel input signals. We discuss the assumptions and probabilistic interpretations of the generative models behind the above algorithms, and discuss their suitability for real-world audio signals. While some of the algorithms operate directly on time-domain signals, most of them produce better results when applied to a non-negative phase-invariant spectrogram representation, and therefore we discuss the differences between the signal representations. We present applications for the proposed methods and show results of selected studies, including automatic music transcription and noise-robust speech recognition.

Signal Quality in Hearing Aids - A Statistical Approach

Rainer Martin (Ruhr-Universität Bochum)

This talk briefly introduces the basic functions of modern digital hearing aids and emphasizes the importance of improving the user experience in noisy and reverberant environments. After identifying the most important dimensions of quality we will explain how these are assessed by means of instrumental and auditive measures. I will show that among other measures, the outlier statistics of the processed signal is a most useful tool for the evaluation of signal quality. With the aim of improving signal quality we will then introduce optimal estimators for estimation of speech coefficients in the discrete Fourier domain as well as a novel smoothing technique which is able to drastically reduce annoying outliers without degrading the desired speech signal. I will conclude this talk with several audio demonstrations.

Session 4: Evolutionary Optimization

Experimental Analysis of Metaheuristics

Mike Preuss (Technische Universität Dortmund)

Experimental research in Metaheuristics, and especially in Evolutionary Computation (EC) has often been regarded as inferior to theory due to a certain arbitrariness of test set, parameter, and measuring choices. However, recently experimentation has become more common even in theoretically dominated approaches (the combined method being termed Algorithm Engineering). We review a number of problems encountered in Metaheuristic experimentation and relate them to challenges in other scientific fields.

Furthermore, we demonstrate how to tackle at least the parameter problem with a model-based tuning approach (SPO), which enables a "fair" comparison at near peak performances. Next to efficiency, we also obtain insight into the parameter interactions of the investigated Metaheuristics as related to the specific application / test problem. Based on some example applications, we discuss the role of parameters and tuning methods for adaptability of algorithms to problems, an important but currently underestimated property of optimization techniques.

Robust Multi-objective Optimisation of Weld Beads for Additive Manufacturing

Jörn Mehnen (Cranfield University)
Heike Trautmann (Technische Universität Dortmund)

Additive Manufacturing is a technique for generating complex shaped rigid metal workpieces. During the welding process material is deposited in a sequential layer-by-layer fashion generating ready-to-use workpieces. Weld bead properties such as width, penetration and reinforcement define the shape and quality of the workpiece. They depend in arc welding on factors such as welding current, welding speed and nozzle-to-plate distance. Due to the fact that area of penetration and dilution are contradictory an engineer has to compromise on each objective. Engineers generally know their goals and prefer certain workpiece properties over others. They also vary their preferences according to circumstances. However, they generally do not know the best parameter settings of the process and choose them based on experience and technical constraints. A model based optimisation process helps finding the best settings in a well-structured manner. The welding process generally generates highly erratic weld bead shapes. Hence, the model results

are superimposed by stochastic errors with generally unknown distribution properties. This paper deals with multi-objective optimisation of additive manufacturing processes taking design preferences, technical constraints and stochastic noise in the objectives into account. A multi-objective evolutionary algorithm using a robust domination criterion and a robust evaluation technique as well as desirability functions is presented. The algorithm calculates robust, efficient and preferable compromise solutions using a multi-objective statistical welding model.

Session 5: Control Charts

Prediction of Spiralling in a Drilling Process

Amor Messaoud (University of Jendouba, Tunisia)
Nils Raabe, Dirk Enk and Claus Weihs (Technische Universität Dortmund)

Deep-hole drilling methods are used for producing holes with high length-to-diameter ratio, good surface finish and straightness. The process is subject to the occurrence of dynamic disturbances called spiralling. It leads to multi lobe-shaped deviation of the cross section of the hole from absolute roundness which constitutes a significant impairment of the workpiece. A common explanation for the occurrence of spiralling is the coincidence of time varying bending eigenfrequencies of the tool with multiples of the spindle rotation frequency. In practice, it is necessary that a process monitoring system is devised to predict the occurrence of spiralling during drilling. This allows the engineers to know when and how to adjust the process. In this work, the application and use of different monitoring strategies are discussed. These strategies are based on control charts in combination with statistical and physical models describing the course of the eigenfrequencies.

Monitoring Variability with EWMA

Philippe Castagliola (Université de Nantes)

SPC (Statistical Process Control) is a collection of statistical techniques able to provide a systematic monitoring of a manufacturing process, which allows high quality final products to be produced. Among these techniques, during the last decade, the use of the EWMA (Exponentially Weighted Moving Average) statistic as a process monitoring tool has become more and more popular in the statistical process control field. Implementing an EWMA chart to control a manufacturing process requires the computation

and plotting of a random variable which is a function of the current sample statistic and of the past samples collected from the process. This allows the EWMA to prevail over the traditional Shewhart chart in terms of statistical sensitivity when small shifts in the process position and/or dispersion are expected. If the properties and design strategies of the EWMA control chart for the mean have been thoroughly investigated, the use of the EWMA as a tool for monitoring the process variability has received a little attention in the literature. The goal of this talk is to present some recent innovative EWMA type control charts for the monitoring of the process variability (i.e. the sample variance, sample standard-deviation and the range) based on several recent references (see below). The outline of the talk is :

- Definition and properties of an EWMA sequence,
- Commonly used procedures for the numerical computation of the Average Run Length (ARL),
- EWMA for monitoring the sample variance, sample standard-deviation and the range,
- Extension to VSI (Variable Sampling Interval) and VSS (Variable Sampling Size) strategies.

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