8th Workshop on Quality Improvement Methods
at the Universitätskolleg Bommerholz

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ABSTRACTS

Physical Modeling of Musical Instruments

Rolf Bader (Universität Hamburg)

Musical Instruments are very complex in terms of their geometry and vibrational behaviour determining their character and quality. Physical Modeling techniques, like Finite-Element (FEM) or Finite-Difference methods (FDM) taking the whole geometry of the instruments into account are capable of goint into details of musical instrument structures crucial for musical performance, like the initial transient phase, radiation characteristics or transfer functions. In nearly all cases transient formulations of discrete FEM or FDM are needed in explicit or implicit form. Here explicit FDM shows more stable results in terms of high frequency consistency as well as performance cost, while FEM are mostly used for fluid-dymanical problems like with flutes or saxophones showing turbulent behaviour. Choices of differential equations representing single or combined structural or fluid problem, especially the coupling of these equations within domains and/or at boundaries, as well as nonlinearities and structural tension with solid problems are crucial for modelling characteristics important to music.

Some issues concerning control charts with estimated parameters

Philippe Castagliola (Université de Nantes)

When monitoring a process using control charts, it is a common practice that a Phase I data set is used to estimate both the unknown in-control process mean 0 and in-control process standard-deviation 0. Once the process is considered to be in-control, these estimated control limits are assumed as fixed. This common practice totally ignores the effect of estimating 0 and 0 and the strong impact in terms of Run Length properties (cdf, ARL, SDRL, ...). In this presentation, we will show how much the RL properties are different in the case where the parameters are supposed known and in the case where the parameters are supposed unknown and estimated. We will also show different strategies in order to overcome the difference between these two cases. We will focus our presentation on the t, EWMA-t, S2 and EWMA-ln(S2) charts with estimated parameters.

Managing Uncertainties in Single- and Multiobjective Design Optimization

Michael Emmerich and Johannes Kruisselbrink (LIACS, Netherlands)

In Design Optimization different sources of uncertainty may occur. First of all the statement of the objective functions and constraints may be vague. Secondly there can be perturbations on control, output and environmental variables. When these uncertainties are not taken into account in optimization tools the results may be dissatisfactory because they lack robustness, or the algorithm may overlook interesting solutions because of a too rigid problem formulation. Moreover, the convergence stability of the optimization algorithm may suffer from noise. Uncertainties can be modelled in a different way: e.g. using fuzzy logic or desirability indexes in case of vagueness of problem formulations and using probabilistic or probabilistic models in case of uncertain input and output variables of the model. We will discuss an integrative framework that captures these cases. Then, for some selected case studies (molecular design, building performance optimization) we discuss how black-box optimization algorithms can be modified in order to deal with these uncertainties.

Applying Balanced Incomplete Block Designs in user studies: how do we analyse the data?

Jan Willem Bikker and Jan Engel (CQM, Netherlands)

In modern consumer-oriented industrial research and development, consumer and user studies become more and more important. In laboratory tests, users are exposed to a selection of test conditions. As the number of test conditions (settings of factor levels) in such studies is often too large for a single user to be exposed to, Balanced Incomplete Block Designs (BIBD) form a popular design type in these studies. The data from the BIBD will have to be analysed and Analysis of Variance (Anova), a widely used statistical method for analysing data from industrial designed experiments, is useful in principal. However, with many factorial effects and the small amount of data per block, Anova is not always useful in BIBD. In this presentation we study the alternative data analysis by Linear Mixed Models that has a different analysis viewpoint, and appears to have many opportunities for data analysis. We shall work out a practical problem and we perform a simulation study. These allow us to draw conclusions concerning the application of LMM for analysing data from BIBD in user studies.

A Project on Design of Experiments in R

Ulrike Grömping (BHT Berlin)

R has already some functionality for Design of Experiments (DoE) that is distributed over various R packages (cf. CRAN Task View Experimental Design, Grömping 2008-2009). However, so far, R has not been successful in conquering the experimentation community outside of small expert circles. With regard to industrial experimentation, the market for DoE Software is dominated by all-round software companies like Minitab Inc. or Statsoft (Statistica), whose products are relatively simple to use. Such products are widely spread among businesses that adhere to the 6-Sigma quality management process, which involves application of DoE by many subject-matter and business process experts with only limited statistics training. Additionally, there are various specialized software products like e.g. NCSS (NCSS, Inc.), Cornerstone (Applied Materials, Inc.) or Stavex (AICOS Technologies AG). The main inhibitors against usage of R for design and analysis of (industrial) experiments are

- R's steep learning curve for occasional or non-expert users
- gaps in R regarding some areas of experimental design, especially fractional factorial plans.

Having powerful DoE facilities in R is considered useful for supporting fast implementation of new research as well as for supporting wide-spread use of DoE in times of tight budgets.

An ongoing project regarding improvement of DoE facilities in R is presented. This project has two missions:

- to extend R's functionality for design and analysis of fractional factorial experiments (by extending R package FrF2) to fully meet state-of-the-art possibilities of benchmark software and exceed benchmark software by also incorporating newer research (e.g. newly published catalogues of designs Block and Mee 2005 or Xu 2009 or non-standard Plackett-Burman type designs like the one published by Box and Tyssedal 2001)
- to supply an interface to DoE functionality that accepts user inputs as close as possible to subject matter requirements and thus frees users from having to focus on unnecessary programming or mathematical detail.

The project targets both the inexperienced occasional user of DoE and the expert user: while the former is not to be confused by many choices that (s)he has to make, the latter must be given all choices that (s)he wants to make.

After a brief introduction to the project concept and key structural aspects of implementation, the talk will focus on

- algorithmic solutions and difficulties regarding implementation of desirable functionality
- choices that have been made or will have to be made regarding default settings for design proposals.

The workshop participants' expertise in Design of Experiments and statistics for quality improvement will hopefully generate useful feedback to be accounted for in the project. References

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On adaptive np control charts

Mohamed Limam (LARODEC, Tunisia)

The design of a control chart requires the specification of three decision variables, namely the sample size, the sampling interval and the action limit under which the process must be stopped for potential repair. Several modifications have been explored to improve the efficiency of the standard static Shewhart charts. Among these innovations, adaptive control charts possessing at least one of the decision variables varying from an inspection epoch to another given the past data information proved to result in quicker detection of out control conditions. Furthermore, they reduce costs due to the implementation of the adaptive control scheme compared to the static one. Most performance evaluation of adaptive charts concentrated on the variable control charts. Few papers have focused on the performance of adaptive attribute charts, especially from an economic viewpoint. In this paper, cost functions of several adaptive schemes of attribute np charts are derived for the two approaches using a dynamic sample size. The first approach, referred to as adaptive control charts using Markov chains, focuses on the position of the last observed sample data on the graphical representation of the control chart. The second approach uses all the available information recorded from the beginning of the process to the current time of the decision making. Resulting charts are called Bayesian control charts. Empirical study shows that adaptive np charts using Markov chains approach outperform the classical static process monitoring where higher cost savings are obtained when a Bayesian procedure is employed.

Supersaturated Designs: Are Our Results Significant?

Robert W. Mee (University of Tennessee)
David J. Edwards (Virginia Commonwealth University)

Two-level supersaturated designs (SSDs) are designs that examine more than n-1 factors in n runs. Although literature involving the construction of SSDs is plentiful, less has been written about analysis of data from these designs. Perhaps this is due in large part to the dearth of actual applications. Whether using forward selection or all-subsets regression, it is common to select models from SSDs that explain a very large percentage of the total variation. Hence, naïve p-values can persuade the user that included factors are indeed active. We propose the use of a global model randomization test in conjunction with all-subsets to more appropriately select candidate models of interest. For settings where the number of factors is too large for repeated use of all-subsets, we propose a short-cut approximation for the p-values. Finally, we propose a randomization test for reducing the number of terms in candidate models with small global p-values.

Multi-Objective Particle Swarm OptimizationMulti-Objective Particle Swarm Optimization

Sanaz Mostaghim (Universität Karlsruhe)

Multi-objective Particle Swarm Optimization (MOPSO) can very quickly find a good approximation of optimal solutions through cooperation and competition among the potential solutions. As an iterative optimization algorithm, MOPSO is motivated from the simulation of social behavior and consists of a population of particles which search the variable space by moving with a particular velocity toward the best global particles (called guides) by using their experience from the past iterations.It is very easy to implement a MOPSO and the parameter setting requires less effort than the existing evolutionary algorithms as there is not selection process involved. In MOPSO, there is no single minimum but a set of non-dominated solutions which are usually used to determine the guide for the particles. Selecting the guides is very difficult yet an important problem for attaining convergence and diversity of solutions. This talk gives an overview on the existing MOPSO methods and the impact of different techniques for improving the quality of solutions. Furthermore, many-objective PSO methods are introduced. In fact, optimization problems with many objectives open new issues for multi-objective optimization algorithms and particularly MOPSO. In high dimensional objective spaces, almost all of the particles get non-dominated and therefore there is no force to move the particles toward the optimal front. In this talk, Many-Objective PSO methods are introduced and compared to other existing methods.

Adaptive Design of experiments for accurate approximation of a target region

Victor Picheny (Ecole des Mines de Saint-Etienne)

This work addresses the issue of designing experiments for a metamodel that needs to be accurate for a certain level of the response value. Such a situation is common in constrained optimization and reliability analysis. Here, we propose an adaptive strategy to build designs of experiments that is based on an explicit trade-off between reduction of global uncertainty and exploration of regions of interest. A modified version of the classical integrated mean square error criterion is used that weights the prediction variance with the expected proximity to the target level of response. It is shown on several examples that a substantial reduction of error can be achieved in the target regions, with reasonable loss of global accuracy.

A Design for Six Sigma Application in Food Design

Anja schleppe (Kraft Foods, Munich, Germany)

A key process step in food production has been optimized over many years from 24 hours duration down to the best the process can do, which is 5-6 hours duration. There is a need to further reduce this production time which requires a new technology that can take it down to even below 1 minute. This technology is developed with a Design For Six Sigma approach starting from pilot plant trials before moving into full-scale production trials. DFMEA and DOE are used, and one specific design change brought an unexpected level of robustness.

Very fast enumeration of orthogonal arrays

Eric D. Schoen (University of Antwerp, Belgium, and TNO Science and Industry, Delft, Netherlands)

In quality improvement experiments, researchers may want to investigate the joint effect of several factors on the properties of some product or process. The experiments are frequently conducted according to an orthogonal array (OA). This is a rectangle of symbols with useful combinatorial properties. Here is an example of such an array.

0 0 0 0 1 1 1 1 2 2 2 2 3 3 3 3
0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1
0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1
0 1 1 0 1 0 0 1 0 1 1 0 1 0 0 1

The rows correspond with experimental factors. Each row-entry is a factor-setting. So the first factor has four settings and the remaining three factors have two settings each. The $N = 16$ columns correspond with different experiments. The array has strength $t = 3$, because each triple of rows is a complete experiment, possibly repeated, in three factors. This property ensures that all main effects are orthogonal to all two-factor interactions.

Given the specification of N, t, and the level-numbers of the factors, there can exist many inequivalent OAs. If we can enumerate all these arrays, we can subsequently study further statistical properties and choose the best array for a particular application.

In my talk, I present a very fast enumeration algorithm. It was implemented in a C program. For $t = 2$, we obtained most cases with $N \leq 28$, for $t = 3$, we obtained most cases with $N \leq 64$, and for $t = 4$, we obtained most cases with $N \leq 162$. I present some of the results, and I discuss when the algorithm is expected to return complete sets in a reasonable amount of time.

Graphical aids for the analyses of two-level non-regular designs

John Tyssedal and Ranveig Niemi (NTNU, Trondheim)

The complex alias pattern between main-effects and two-factor interactions for two-level non-regular designs has been considered a problem for analysing these designs. If only a few two-factor interactions are active, however, the pattern induced into contrasts from active interactions may be very structured. This is in particular the case for the 12 run and the 20 run PB designs, probably the two most important ones for physical experimentation. This talk presents a graphical method for the analysis of non regular two-level orthogonal arrays. The method consists of two steps. The first step is called contrast-plot interpretation and is directed towards revealing the cause for the pattern observed in the contrast plots. The second step is called alias reduction and aims at simplifying the pattern by reducing the aliasing caused by effects that with a high degree of certainty may be considered active. The method is tested out on the 12 run and the 20 run PB design with good results even for cases were the heredity principle does not hold.

Efficient Multi-Objective Optimization of Production-Engineering Problems By Means Of Design and Analysis Of Computer Experiments

Tobias Wagner (Universität Dortmund)

Multi-objective optimization (MOO) focuses on the approximation of a set of optimal solutions for a given problem with more than one quality indicator. Compared to the approximation of a single optimal solution, this inevitably demands a higher computational effort, which has made MOO often unapplicable for production-engineering problems. The additional use of flexible modeling techniques can directly incorporate the information gained from conducted experiments into the optimization process. Thus, these methods can be used to allow an efficient optimization even of multi-objective production-engineering problems. Design and Analysis of Computer Experiments (DACE) represents such a flexible modeling technique and has already been successfully applied in the optimization of computer experiments. However, DACE is based on the assumption of deterministic output, which does not hold for most production-engineering problems. In this talk, enhancements of DACE to allow for noise in the measurement of quality indicators are introduced. Based on experiments on noisy versions of popular benchmark functions, it is shown that the enhanced DACE models are superior to standard regression techniques with respect to modeling error and accuracy in detecting the optimum. Furthermore, criteria to evaluate the expected improvement of a solution for an approximation set are derived by means of predictions of the models. First experimental results are utilized to show the potential of both, the enhanced modeling technique as well as the improvement criteria, to efficiently optimize multi-objective production-engineering problems.