13th Workshop on Quality Improvement Methods
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Königswall 1. D-44137 Dortmund
tel.: +49 231 90550 fax.: +49 231 9055900

ABSTRACTS

Method Development for Improvement of Forecasting Quality through constant Data Enhancement

Thomas Lehmann and Jörg Keller, Daimler AG

Limited resources, regulation and enhanced mobility have led to a rethink in automotive industry and government. From combustion engine optimization to hybrid and battery electric vehicles there are several measures to reduce CO_2 emission. Since high voltage battery technology is a relatively uncharted business concerning ageing, it is essential to observe the quality of battery through the entire value added chain. Elements are: cell- and battery production, vehicle production, field and after sales. Data Enhancement can be achieved by including real costumer data of field feedback.

The main task in this field is forecasting quality by parameters like failure rate, wear characteristics and warranty cost. Due to a consequent chaining of process data an improvement of estimation can be realized. For evaluation a test case of forecasting wear characteristics will be presented.

A Bayesian Application of a Gaussian Process Model to Predict Smart Power Semiconductor Lifetime Data

Kathrin Plankensteiner, Alpen–Adria–University, Klagenfurt

In automotive industry end-of-life tests are necessary to verify that semiconductor products operate reliably. Based on the steadily increasing demands on device lifetime and limited resources, it is neither possible to test, nor to inspect all devices. Consequently, reliable forecasts are needed. For this purpose, accelerated stress tests in combination with statistical models are commonly applied to model the lifetime of the devices. Frequently used acceleration models like Arrhenius are inaccurate because the investigated lifetime behavior is highly complex, e.g. mixture distributed and censored, and cannot be captured by simple models. Previous work indicates that the applications of Bayesian Mixtures-of-Experts or Bayesian network models lead to a satisfying interpolation quality, but their performances are insufficient in case of extrapolation. Based on these results, it is assumed that ordinary regression based linear models cannot capture the entire behavior of the data.

To compensate for the limitations of ordinary regression models, we propose to include physical aspects into the lifetime model such as the device degradation over time. The degradation is thereby indicated by a previous crack propagation study as well as temperature variations and electrical measurements during the stress test. These indicators have all different timestamps as well as different number of data points. Typical assumptions like independency or homogeneity do not hold, therefore, commonly used threshold models, e.g. Brownian motion, cannot be applied and a more generalized model has to be considered. Therefore, the observed lifetime is modeled by a Bayesian Gaussian process depending on correlated and time-dependent physical parameters.

Application of Data Depth to Models in Construction Engineering

Christoph Kustosz and Christine Müller, TU Dortmund University

Due to specific properties of concrete, AR processes with non-standard error distributions can be considered to describe crack growth processes. Based on models from engineering we introduce a stochastic version of the Paris-Erdogan equation for crack growth and propose test statistics based on simplicial depth to account for specific physical properties. This leads to the analysis of robust estimators for explosive AR(1) processes with and without intercept. The limit distributions of the resulting test statistics are derived and tests for $H_0 : \theta_1 = \theta_1^*$ and $H_0 : (\theta_0, \theta_1) = (\theta_0^*, \theta_1^*)$ are proposed and compared with tests based on simplified depth statistics and standard tests for AR processes. We show that for crack growth in prestressed concrete simplicial depth gives a considerable alternative to the existing methods. Since calculation of simplicial depth is computationally costly we also discuss the efficient implementation.

Optimization of a Simulation for Inhomogeneous Mineral Subsoil Machining

Claus Weihs, Swetlana Herbrandt, Manuel Ferreira and Christian Rautert, TU Dortmund University

For the new generation of concrete which enables more stable constructions we require more efficient tools. Since the preferred tool for machining concrete is a diamond impregnated drill with substantial initial investment costs, the reduction of tool wear is of special interest. The stochastic character of the diamond size, orientation and position in sintered segments as well as differences in the machined material justifies the development of a statistical motivated simulation. In the simulation presented in the past, workpiece and tool are subdivided by Delaunay tessellations into predefined fragments. The heterogeneous nature of the ingredients of concrete is solved by Gaussian Random Fields. Before proceeding with the simulation of the whole drill core bit, we have to adjust the simulation parameters for the two main components of the drill, diamond and metal matrix, by minimizing the discrepancy between simulation results and the conducted experiments. Due to the fact that our simulation is an expensive black box function with stochastic outcome and constrained parameters, we use the advantages of model based optimization methods.

Monitoring of infectious diseases for safety of plasma derived medicines

Mart P. Janssen, University Medical Center Utrecht

Plasma from blood or plasma donors is used for the production of various plasma derived medicines. A well-known example is Factor VIII which is used to treat haemophilia patients. Registration of plasma derived medicines for the European market requires annual reporting of epidemiological data on infections in the donor population. These data consist of the number of detected hepatitis (B/C) and HIV infections per blood collection center, and the associated number of donors and donations. With this information, the incidence and prevalence of these diseases can be estimated and changes herein monitored. Manufacturers are also required to set acceptable ranges for changes within and differences among blood collection centers. The purpose of the regulation is to force manufacturers to actively manage their product risks. However, there is no guidance on how this should be done nor are any criteria provided. In this presentation various strategies for monitoring infections in donor populations applied in practice will be illustrated and discussed.

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Cusum Control Charts based on Bootstrap Techniques

Nihan Acar and Meral Yay, Mimar Sinan Fine Arts University, Istanbul

In recent years, increased amount of study about the application of bootstrap techniques on control charts have been observed in literature. Considering that the bootstrap techniques are generally used when the parametric assumptions are not provided and there is no prior information about the shape of the distribution, it is possible to obtain control limits based on bootstrap techniques on control charts with a simulation study. Cumulative Sum (CUSUM) Control Charts are presented by English statistician E.S. Page in 1954 on the purpose of providing control regarding a process. These diagrams help to reveal sudden changes in the data sets which do not include much variability and are evaluated as cumulative sum graphics of deviations from the population values. In this study lower and upper control limits on CUSUM diagrams will be obtained with the help of bootstrap technique, which is developed as an alternative way when parametric assumptions are not provided.

Monitoring the Coefficient of Variation for Short Run Production

Phillipe Castagliola, LUNAM Université, Nantes

Monitoring the coefficient of variation is an effective approach to Statistical Process Control when the process mean and standard deviation are not constant but their ratio is constant. The CV has several applications. For instance, the CV is commonly used in renewal theory, queuing theory, and reliability theory. In the field of finance, it is interpreted as a measure of the risk faced by investors, by relating the volatility of the return on an asset to the expected value of the return. It is also adopted in chemical and biological assay quality control to validate results. It can also be used in the fields of materials engineering and manufacturing where some quality characteristics related to the physical properties of products constituted by metal alloys or composite materials often have a standard-deviation which is proportional to their population mean. These properties are usually related to the way atoms of a metal diffuse into another. Tool cutting life and several properties of sintered materials are typical examples from this setting.

Until now, research has not investigated the monitoring of the coefficient of variation for short production runs. Viewed under this perspective, this presentation investigates new methods to monitor the coefficient of variation for a finite horizon production by means of one-sided Shewhart-type and Run-Rules-type charts. The truncated run length properties of these charts are derived and Tables are provided for the statistical properties of the proposed charts when the shift size is deterministic. Illustrative examples are given in order to illustrate the use of these charts on real data.

The Use of Inequalities of Camp-Meidell Type in Nonparametric Statistical Process Monitoring

Rainer Göb and Kristina Lurz, University of Würzburg

A few authors have used the classical Camp-Meidell inequality for the nonparametric analysis of statistical process monitoring. The following issues have not received suffcient attention. i) The use of moments of order higher than 2 in the inequalities provides tighter bounds. ii) The problem of estimating the moments in the bounds, e. g., from a phase 1 sample, cannot be neglected. The present study analyses both aspects i) and ii). Appropriate estimators, their properties, and the effect of estimation on the properties of process monitoring charts are investigated. In particular, the use of empirical Camp-Meidell bounds in quantile control charts is studied.

Understanding the confounding structure of factorial experiments

Ulrike Grömping, Beuth University of Applied Sciences, Berlin

Confounding in regular 2-level fractional factorial plans is measured with the well-known concepts of resolution and – more generally – minimum aberration. Xu and Wu (2001) introduced Generalized Minimum Aberration (GMA), which is a natural extension of minimum aberration (MA) to non-regular and also mixed level factorial plans. Until recently, the basis of GMA – the generalized word length pattern GWLP – was defined in a purely technical way only. Grömping and Xu (2013) derived a simple interpretation of the number of shortest words, so that the GWLP becomes more tangible. This interpretation relates the number of shortest words to confounding of model matrix columns in a coding invariant manner. Coding invariance is of course important for assessing the usefulness of an experimental plan for qualitative factors. According to Grömping and Xu (2013), the number of shortest words can be interpreted as a sum of R^2 values among orthogonal model matrix columns or – more generally – as a sum of squared canonical correlations. On the basis of this interpretation, it is also possible to dissolve the problem pointed out by Wu and Zhang (1993) of adequate treatment of factors at different numbers of levels: Grömping (2013) proposes the use of average R^2 frequency tables and squared canonical correlation frequency tables (ARFTs and SCFTs) for detailed investigation of the worst-case confounding. The talk illustrates the meaning of these concepts with the help of mosaic plots (Hartigan and Kleiner 1981, 1984), which the author considers a very useful tool for visualizing orthogonal array projections (see Grömping 2014).

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Optimal Crossover Designs for the proportional Model

Wei Zheng, Indiana University – Purdue University Indianapolis

In crossover design experiments, the proportional model, where the carryover effects are proportional to their direct treatment effects, has drawn attentions in recent years. We discover that the universally optimal design under the traditional model is E-optimal design under the proportional model. Moreover, we establish equivalence theorems of Kiefer-Wolfowitz's type for four popular optimality criteria, namely A, D, E and T(trace).

Universally optimal designs under interference models with and without block effects

Katarzyna Filipiak, Poznań University of Life Sciences

Neighbor designs and some methods of their construction was introduced by Rees (1967). Henceforth many methods of construction of neighbor designs as well as of their generalizations are available in the literature. However there are only few results on their optimality. Therefore the aim of the talk is to give an overview of study on this problem. We present recent results on optimality of designs under three interference models with block effects: model with one-side neighbor effects, model with two-sided equal neighbor effects, and model with two-sided neighbor effects, and we compare optimality results with respective models without block effects.

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Generalized Kushner's Methods

Pierre Druilhet, Université Blaise Pascal, Aubière Cedex

Cross-over designs are devices used in many fields: drugs experiment, field experiment, sensory analysis, animal feeding experiments, etc. Depending on the application, several statistical models can be proposed to modelize both the correlations and the interference between treatments. The related optimal design may be highly dependant on the chosen statistical model and the parameter of interest. Kushner (1997, Ann. Stat) and Kunert and Martin (2000, Ann Stat.) proposed new methods to obtain optimal designs for direct treatment effects under various models. In this talk, we use a generalisation of these techniques to compare efficiencies of cross-over designs w.r.t. the chosen model and the parameter of interest. We also show how we can reduce, in some situations, the number of subject by using invariance under permutation subgroups.