10th Workshop on Quality Improvement Methods
at Haus Villigst

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ABSTRACTS

Physical Statistical Modeling of Bending Eigenfrequencies

Nils Raabe (TU Dortmund)

Deep hole drilling methods have been developed for the production of holes with a high ratio of length to diameter. Due to the necessarily slender shape of the boring tool, deep hole drilling processes are typically object to dynamic disturbances. One type of these disturbances resulting from peridodic deflections of the bar is called spiralling. As spiralling gets likely when multiples of the rotational frequency of the tool coincide with specific bending eigenfrequencies the determination of the latter frequencies is of primary interest.

We introduce an alternative to conventional modal analysis techniques by means of a combination of statistical and physical models. In contrast to modal analysis this combination is based on measures recorded during the process. By this on the one hand the bending eigenfrequencies can be determined both more realistic and efficient. On the other hand statistical estimation yields the opportunity of quantification of uncertainty by interval estimation.

The parts of the model are given by a physical discretized analogous model of the boring bar with its supporting elements and an embedded statistical model describing the spectral properties of the deflections of the bar. As the physical model contains unknown parameters, these can be estimated based on measurements by applying the maximum likelihood method. By using the fitted values as plugin estimates the bending eigenfrequency courses and confidence bands can be derived. The proposed method has been tested and investigated based on an extensive simulation study and successfully applied to real structure borne sound data.

Classification with Reject Option in Music Information Retrieval

Hanna Lukashevich (Fraunhofer IDMT)

Classification methods applied in music information retrieval (MIR) typically classify all items. In many applications it may be preferable to discard ambigu- ous classification results and thus to classify the items only if the high accuracy can be reached. There are two cases of ambiguous classification that typically occur in MIR. First, the fusion of music styles causes natural blurring of the borders between the classes. In addition, the feature representations of musical signals are imperfect. Second, the variability of the music over the world makes it impossible to collect representative training data sets

for each and every music style. The latter claims for a open-world assumption during classification.

The contribution will discuss the state-of-the-art rejection methods in classification with application to music information retrieval.

Optimal Preventive Maintenance in Degradation Processes

Waltraud Kahle (Otto-von-Guericke-University Magdeburg)

We consider the Wiener process with drift as a model of damage and degradation. A failure occurs when the degradation reaches a given level h first time. In this case, the time to failure is inverse Gaussian distributed.

For preventive maintenance, inspections of the degradation are regularly carried out. If at inspection time the degradation is larger than a predefined level a, then the item will be replaced by a new one.

There are three kinds of costs:

- costs of inspection,
- costs of (preventive) maintenance,
- costs of a failure.

In the talk, we consider the problem of defining optimal time intervals between inspections, as well as an optimal replacement level level a.

Accelerated lifetime testing plans for high tech insulation (HTI) products

Rainer Göb and Kristina Lurz (University of Würzburg)

High tech insulation (HTI) products are gaining shares on the market for thermal insulation. They are used for high quality and high convenience pur- poses, e. g., in transport containers, domestic appliances or thermic isolation of his- toric buildings. The HTI manufacturing sector is evolving, but immature. Producers and users have an urgent demand for quality control techniques. Hitherto, quality control and service lifetime prediction for HTI products have mainly been considered from a physical viewpoint, with strong emphasis on measurement issues. Rigorous statistical approaches are still missing. From a review of the physical models for HTI product degradation over time we build a mixed nonlinear regression model of degradation

as a function of time and ambient temperature. The model accounts for measurement-to-measurement and for panel-to-panel variation. We investigate inferential techniques for model parameter estimation and life-time prediction, and we study the design of accelerated experiments on HTI products.

Convex hull peeling: a new nonparametric multivariate control chart

Amor Messaoud (University of Jendouba)
Giovanni C. Porzio (University of Cassino)
Mohamed Limam (University of Tunis)

Convex hull peeling a multivariate data set consists of identifying its successive layers, from the outermost to the innermost. It is used in literature for many purposes in multivariate data analysis, including data ordering, trimming, outlier detection, robust estimation of location, correlation and probability contours.

This work develops a new nonparametric multivariate exponentially weighted moving average control chart using convex hull peeling multivariate data sets. First, the observations obtained from an in-control process are peeled. The convex hull probability depth is used to obtain an inner-outward ordering of the data according to the in-control distribution F^0. That is, an outer-inward sequence of nested convex hulls of increasing quality levels is defined, where the deepest points will correspond to items of higher quality. Second, given a new observation X in the monitoring phase, the probability content under F^0 of the convex hull to which X belongs in the peeling sequence is computed. This latter is used in turns as the statistic that defines the proposed control chart.

In this presentation, the proposed chart is presented. Its design and its on-line implementation are discussed. Simulation results regarding its performance are presented and compared with existing procedures in the literature. Finally, its performance is evaluated using real data sets.

Identification of active effects in unreplicated factorial designs

Christos Koukouvinos (National Technical University of Athens)

Unreplicated factorial designs are widely used in screening experiments due to their economic run size. However, they are difficult to analyze because there are no degrees of freedom left to estimate the experimental error. Many

methods have been proposed for the analysis of such designs, with Daniel's (1959) and Lenth's (1989) being the most popular. We present two methods for analyzing unreplicated factorial designs. The first method is based on the representation of the effects on a normal probability plot originally proposed by Daniel (1959), while the second takes advantage of the projective property of factorial designs. The presented methods are compared to existing techniques via an extensive simulation study.

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The use of orthogonal arrays in robust parameter designs methodology

Panagiotis Angelopoulos (National Technical University of Athens)

Robust parameter design was originally introduced by Taguchi (1986) as an engineering methodology for quality improvement of products and processes. A robust design of a system is one in which two different types of factors are varied; control factors and noise factors. Control factors are variables with levels that are adjustable, whereas noise factors are variables with levels that are hard or impossible to control during normal conditions, such as environmental conditions, raw-material properties, etc. Robust parameter design aims at the reduction of process variation by properly selecting the levels of control factors so that the process becomes insensitive to changes in noise factors. Taguchi (1986, 1987) proposed the use of crossed arrays (inner-outer arrays) for robust parameter design. A crossed array is the cross-product of an orthogonal array involving control factors (inner array) and an orthogonal array involving noise factors (outer array). Objecting to the run size and the flexibility of crossed arrays, several authors combined control and noise factors in a single design matrix, which is called a combined array, instead of crossed arrays. We will present the use of orthogonal arrays in Taguchi's methodology as a useful tool for designing robust parameter designs with economical run size. Furthermore we will present a method for validating the use and performance of combined arrays.

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Run orders in factorial designs to protect against a possible time trend

Adrian Wilk and Joachim Kunert (TU Dortmund)

In the presence of a time trend, the results of an experimental design realised in a time sequence depend on the run order in the presence of a time trend. For example, imagine the situation that a monotone time trend exists and that from a factor with two levels the low level runs are all executed before the first high level run is performed. In doing so the factor would be liable to be declared to have a significant influence on the response variable by a statistical test, although the factor is not active in reality. This is due to the fact that the effect estimator is highly correlated with the time trend. Hence experimenters try to get a grip on this difficulty by a suitable run order.

Different strategies exist to compensate a possible time trend. We compare three strategies with respect to their performance. The power is quantified by the probability to identify truly active effects as active effects. A further criterion describes the keeping of the level of significance. We use simulations to quantify the influence of a time trend on the various designs and observe good performance of randomised orders. In our simulation studies we confine ourselves to analysing unreplicated factorial designs of length n=8, n=16 and n=32. Because there are no degrees of freedom for estimation of variance, the designs are analysed via half-normal plots. We use four different proposals to estimate the error variance and compare these proposals with each other.

Relative projection aberration for mixed level orthogonal arrays

Ulrike Grömping (Beuth University of Applied Sciences Berlin)

Traditionally, a few orthogonal arrays have been proposed and studied intensely, e.g. the L12, L18 or L36; additionally, the regular fractional factorial designs and screening designs by Plackett and Burman (1946) have been frequently used. However, researchers often have research needs that go beyond those simple designs. If a more general request is formulated, it is often accommodated using a non-orthogonal design obtained using a specified model and some optimality criterion (e.g. D-optimality), or it is forced into an existing orthogonal scheme by omitting some factors or factor levels.

In statistical theory, general mixed level orthogonal arrays have been systematically studied for some time, starting with the seminal paper by Xu and Wu (2001), who introduced generalized minimum aberration. Xu, Phoa and Wong (2009) gave an excellent overview over this branch of research. In recent years, there are also substantial efforts of enumeration of non-isomorphic orthogonal arrays, for example by Schoen (2009). For many experimental situations, there are a large number of competing arrays. Choice between them (for example, they cannot all be included into any software because of storage space constraints) or choice of a subset of columns from an individual array requires criteria for assessing the quality of the resulting designs.

Orthogonality is an attractive criterion because it comes with model robustness. For example, if all main effects are orthogonal to all two-factor interactions, main effects can be estimated without bias, even if an active two-factor interaction has been omitted from the statistical model. In this sense, the degree of orthogonality a design achieves is a measure of model robustness it guarantees. This talk is concerned with criteria for measuring the degree of orthogonality for mixed level orthogonal arrays, aiming for maximized model robustness (cf. Grömping 2011). The main purpose for developing these criteria is selection of orthogonal arrays for inclusion into software and automatic allocation of experimental factors to selected columns of larger orthogonal arrays (cf. e.g. R-package DoE.base, Grömping 2009-2011).

Mixed level orthogonal arrays compete with letter-optimal designs. Recently, Schoen (2010) compared the behavior of orthogonal arrays and D-optimal designs for various scenarios and arrived at the (not too surprising) conclusion that neither approach is always superior. Jones and Nachtsheim (2011) proposed to optimize the alias structure of a design under constraints on D-optimality. With the criteria proposed here - once fully understood - it should also be possible to take the reverse route: optimize D-efficiency under constraints on model robustness criteria.

The talk is a presentation of work in progress. The workshop participants' expertise in Design of Experiments and statistics for quality improvement will hopefully generate useful feedback to be accounted for in further development and software implementation.

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Common mistakes in designing experiments

Bertram Schäfer (STATCON, Witzenhausen)

'Common mistakes in designing experiments' focuses on the setup or definition phase of experimental designs. In particular the design size, as well as the design type and the number of factors will be discussed. In addition the effects of improper randomization and wrong specification of factors levels are shown. This talk does not cover mistakes or problems in the analysis of data.