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On combining control charts using ensemble method techniques for online data stream processes with concept drift

Dhouha Mejri, TU Dortmund University, ISG Tunis, University of Tunis, Mohamed Limam, ISG Tunis and Dhofar University, Oman and Claus Weihs, TU Dortmund University

Monitoring online data stream processes with concept drift based on adaptive control chart has recently interested many researchers due to the increase of the need of dealing with time changing data stream processes. However, monitoring a process with individual control charts such as EWMA, CUSUM and XBAR does not have the ability of detecting both small, moderate and large shifts. Moreover, some proposed combined control charts transfer some knowledge from one chart to another one to benefit from some additional information about the shift. We propose a Dynamic Ensemble Control (DEC) model to combine EWMA, CUSUM and XBAR charts, based on ensemble methods, which uses all the knowledge stored in different charting statistics of each individual chart, combine their decisions and monitor both large and small process shift simultaneously. The proposed combination benefits from the online characteristic of DWM-WIN algorithm of [MEJ13] in detecting the state of the process in nonstationary environment. It consists of three steps: first transforming the task of determining the state of the process into a classification problem by treating control charts as attributes of the data where the drift has to be predicted. Second, DWM-WIN is applied as an ensemble method to combine the different control charts. Third, misclassification error rates of DWM-WIN are monitored based on the time adjusting control chart for concept drift detection. The proposed control chart does not only exhibit superior robustness to individual EWMA, CUSUM and XBAR for a variant of performance measures but also presents a new heuristic for shift learning and monitoring in nonstationary environment.

Keywords
Statistical Porcess Control, ensemble methods, dynamic weighted majority algorithms, concept drift, data stream.

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An EWMA-type Chart for Monitoring Poisson Counts

Athanasios C. Rakitzis and Philippe Castagliola, Université de Nantes & IRCCyN UMR CNRS 6597 and Petros E. Maravelakis, University of Piraeus

In the literature, there are several EWMA charts for monitoring count data. In that case, the values of the plotted statistic are not integers while the set of the possible attainable values of the EWMA statistic changes at each sampling time. Consequently, the actual performance of an EWMA chart for count data can only be approximated. Motivated by this fact, we propose and study a new control charting procedure with memory that is suitable for the monitoring of observations from any discrete distribution. The proposed scheme uses a pair of non-negative integer-valued weights in the recent as well as in the past observations, while the plotted statistic takes only non-negative integer values. For the statistical design of the proposed scheme, it is required the determination of the weights and a control limit (for the one-sided schemes, upper- or lower-sided) or a pair of control limits (for the two-sided scheme). The entire run length distribution of the proposed chart can be exactly evaluated via an appropriate Markov chain technique. Also, we present the results of an extensive numerical study concerning the design and performance of this new control chart in the monitoring of Poisson observations. Our analysis reveals that the proposed scheme is very sensitive in the detection of small shifts in the mean of a Poisson process, especially for the downward ones. Finally, comparisons with other competitive schemes are also given.

Keywords
Average Run Length (ARL), Count data, Markov chain, Poisson distribution, Poisson CUSUM, Poisson EWMA.

On control charts and the detection of increases in the traffic intensity

Manuel Cabral Morais and António Pacheco, CEMAT and Instituto Superior Técnico, Universidade de Lisboa

The traffic intensity (ρ) is a crucial parameter of a queueing system since it is a measure of the average occupancy of a server. Expectedly, an increase in ρ must be detected quickly so that a corrective action can be taken, such as allocating more servers or increasing the service rate. In this paper, we:

- review existing procedures used to monitor the traffic intensity of $G/M/1$ and $M/G/1$ queues;
- focus on control charts, whose control statistics are integer-valued and modelled by discrete time Markov chains, to detect increases in ρ;
- investigate the stochastic monotonicity properties of the associated probability transition matrices;
- explore the implications of these properties to provide insights on the performance of such control charts and compare them with competing procedures.

Keywords
statistical process control, run length, phase-type distributions, stochastic ordering

Uncertainty progression in process chains

Oliver Meyer, TU Dortmund University

Industrial production processes usually consist of several sequential sub-processes, which can be represented by individual statistical models. Such sequences of sub-processes are often referred to as process chains. In traditional process analysis these models are treated to be (statistically) independent from one another. Since these models intertwine and the results of earlier sub-processes are often used as independent variables for later ones, this approach appears to be unsatisfactory. The purpose of this presentation is to introduce a method which allows us to predict and analyse the transfer and the progression of uncertainty in process chains. The individual sub-processes are therefore described using linear regression models. This method allows us not only to determine uncertainty that is generated by model prediction, but also to consider uncertainty from nondeterministic independent variables. In the following presentation we intend to show that the developed method is valid by testing it using simulated regression data. We will further introduce an implementation of the previously mentioned method for the statistical programming language R, and a practical example based on data from the field of automobile industry will be discussed.

Without statistical DoE, 30% of experimental runs are wasted

Ursula Garczarek, Unilever

Statisticians claim that applying statistical Design of Experiments (DoE) is better than its next best counterpart, the so-called One-Factor-At-a-Time (OFAT) approach. The prominent example consists of a quadratic function describing the outcome, with its maximum somewhere inside the spanned range of the two design factors. OFAT misses the optimum, DoE comes close. Proof done!? So why remains OFAT so popular, and why are those companies where research is still done without proper DoE not all going bankrupt?
Getting DoE in a company implemented costs efforts and it requires investments in statistical consultancy, training of employees and software. To justify those efforts, one convincing example is not good enough, a business case is needed that quantifies the cost reduction by DoE. In my presentation I will show the design and result of a simulation that I ran to deliver evidence to the rather bold statement: Without statistical DoE, 30% of experimental runs are wasted. Running the simulation with a clear goal in mind, I learned also a lot about those scenarios, where OFAT is actually not so bad.

How well do we need to measure our drilling mud?

Winfried Theis, Shell

Shell is always working to improve the quality of well construction operation, to ensure safe exploration of and production from the gas and oil reservoirs around the world. At the same time it is necessary to reduce costs as it becomes necessary to drill more wells to access smaller or unconventional reservoirs in an economical manner. One important part of the drilling operation is the hydraulic system formed by the drilling mud that is used to transport the cuttings from the hole. In this project the goal is to develop an online measurement system for the drilling mud. When considering the choice of the sensors the question arose, what is the measurement system performance requirement for the sensors on the hydraulic system for sufficient control of the outputs. As the hydraulic system is a complex non-linear system a simulator based on first principles was used to learn how random disturbances are propagated through the system. A series of designs of experiments for computer simulations was used to determine the most important influences on the sensitivity of the hydraulic system and subsequently to find safe upper limits for the measurement uncertainties.

Keywords
Measurement uncertainty, Design of Experiments, Computer experiments

Bayesian prediction of crack growth based on a hierarchical diffusion model

Simone Hermann, TU Dortmund University

In many research areas of engineering it is of particular interest to understand the process of material fatigue and to predict the failure time. Experiments are often very expensive because they take a long time and the constructions are costly. To extract as much information as possible from the available experiments and to predict fatigue, statistical models are a valuable tool.
A general Bayesian approach for stochastic versions of deterministic growth models is presented to provide prediction for crack propagation in an early stage of the growth process. To improve the prediction, the information of other crack growth processes is used in a hierarchical (mixed-effects) model. Two stochastic versions of a deterministic growth model are compared. One is a nonlinear regression setup where the trajectory is assumed to be the solution of an ordinary differential equation with additive errors. The other is a diffusion model defined by a stochastic differential equation (SDE) where the increments have additive errors. While Bayesian prediction is known for the hierarchical model based on nonlinear regression, we propose a new Bayesian prediction method for the hierarchical diffusion model.
The presented methods are applied on the degradation data set of Virkler et al. (1979) where sixty-eight replicate constant amplitude tests in aluminum alloy were carried out to investigate the fatigue crack propagation.

An overview of estimation strategies for discretely observed jump processes

Johanna Kappus, Universität Rostock

In many fields of applications, stochastic processes with jumps have become increasingly popular during the past decade. Consequently, the interest in statistical methods for jump processes has grown.

In this talk, the relevance of jump processes in the modelling of extremal events is discussed. Moreover, an overview of nonparametric and adaptive estimation strategies for discretely observed jump processes is provided.

(Non-)regularity of general orthogonal arrays and consequences for experimentation

Ulrike Grömping, Beuth University of Applied Sciences, Berlin

Recently, Grömping and Xu (2014) introduced an individual degree of freedom related generalized resolution GR_{ind} for arbitrary orthogonal arrays. With R the resolution of an array, $R \leq GR_{ind} < R+1$. It is conjectured that designs with large GR_{ind} are particularly suitable for experimentation, if model robustness is desired. The building blocks of GR_{ind} are squared canonical correlations of a factor's main effects model matrix with the full model matrix of $R-1$ other factors in R factor sets. These are all 0 or 1 for regular designs (which implies $GR_{ind} = R$). With recently added functionality of the R package DoE.base, it is for the first time straightforward to identify designs without regular aspects (i.e. $GR_{ind} > R$) and thus to compare their behavior to regular designs of comparable sizes. It is expected that they will show superior behavior in terms of model robustness.

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A semi-parametric model for recurrent events and its statistical properties

Eric Beutner, Maastricht University

Recurrent event data arise from the study of processes that generate events repeatedly over time. Such processes occur in many settings such as biomedicine, clinical trials and engineering. In this talk, we give an introduction to a semi-parametric model for recurrent events that accounts for interventions through an effective age process. Probably the best known effective age process is the one arising from a renewal process where, after each event occurrence, the effective age is set back to zero. Another case in point is the non-homogeneous Poisson process that results from minimal repairs. We also discuss the following question: Suppose we profile out the infinite-dimensional parameter by using a right-continuous step function. Can we use the resulting profile likelihood function of the above mentioned semi-parametric model for recurrent events if the effective age process is parametrically specified?

Statistical methods for quality assessment of adjusted fundamental constants

Olah Bodnar and Clemens Elster, Physikalisch-Technische Bundesanstalt, Berlin, Germany

The International Bureau of Weights and Measures (BIPM) defines metrology as the science of measurement and its application. The quality of measurement results is generally characterized by their uncertainty, and specific guidelines prescribe how these uncertainties are calculated [1]. Measurement uncertainty plays an important role for calibration services and is essential in assessing the conformity of product specifications in industry.
One particular task in metrology is the determination of fundamental constants such as the Planck constant or the Newtonian constant [2]. Many areas of science and industry are finally affected by the accurate measurement of these constants. It is essential that the uncertainties associated with the corresponding estimates are reliably assessed. The determination of fundamental constants typically involves the combination of measurement results obtained by different laboratories using the same or different measurement methods. The value of a fundamental constant is then determined as a consensus value based on all estimates and their uncertainties. This adjustment is done on a regular basis by the Committee on Data for Science and Technology (CODATA) [2]. The employed techniques are based on least-squares adjustment, elimination of outliers and artificial enlargement of uncertainties. In this talk we present two statistical models as an alternative.
The considered statistical models comprise the generalized location-scale model (GLSM) as well as a generalized marginal random effects model (GMREM). We present a Bayesian inference for these models on the basis of a noninformative prior which is taken as the Berger-Bernardo reference prior [3]. The reference prior is based on an information theoretic criterion (see [3] and also [4]). The GLSM has been studied since long and its reference prior is well known [5]. The GMREM together with the corresponding reference prior have been proposed recently [6]. After introducing the GLSM and the GMREM we present results of a simulation study which

investigates the (frequentist) properties of the two model approaches. The study also explores the robustness of the corresponding inferences against model violations, in particular by assessing the inferences made on the basis of one of these models when the other one applies. Finally, both methods are applied for the adjustment of the Planck constant and the Newtonian constant, and the results are compared with those recently published by CODATA.

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