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Sven Knoth

Dept. Mathematics/Statistics
Helmut Schmidt University
Hamburg, Germany

Wolfgang Schmid

Dept. Statistics
European University Viadrina
Frankfurt (Oder), Germany

Manuel Cabral Morais

CEMAT, Dept. Mathematics
Instituto Superior Técnico
University of Lisboa
Lisboa, Portugal

Book of Abstracts

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Introduction

It is already the XV$^{\text{th}}$ International Workshop on "Intelligent Statistical Quality Control" (ISQC 2025) following:

year	place
2023	Washington/DC, USA
2019	Hong Kong
2016	Hamburg, Germany
2013	Sydney, Australia
2010	Seattle, USA
2007	Beijing, China
2004	Warsaw, Poland
2001	Waterloo, Canada
1998	Würzburg, Germany
1995	Osaka, Japan
1990	Baton Rouge, USA
1986	Lyngby, Danmark
1983	Kent, UK
1980	Berlin, Germany

This time, it is hosted by the University of Lisboa in Portugal. We hope that it will be as successful as the previous ones. On the next pages of this booklet some useful information are collected.

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Abstracts

Legend of abstract markers (used throughout the following pages)

label	meaning
✌	available in proceedings
◐	to be clarified
🗃	available in file repository
arXiv	published on `https://arxiv.org/`
🔭	work in progress
☍	already published
☕	might be published later (in Springer book or elsewhere)

An Adaptive EWMA Control Chart for Monitoring Multivariate Functional Data

Christian Capezza, Giovanna Capizzi, Fabio Centofanti, Antonio Lepore and Biagio Palumbo

Dept. Industrial Engineering, U Naples Federico II, Naples, Italy, christian.capezza@unina.it, fabio.centofanti@unina.it, antonio.lepore@unina.it, biagio.palumbo@unina.it; Dept. Statistical Sciences, U Padua, Italy, giovanna.capizzi@unipd.it

Monitoring the quality characteristics of industrial processes has become increasingly complex due to the prevalence of data observed as a function of time or space. This paper introduces a novel *Adaptive Multivariate Functional EWMA* (AMFEWMA) control charting scheme to extend the exponentially weighted moving average (EWMA) scheme to multivariate functional quality characteristics, i.e., to multivariate profile monitoring. The scheme dynamically adjusts the EWMA weighting parameter to enhance sensitivity across a range of out-of-control (OC) scenarios, effectively balancing the detection of mean shifts without requiring prior knowledge of its magnitude, as a traditional EWMA scheme necessitates.

The AMFEWMA approach consists of three key steps: (1) functional data smoothing, which transforms noisy discrete observations into smooth functional representations; (2) multivariate functional principal component analysis, which reduces dimensionality by identifying dominant functional modes of variation; and (3) adaptive monitoring, where the EWMA statistic is computed with weights that adapt to deviations observed in the data. The flexibility of the AMFEWMA chart allows it to behave like a Shewhart chart when large deviations are present while retaining sensitivity to smaller persistent changes.

The performance of the proposed method is validated through an extensive Monte Carlo simulation study. Compared to conventional functional EWMA schemes and multivariate Shewhart control charts, AMFEWMA consistently achieves superior detection under various OC conditions. In particular, it adapts effectively to unknown changes in the mean of the process, demonstrating robustness and versatility. A case study involving the monitoring of a resistance spot welding process in automotive manufacturing is presented. Dynamic resistance curves (DRCs) measured from multiple welding points are multivariate functional quality characteristics. The AMFEWMA chart successfully detects electrode wear-related changes in the DRCs, indicating weld quality degradation. This highlights the practical applicability of the method for modern industrial settings where functional data are prevalent. The AMFEWMA control chart is implemented in the open-source statistical software R and made available in the funcharts package, ensuring reproducibility and accessibility for practitioners.

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Comparison of some linear-rank based control charts for location

Fernanda Figueiredo, Subhabrata Chakraborti and Adelaide Figueiredo

U Porto, School of Economics/Management & CEAUL and LIAAD/INESC TEC, resp., Portugal, otilia@fep.up.pt, adelaide@fep.up.pt; U Alabama, Culverhouse, College of Business, USA, schakrab@ua.edu

In many practical situations involving process monitoring, the data distribution is unknown, and therefore, a nonparametric control chart is required. In this work we consider some linear rank-based control charts for location and we compare their performance.

Suppose we have available a reference sample $(X_1, X_2, \ldots, X_m)$ taken from an in-control and stable process, and let $(Y_1, Y_2, \ldots, Y_n)$ be the current arbitrary test sample. Assume that these samples are independent, as well as the observations within each sample, and drawn from two populations with continuous cumulative distribution functions F_X and F_Y, respectively. Let us consider the combined ordered sample of size N and the corresponding vector of indicator random variables $(Z_1, Z_2, \ldots, Z_N)$, where $Z_i = 1$ if the i-th random variable in the combined ordered sample is from population Y, and $Z_i = 0$ if the i-th random variable in the combined ordered sample is from population X, for $i = 1, \ldots, N = n + m$.

A linear rank-based statistic is defined as a linear function of the indicator variables Z_i, as

$$T_N(Z) = \sum_{i=1}^{N} a_i Z_i \ ,$$

where a_i are given constants, called weights or scores. Several nonparametric tests are obtained by choosing appropriate scores, for instance, the Wilcoxon rank-sum and the van der Waerden tests for location (for details see Gibbons and Chakraborti, 2020). In this paper we consider different sets of weights a_i, so that several linear rank statistics, popular in the literature, the corresponding charting statistics T_N and the control limits are obtained. Performance of these charts are examined, both in terms of in-control and out-of-control properties, for data from symmetric non-normal distributions with different tail weights.

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Multivariate, -stream and smoothed distances EWMA control charts ☕

Sven Knoth

Dept. Mathematics & Statistics, Helmut Schmidt U Hamburg, Germany, knoth@hsu-hh.de

Multivariate EWMA control charts were introduced in Lowry et al. (1992) and became a popular and effective tool for monitoring multivariate data. However, multi-stream data are somehow related to the aforementioned framework. In both cases, correlation between the components respective streams is considered. However, whereas the multivariate EWMA charts deploys a distance (Mahalanobis) in the multivariate space, the multi-stream EWMA chart comprises a set of univariate control charts. Furthermore, it is tempting to insert the observed distances directly into a EWMA smoothing. Here, the calculation of the detection performance of multi-stream EWMA charts (not many results are available so far) and distance smoothing charts is discussed This allows an appropriate comparison with the better investigated multivariate EWMA charts (Rigdon 1995a/b, Knoth 2017). Essentially, numerical methods are applied. Extensive Monte Carlo studies confirm their validity. Eventually, some recommendations regarding the choice of the schemes are given.

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Unscrambling Billing Fraud – GoF Tests or Measuring Contamination? ✌

Wolfgang Kössler, Hans-Joachim Lenz and Marco Marozzi

Institut Informatik, Humboldt U Berlin, Germany, wolfgang.koessler@hu-berlin.de; Institut Statistik & Ökonometrie, Freie U Berlin, Germany, Hans-J.Lenz@fu-berlin.de; Dept. Mathematics & Computer Science, U di Ferrara, Italy, marco.marozzi@unife.it

Data Quality Control and Fraud Detection like billing fraud have a common interface when being based on Benford's Law. Usually, statistical goodness-of-fit (GoF) tests are applied for testing whether or not the data at hand is conforming to Benford or not. Contrarily, this study is devoted to an alternative way of looking at the same problem. Instead of running GoF tests we vote for estimating the percentage of contamination of a given data set. First, we look at the divergence between the Benford distribution and a given empirical distribution. Let us consider, for simplicity, only the first digit distribution of Benford's Law. Let be p_i the Benford first digit probabilities and n_i, $i = 1, \ldots, 9$ the number of observations with first significant digit i in a sample of size n. We choose two measures,

$$\Delta = \frac{\sum_{n_i > np_i} (n_i - np_i)}{n} \quad \text{and} \quad \pi^* = 1 - \min_{i=1,\ldots,9} \frac{n/n_i}{p_i} \,.$$

Δ can be interpreted as the minimal relative amount of observations to be *shifted* to get a perfect fit with respect to Benford's Law, whereas π^* can be interpreted as the minimal relative amount of observations to be *removed* to get a perfect fit with respect to Benford's Law, cf. also Medzihorsky (2015).

Note that fraudulent data is intrinsically sparse, while data quality control problems benefit from the Big Data feature. Therefore we prefer data of moderate or large size in our experiments. We run Monte Carlo simulations of π^* and of Δ for various sample sizes $n = 1\,000$, $10\,000$ and $100\,000$, generating Benford data for some contamination patterns. We use the contamination model of Kössler, Lenz and Wang (2024) with added items of small (1.5), medium (6.5) and large values (9.5). Moreover, we do not consider the first non-zero or significant digit alone, but the second one, and both the first and second one, too.

It will be shown that π^* is seriously biased, but with the same bias for all alternatives considered. Δ is only slightly biased but the bias may be positive or negative dependent on the alternative. Therefore we suggest π^* with bias correction as a measure of contamination.

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Large-Language-Models (LLMs) for Time Series Analysis ◐

Ziyue Li

Dept. Information Systems, U Köln, Germany, zlibn@wiso.uni-koeln.de

This talk explores the application of large language models (LLMs) to the domain of time series analysis, leveraging their advanced capabilities for a variety of predictive tasks. We investigate the use of LLMs for time series prediction and spatiotemporal prediction, highlighting their effectiveness in capturing complex temporal and spatial dependencies. Furthermore, we delve into time series classification, demonstrating the models' proficiency in distinguishing patterns and anomalies within sequential data. A novel contribution of our work is the integration of time series and text dual modality, where we show how LLMs can simultaneously process and relate temporal data with textual information, enhancing the overall predictive accuracy and interpretability. Our comprehensive experiments reveal that LLMs, when applied to time series analysis, significantly outperform traditional methods, providing a robust framework for future research and practical implementations in this field.

Robust one-class support vector machine with Least Squares ✌

Edgard Maboudou and Randyll Pandohie

Dept. Statistics & Data Science, U Central Florida, USA; Edgard.Maboudou@ucf.edu

One-class classification is a cornerstone of anomaly detection and data description, particularly in high-dimensional data domains. Least Squares Support Vector Data Description (LS-SVDD) has been performing well in one-class classification and novelty detection tasks. In this study, we propose Robust version of Least Squares Support

Vector Data Description (Robust LS-SVDD), a novel enhancement of the LS-SVDD framework.

This method redefines the initial optimization problem of LS-SVDD using a correntropy loss function. Consequently, this new optimization prob- lem increases the significance of samples that are more likely to represent the target class while decreasing the impact of samples that are more likely to represent outliers. To efficiently address the optimization challenge associated with the proposed model, the half-quadratic optimization method was utilized to generate a dynamic optimization algorithm. Simulation studies demonstrate that the proposed one-class classifier has very good performances.

Generative AI Applications and Opportunities for Quality Control Researchers and Practitioners

Fadel M. Megahed, Ying-Ju (Tessa) Chen, Bianca Maria Colosimo, Marco Luigi Giuseppe Grasso, L. Allison Jones-Farmer, Joshua Ferris, Sven Knoth, Douglas C. Montgomery, Hongyue Sun, Inez Zwetsloot

Farmer School Business, Miami U, Oxford, OH, USA, fmegahed@miamioh.edu, farmerl2@miamioh.edu, ferrisj2@miamioh.edu; Dept. Mathematics, U Dayton, Dayton, Ohio, USA, ychen4@udayton.edu; Dept. Mechanical Engineering, Politecnico di Milano, Milan, Italy, biancamaria.colosimo@polimi.it, marcoluigi.grasso@polimi.it; Dept. Mathematics & Statistics, Helmut Schmidt U Hamburg, Germany, knoth@hsu-hh.de; School Computing & Augmented Intelligence, Arizona State U, Tempe, AZ, USA, doug.montgomery@asu.edu; College of Engineering, U Georgia, Athens, GA, USA, hongyuesun@uga.edu; Faculty Economics & Business, U Amsterdam, The Netherlands, i.m.zwetsloot@uva.nl

Generative AI tools such as ChatGPT, Claude, and Gemini have captured global attention. These systems are fast, accessible, and increasingly powerful. Yet, their practical use in industrial quality control is still emerging. This talk will introduce key ideas and highlight how our community can shape the responsible use of generative AI.

We will present real examples from our recent research and applications:

- Using generative AI for structured text extraction and annotation, including when and how to assess reliability (with a quick demo using our structured text extraction app).
- Building chatbots to support quality control practice (e.g., ChatSQC).
- Adapting OpenAI's CLIP model for image inspection in manufacturing settings, including a public tool to try few-shot learning with your industrial images (with the CLIP for Industrial Quality Control tool).
- Demonstrating how these tools can support forecasting workflows in time series analysis using our StatsForecast app.

Throughout the talk, we will highlight several web-based tools, code snippets, and use cases attendees can explore in their research. We will highlight risks, such as model hallucinations and over-reliance on AI-generated content, and suggest practical steps to evaluate whether generative AI suits a given task.

Monitoring the traffic intensity of single-server queues

Aníbal Pires and Manuel Morais

Dept. Math. & CEMAT, Instituto Superior Técnico, U Lisboa, Portugal, anibal.camara.pires@tecnico.ulisboa.pt, maj@math.ist.utl.pt

In this paper, we discuss ARL-unbiased control charts for monitoring the traffic intensity (ϱ) of single-server queuing systems. These charts are specifically designed to detect any shifts in ϱ earlier than they trigger a false alarm.

The building blocks of the control statistics of all these charts are: X_n, the number of customers left behind in the M/G/1 system by the n^{th} departing customer; $\hat{X}_n$, the number of customers seen in the GI/M/1 system by the n^{th} customer arriving; and W_n, the waiting time of the n^{th} arriving customer to a GI/G/1 system.

We briefly review the ARL-unbiased Shewhart-type charts for monitoring ϱ proposed by Morais and Knoth (2018). We use a Shiny App to determine their parameters and visualize their ARL profiles (under three out-of-control scenarios), thus enhancing the user experience.

We also propose ARL-unbiased EWMA-type control charts for monitoring ϱ and present some preliminary, yet compelling, results.

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High-dimensional change point estimation on the community structure of networks

Cathy Yi-Hsuan Chen, Yarema Okhrin, Tengyao Wang

Adam Smith Business School, U Glasgow, UK, CathyYi-Hsuan.Chen@glasgow.ac.uk; Faculty of Business & Economics, U Augsburg, Germany, yarema.okhrin@uni-a.de; Dept. Statistics, LSE, London, UK, t.wang59@lse.ac.uk

Community detection plays a central role in network analysis, with methods such as K-means, stochastic block models, LDA, and spectral clustering forming the backbone of modern approaches. However, most existing techniques assume a static community structure and overlook potential temporal changes. In dynamic networks, community structure and node-level properties like degree and centrality often evolve, highlighting the need for change point detection methods tailored to community dynamics. This paper proposes a novel framework for detecting multiple change points in the community structure of evolving networks by building on the Spectral Clustering On Ratios-of-Eigenvectors (SCORE) method. SCORE, based on the Degree Corrected Block Model (DCBM), is particularly effective for sparse networks with degree heterogeneity. By tracking changes in the coordinate-wise SCORE derived from the leading eigenvectors of the adjacency matrix, our method identifies structural shifts while accounting for time-varying degree heterogeneity. We develop algorithms for scenarios with an unknown number of communities ($K > 2$) and multiple change points, and provide theoretical guarantees for consistency and convergence rates. Our results address a critical gap in dynamic network analysis and reduce false alarms due to uncorrected degree variability.

Statistical process monitoring for additive manufacturing using semi-structured regression models ✌

Philipp Otto, Mohammadreza Nasiri Boroujeni, Raffaele Mattera and Giulio Mattera

School of Mathematics & Statistics, University of Glasgow, UK, Philipp.Otto@glasgow.ac.uk; Leibniz U Hannover, Institute Cartography &Geoinformatics, nasiri@ikg.uni-hannover.de; Dipartimento di Scienze Sociali ed Economiche, U Roma la Sapienza, Italy, raffaele.mattera@uniroma1.it; Dept. of Chemical, Materials & Production Engineering, U Naples Federico II, Italy, giulio.mattera@unina.it

Ensuring process stability and defect detection in additive manufacturing, particularly in arc welding, requires statistical monitoring techniques capable of handling complex and high-dimensional data. We propose a novel monitoring framework based on an exponentially weighted moving average (EWMA) control charts applied to residuals from a semi-structured distributional regression model. The model is designed to capture dependencies in a bivariate response variable consisting of two correlated and periodic time series while incorporating high-dimensional welding spot images as covariates through convolutional neural networks (CNNs). This flexible approach allows for a joint representation of temporal and spatial/image process characteristics, enabling a more comprehensive assessment of deviations from the target process.

To ensure effective monitoring, the control charts are calibrated using Monte Carlo simulations based on model estimates obtained in Phase I. This calibration process accounts for inherent variability in the data and ensures appropriate false alarm rates. The methodology is then applied to real-world additive manufacturing data, demonstrating its ability to identify process anomalies and detect defective regions in the final welding product, which has a wall-like structure. The proposed framework provides a statistically rigorous approach to quality assurance in advanced manufacturing, offering a data-driven solution for real-time monitoring and process optimisation.

Sequential Change Point Detection Using LS-SVR and LS-SVDD for Real-Time Anomaly Detection ✌

Edgard M. Maboudou-Tchao and Randyll Pandohie

Dept. Statistics & Data Science, U Central Florida, USA; Randyll.Pandohie@ucf.edu

This research advances the field of one-class classification by introducing a novel methodology for sequential multiple change point detection in time series and regression data. Unlike traditional batch methods that require the entire dataset for analysis, our approach emphasizes sequential detection, enabling real-time processing and immediate anomaly detection in evolving data streams. We leverage Least Squares Support Vector Regression (LS-SVR) in combination with Least Squares Support Vector Data Description (LS-SVDD) for their ability to handle non-linear patterns in anomaly identification. The proposed methodology is multi-modal, allowing its application to both time series and regression problems. It is evaluated through experiments on both simulated time series datasets and a real-world dataset, covering a wide range of change point scenarios. Our results demonstrate the effectiveness of this approach in accurately detecting multiple change points sequentially and paving the way for real-time monitoring applications as well as change point detections across various domains.

Sequential Sampling for Optimization under Functional Uncertainty: A Robust Approach in Function Space

Pouya Ahadi, Kamran Paynabar

H. Milton Stewart School Industrial & Systems Engineering, Georgia Institute of Technology Atlanta, GA, USA, kamran.paynabar@isye.gatech.edu, pouya.ahadi@gatech.edu

Sequential sampling is widely used to identify optimal input values that achieve a desired response. Most existing work focuses on scalar responses and/or assumes Gaussian uncertainty. We introduce Functional Robust Bayesian Optimization (FRBO), a novel framework for optimizing functional responses under uncertainty, where the entire mapping from design inputs to responses may vary within a structured function space. FRBO assumes the true response function lies within a smooth, norm-bounded region surrounding an unknown reference function. We model this ambiguity using a Reproducing Kernel Hilbert Space (RKHS) ball and derive a robust surrogate objective that captures both interpolation error and epistemic uncertainty. This approach enables principled acquisition without relying on posterior sampling, facilitating non-parametric robustness in black-box optimization settings. FRBO accommodates both scalar and functional-valued responses and is applicable across diverse domains such as optics and materials design. Beyond providing theoretical guarantees on worst-case regret, we validate our approach through numerical studies, demonstrating that FRBO consistently outperforms existing baseline methods.

Taming False Alarms: Practical Strategies for Monitoring Modern Processes

Marcus B. Perry

Department of Info Systems, Statistics, and Management Science, U of Alabamna, USA; mbperry@ua.edu

Modern industrial processes frequently generate multivariate, non-Gaussian data characterized by both spatial and temporal dependencies. These complexities pose significant challenges for statistical process monitoring, particularly in maintaining reliable control over the false alarm rate. This talk introduces some simple and practical monitoring strategies that serve as alternatives to, or enhancements of, conventional multivariate control charts. These strategies provide improved control over the true false alarm rate, making them especially well-suited for modern process environments where standard assumptions often fail.

Multivariate Statistical Process Control for Shrimp Farming: A Case Study in Northern Peru

Ana Valeria Quevedo, Susana Vegas and Mario Quinde

Facultad de Ingeniería, Universidad de Piura, Peru

valeria.quevedo@udep.edu.pe, susana.vegas@udep.edu.pe, mario.quinde@udep.edu.pe

Shrimp farming in northern Peru is a vital and expanding industry, contributing 41%

of the national harvest and 73% of aquaculture export value, while supporting rural livelihoods and sustainable development (Produce, 2024). However, the sector faces significant challenges, including declining international prices, company closures, vulnerability to climate events like El Niño, and the lack of advanced tools to monitor the complex variables affecting shrimp growth. Effective production requires continuous monitoring of critical variables across shrimp growth stages. Traditional Statistical Process Control (SPC) methods often fail to address the challenges posed by Industry 4.0 processes, where data violates assumptions of independent multivariate normal distribution and autocorrelation between successive observations assumptions.

Advancements in sensor technology have created challenges for conventional control charts. This paper addresses these challenges by applying multiway principal component analysis (MPCA), which reduces the dimensionality of the monitoring space while preserving critical information from measured variables. Unlike conventional multivariate SPC charts, MPCA does not require assumptions of normality or independence between consecutive observations (Ferrer, 2014), while maintaining the simplicity of conventional MSPC charts. Key monitoring statistics, such as um of squares of standardized scores (Hotelling's T^2) and Squared Prediction Error (SPE), are used to summarize the data and detect deviations from normal operation, enabling early corrective actions.

This study uses real-world data from a small shrimp farm located in La Bocana, Colan, Piura, a rural community one kilometer from the sea. As part of an ongoing Concytec-Peru-funded project (PE501082044-2023), an IoT-based system will be integrated with the statistical tools to monitor shrimp growth. The parameters being sensor-collected include oxygen level, salinity, pH and temperature, which are critical for ensuring the adequate adaptation of post-larvae shrimp. The sensor-based data is periodically sent to a server, as input for designing and validating control charts to monitor these parameters in real time. The analysis uses three months of data from the IoT-based monitoring system.

The paper demonstrates the design and validation of T^2 and SPE charts for Phase I, as well as their application for Phase II analysis. By applying MPCA for effective process monitoring, this study seeks to improve decision-making and enhance operational efficiency in shrimp farming. This study addresses the limitations of conventional control charts, leveraging modern sensor technologies to promote sustainable practices and support rural development in northern Peru.

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Correlation- and Causal-based Fault Detection and Diagnosis in Large-scale Statistical Process Monitoring: Some Problems and Mitigating Solutions

Marco S. Reis

U Coimbra, CERES, Dept. Chemical Engineering, Coimbra, Portugal, marco@eq.uc.pt

Detection and diagnosis constitute two major tasks of Statistical Process Monitoring (SPM). Whereas detection is focused on quickly signaling the occurrence of a fault in the process, diagnosis regards the analysis of its origin, directing a human agent towards potential root causes. Thus, despite the logical and sequential interconnection, their scope is fundamentally distinct, and the methods developed over time reflect such a difference. Fault detection methods require the definition of a Normal Operating Conditions (NOC) envelope and the continuous testing of whether new observations fall inside or outside it. In SPM, underlying such envelope is a stochastic model of the NOC process, based on which a probabilistic coverage for Phase II is attributed. No causal reasoning is therefore required for the purposes of detection. On the other hand, causality is fundamental for fault diagnosis. Still, causal reasoning is underrepresented among SPM diagnosis methods proposed, where correlation-based methods dominate.

In this talk, the focus will be placed on SPM for large-scale systems. Some problems that occur in the high-dimensional regime (number of variables > number of observations) will be discussed, regarding fault detection and diagnosis. Both correlation-based approaches (SPM based on Principal Component Analysis, SPM-PCA) and Causal-based approaches (centralized or distributed) are considered. Concerning correlation-based approaches, as more variables are analyzed, the existing latent variable methods begin experiencing difficulties, such as problems in setting control limits for the multivariate statistics, as well as a decreased sensitivity in detecting localized faults through the PCA Q (or SPE) statistic. This topic will be discussed, and mitigating solutions will be presented.

On the other hand, causal-based SPM will also be discussed. Centralized and decentralized approaches for large-scale systems are covered, where hierarchical distributed monitoring approaches tend to perform better. This methodology consists of finding the natural functional modules of the causal network by exploring its graph topology and identifying the strongly linked "communities". Decentralized systems are also more robust to hardware failures (in the communication infrastructure or elsewhere).

Toward Robust Feature Reduction in Diabetes Analytics: A Novel PCA-Based Framework for Generalizable Machine Learning Models

Magda Ruiz, Santiago Alférez, Luis Eduardo Mujica

Dept. Matemàtiques, Escola d'Enginyeria de Barcelona Est (EEBE), U Politècnica de Catalunya (UPC), San Adrià de Besòs-Barcelona, Spain, magda.ruiz@upc.edu, santiago.alferez@upc.edu, luis.eduardo.mujica@upc.edu

Managing diabetes requires advanced methods to process high-dimensional clinical data and derive actionable insights for diagnosis and treatment. This study introduces a novel framework that combines Principal Component Analysis (PCA) with a resampling-based methodology to create a generalizable non supervised PCA model. The proposed approach addresses two key challenges: dimensionality reduction and model generalization. By retaining clinically relevant features, improving computational efficiency, and enhancing predictive accuracy, the framework enables the integration of PCA into ensemble learning models effectively.

To ensure robustness, statistical analyses were conducted, including hypothesis tes¡ng for feature significance, confidence intervals for classification metrics, and calibration plots to evaluate model reliability. Statistical tests validated feature importance (H_0: the feature does not contribute to the model) and performance improvements (H_0: no significant improvement over baseline models). Results demonstrated significant enhancements ($p < 0.05$) in sensitivity and specificity across resampling iterations. Ensemble models trained with original features frequently achieved sensitivity and specificity values around or exceeding 80%, while PCA-based models offered competitive performance, highlighting the adaptability of the proposed framework.

Framed within the paradigm of "data as a language," this methodology draws parallels between structured feature extraction and the syntactic organization of language systems. Standardizing feature representation improves interpretability, much like the distillation of meaning in language. Applied to diabetes datasets, this study highlights the potential of robust and generalizable machine learning frameworks to meet the practical demands of healthcare analytics, advancing clinical decision-making with transparency and reproducibility.

EWMA Charts for Matrix-Valued Processes

Sven Knoth, Yarema Okhrin, Viktoriia Petruk, Wolfgang Schmid

Dept. Mathematics & Statistics, Helmut Schmidt U Hamburg, Germany, knoth@hsu-hh.de; Dept. Statistics & Data Science, Faculty of Business and Economics, U Augsburg, Germany, yarema.okhrin@uni-a.de; Dept. Statistics, Faculty of Business Administration and Economics, European U Viadrina, Frankfurt (Oder), Germany, Petruk@europa-uni.de, Schmid@europa-uni.de

In recent years, matrix-valued data has received an increasing amount of attention. This is due to their frequent application in various fields, such as signal processing, finance, medicine, engineering, among others. Here we consider matrix-valued time series processes and our aim is to detect changes in the mean behavior.

An obvious way to handle the problem is to make use of vectorization, i.e. the columns of the matrix are written together as a matrix. The problem is then reduced to the detection of a change in a vector time series. Such problems have been discussed by, e.g. Kramer and Schmid (1997), Bodnar et al. (2023), and Bodnar et al. (2024). The disadvantage of vectorization consists in the fact that the resulting time series process may be high-dimensional and the process identification is quite difficult.

In the last five years, other types of matrix-valued time series processes have been proposed (e.g., Chen et al. (2021), Wu and Bi (2023)). These approaches are characterized by fewer parameters and, for that reason, are of great interest in practice.

Using these new types of time series model, we derived EWMA control charts for matrix-valued time series. The control design is calculated, and some explicit results are given for matrix-valued autoregressive processes. The performance of the charts is compared with each other within an extensive simulation study.

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Brake Rotor Balance Case Study: The Importance of Looking Forward and Backward in Variation Reduction Projects ✌

Stefan Steiner and R. Jock Mackay

Business & Industrial Statistics Research Group, Dept. Statistics & Actuarial Sciences, U Waterloo, Canada, stefan.steiner@uwaterloo.ca, jock.mackay@uwaterloo.ca

Reducing variation in critical process outputs is a crucial undertaking that can lead to higher-quality products and increased customer satisfaction. Most teams proceed systematically to reduce variation, for example, by following the DMAIC framework in Six Sigma or the Statistical Engineering algorithm. A systematic approach involves multiple steps, where, in most steps, the team conducts one or more empirical investigations to gain a deeper understanding of how the process works. The team must make several key decisions to effectively design and execute each investigation, including specifying the investigation's goals and determining what data to collect. In making these decisions, it is essential that the team looks forward, keeping the overall project goal in mind, and looks back to see what has been learned so far and how it should impact the investigation plan and analysis. This paper explores the importance of looking forward and backward in variation reduction projects, both in general and through a detailed case study on balancing brake rotors.

Applying Design of Experiments in Toxicity Evaluation of Chemical Substances ✌

Tomomichi Suzuki and Jun-ichi Takeshita

Dept. Industrial & Systems Engineering, Tokyo University of Science, Japan, szk@rs.tus.ac.jp; National Institute of Advanced Industrial Science and Technology, Japan, jun-takeshita@aist.go.jp

Repeated-dose toxicity testing is crucial for the safety evaluation of industrial chemicals, pharmaceuticals, pesticides, and other substances. However, the development

of alternative methods to animal testing for evaluating repeated-dose toxicity has not progressed significantly. The purpose of this study is to evaluate repeated-dose toxicity by employing molecular descriptors that represent the characteristics of chemical substances. By combining molecular descriptors and performing stratification, groups with similar chemical structures were created. In this process, fractional factorial designs using orthogonal arrays are applied to investigate the effects of the molecular descriptors. The study identified characteristics of substances that either exhibit or do not exhibit toxicity.

Adaptive Multimodal Industrial Fault Diagnosis via Collaborative Representation Enhancement ◐

Di Wang, Xinyu Pan, Fugee Tsung

Dept. Industrial Engineering & Management, Shanghai Jiao Tong U, Shanghai, China, d.wang@sjtu.edu.cn, xinyu_pickle@sjtu.edu.cn; Information Hub, Dept. Industrial Engineering & Decision Analytics, HKUST, Hong Kong, season@ust.hk

Industrial fault diagnosis increasingly benefits from the rise of large models, which offer generalizable architectures capable of processing diverse data sources. Within this context, multimodal fault diagnosis, which integrates data sources from multiple modalities such as vibration, process, and video, has emerged as an effective technique to enhance diagnosis accuracy. However, most existing methods assume that all modalities are available, which rarely holds in practice due to sensor failures, deployment constraints, etc. Moreover, unimodal diagnosis remains practical but often lacks sufficient information to ensure reliable performance in complex industrial settings. This paper proposes an adaptive multimodal fault diagnosis method that enables bidirectional enhancement between multimodal and unimodal representations under incomplete modality scenarios. For model construction, a cross-fusion channel attention module is introduced to align features across modalities, and then a shared temporal attention module captures sequential dependencies and facilitates representation sharing. Finally, a multi-head diagnosis structure jointly supervises both multimodal and unimodal branches. For parameter estimation, we develop a similarity-aware gradient fusion strategy to adaptively balance multimodal and unimodal learning, ensuring stable optimization and knowledge transfer. Experiments on real-world industrial PRONTO dataset demonstrate that our method achieves superior performance and adaptability across various scenarios with varying modality availability.

A proposal for milliseconds data analysis from a controlled process ◐

Shu Yamada, Taisei Kajihara, Hiroki Kawabe and Keisuke Shida

Dept. Industrial & Systems Engineering, Keio U, Yokohama, Kanagawa, Japan, shu.yamada@keio.jp, shida@keio.jp

With the development of sensors and information technology, it is possible to collect large amounts of time series data. For example, in an injection process of about 10 seconds, it is possible to obtain data on the state of the inside of the injection machine in milliseconds. Such data can be considered time series data related to the time axis. In addition, in a highly controlled process, the range of variation of the factors is extremely narrow, so it is difficult to find a correlation with the response variable,

which is the indicator of the result. In this study, we show a data analysis approach for producing good products by utilizing data that is difficult to correlate, which is collected in milliseconds during the injection process. The novelty of this method is that it combines machine learning methods such as 1D EfficientNet, 1D CNN, and Grad-CAM, visualization using Gaussian process regression, and knowledge from the field. We show that the proportion of products within the standard is higher than in the past by effectively applying these methods.

A Note on the Analysis of Lifetime Data Using Cumulative Exposure Models ◐

Watalu Yamamoto, Lu Jin

Graduate School of Health Management, Keio U, Toyko, Japan, watalu@keio.jp; Dept. Informatics, U Electro-Communications, Tokyo, Japan, jinlu@inf.uec.ac.jp

When the exposure to factors that affect the degradation rate is observed as a covariate, the cumulative exposure model can be applied to construct a life distribution model based on cumulative exposure as an alternative characteristic of degradation. This is considered to be useful for understanding the reliability characteristics of objects for which it is difficult to observe degradation and for planning maintenance measures. However, there are not many examples of applications that have led to improved reliability using this model, and it is still easier to apply regression analysis using the covariates of the survival time distribution. In this paper, we will look at the usage and precautions for models that can be used for reliability estimation, such as survival time regression and cumulative exposure models, in situations where the amount of degradation is not measured.

Quickest causal change point detection via adaptive intervention ◐

Haijie Xu and Chen Zhang

Dept. Industrial Engineering, Tsinghua University, Beijing, China, xu-hj22@mails.tsinghua.edu.cn, zhangchen01@tsinghua.edu.cn

In this paper, we address an online change-point detection problem, where the multivariate data arriving at each time step follows a Gaussian distribution determined by a linear causal graph. We assume that anomalies are caused by changes in the distribution of nodes, the structure of edges, or the weights of edges within the graph. In a highly innovative approach, we introduce the concept of intervention to enhance the detection effectiveness of the algorithm specifically for causal graphs. We proposed a novel centralization technique that consolidates changes caused by causal propagation across nodes into a single dimension. By applying appropriate interventions, the magnitude of change can be amplified, thereby improving monitoring performance. We propose an algorithm for calculating suitable intervention values such that we can construct a Kullback-Leibler divergence-based estimator to choose the optimal intervention node.

Based on this, two monitoring algorithms, max-AI and multi-AI, are proposed. The former requires a shorter time window for monitoring but assumes the causal graph undergoes only a single change. In contrast, the latter is more robust to multi-change scenarios, albeit requiring a longer time window. Both algorithms achieve a balance between exploration and exploitation using an epsilon-greedy approach. Theoretically,

we prove that both algorithms asymptotically attain the optimal lower bound of the expected detection delay under out-of-control conditions, given a specified in-control average run length.

Additionally, we conducted simulations under various conditions, including different network sizes, network sparsity levels, node noise levels, intervention strengths, as well as varying anomaly magnitudes. By comparing our algorithm with baseline methods, we validate its superiority across these scenarios. Finally, we validate their performance in real-world settings from ecology and psychology.

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