Joint PhD Seminar in Statistics, Financial and Actuarial Mathematics

Universität Bremen,
Christian-Albrechts-Universität zu Kiel,
Carl von Ossietzky Universität Oldenburg

September, 26 and 27, 2024
Oldenburg, Germany

Room: W03 2-240
Carl-von-Ossietzky-Straße 11, 26129 Oldenburg

Online Room:
`https://meeting.uol.de/rooms/2yt-x9s-scn-8jd/join`

Welcome

Dear attendees,

welcome to the Carl von Ossietzky Universität Oldenburg (or online through BBB, see link above) for the 9th joint PhD Seminar in Statistics, Financial and Actuarial Mathematics organized in the ZeSOB framework by the universities of Bremen and Oldenburg. It is a tradition that each year we invite an external group of researchers to join us in this seminar. We are happy that this year our colleagues from Christian-Albrechts-Universität zu Kiel have agreed to be our guests.
The scope of this seminar is to bring together PhD students in the mentioned fields of study, interconnecting them, allowing for networking, and to foster discussions among you both on topics of your research and on general PhD related questions. Moreover, the opportunity to present your results in an extended format of 30 minutes allows the colleagues from other places to get a deeper insight into current research of the other groups and will hopefully give you valuable feedback for your work on top of your advisors'. In addition for those of you who have just recently started their PhD, we also offer a format where you can just present your project without already having own results.
On a voluntary base, after the PhD seminar, the slides of the presentations will be made accessible. Please send your presentation to `gero.junike@uol.de`.

Organizing Team

Werner Brannath
Marcus Christiansen
Thorsten Dickhaus
Gero Junike
Angelika May
Peter Ruckdeschel

Speakers

Theis Bathke, Carl von Ossietzky Universität Oldenburg
Caro Franco-Castiblanco, Universität Bremen
Daniel Ochieng, Universität Bremen
Friederike Preusse, Universität Bremen
Ivo Richert, Christian-Albrechts-Universität zu Kiel
Boy Schultz, Christian-Albrechts-Universität zu Kiel
Tom Splittgerber, Universität Bremen
Hauke Stier, Carl von Ossietzky Universität Oldenburg
Henrik Valett, Christian-Albrechts-Universität zu Kiel
Fan Yu, Christian-Albrechts-Universität zu Kiel

Supervisors

Sören Christensen, Christian-Albrechts-Universität zu Kiel
Jan Kallsen, Christian-Albrechts-Universität zu Kiel
Mathias Vetter, Christian-Albrechts-Universität zu Kiel

Werner Brannath, Universität Bremen
Thorsten Dickhaus, Universität Bremen

Marcus Christiansen, Carl von Ossietzky Universität Oldenburg
Angelika May, Carl von Ossietzky Universität Oldenburg
Gero Junike, Carl von Ossietzky Universität Oldenburg
Peter Ruckdeschel, Carl von Ossietzky Universität Oldenburg

How to reach the Carl von Ossietzky Universität Oldenburg

By Car:

Coming from Bremen, take the A28 to Oldenburg and use exit 12, Oldenburg Haarentor, turn right into the Ammerländer Heerstraße and follow the signs to Campus Wechloy, i.e., on Ammerländer Heerstraße, you drive straight on until the Mercedes merchant Senger to your right, where you turn right into the Carl-von-Ossietzky-Straße. Keep on this street until you reach the parking lot of Campus Wechloy.

GPS: Carl-von-Ossietzky-Straße 9–11, 26129 Oldenburg

By rail and bus:

Coming from Bremen, almost all trains from Nordwestbahn to Oldenburg also stop in Oldenburg Wechloy from where it is a 5min walk to the venue of the PhD Seminar. From Oldenburg Hauptbahnhof (main station), you may also take bus 306 which has Wechloy as final destination.

Room:

The building is W03 (marked with a red kite symbol on Fig. 1 below), and there the room will be **W03 2-240**.

Programme Overview

Contents and Timeline: Thursday, Sept. 26, 2024

13:30 – 13:35 Welcome Address and Organisational Preliminaries — *Gero Junike*

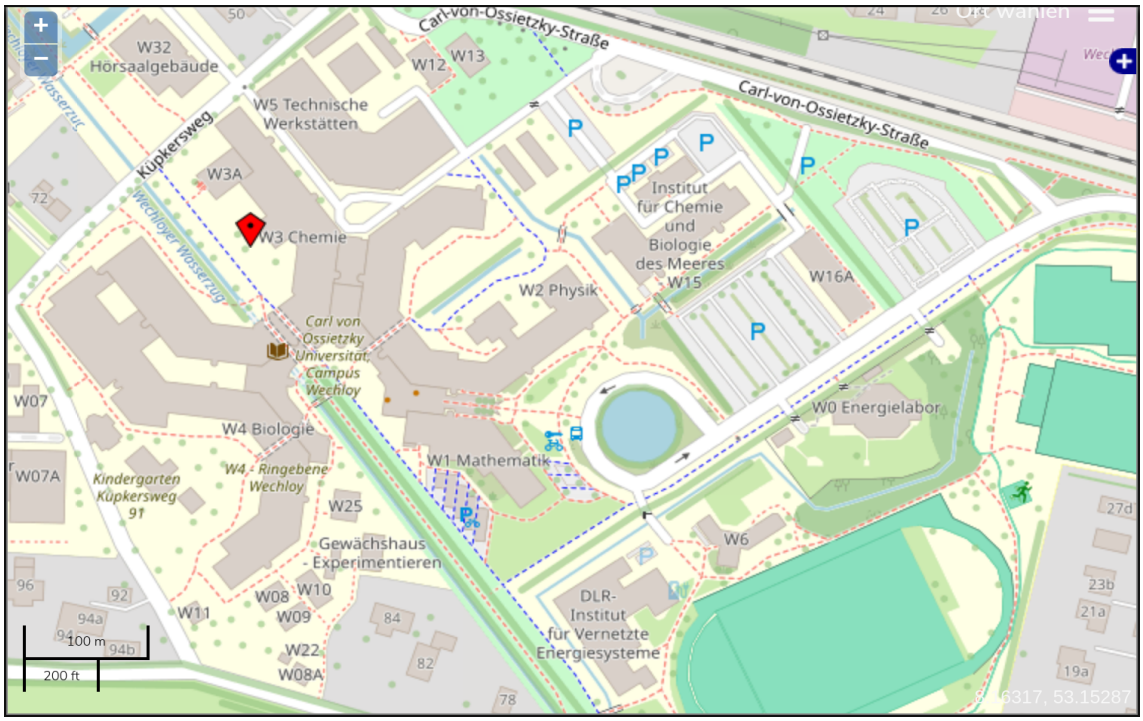

Fig. 1. Map of the Wecholy Campus, Oldenburg

13:35 – 14:00 Mutual Introduction — every attendee shortly introduces her/himself

Block 1: Finance and Insurance — Chair: *Marcus Christiansen*

14:00 – 14:30 *Hauke Stier*: From characteristic functions to multivariate distribution functions and European option prices by the damped COS method

14:45 – 15:15 *Theis Bathke*: Reserves of path dependent life insurance cash-flows in non-Markov models

15:30 – 16:00 Break

Block 2: Statistics: tests and models — Chair: *Peter Ruckdeschel*

16:00 – 16:30 *Tom Splittgerber*: Lipschitz-DeepGLM: a careful Neural Network extension of generalized linear models

16:45 – 17:15 *Caro Franco-Castiblanco*: Sample Size Considerations for Three-Level Trials with Heterogeneous Variances

17:30 – 18:00 *Daniel Ochieng*: P-value statistics for multiple hypothesis testing of discrete data models

19:00 Joint Dinner at Drögen Hasen, Drögen-Hasen-Weg 111, 26129 Oldenburg

Contents and Timeline: Friday, Sept. 27, 2024

Block 3: Polynomial processes — Chair: *Thorsten Dickhaus*

09:30 – 10:00 *Henrik Valett*: Parameter estimation for polynomial processes

10:15 – 10:45 *Ivo Richert*: Quasi-Maximum Likelihood Estimation of Partially Observed Affine and Polynomial Processes

11:00 – 11:15 Break

Block 4: Decision Making over Time — Chair: *Werner Brannath*

11:15 – 11:45 *Boy Schultz*: Existence of equilibria in Dynkin games of war-of-attrition type

12:00 – 12:30 *Friederike Preusse*: Identifying rapid changes of the hemodynamic response in event-related functional magnetic resonance imaging

12:45 – 13:15 *Fan Yu*: Jump process with regression estimator

13:30 Closing Address — *Gero Junike*

Abstracts

From characteristic functions to multivariate distribution functions and European option prices by the damped COS method

Hauke Stier

Carl von Ossietzky Universität Oldenburg

Supervisor: Gero Junike

14:00 - 14:30, Thursday, September 26$^{\text{th}}$, Block 1

We provide a unified framework to obtain numerically certain quantities, such as the distribution function, absolute moments and prices of financial options, from the characteristic function of some (unknown) probability density function using the Fourier-cosine expansion (COS) method. The classical COS method is numerically very efficient in one-dimension, but it cannot deal very well with certain integrands in general dimensions. Therefore, we introduce the damped COS method, which can handle a large class of integrands very efficiently. We prove the convergence of the (damped) COS method and study its order of convergence.

The method converges exponentially if the characteristic function decays exponentially. To apply the (damped) COS method, one has to specify two parameters: a truncation range for the multivariate density and the number of terms to approximate the truncated density by a cosine series. We provide an explicit formula for the truncation range and an implicit formula for the number of terms. Numerical experiments up to five dimensions confirm the theoretical results.
Keywords: Fourier-transform, numerical integration, inversion theorem, COS method, CDF, option pricing.

The talk is based on the paper `https://arxiv.org/pdf/2307.12843`

Reserves of path dependent life insurance cash-flows in non-Markov models

Theis Bathke

Carl von Ossietzky Universität Oldenburg

Supervisor: Marcus Christiansen

14:45 - 15:15, Thursday, September 26$^{\text{th}}$, Block 1

In multi-state life insurance, incidental policyholder behavior gives rise to expected cash flows that are not easily targeted by classic non-parametric estimators if data is subject to sampling effects. 2 approaches to the modeling of scaled insurance contracts in non-Markov models are introduced. The first uses two-dimensional conditional transition rates which are able to capture the intertemporal dependency structure of the different transitions and are in line with current actuarial work flows. The second introduces a scaled version of the Nelson Aalen and Aalen-Johansen estimators, which allows for a very efficient estimation. A simulation study showcases strengths and weaknesses of both approaches. Finally, the scaled Aalen Johansen estimator is extended to general scaling factors, which improves the forward rate concept for non-Markov actuarial modeling.
Keywords: Incidental policyholder behavior; life insurance; non-Markov models; two-dimensional forward rates; Aalen-Johansen.

Lipschitz-DeepGLM: a careful Neural Network extension of generalized linear models

Tom Splittgerber

Universität Bremen,

Supervisor: Werner Brannath

16:00 - 16:30, Thurday, September 26$^{\text{th}}$, Block 2

In a variety of different fields, generalized linear (mixed) models (GL(M)M) are a well-established approach of statistical analysis. While they are inherently limited in their expressiveness due to their simple structure and necessary strong assumptions, in practice GL(M)M often perform reasonably well. Additionally, this same simplicity entails good interpretability and quantifiability of uncertainty. In contrast, the younger method of neural networks (NN)

usually trades interpretability and verifiability for expressiveness. NNs have been shown to (theoretically) be universal approximators, but their inner workings are mostly incomprehensible to humans. These shortcomings limit the usefulness of NNs in areas like medical and epidemiological research, where a high (ideally quantifiable) degree of confidence in model predictions is paramount. The presented newly developed methods aim at combining these two methods and their respective strengths by transforming in- and output of a traditional GLM with a neural network. By choosing so-called "invertible Residual Neural Networks" (i-ResNet) with a strictly controlled Lipschitz-constant, we can bound the "amount" of deviation from the basic GLM. Our methods not only enable the learning of arbitrary nonlinear dependencies and interactions while strictly bounding the strength of the nonlinearity, they also allow, through the invertibility of the network, to compensate for a misspecified target distribution through the change-of-variables formula. In my talk, I will give a brief introduction to i-ResNet, introduce the newly developed method of Lipschitz-DeepGLM and illustrate their properties on some real and simulated data examples. This is joint work with Werner Brannath, Marvin Wright, Niklas Koenen and Jens Behrman. It is a project in, and supported by, the LifespanAI research unit composed of members from the University of Bremen and the Leibniz-Institut Bremen (BIPS).
Keywords: Deep Learning, Neural Networks, Generalized linear models, Invertible Residual Networks (i-ResNet), Interpretable machine learning, Orthogonal complement.

Sample Size Considerations for Three-Level Trials with Heterogeneous Variances

Caro Franco-Castiblanco

Universität Bremen,

Supervisor: Werner Brannath

16:45 - 17:15, Thursday, September 26$^{\text{th}}$, Block 2

Existing formulas for sample size determination in multilevel studies assume homogeneous within-level variances among the different levels. However, in practice, the within-level variability may be heterogeneous, which can cause a biased sample size determination and over- or under-estimated power. This work investigates how within-level heterogeneity within a three-level model affects the sample size and power. We consider two designs for sample size determination: a classical three-level design (Cluster Randomized and Multisite Cluster trials), where sample size is optimized for one level while the others remain fixed, and a novel three-level Random Sites of Different Capacities design. In three-level Random Sites of Different Capacities additional information of the cluster capacity is taking into account for the sample size determination. For each design, we develop a method to account for within-level heterogeneity in sample size determination. Further, we propose a variance component estimation based on conditional means and variance using a level-specific model. Finally, we conduct a simulation study to evaluate the accuracy of the variance estimation and power performance. For comparison, the performance of the sample size determination under homogeneity was also evaluated.
Keywords: Heterogeneous variances, Multilevel trials, Sample size determination.

P-value statistics for multiple hypothesis testing of discrete data models

Daniel Ochieng

Bremen University

Supervisor: Thorsten Dickhaus

17:30 - 18:00, Thurday, September 26^{th}, Block 2

Conservativeness of a p-value can occur if the test statistic from which it is derived is discrete, or if the true parameter value under the null is not an LFC (least favorable parameter configuration). We present a single- and two-stage ran- domized p-value to deal with these two sources of conservativeness. We illustrate their effectiveness for testing a composite null hypothesis under a binomial model. We also extend our p-values to equivalence tests frequently used in "bioquivalence studies" for establishing practical equivalence rather than the usual statistical significant difference. Compared to non-randomized p-values, the resulting ran- domized p-values are less conservative under the null hypothesis and less powerful under the alternative hypothesis. We also conduct the equivalence tests using a Bayesian procedure by computing the posterior probability that the null hypoth- esis is true. Since the posterior probabilities are uniformly distributed under the null hypothesis, they can be used in place of the frequentist p-value with a TOST procedure to conduct equivalence tests. This procedure is also preferred since it leads to reduced sample sizes or more powerful tests than the TOST procedure when used with the frequentist p-value. The behavior of the power function for the tests based on the proposed p-values and posterior probabilities as a func- tion of the sample size is also investigated. We evaluate the performance of the p-values in estimating the proportion of true null hypotheses in multiple test- ing. The various claims in this research are verified using a simulation study and real-world data analysis.

Keywords: Conservative tests; Bayesian equivalence; randomized tests; TOST; posterior probability; prior distribution.

Parameter estimation for polynomial processes

Henrik Valett

Christian-Albrechts-Universität zu Kiel

Supervisor: Jan Kallsen

09:30 - 10:00, Friday, September 27^{th}, Block 3

We consider parameter estimation for discretely observed generic polynomial (and in particular affine) Markov processes, which are often used in mathematical finance, e.g. in form of the popular Heston model or of (exponential) Levy-driven models. Our approach is based on quasi-likelihood methods. Specifically, we consider polynomial martingale estimating functions up to a certain degree. Within this class the Heyde-optimal estimating function can be computed in closed form. This allows us to derive consistency and asymptotic normality, based on results from [1] and the ergodic theory for Markov processes.

[1] Sorensen, M. (2012). Estimating functions for diffusion-type processes. Statistical methods for stochastic differential equations, 124, 1-107.
Keywords: polynomial processes, affine processes, parameter estimation, estimating functions.

Quasi-Maximum Likelihood Estimation of Partially Observed Affine and Polynomial Processes

Ivo Richert

Christian-Albrechts-Universität zu Kiel

Supervisor: Jan Kallsen

10:15 - 10:45, Friday, September 27$^{\text{th}}$, Block 3

In spite of their computational tractability and versatility in modelling real-world phenomena, existing theory on the statistical estimation of parameterised affine or polynomial processes is surprisingly sparse and has yet only focused on specific examples of polynomial diffusions in the past. Moreover, many practical applications such as stochastic volatility or other latent-factor models from financial mathematics lack a full observability of the components of the employed polynomial process, vitiating many classic statistical estimation methodologies. We close this gap by developing a general framework for estimating affine and polynomial processes partially observed at discrete points in time. This is achieved by developing a canonical discrete-time representation of polynomial processes in the form of a vector-autoregressive model, and then approximating the transition dynamics of this model by those of a Gaussian process with matched first and second moments using the popular Kalman filter. We establish weak consistency and asymptotic normality of the resulting Quasi-Maximum Likelihood estimators and provide explicitly computable expressions of the asymptotic estimator covariance matrix. In addition, we illustrate our results by using the example of the popular Heston stochastic volatility model from financial mathematics as well as by the example of multivariate Levy-driven Ornstein-Uhlenbeck processes.

Keywords: polynomial processes, polynomial state space models, parameter estimation, quasi-maximum likelihood estimation, affine processes, filtering

Existence of equilibria in Dynkin games of war-of-attrition type

Boy Schultz

Christian-Albrechts-Universität zu Kiel

Supervisor: Sören Christensen

11:15 - 11:45, Friday, September 27$^{\text{th}}$, Block 3

One of the fundamental results in optimal stopping theory states that for Markovian problems, optimal stopping times exist in the class of (Markovian) pure first-entry times. On the other hand, when it comes to Markovian games of optimal stopping, equilibria in the class of (Markovian) pure first-entry times do only exist under restrictive assumptions, while the most general existence results do only provide equilibria in the class of randomized stopping times. Due to the vastness of the class of randomized stopping times such equilibria can hardly be

pinpointed and their inherent path-dependency compromises subgame perfection. Therefore, it is natural to restrict the scope to the inbetween-class of Markovian randomized stopping times. We outline a general scheme to existence of equilibria in that class based on the example of a war-of-attrition type Dynkin game.
Keywords: Dynkin games, war-of-attrition, Markovian randomized stopping times, Markov-perfect Nash equilibrium.

Identifying rapid changes of the hemodynamic response in event-related functional magnetic resonance imaging

Friederike Preusse

Universität Bremen

Supervisor: Thorsten Dickhaus

12:00 - 12:45, Friday, September 27$^{\text{th}}$, Block 4

The hemodynamic response (HR) in event-related functional magnetic res- onance imaging is typically assumed to be stationary. While there are some ap- proaches in the literature to model nonstationary HRs, very few focus on rapid changes in the overall shape of the HR. In this work, we propose statistical procedures to in- vestigate whether and how the shape of the HRs in pre-defined regions change over time, assuming that the HRs change rapidly. To this end, we compare shape paramet- ers of the HRs before and after the change points at the group level. We differentiate between two scenarios. In the first scenario, reliable information about the change point locations are available. In the second scenario, no prior information about the times of change are available. We suggest using model selection approaches to estimate the change point locations at the subject level. To account for this model selection at the group level, the within-subject variances of the shape parameters are estim- ated based on post-selection inference procedures. We assess the properties of the proposed procedures in a simulation study and apply the procedures to data from a rule-based category learning experiment.

Keywords: time series analysis, change points, task-based functional magnetic resonance imaging, post-selection inference.

Jump process with regression estimator

Fan Yu

Christian-Albrechts-Universität zu Kiel

Supervisor: Mathias Vetter

12:45 - 13:15, Friday, September 27$^{\text{th}}$, Block 4

We are given two (somewhat related) processes Y and Z with possible jumps. A real world example in finance: Y is an asset we are interested in and Z is a risk factor. We develop tools to study jump correlation of two processes from high-frequency observations from either finite time horizon or infinite time. In the simple case we assume all processes are Levy and for a

particular choice of jumps under this assumption we can show our regression type estimator in the simple case is asymptotic and gives the CLT result.
Keywords: high-frequency observations, alpha stable, Levy process, regression.

Presentations