
3rd Workshop on

# Goodness-of-fit and Change-point Problems

*September 8. - 10., 2017*

*Bad Herrenalb, Germany*

Scientific Committee:

Norbert Henze
Claudia Kirch
Simos G. Meintanis

# Conference venue

The conference venue is the **Church House of the Protestant Academy Baden** in Bad Herrenalb.

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# Programme

Friday, September 8

| | | |
|---|---|---|
| 12.30 | Lunch | |
| 13.55 | N. Henze | Address of Welcome |
| 14.00-14.30 | E. Khmaladze | On distribution free empirical processes for problems with covariates |
| 14.30-15.00 | K. Fokianos | Test of independence based on multivariate distance correlation matrix |
| 15.00-15.30 | Th. Verdebout | Testing uniformity on high-dimensional spheres |
| 15.30-16.00 | Y.Y. Nikitin | Asymptotic comparison of some normality tests based on characterizations |
| 16.00-16.30 | Coffee break | |
| 16.30-17.00 | A. Munk | Multiscale blind source separation |
| 17.00-17.30 | H. Cho | Simultaneous multiple change-point and factor analysis for high-dimensional time series |
| 17.30-18.00 | G. Schneider | Multiscale change point detection in neuronal spike trains |
| 18.00-18.30 | R. Killick | Multivariate changepoint detection with subsets |
| 18.30 | Dinner | |

Saturday, September 9

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| 09.00-09.30 | V. Patilea | Testing the influence of functional variables on functional responses |
| 09.30-10.00 | E. Paparoditis | Bootstrap-based testing for functional time series |
| 10.00-10.30 | | Discussion about future meetings |
| 10.30-11.00 | Coffee break | |
| 11.00-11.30 | L. Horvath | A new class of change point test statistics of Rényi type |
| 11.30-12.00 | M. Husková | Structural breaks in panel data |
| 12.00-12.30 | H. Dehling | Change-point tests based on ordinal patterns |
| 12.30-14.00 | Lunch | |
| 14.00-14.30 | H. Dette | Equivalence of regression curves |
| 14.30-15.00 | H. Koul | Model checking in measurement error<br>Tobit regression using validation data |
| 15.00-15.30 | M. Delgado | Testing coefficients constancy |
| 15.30-16.00 | M.-D. Jiménez-Gamero | Goodness-of-fit tests for GARCH models |
| 16.00-16.30 | Coffee Break | |
| 16.30-17.00 | N. Neumeyer | Change-point tests in nonparametric time series models |
| 17.00-17.30 | J. Steinebach | Estimating a gradual parameter change in an AR(1)-process |
| 17.30-18.00 | M. Wendler | Change-point detection and U-statistics |
| 18.00-18.30 | R. Fried | ROBTS - An R-package for robust time series analysis and change-point detection |
| 18.30 | Dinner | |

Sunday, September 10

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| 09.00-09.30 | Ch. Weiß | Goodness-of-Fit Testing for Count Time Series |
| 09.30-10.00 | D. Wied | Residual based inference on moment hypotheses, with an application to testing for constant correlation |
| 10.00-10.30 | W. Stummer | Some "Universal" Method of Robust Goodness-of-Fit Inference |
| 10.30-11.00 | Coffee break | |
| 11.00-11.30 | A. Leucht | A test for independence based on the probability weighted empirical characteristic function |
| 11.30-12.00 | W. Stute | On A French Nutshell - Ft Fourier, Poisson, Le Cam - and Riemann |
| 12.30 | Lunch | |

# Abstracts

**Haeran Cho**, University of Bristol, United Kingdom

### Simultaneous multiple change-point and factor analysis for high-dimensional time series

*Abstract:* We propose the first comprehensive treatment of high-dimensional time series factor models with multiple change-points in their second-order structure. We operate under the most flexible definition of piecewise stationarity, and estimate the number and locations of change-points consistently as well as identifying whether they originate in the common or idiosyncratic components. Through the use of wavelets, we transform the problem of change-point detection in the second-order structure of a high-dimensional time series, into the (relatively easier) problem of change-point detection in the means of high-dimensional panel data. Our methodology circumvents the difficult issue of the accurate estimation of the true number of factors by adopting a screening procedure. In extensive simulation studies, we show that factor analysis prior to change-point detection improves the detectability of change-points, and identify and describe an interesting 'spillover' effect in which substantial breaks in the idiosyncratic components get, naturally enough, identified as change-points in the common components, which prompts us to regard the corresponding change-points as also acting as a form of 'factors'.

*This talk is based on a joint work with Matteo Barigozzi and Piotr Fryzlewicz*

**Herold Dehling**, Ruhr-Universität Bochum, Germany

## Change-point tests based on ordinal patterns

*Abstract:* We propose new concepts in order to analyse and model the dependence structure between two time series. Our methods rely exclusively on the order structure of the data points. Hence, the methods are stable under monotone transformations of the time series and robust against small perturbations or measurement errors. Ordinal pattern dependence can be characterised by four parameters. We propose estimators for these parameters, and we calculate their asymptotic distributions. Furthermore, we derive a test for structural breaks within the dependence structure. All results are supplemented by simulation studies and empirical examples.

*This talk is based on a joint work with Alexander Schnurr (Siegen)*

*References:*

[1] A. Schnurr and H. Dehling (2017): Testing for structural breaks via ordinal pattern dependence. Journal of the American Statistical Association. DOI: 10.1080/01621459.2016.1164706

**Miguel A. Delgado**, Department of Economics, Universidad Carlos III de Madrid, Spain

## Testing Coefficients Constancy

*Abstract:* This talk addresses the problem of testing that coefficients are constant in linear models in the direction that they are unknown functions of an observed variable. This includes specification testing of partially linear models in the direction of linear alternatives, and specification testing of interactive effects. Test statistics depend on partial sums of concomitants involving residuals, which resemble classical parameter stability tests where parameters vary with time under the alternative hypothesis. The test is optimal in the direction of discontinuous regression alternatives when the variable determining the jump is independent of the regressors. The test is implemented using bootstrap critical values. We study the finite performance of the test by means of Monte Carlo experiments and applications using real data.

*This talk is based on a joint work with Luis A. Arteaga-Molina (Universidad de Cantabria).*

**Holger Dette**, Ruhr-Universität Bochum, Germany

## Equivalence of regression curves

*Abstract:* This paper investigates the problem whether the difference between two parametric models $m_1, m_2$ describing the relation between a response variable and several covariates in two different groups is practically irrelevant, such that inference can be performed on the basis of the pooled sample. Statistical methodology is developed to test the hypotheses $H_0 : d(m_1, m_2) \geq \varepsilon$ versus $H_1 : d(m_1, m_2) < \varepsilon$ to demonstrate equivalence between the two regression curves $m_1, m_2$ for a pre-specified threshold $\varepsilon$, where $d$ denotes a distance measuring the distance between $m_1$ and $m_2$. Our approach is based on the asymptotic properties of a suitable estimator $d(\hat{m}_1, \hat{m}_2)$ of this distance. In order to improve the approximation of the nominal level for small sample sizes a novel bootstrap methodology is developed, which addresses the specific form of the interval hypotheses. In particular, data has to be generated under the null hypothesis, which implicitly defines a manifold for the parameter vector. The results are illustrated by means of a simulation study and a data example. It is demonstrated that the new methods substantially improve currently available approaches with respect to power and approximation of the nominal level.

*References:*

[1] Dette H, Möllenhoff K, Volgushev S, Bretz F (2017) Equivalence of regression curves. Journal of the American Statistical Association (in press)

**Konstantinos Fokianos**, University of Cyprus, Cyprus

## Tests of independence based on multivariate distance correlation matrix

*Abstract:* We introduce the notions of multivariate auto-distance covariance and correlation functions for time series analysis. These concepts have been recently discussed in the context of independent and time series data, but we extend them in a different direction by putting forward their matrix version. We discuss their interpretation, and we give consistent estimators for practical implementation. Additionally, we develop a procedure for testing the iid hypothesis for multivariate time series data. The proposed test statistic performs better than the standard multivariate version of the Ljung-Box test statistic. Several computational aspects are discussed, and some data examples are provided for illustration of the methodology.

*This talk is based on a joint work with Maria Pitsillou.*

**Roland Fried**, TU Dortmund University, Germany

## robts - An R-package for robust time series analysis and change-point detection

*Abstract:* This talk reports our progress on methods for robust time series modeling and change-point detection. Our methods are implemented in the R-package robts, which is available from R-Forge. This package provides different techniques for robust estimation of autocorrelations, partial autocorrelations and spectral densities, for fitting autoregressive time series models, for model diagnostics and prediction. Since many time series models assume second order stationarity, we include robust tests for checking the hypothesis of a stationary mean, of a stationary variance or of stationary autocovariances. In particular, the talk illustrates the advantages of tests which are based on suitable U-statistics or U-quantiles when testing for a constant mean function.

*This talk is based on joint work with Herold Dehling, Alexander Dürre, Isabel Garcia, Tobias Liboschik, Daniel Vogel and Martin Wendler.*

*References:*

[1] H. Dehling, R. Fried, I. Garcia, M. Wendler (2015). Change-Point Detection under Dependence Based on Two-Sample U-Statistics. In D. Dawson et al. (eds.): Asymptotic Methods in Stochastics, Springer, New York, 195–220.

[2] H. Dehling, R. Fried, M. Wendler (2015). A Robust Method for Shift Detection in Time Series. https://arxiv.org/pdf/1506.03345.pdf

[3] A. Dürre, R. Fried, T. Liboschik (2015). Robust Estimation of (Partial) Autocorrelation. Wiley Interdisciplinary Reviews: Computational Statistics, **7**, 205–222.

[4] D. Vogel, R. Fried (2015). Robust Change Detection in the Dependence Structure of Multivariate Time Series. In K. Nordhausen, S. Taskinen (eds.): Modern Nonparametric, Robust and Multivariate Methods, Springer International Publishing, Cham, 265–288.

**Lajos Horváth**, University of Utah, USA

## A new class of change point test statistics of Rényi type

*Abstract:* A new class of change point test statistics is proposed that utilizes a weighting and trimming scheme for the cumulative sum (CUSUM) process inspired by Rényi (1953). Theory and simulations both demonstrate that this new class of statistics possess superior power compared to traditional change point statistics based on the CUSUM process when the change is near the beginning or end of the sample. Generalizations of these "Rényi" statistics are also developed to test for changes in the parameters in linear and non-linear regression models. In this latter context, we applied the proposed statistics, as well as several others, to test for changes in the relationship in worker productivity and worker compensation in the U.S.A from 1947-2016. We observed that the "Rényi" statistic was the only one capable of the early detection of a well known change point in the linear relationship between these series beginning in the 1960's.

*This talk is based on a joint work with Gregory Rice and Curtis Miller.*

*References:*

[1] Rényi, A.: On the theory of order statistics. *Acta Mathematica Academiae Scientiarum Hungaricae* **4**(1953), 191–231.

**Marie Hušková**, Charles University, Czech Republic

## Structural breaks in panel data

*Abstract:* The talk concerns testing and detection of the structural breaks in the panel data setup when $T$ (time dimension) is finite or moderate and $N$ (number of panels/assets/individuals) tend to infinity. This is typically related to large (firm-level) data containing financial information about a large number of firms/stocks across a limited number of years/quarters/months. More often, most of the published works deals with large $T$ and small or moderate $N$ .

A general approach for testing for the break(s) in this setup is proposed. Asymptotic behavior of the test statistics, along with an alternative wild bootstrap procedure are investigated.

The theoretical results are accompanied by simulations. The practical application demonstrates the testing procedure in the framework of the four factors CAPM model. In particular, it concerns breaks in monthly returns of the US mutual funds during the period January 2006 to February 2010 which covers the subprime crises.

*This talk is based on a joint work with J. Antoch, J. Hanousek, L.Horváth and S. Wang*

*References:*

[1] J. Antoch, J. Hanousek, M.Hušková, L.Horváth and S. Wang (2017). Structural breaks in panel data. Large number of panels and short length time series. DISCUSSION PAPER SERIES, Financial Economics n. 6011-1488545005.

**M. Dolores Jiménez-Gamero**, Universidad de Sevilla, Spain

## Goodness–of–Fit Tests for GARCH Models

*Abstract:* In this talk we consider a multiplicative strictly stationary process

$$x_t = \sigma_t \varepsilon_t, \quad t \in \mathbb{Z}, \tag{1}$$

where $\varepsilon_t$ and $\sigma_t$ are independent and $\{\varepsilon_t\}_{t\in\mathbb{Z}}$ is a sequence of iid random variables with mean zero and unit variance. This implies that $\sigma_t^2 = \mathrm{Var}(x_t|\mathbb{I}_{t-1})$, where $\mathbb{I}_t$ denotes the information available at time $t$. A popular specification of the conditional variance takes the general form

$$\sigma_t^2 = h(\boldsymbol{\Upsilon}_{t,p,q}), \tag{2}$$

where $\boldsymbol{\Upsilon}_{t,p,q} = (x_{t-1}, \ldots, x_{t-p}, \log(\sigma_{t-1}^2), \ldots, \log(\sigma_{t-q}^2))'$ and $h : \mathbb{R}^r \mapsto \mathbb{R}$, $r = p + q$, with $p \geq 1$ and $q \geq 0$. The classical GARCH corresponds to

$$h(\Upsilon_{t,p,q}) = \mu + \sum_{j=1}^{p} b_j x_{t-j}^2 + \sum_{j=1}^{q} \gamma_j \sigma_{t-j}^2. \tag{3}$$

Nevertheless, there exist numerous alternative instances of (2) (see, e.g. [1]).

In this piece of work we construct goodness–of–fit tests for correct specification of the function $h(\cdot)$ figuring in (2) in the context of the multiplicative model (1). This problem has been previously considered by other authors. Many of the proposed methods suffer from at least one of the following drawbacks: (i) being specific to a particular GARCH model, often of given (low) order, (ii) assume rather strong conditions on (1) (such as the existence of certain moments), and (iii) not being consistent under all fixed alternatives. On the contrary, our method is for an arbitrary function $h(\cdot)$, and for general order $(p, q)$, and it will be seen to be consistent under arbitrary model deviations.

*This talk is based on a joint work with Sangyeol Lee, Seoul National University, South Korea, and Simos G. Meintanis, National and Kapodistrian University of Athens, Greece.*

*References:*

[1] C. Francq, J.M. Zakoïan (2010). GARCH Models: Structure, Statistical Inference and Financial Applications. Wiley, New York.

**Estate Khmaladze**, University of Wellington, New Zealand

## On distribution free empirical processes for problems with covariates

*Abstract:* Consider a sample $(\xi_i, X_i)_{i=1}^n$ with $\xi_i$s being "responses" and $X_i$s being "explanatory variables" or "covariates". Consider two different families, $F_x$ and $Q_x$ as two different models for conditional distribution of $\xi_i$ given $X_i = x$. The paper shows how the empirical process for testing the model $F_x$ can be transformed into a process with the same asymptotic behavior as the empirical process for testing $Q_x$, thereby rendering the two testing problems equivalent. The transformations suggested are one-to-one and form a group of unitary transformations, thus creating surprisingly broad classes of equivalent problems. Therefore, within each class of equivalent testing problems only one is necessary on which to build asymptotic theory.

**Rebecca Killick**, Lancaster University, United Kingdom

## Multivariate Changepoint Detection with Subsets

*Abstract:* Historically much of the research on changepoint analysis has focused on the univariate setting. However, increasingly data found in contemporary scientific fields are multivariate in nature, with each observation in a sequence containing the values of multiple variables which have been observed simultaneously. The multivariate changepoints which may be observed within such time series can be categorized as either fully-multivariate or subset-multivariate. Fully-multivariate changepoints refer to those changes in structure which occur simultaneously in all variables. Conversely, subset-multivariate changepoints refer to those which occur in only a subset of the observed variables. Traditionally, multivariate changepoint detection methods typically assume that all changes within a series are fully-multivariate. Some recent papers have taken into account that all variables may not change but either do not explicitly output the subsets or do a fully multivariate analysis followed by subset determination. The work in this presentation is the first to create a dynamic program specifically for detecting changes in subset-multivariate time series. We present both exact and approximate optimization methods for determining the number, location and affected subsets of changepoints. Simulation studies demonstrate the performance of the approach on fully multivariate, as well as large, medium and small proportions of affected subsets and we apply the approach to acoustic sensing data.

**Hira L. Koul**, Michigan State University, United States

## Model Checking in Measurement Error Tobit Regression Using Validation Data

*Abstract:* Consider the following regression model where response variable is truncated at $0$ and the $p$-dimensional covariate vector $X$ is measured with error.

$$Y^* = \mu(X) + \varepsilon, \qquad Y = Y^* I(Y^* > 0), \quad E(\varepsilon) = 0, \quad Z = X + u,$$
$$\varepsilon,\ X \text{ and } u \text{ mutually independent, } E(u) = 0,\ \mu(x) = E(Y^*|X = x).$$

This is the so called measurement error Tobit regression model, where one observes $Y$, i.e., observe $Y^*$ only when $Y^* > 0$, and $Z$ instead of $X$.

This talk will discuss some tests for the problem of fitting a parametric model to the regression function $\mu(x)$ in this model.

Let $F_\varepsilon$ and $F_u$ denote the distribution functions of $\varepsilon$ and $u$, respectively. Assume $F_\varepsilon$ is known. Let $Q_j(u) = \int_u^\infty x^j dF_\varepsilon(x), j = 0, 1$. Then the function

$$q(x) := E(Y|X = x) = \mu(x)Q_0(-\mu(x)) + Q_1(\mu(x)) = \int_{-\mu(x)}^\infty [1 - F_\varepsilon(s)]ds$$

is strictly increasing in $\mu(x)$ and the problem of fitting a parametric model to $\mu(x)$ is transformed to that of fitting the implied parametric model to $q(x)$.

Koul, Song and Liu (2014) (KSL) used this idea to propose a class of tests for this hypothesis when there is no measurement error in the above model. Their test is based on a modified version of the Zheng (1996) statistics and is applicable for any known $p \geq 1$.

In the presence of measurement error, one constructs yet another regression function $g(z) := E(Y|Z = z) = E(q(X)|Z = z)$, and the problem now becomes of fitting a parametric model to $g$. Song and Yao (2011) proposed a test for this problem. This test is the first of its kind and is based on the ideas of Khmaladze (1981) via the Stute, Thies and Zhu (1998) transformation of a marked residual empirical process. However, this test is applicable only for the case of one-dimensional covariate, i.e., $p = 1$, and when $F_u$ is known.

To overcome the assumption of known $F_u$, we assume the availability of independent validation data. Having $F_u$ unknown renders $g$ to be unknown. We use the validation data to estimate $g$ nonparametrically and use this estimate of $g$ to develop the analogs of the KSL tests here. We establish asymptotic normality of

the proposed statistics under null and under some alternate hypotheses. A finite sample simulation study shows superiority of a member of the proposed class of tests over some existing tests.

*This talk is based on a joint work with Ms. Pei GENG.*

*References:*


[1] Khmaladze, É. V. (1981). Martingale approach to nonparametric goodness of fit tests. *Theory Probab. Appl.* **26**, 240–258.

[2] Koul, H.L., Song, W. and S. Liu (2014). Model checking in Tobit regression via nonparametric smoothing. *J. Multivariate Anal.* **125**, 36–49.

[3] Song, W. (2009). Lack-of-fit testing in errors-in-variables regression model with validation data. *Statist. Probab. Lett.* **79**, 765–773.

[4] Song, W. (2011). Distribution-free test in Tobit mean regression model. *J. Stat. Plann. Inference* **141**, 2891–2901.

[5] Song, W. and Yao, W. (2011). A lack-of-fit test in Tobit errors-in-variables regression models. *Statist. Probab. Lett.* **81**, 1792–1801.

[6] Stute, W., Thies, S. and Zhu, Li-Xing. (1998). Model checks for regression: an innovation process approach. *Ann. Statist.*, **26**, 1916–1934.

**Anne Leucht**, Technische Universität Braunschweig, Germany

## A test for independence based on the probability weighted empirical characteristic function

*Abstract:* It is well known that the components of a random vector $X = (X_1, \ldots, X_p)'$ are stochastically independent if and only if the characteristic function $\varphi_X$ of the vector is equal to the product of the marginal characteristic functions, i.e.

$$\varphi_X(\underline{t}) = \prod_{m=1}^{p} \varphi_{X_m}(t_m) \quad \forall \underline{t} = (t_1, \ldots, t_p)'.$$

Hence, tests for independence can be based on the comparison of the empirical counterparts of these functions. Kankainen and Ushakov (1998) propose a distribution-free test based on a statistic of $L_2$-type. Consistency of the test can be proven for every weighting measure $Q$ that is absolutely continuous with respect to Lebesgue measure and satisfies $0 < Q(\mathbb{R}^p) < \infty$. Of course, the finite sample performance of the test heavily relies on the choice of $Q$.

Therefore, we propose a data-driven choice of the weighting measure. The resulting test statistic may be written in a closed form convenient for computer implementation. We derive its asymptotics under the null based on new results on weighted empirical characteristic function processes. Moreover, our test inherits consistency from the test of Kankainen and Ushakov (1998). Simulations show that the new test compares well to standard methods of testing independence.

*This talk is based on a joint work with Simos Meintanis (University of Athens) and Claudia Strauch (Universität Heidelberg, Technische Universität Braunschweig).*

*References:*

[1] A. Kankainen and N. G. Ushakov (1998). A consistent modification of a test for independence based on the empirical characteristic function. *Journal of Mathematical Sciences* **89**, 1486–1494.

**Axel Munk**, University of Göttingen and Max-Planck Institute for Biophysical Chemistry, Germany

### Multiscale Blind Source Separation

*Abstract:* We provide a new methodology for statistical recovery of single linear mixtures of piecewise constant signals (sources) with unknown mixing weights and change points in a multiscale fashion. Fundamental to our approach is exact recovery within a neighborhood of the mixture when the sources take only values in a known finite alphabet, e.g. binary values when a superposition of signals is received. We provide the SLAM (Separates Linear Alphabet Mixtures) methodology to estimate the mixing weights and sources. For Gaussian error we obtain uniform confidence sets and optimal rates (up to log-factors) for all quantities. As we allow for increasing number of changes and mixture components, our approach can be viewed truly high dimensional and nonparametric. The curse of dimensionality is overcome by the finite alphabet assumption, which can be viewed as a certain type of sparsity. SLAM is efficiently computed as a nonconvex optimization problem by a dynamic program tailored to the finite alphabet assumption. Its performance is investigated in a simulation study. Connections to independent component analysis, sparse recovery and nonnegative matrix factorization will be discussed. The considered model and methodology is relevant to a variety of applications ranging from mobile communication to molecular biology. In this talk, we show how our methodology can be used to assign copy-number aberrations from genetic sequencing data to different clones and to estimate their proportions.

*This is joint work with Merle Behr (Göttingen) and Chris Holmes (Oxford).*

*References:*

[1] Behr, M., Holmes, C., Munk, A. (2017). Multiscale blind source separation. arXiv:1608.07173, The Annals of Statistics, to appear.

[2] Behr, M., Munk, A. (2017). Identifiability for blind source separation of multiple finite alphabet linear mixtures. arxiv.org 1505.05272 , IEEE Trans. Inf. Theory. To appear.

**Natalie Neumeyer**, University of Hamburg, Germany

## Change-point tests in nonparametric time series models

*Abstract:* A weakly dependent time series $(X_t, Y_t), t \in \mathbb{Z}$, in $\mathbb{R}^d \times \mathbb{R}$ is considered, for which we develop a procedure to detect whether the nonparametric conditional mean function $m_t(\cdot) = E[Y_t|X_t = \cdot]$ is stable in time $t \in \mathbb{Z}$. We also allow for heteroscedasticity. Our proposal is based on a modified CUSUM type test procedure, which uses a sequential marked empirical process of residuals. We show weak convergence of the considered process to a centered Gaussian process under the null "$m_t(\cdot) \equiv m(\cdot)$ for all $t$" and a stationarity assumption. This requires some sophisticated arguments for sequential empirical processes of weakly dependent variables. As a consequence we obtain convergence of Kolmogorov-Smirnov and Cramér-von Mises type test statistics. The proposed procedure acquires a very simple limiting distribution and nice consistency properties against change-point alternatives, features from which related tests are lacking. A small simulation study is presented to investigate the finite sample performance of our tests.

*This talk is based on a joint work with Maria Mohr, University of Hamburg.*

**Yakov Yu. Nikitin** , Saint-Petersburg University, Russia

## Asymptotic comparison of some normality tests based on characterizations

*Abstract:* Goodness-of-fit tests based on characterizations demonstrate growing popularity in recent years. Such tests reflect some intrinsic and hidden properties of probability distributions connected with the given characterization, and therefore can be more efficient or more robust than others. We compare by local efficiency some scale-free U-empirical tests of normality of integral type and of Kolmogorov type. They are based on characterizations of Polya, of Shepp, and some others. We show that often they are quite efficient for common alternatives.

**Efstathios Paparoditis**, University of Cyprus, Cyprus

## Bootstrap-Based Testing for Functional Time Series

*Abstract:* A new bootstrap procedure for functional time series is proposed which exploits a basic representation of the vector time series of Fourier coefficients appearing in the Karhunen-Loéve expansion of the functional process. A double, sieve-type bootstrap method to generate functional pseudo-time series is developed, which uses a finite set of functional principal components to capture the essential driving parts of the infinite-dimensional process and a finite order parametric process to mimic the temporal dependence structure of the corresponding vector time series of Fourier coefficients. By allowing the number of functional principal components as well as the order of the model used to increase to infinity (at an appropriate rate) as the sample size increases, consistency of the sieve bootstrap procedure for a wide range of statistics is established. Interesting applications in the context of fully functional testing are discussed.

*References:*

[1] E. Paparoditis (2016). Sieve Bootstrap for Functional Time Series, manuscript.

[2] E. Paparoditis (2017). Score Process Representations and Sieve Bootstrap for Linear Functional Processes, manuscript.

**Valentin Patilea**, CREST, Ensai, France

## Testing the influence of functional variables on functional responses

*Abstract:* The problem considered is the test of the effect of a Hilbert space valued covariate on a Hilbert space valued response, that is the test of the nullity of the conditional expectation of the response given the covariate. This general framework includes the model check problem for standard regressions and functional regressions against general alternatives. It also includes the problem of testing conditional independence with functional data. The significance test for functional regressors in nonparametric regression with general covariates and scalar or functional responses is another example. We propose a new test based on kernel smoothing. The test statistic is asymptotically standard normal under the null hypothesis provided the smoothing parameter tends to zero at a suitable rate. The one-sided test is consistent against any fixed alternative and detects local alternatives a la Pitman approaching the null hypothesis. In particular we show that neither the dimension of the outcome nor the dimension of the functional covariates influences the theoretical power of the test against such local alternatives. The uniform consistency against special classes of functions of the covariate is also studied. Simulation experiments and a real data application illustrate the performance of the new test with finite samples.

*This talk is based on a joint work with Samuel Maistre.*

**Gaby Schneider**, Johann Wolfgang Goethe University Frankfurt, Germany

## Multi-scale change point detection in neuronal spike trains

*Abstract:* Neuronal spike trains show a high diversity of patterns, including short- and long-term changes in their intensity or regularity of spike events. In order to analyze their impact on information processing, we require (1) point process models that capture these patterns and (2) techniques for localizing change points that may occur on different time scales.

We discuss a class of point process models that exhibit changes in the intensity and variance of life times and that resemble empirical spike trains. A multiple filter test [1] is then used to test the null hypothesis of constant intensity or variance of life times. After rejection of the null hypothesis, change points are localized using a multiple filter algorithm. This two step procedure first localizes changes in the intensity and then incorporates this information to investigate changes in the regularity of spiking events [2,3]. An extension also allows estimation of change points in point processes with weak dependencies as often observed in experimental spike trains [4].

This work was supported by the BMBF (01ZX1404B) and by the Priority Program 1665 of the DFG (SCHN 1370/2-1).

*This talk is based on joint work with Michael Messer, Stefan Albert, Julia Schiemann, Kauê M. Costa and Jochen Roeper.*

*References:*

[1] M. Messer, M. Kirchner, J. Schiemann, J. Roeper, R. Neininger, G. Schneider (2014): A multiple filter test for the detection of rate changes in renewal processes with varying variance. Ann. Appl. Stat. **8**, No. 4, 2027–2067.

[2] M. Messer, G. Schneider (2016) The Shark Fin Function - Asymptotic Behavior of the Filtered Derivative for Point Processes in Case of Change Points. Stat. Inf. Stoch. Proc.

[3] S. Albert*, M. Messer*, J. Schiemann, J. Roeper, G. Schneider (submitted) Multi-scale detection of variance changes in renewal processes in the presence of rate change points.

[4] M. Messer, K.M. Costa, J. Roeper, G. Schneider (2017) Multi-scale detection of rate changes in spike trains with weak dependencies. J. Comp. Neurosci. **42**, 187–201.

**Josef G. Steinebach**, University of Cologne, Germany

## Estimating a gradual parameter change in an AR(1)-process

*Abstract:* In this talk we present some work in progress concerning the estimation of a change-point at which the parameter of a (non-stationary) AR(1)-process possibly changes in a gradual way. More precisely, we observe a time series $X_1, \ldots, X_n$ possessing the structure

$$X_t = (\beta_0 + \beta_1 g(t, t_0))X_{t-1} + e_t \quad (t = 1, 2, \ldots), \quad \text{with} \quad X_0 = e_0,$$

where $\{e_t\}_{t=0,1,\ldots}$ is a sequence of centered innovations, $\beta_0$, $\beta_1$ are unknown parameters satisfying $|\beta_0| < 1$, $\beta_1 \to 0$, $\beta_1\sqrt{n} \to \infty$ $(n \to \infty)$, and $g(\cdot, t_0)$ is a (known) real function such that $g(t, t_0) = 0$ $(t \le t_0)$ and $g(t, t_0) \neq 0$ $(t > t_0)$. That is, we assume that the parameter $\beta_0$ of the AR(1)-process changes *gradually* at an unknown time-point $t_0 = \lfloor n\tau_0 \rfloor$, with $0 < \tau_0 < 1$.

We suggest to make use of the least squares estimator $\widehat{t_0}$ for $t_0$, which is obtained by minimizing

$$S(b_0, b_1, t_*) = \sum_{t=1}^{n} [X_t - (b_0 + b_1 g(t, t_*)X_{t-1}]^2$$

with respect to $b_0, b_1 \in \mathbb{R}$, $t_* = 0, 1, \ldots, \lfloor n(1-\delta) \rfloor$, $\delta > 0$ arbitrarily small.

As a first result it can be shown that, under certain regularity and moment assumptions, $\widehat{t_0}$ is a consistent estimator for $t_0$, i.e., $\widehat{t_0}/n \xrightarrow{P} \tau_0$ $(n \to \infty)$. Some possible further investigations will also be discussed and the results of a small simulation study will be presented to demonstrate the finite-sample behaviour of the suggested estimator.

*This talk is based on joint work with Marie Hušková and Zuzana Prášková (Prague).*

*Reference:*

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**Wolfgang Stummer**, University of Erlangen-Nürnberg, Germany

## Some "Universal" Method of Robust Goodness-of-Fit Inference

*Abstract:* We present a method for the goal-oriented design of outlier- and inlier-robust goodness-of-fit testing under synchronous parameter estimation. Furthermore, the same technique can be "universally" used for the detection of distributional changes, testing for homogenity resp. independence, exploratory model search, and some Bayesian decision procedures.

In order to achieve this goal, we enlarge the concept of *scaled Bregman distances between two distributions*, which was introduced in [2],[3] and which generalizes the widely-used (non-robust) concepts of Kullback-Leibler information distance/relative entropy, Pearson's chisquare distance, Hellinger distance, etc. The classical (i.e., unscaled) Bregman distances – such as the $L^2-$distance – are covered as well. In order to visualize effectively and transparently the corresponding robustness properties, we present 3D-plots of the recently developed *density-pair adjustment functions* (cf.[1]). Some special cases will be illustrated. For the discrete case, some universally applicable results on the asymptotics of the underlying scaled-Bregman-distance test statistics are derived, too.

*This talk is mainly based on several joint works with A.-L. Kißlinger (Erlangen-Nürnberg).*

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**Winfried Stute**, Universität Giessen, Germany

## On A French Nutshell - Ft Fourier, Poisson, Le Cam - and Riemann

*Abstract:* Since Fake News nowadays play an important role in the media, I start with a fake theorem stating that because Brownian Motion and a Poisson Process admit the same eigenstructure, they are identical. A closer look at this "result" brings us to the Karhunen-Loève decomposition of the Poisson Process. As it turns out an essential question becomes how to invert a Fourier transform when densities don't exist. Interestingly enough this analysis brings us to solutions of problems which at first sight seem to be uncorrelated.

**Thomas Verdebout**, Université libre de Bruxelles (ULB), Belgium

## Testing uniformity on high-dimensional spheres against symmetric and asymmetric spiked alternatives

*Abstract:* The problem of testing uniformity on high-dimensional unit spheres is considered. We are primarily interested in non-null issues and focus on spiked alternatives. We show that such alternatives lead to two Local Asymptotic Normality (LAN) structures. The first one is for a fixed spike direction theta and allows to derive locally asymptotically optimal tests under specified theta. The second one relates to the unspecified-theta problem and allows us to identify locally asymptotically optimal invariant tests. Interestingly, symmetric and asymmetric spiked alternatives lead to very different optimal tests, based on sample averages and sample covariance matrices, respectively. Most of our results allow the dimension p to go to infinity in an arbitrary way as a function of the sample size n. We perform Monte Carlo studies to illustrate our asymptotic results and we treat an application related to testing for sphericity in high dimensions.

*This talk is based on a joint work with Chr.Cutting (ULB) and Davy Paindaveine (ULB)*

**Christian H. Weiß**, Helmut Schmidt University Hamburg, Germany

## Goodness-of-Fit Testing for Count Time Series

*Abstract:* Popular goodness-of-fit tests like the famous Pearson test compare the estimated probability mass function with the corresponding hypothetical one. If the resulting divergence value is too large, then the null hypothesis is rejected. If applied to i. i. d. data, the required critical values can be computed according to well-known asymptotic approximations, e. g., according to an appropriate $\chi^2$-distribution in case of the Pearson statistic. This talk presents an approach of how to derive an explicit asymptotic approximation for the classical Pearson statistic if being concerned with time series of autocorrelated counts. Solutions are presented for both a fully specified null model as well as for the more important case where parameters have to be estimated. The proposed approaches are exemplified for different types of CLAR(1) models, INAR(p) and INMA(q) models, discrete ARMA models, and Hidden-Markov models. The asymptotic approximations are easily implemented in computational software and efficiently computed without the need for bootstrap implementations. The simulation study shows that the asymptotic approximation works rather well for time series of finite length, and that the resulting Pearson test can be successfully applied in practice to uncover model violations.

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**Martin Wendler**, University of Greifswald, Germany

## Change-Point Detection and $U$-Statistics

*Abstract:* In many applications it is important to know whether the amount of fluctuation in a series of observations changes over time. The classical approach based on the CUSUM test applied to the squared centered, is very vulnerable to outliers and impractical for heavy-tailed data, which leads us to contemplate test statistics based on alternative, less outlier-sensitive scale estimators. It turns out that the tests based on Gini's mean difference (which is a $U$-statistic) or generalized $Q_n$-estimators (which is a $U$-quantile) are very suitable candidates.

To show the consistency of the test statistic, we prove a functional central limit theorem for the sequential $U$-statistics and $U$-quantile process without under weak short-range dependence conditions. In our simulations we demonstrate that the new tests improve upon the classical test not only under heavy tails or in the presence of outliers, but also under normality.

*This talk is based on a joint work with Carina Gerstenberger und Daniel Vogel*

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**Dominik Wied**, University of Cologne, Germany

## Residual-Based Inference on Moment Hypotheses, With an Application to Testing for Constant Correlation

*Abstract:* Often, inference on moment properties of unobserved processes are conducted on the basis of estimated counterparts obtained in a preliminary step. In some situations, the use of residuals instead of the true quantities affects inference even in the limit, while in others there is no asymptotic residual effect. For the case of statistics based on partial sums of nonlinear functions of the residuals, we give here a characterization of the conditions under which the residual effect does not vanish as the sample size goes to infinity (generic regularity conditions provided). An overview of methods to account for the residual effect is also provided. The analysis extends to models with breaks in parameters at estimated time, in spite of the discontinuous manner in which the break time enters the model of interest. To illustrate the usefulness of the results, we propose a test for constant correlations allowing for breaks at unknown time in the marginal means and variances. We find, in Monte Carlo simulations and in an application to US and German stock returns, that not accounting for changes in the marginal moments has severe consequences.

*This talk is based on a joint work with Matei Demetrescu, University of Kiel*

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