MaPhySto Summerschool on

Empirical Processes

Centre for Mathematical Physics and Stochastics — MaPhySto
Department of Mathematical Sciences, University of Aarhus
9-20 August, 1999

Program, abstracts and other information for the participants.

Contents

1 Final Course Schedule

All lectures will take place in Auditorium G1 (see map at the end of this leaflet).

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9.00-10.00	Registration	JAW	JAW	PG	JAW
10.00-10.10	OEBN: Welcome				
10.20-11.20	JHJ	RMD	JAW	PG	RMD
11.30-12.30	JHJ	RMD	Eclipse?	JHJ	RMD
12.30-14.00	Lunch				
14.30-15.30	RMD	JHJ	PG	VDP	VD
15.45-16.15	-	FB	GP (1 hour)	DM	TS
16.30-17.00	-	AB	-	RB	-

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9.00-10.00	AVV	JHJ	AVV	AVV	PG
10.20-11.20	AVV	PG	RMD	AVV	PG
11.30-12.30	JHJ	PG	RMD	RMD	JHJ
12.30-14.00	Lunch				
14.30-15.30	WS	SVG	SEG	MBH	
15.45-16.15	LM	MP	MS	RMC	
16.30-17.00	-	-	RH	AB	

Legend

AB:= A. Bufetov
AVV:= A. Van der Vaart
DM:= D. Marinucci
FB:= F. Bravo
GP:= G. Peskir
JAW:= J.A. Wellner
JHJ:= J. Hoffmann-Jørgensen
LM:= L. Menneteau
MBH:= M.B. Hansen
MP:= M. Piccioni
MS:=M. Scavino
SVG:= S. van der Geer
OEBN:= O.E. Barndorff-Nielsen
PG:= P. Gänssler
RB:= R. Bilba
RMC:= R. McCrorie
RMD:= R.M. Dudley
SEG:= S.E. Graversen
RH:= R. Huntsinger
TS:= T. Schreiber
VD:= V. Dobric
VHP:= V. de la Peña
WS:= W. Stute

2 Abstracts of main lectures

Richard M. Dudley (MIT):

Uniform Central Limit Theorems.

ABSTRACT: One of the main topics of empirical process theory is asymptotic normality of suitably normalized partial sums uniformly over classes of sets and functions. For the uniform convergence to hold there must be a limiting Gaussian process with sample continuity and boundedness. First, these properties of Gaussian processes will be treated in terms of metric entropy and the Talagrand-Fernique majorizing measure theorem. Then, combinatorial properties sufficient for uniform central limit theorems uniformly over all underlying probability measures will be studied. A good property for families of sets is finiteness of the Vapnik-Chervonenkis or VC index, also studied in computer learning theory. The VC property has various extensions to families of functions. Another useful property is bracketing, where families of functions are covered by unions of brackets $[f_i, g_i]$, where $[f, g]$ is the set of measurable functions h with $f \leq h \leq g$, and there are suitable bounds of the number of brackets in relation to some distance between f_i and g_i in mean or mean square. Some of the lectures was based on parts of a book by the author, also called *Uniform Central Limit Theorems* published by Cambridge University Press.

- R. M. Dudley: *Notes on Empirical Processes*, Lecture Notes no. 4, 1999, Centre for Mathematical Physics and Stochastics, University of Aarhus.

Aad Van der Vaart (Amsterdam) and Jon A. Wellner (Seattle):

Empirical Processes at Work in Statistics .

ABSTRACT: The lectures of Van der Vaart and Wellner will focus on the use of empirical process methods in dealing with a variety of questions and problems in statistics. Our examples and applications will be drawn from problems concerning semi-parametric models and non-parametric estimation for inverse problems. We will begin with a review of bounds for suprema of empirical processes, and will then discuss uses of these bounds in establishing:

a) consistency of M- and Z-estimators;

b) rates of convergence;

c) convergence in distribution of maximum likelihood, sieved and penalized maximum likelihood estimators.

Peter Gänssler (Munich):

Empirical and Partial-sum Processes Revisited as Random Measure Processes.

ABSTRACT: In a general framework of so-called random measure processes (RMP's) we present uniform laws of large numbers (ULLN) and functional central limit theorems (FCLT) for RMP's yielding known and also new results for empirical processes and for so-called smoothed empirical processes based on data in general sample spaces. At the same time one obtains results for partial-sum processes with either fixed or random locations. Proofs are based on tools from modern empirical process theory as presented e.g. in Van der Vaart and Wellner [(1996): Weak Convergence and Empirical Processes; Springer Series in Statistics]. Our presentation will be also guided by showing up some aspects of the development of empirical process theory from its classical origin up to the present which offers now a wide variety of applications in statistics as demonstrated e.g. in Part 3 of Van der Vaart and Wellner [1996].

- Peter Gaenssler and Daniel Rost: *Empirical and partial-sum processes; revisited as random measure processes*, Lecture Notes no. 5, 1999, Centre for Mathematical Physics and Stochastics, University of Aarhus.

Jørgen Hoffmann-Jørgensen (MaPhySto, Aarhus):

Convergence in Law of Random Elements and Sets.

ABSTRACT: The classical definition of convergence in law of random elements is founded on convergence of the upper expectation of continuous functions. This concept has served very well in the theory of law convergence of empirical processes when the underlying topological space is metrizable or at least has sufficiently many continuous functions. However, in the context of law convergence of random sets associated to empirical processes (e.g. zero-sets or max-sets), the concept trivializes because the natural topology (the upper Fell topology) has no non-constant continuous functions. In the lectures I shall present a new concept of law convergence (convergence in Borel law) which coincides with the classical definition in "nice" topological spaces, and I shall demonstrate how this concept provides sensible limit theorems for random sets. In particular, we shall derive new and old results for law convergence of a certain class of estimators (J-estimators) which includes zero estimators and maximum estimators.

- Jørgen Hoffmann-Jørgensen: *Convergence in Law of Random Elements and Sets*, Lecture Notes No. ? (to appear in fall 1999), Centre for Mathematical Physics and Stochastics, University of Aarhus.

3 Titles and abstracts of afternoon talks

Radu Bilba ("George Bacovia" University, Romania):

Empirical Processes and Evolutionary Optimization.

Francesco Bravo (University of Southampton):

Testing for overidentifying restrictions via empirical likelihood.

ABSTRACT: In this paper, we obtain a second order Edgeworth approximation to the density of the empirical likelihood ratio test for overidentifying restrictions, by embedding the mement restrictions into the empirical likelihood framework. The resulting corrected critical values are then used to improve on the first order asymptotic distribution, as shown in a small Monte Carlo experiment.

Alexander Bufetov (Independent University of Moscow):

Ergodic theorems for free semigroup and group actions.

ABSTRACT: New ergodic theorems are established for actions of finitely generated free semigroups and groups by measure-preserving transformations of Lebesgue spaces.
Fix a Markov measure on the space of infinite sequences of generators in the semigroup, and assign to each element of the semigroup the measure of the corresponding cylinder in this sequence space. Then average the semigroup elements with these weights.
The main result of the talk is pointwise and mean ergodic theorems for these time averages.

Alexander Bufetov (Independent University of Moscow):

Entropy of random dynamical systems.

ABSTRACT: Entropy was introduced into dynamical systems by Kolmogorov in 1958.
Recall that a classical dynamical system consists of a phase space and its self-map T.
Now suppose that we have *several* self-maps $T_1, \dots, T_m$ of our phase space X, chosen at random according to some law. This object is called a random dynamical system. In this talk, entropy will be defined and studied for such random dynamical systems.
This random entropy, as well as its classical counterpart, is closely related to the entropy discussed in Prof. Richard M. Dudley's lectures.

Vladimir Dobric (Lehigh University):

Wavelet design for empirical measures.

ABSTRACT: One of non-parametric statistical estimation methods of a density f is by a wavelet expansion for its empirical measure. Suppose further that f is in some class $\mathcal{F}$. Then a proper wavelet design adapted to $\mathcal{F}$, together with the right choice of the resolution level in the wavelet expansion of the empirical process, will yield a uniform over $\mathcal{F}$ estimate for the mean integrated square error. The lecture will describe problems and solutions associated with wavelet design, focusing attention to multi-dimensional case.

Svend Erik Graversen (University of Aarhus):

Stopping Brownian Motion without Anticipation as Close as Possible to its Ultimate Maximum.*

ABSTRACT: Let $B = (B_t)_{0 \leq t \leq 1}$ be standard Brownian motion started at zero, and let $S_t = \max_{0 \leq r \leq t} B_r$ for $0 \leq t \leq 1$. Consider the optimal stopping problem

$$V_* = \inf_{\tau} E(B_\tau - S_1)^2$$

where the infimum is taken over all stopping times of B satisfying $0 \leq \tau \leq 1$. We show that the infimum is attained at the stopping time

$$\tau_* = \inf \left\{ 0 \leq t \leq 1 \mid S_t - B_t \geq z_* \sqrt{1-t} \right\}$$

where $z_* = 1.12...$ is the unique root of the equation

$$4\Phi(z_*) - 2z_*\varphi(z_*) = 0$$

with $\varphi(x) = (1/\sqrt{2\pi})\, e^{-x^2/2}$ and $\Phi(x) = \int_{-\infty}^{\infty} \varphi(y)\, dy$. The value V_* equals $2\Phi(z_*) - 1$. The method of proof relies upon the Itô-Clark representation theorem, time-change arguments, and the solution of a free-boundary problem.

Martin B. Hansen (Aalborg University):

Spatial Models for Nondestructive Evaluation†.

ABSTRACT: Many nondestructive evaluation methods are based on physically quantities which are modelled by partial differential equations. Examples are boundary measurements of scattered ultrasound, temperature diffusions, and voltage potentials. We consider the problem of determining the locations and the sizes of linear cracks in an electrically conducting media. General purpose imaging algorithms seek to reconstruct an unknown distributed conducting profile. A different and more efficient approach in the case of crack detection has been introduced by Santosa and Vogelius (1991), Liepa et al. (1993),

*Joint work with G. Peskir and A. Shiryaev.

†Joint work with Kim E. Andersen and Steve P. Brooks.

and Bryan and Vogelius (1994). In their algorithm the Fréchet derivative of the solution operator is used in a Newton Raphson like algorithm to iteratively solve the inverse problem of crack detection. These methods have only showed successful when the number of cracks are known a priori and they do not give variability assessments when the signal is measured in random noise. By introduction of Markov chain Monte Carlo methods, new interesting algorithms for nondestructive evaluation become available. Inspired by the work of Nicholls and Fox (1998) we suggest to use a Bayesian approach for crack detection. We put a prior distribution on the space of cracks and use a likelihood based on boundary measurements with Gaussian errors. For posterior sampling we suggest to use a reversible jump MCMC algorithm (Green, 1995).

Reid Huntsinger (Infoworks, Chicago):

Optimal allocation of treatments.

ABSTRACT: We consider a problem in which the conditional distribution of a random variable Y (the response) given a random vector X (the features) depends on a factor T, called the treatment. The object is to choose a rule which, for each x-value, selects one of the treatments in such a way as to minimize expected loss. To assist in the selection, samples from the joint distributions of (Y, X) for each treatment are available.

We consider allocation rules derived from Vapnik-Cervonenkis classes of sets and show that minimization of the empirical risk yields rules whose risk converges to the best possible within the class, uniformly over a large class of probability measures.

Domenico Marinucci ("La Sapienza", Roma):

The Empirical Process for Bivariate Long Memory Sequences.

ABSTRACT: We consider here the empirical process for bivariate stationary long range dependent sequences. We establish under suitable conditions weak convergence to a fully degenerate process, thus generalizing well-known results by Dehling and Taqqu (1989) and Ho and Hsing (1996) for the univariate case. We consider both Gaussian-subordination and linearity conditions; main tools for the proofs are Hermite/Appell orthogonal expansions, which produce extremely neat results for the indicator function of long memory processes. Applications to nonparametric statistical procedures are also illustrated.

Roderick McCrorie (LSE London):

Random measure and continuous time econometric models.

ABSTRACT: It is shown how random measure can be used to facilitate estimating the parameters of stochastic differential equations using solution methods from ordinary differential equations alone.

Ludovic Menneteau (Université Paris VI):

Some large deviations principles for local empirical processes.

ABSTRACT: Local empirical processes have been introduced in the begining of the 90's to study statistics which are functions of the observations in a suitable neiborhood of a point (e.g. kernel density and regression function estimators). In this work, we establish some large deviations principles for sequential (i.e. time dependent) local empirical processes indexed by functions. As corollaries, we obtain some functional laws of the iterated logarithm which generalize the previous results of Deheuvels and Mason and of Einmahl and Mason.

Victor H. de la Peña (Columbia University):

Randomly Stopped Banach Valued Processes.

ABSTRACT: In this talk we will review a series of results involving randomly stopped processes with values in Banach spaces. We will begin with Klass' (1988, 1990) decoupling inequality for sums of independent Banach-valued variables and its extension to continuous time processes with independent increments from de la Peña and Eisenbaum (1997). We will also discuss in detail recent extensions of these results with applications to bounds on the expected time it takes a processes with possibly dependent increments to cross a boundary, relating this expectation to the function determined by the expectation of the supremum of the norm of the process, therefore connecting boundary crossing by non-random functions to boundary crossing by random processes.

Goran Peskir (University of Aarhus):

Sequential Testing Problems for Poisson Processes[‡]*.*

ABSTRACT: We present the explicit solution of the Bayesian and variational problem of sequential testing of two simple hypotheses about the intensity of an observed Poisson process. The method of proof consists of reducing the initial problem to a free-boundary differential-difference Stephan problem, and solving the latter by use of the principles of smooth and continuous fit. A rigorous proof of the optimality of the Wald's sequential probability ratio test in the variational formulation of the problem is obtained as a consequence of the solution of the Bayesian problem.

Mauro Piccioni (University of L'Aquila):

Mean field models for feedforward neural networks.

ABSTRACT: After having proved a version of the Gibbs conditioning principle for measurements affected by Gaussian noise, the application to nonlinear regression problems in a Bayesian framework is considered. A particularly important example is the model

[‡]Joint work with A. N. Shiryaev.

of a network woith a number of hidden nodes growing to infinity. The computational advantage of using the limiting distribution of weights is discussed.

Marco Scavino (Centro de Matematica, Uruguay):

A test of normality particularly powerful for alternatives of skewness.

ABSTRACT: We adapt a class of transformed empirical processes introduced in the literature by Alejandra & Enrique M. Cabaña (Annals of Statistics, 1997) to construct a test of normality. Our Kolmogorov-Smirnov (K-S) type test is designed to be especially powerful for alternatives of skewness - properly defined - based upon the skew-normal distribution, well studied by A. Azzalini (Scand. J. Statist., 1985), instead of employing the usual third order Hermite polinomial (as in Durbin, Knott, Taylor, J.R. Statist. Soc. B, 1975). A numerical example illustrates the improving of the power of our K-S modified test with respect to the classical K-S test.

Tomasz Schreiber (Nicholas Copernicus University, Poland):

Maximum likelihood estimation of uniform distribution support.

ABSTRACT: Let $Z_1, Z_2, ...$ be a sequence of i.i.d. $\mathbf{R}^k$-valued random vectors distributed uniformly on a compact set A_0 belonging to a certain known class $\mathcal{C}$ of compact sets. For A_0 we consider the maximum likelihood estimator $\hat{A}_n$ which minimizes the volume λ among the sets from $\mathcal{C}$ covering the whole sample $Z_1, Z_2, ...$ We propose some regularity assumptions to be imposed on class $\mathcal{C}$, which guarantee that

$$\lambda(A_0 \triangle \hat{A}_n) = O_P(n^{-1}),$$

where $\triangle$ denotes the symmetric difference. We give some examples of classes satisfying these conditions.

Winfried Stute (University of Giessen):

Nonparametric Model Checks.

ABSTRACT: In this talk we review a general methodology on how to design checks for composite models. To obtain the distribution of the test statistics for small to moderate sample sizes some martingale transform is proposed, which maps the complicated underlying test process into an approximate Brownian Motion w.r.t. proper time. Also some principal component analysis is discussed, which aims at constructing optimal tests when the alternative to the null model is specified.

Sara van de Geer (University of Leiden):

Penalized M-estimation.

ABSTRACT: Let $X_1, \ldots, X_n$ be independent observations with distribution depending on a parameter θ_0 in a normed vector space $(\Lambda, \|\cdot\|)$. We consider M-estimation of θ_0, using a convex loss function and a penalty $I : \Lambda \to [0, \infty)$, with I some pseudo-norm (e.g. a Besov-norm). We prove rates of convergence using empirical process theory techniques. Also, we show that an appropriate choice of I yields adaptive estimators.

4 List of participants

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