INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Team CQFD

Contrôle de Qualité & Fiabilité Dynamique

Futurs

THEME NUM

Activity Report

2007

Table of contents

1. Team

CQFD is a joint team with IMB (Institut de Mathématiques de Bordeaux) UMR CNRS 5251, and with the laboratory IMS (Intégration du Matériau au Système) UMR CNRS 5218, Universités de Bordeaux 1, 2 and 4.

Head of the team

François Dufour [Professeur, Bordeaux 1, HdR]

Administrative Assistant

Brigitte Cournou

Research scientists

Bernard Bercu [Professeur, Bordeaux 1, HdR]
Marie Chavent [Maître de Conférences, Bordeaux 2]
Pierre Del Moral [Directeur de recherche, HdR]
Yves Dutuit [Professeur, Bordeaux 1, HdR]
Anne Gégout-Petit [Maître de Conférences, Bordeaux 2]
Benoîte de Saporta [Maître de Conférences, Bordeaux 4]
Jérôme Saracco [Professeur, Bordeaux 4, HdR]
Huilong Zhang [Maître de Conférences, Bordeaux 1]

PHD Students

Karen Gonzales [MENRT grant]
Farres Innal [MENRT grant]
Vanessa Kuentz [MENRT grant]
Sanae Louidi [MENRT grant]
Thi Mong Ngoc Nguyen [BDI/CNRS grant]
Victor Vasquez [ECOS/CONACIT grant]

2. Overall Objectives

2.1. Presentation

Economic, scientific and military competition leads many industrial sectors to design ever more successful and reliable processes and equipment.

Reliability and quality control, and more generally dependability and safety, have become a crucial area in the field of industrial engineering. The term reliability is an acquisition of the 20th century. Initially, reliability was developed to meet the needs of the electronics industry. This was a consequence of the fact that the first complex systems appeared in this field of engineering. Such systems have a huge number of components which made their global reliability very low in spite of their relatively highly reliable components. This led to a specialized applied mathematical discipline which allowed one to make an a priori evaluation of various reliability indexes at the design stage, to choose an optimal system structure, to improve methods of maintenance, and to estimate the reliability on the basis of special testing or exploitation.

Our objective is to apply probabilistic and statistical tools from estimation and control theory to dependability and safety. We wish to investigate the following fields:

1) Design and analysis of realistic and accurate random models for dependability. In particular, we will study parametric models for dynamic reliability and semi- or non-parametric models for quality control.
2) Implementation of estimation algorithms in relation with our stochastic models and evaluation of reliability indexes.
3) Design of control for maintenance and reconfiguration.

We stress the fact that points 1) and 2) are strongly interlinked. Indeed, designing mathematical models for reliability is an important and basic research field. However, our models will be legitimated and practically validated by point 2). In particular, the feasibility of estimation routines and the quality of the evaluation of reliability indexes will be crucial. Point 3) deals with control through practical issues of maintenance and reconfiguration. This last point legitimates and is based on the first two ones: only after modelling, identifying and evaluating reliability indexes, shall we be able to compute a cost criterion to be optimized.

2.2. Highlights

CQFD is a young team just started in march 2007.

P. Del Moral joined INRIA Bordeaux in september 2007. One of his main research areas is concerned with stochastic algorithms and more particularly interacting particle systems and genealogical tree based models. Since september 2007, several new research directions have been discussed with the CQFD team members to apply these tree based particle models to find prediction and control strategies of critical rare event realizations given observations.

3. Scientific Foundations

3.1. Dynamic Reliability

Keywords: *Markov process*, *Markov-switching autoregression*, *PDMP*, *active maintainability*, *adaptive control*, *availability*, *dependability and safety*, *dynamic reliability*, *estimation*, *multi-model approach*, *rare events*, *robustness*, *stability analysis*, *stochastic control*, *stochastic stability*.

PDMP Piecewise Deterministic Markov Process

3.1.1. Modeling

In dependability and safety theory, modeling is a key step to study the properties of the physical processes involved. Nowadays, it appears necessary to take explicitly and realistically the dependencies into account, meaning the dynamic interactions existing between the physical parameters (for example: pressure, temperature, flow rate, level, ...) of the system and the functional and dysfunctional behavior of its components. Classically, the models described in the dependability and safety literature do not take such interactions into account. A first set of methods used in reliability theory is the so-called combinatory approaches (fault trees, event trees, reliability diagrams and networks, ...), which can be used to identify and evaluate the combinations of events leading to the occurrence of other desirable or undesirable events. These powerful methods suffer from the fact that such combinations do not take the order of occurrence into account, in the sense that they eliminate any notion of dependency between events. A second set of methods is described by finite state Markov (or semi-Markov) models. In this context, the system is described by a fixed number of components which can be in different states. For any component, the set of its possible states is assumed to be finite (generally it contains only two elements: an operational and a failure state). One of the main limitations encountered with such models is their difficulties to model correctly the physical processes involving deterministic behavior. To overcome such difficulties, dynamic reliability was introduced in 1980 as a powerful mathematical framework capable of explicitly handling interactions between components and process variables. Nowadays in the literature, the multi-model approach appears as a natural framework to formulate dynamic reliability problems. The behavior of the physical model is thus described by different modes of operation from nominal to failure states with intermediate dysfunctional regimes. For a large class of industrial processes, the layout of operational or accident sequences generally comes from the occurrence of two types of events:

1) The first type of event is directly linked to a deterministic evolution of the physical parameters of the process.
2) The second type of event is purely stochastic and usually corresponds to random demands or failures of system components.

In both cases, these events will induce jumps in the behavior of the system leading to stable or unstable trajectories for the process.

In 1980, M.H.A. Davis [27] introduced in probability theory the Piecewise Deterministic Markov Processes (PDMP) as a general class of models suitable for formulating optimization problems in queuing and inventory systems, maintenance-replacement models, investment scheduling and many other areas of operation research. These models are described by two variables: to the usual Euclidean variable representative of the state of the process, one adds a discrete variable, called regime or mode and takes values in a finite or countable set. In this context, the state variable represents the physical parameters of the system under consideration. For example, it can be the position or the orientation of a satellite or the pressure in a tank. The mode characterizes the regimes of operation of the physical system from nominal to failure regime. From a mathematical point of view, the notion of a piecewise deterministic Markov process is very intuitive and simple to describe. The state space of this system is given, for example, by an open subset E of the set $\mathbb{R}^d$. Starting from $x \in E$, the process follows a deterministic trajectory, namely a flow indexed by the mode, until the first jump time T_1, which occurs either spontaneously in a random manner or when the trajectory hits the boundary of E. Between two jumps, the mode is assumed to be constant. In both cases, a new point and a new regime are selected by a random operator and the process restarts from this new point under this new mode. There exist two types of jump :

1) The first one is deterministic. From the mathematical point of view, it is given by the fact that the trajectory hits the boundary of E. From the physical point of view, it can be seen as a modification of the mode of operation when a physical parameter reaches a prescribed level (for example when the pressure of a tank reaches the critical value).
2) The second one is stochastic. It models the random nature of failures or inputs that modify the mode of operation of the system.

As it has been illustrated above, the key asset of this mathematical model is that it takes naturally into account the two kinds of events previously described. Several examples can be found in [30], [43], [34], [41] and [16]. Most stochastic processes presented in T. Aven and U. Jensen [22] are special cases of piecewise deterministic Markov processes.

In conclusion, it is claimed that piecewise deterministic Markov processes provide a general framework to study dynamic reliability problems. Their dynamical properties allow explicit time dependencies, in contrast with piecewise constant jump Markov processes. Consequently, these processes are really suitable for modeling real phenomena of dynamic reliability.

3.1.2. Estimation

The probabilistic background offers a very suitable framework to evaluate material quality from the dependability and safety point of view. One can classically characterize the performances of a system by several indicators : availability, reliability, maintainability, safety, etc. Evaluating all these indicators is crucial. It makes it possible to calculate a certain *cost* in order to measure the performances of the system. Hence, the well-known topic in control, called *robustness*, is given emphasis. In this framework, it is necessary to define the concept of subsystem and sensitivity:

1) Which are the subsystems of greater impact on the cost?
2) What is the evolution of cost sensibility with respect to modifications of one or several components of the system ?

For instance, evaluating the production availability of a factory is a vital concern for the industrial world. This notion complements the more classical notions of instantaneous availability and asymptotic availability. Production availability is a probability measure of the regularity of production. Previously, its calculation was usually based on the naive hypothesis that the production level associated with each mode of regime (operational, damaged, partial breakdown, ...) was instantaneously reached as soon as the system entered that state. Consequently, modeling of production availability was done via a discrete random variable and a typical trajectory of the production availability was piecewise constant. It was shown in [32] on a large set of real cases that this hypothesis was not realistic. In fact, the production level evolves continuously and is influenced by the mode of regime as well as internal variables of the system such as pressure, temperature, etc.

Quite obviously, it is necessary to take into account the naturally continuous dynamic of indicators in Reliability, Availability and Maintainability (RAM). In particular, we shall see that the so-called Piecewise Deterministic Markov Processes are very suitable tools to define and evaluate the indicators in RAM for physical systems.

We are also interested in evaluating the occurence of rare and critical events. In this context, random tree based algorithms have recently been applied with success in generating the excursion distributions of Markov processes evolving in critical and rare event regimes. For a rather detailed discussion on these advanced particle techniques with their applications in stochastic engineering we refer to the research monograph [4] and to the more recent article dedicated to rare event simulation [28]. In the path integration formalism, the distributions of a process evolving in a rare event can always be represented as a Feynman-Kac measures on trajectory spaces or on excursions between regions. In this interpretation, we stress that the occupation measures of genealogical trees associated with the corresponding genetic type particle algorithms give a precise statistical description of the strategy employed by the random process during these rare events. These descriptions allows thus to analyze the chain of elementary events leading the process to enter in such critical regions.

3.1.3. Synthesis of maintainability and reconfiguration systems

In the domain of safety and dependability, the notions of control and maintainability play a prominent role in the design of reliable systems. This maintainability can be *active* or *passive*.

In this context of vulnerability, the usual way to make the system more tolerant towards failures is to introduce several redundancies. We improve the reliability of a system not only by improving the reliability of its components but also via their redundant organization. This is commonly called *passive maintainability*. However, it is not always possible to introduce direct physical redundancy which clearly restricts the usefulness of this approach. For example, it seems impossible to put motor units or pressure transducers in the same place on certain structures such as oil wells or communication satellites.

A second approach, more realistic and promising, is *active maintainability*. It is organized in the two following steps:

1) Detection and identification of failures,

2) Reconfiguration of the system.

In this context, PDMP are especially well-adapted for modeling real physical systems. In fact, a natural approach is first to make out a list of possible failures or breakdowns. This will lead to the constitution of a set of regimes or modes for the system described in section 3.1.1. Then, after the detection and identification of all those regimes, the control or maintainability process will be in a position to react and maintain the system in a damaged but acceptable mode. However, this modeling approach is subject to a number of limitations in terms of *efficiency/complexity*. More precisely, if a non-identified breakdown occurs, this approach can fail dramatically. A simple way to rectify this situation out is to include this kind of failure into the list of possible regimes. However, this will increase the complexity of the model. Therefore, a compromise must be sought during the modeling phase.

3.2. Statistical Quality Control

Keywords: *SIR method*, *conditional quantiles*, *kernel estimation*, *martingales*, *recursive estimation procedures*, *reliability*, *semi-parametric models*, *statistical quality control*, *stochastic approximation algorithms*, *tolerance curves and hyper surfaces*.

3.2.1. Modeling

A classical aim of reliability is to study censored survival data. In this context, several parametric, semi-parametric, and non-parametric forms of modeling for survival functions estimation have already been proposed. In this project, we focus our attention on another aspect of reliability: Statistical Quality Control (SQC). More precisely, we wish to develop non-parametric and semi-parametric modeling in order to provide tolerance curves and hyper surfaces.

Tolerance curves are used in industry to predict performance of the manufacturing process from external measures such as temperature or pressure. They are particularly useful when the quality control is late (long manufacture time, intermediate storage ...) or results from small size samples. Tolerance curves provide the inspectors with a tool to control whether the evaluated parameters are within the interval required in the specifications and to make the inspection organization more efficient. Because of their graphical representation, they are particularly easy to use.

A tolerance interval differs from the well-known confidence interval. A confidence interval gives information about the position of the mean value of the parameter whereas a tolerance interval gives information about the position of the parameter and the probability for this parameter to be in this interval. Let Y be the random variable which represents this parameter and X the covariate (temperature, pressure,...). To take these covariate into account in the evaluation of the tolerance interval of Y, the conditional distribution of Y given X is studied. When X is in $\mathbb{R}$, the conditional quantiles of Y given X are used to build tolerance curves and when X is in $\mathbb{R}^p$, they are used to build tolerance hyper surfaces. Finally when $Y \in \mathbb{R}^q$, several parameters are studied simultaneously and multivariate or spatial conditional quantiles are used to build a tolerance region.

Three types of modeling can be used to define conditional univariate or multivariate quantiles. Parametric modeling has the advantage of giving results easy to interpret but the parametric shape of the conditional distribution of Y given X has to be predetermined. Non-parametric modeling is more flexible because it relaxes the constraint on the conditional distribution. However, in practice the results are difficult to interpret. Semi-parametric modeling is therefore a compromise between these two types of modeling and gives results easy to interpret. Real indices $X'\beta$ are indeed incorporated in order to reduce the dimension of the explicative part of the model and no parametric structure is imposed on the link between Y and $X'\beta$.

The choice of parametric, non-parametric or semi-parametric modeling is thus a key point in the estimation of tolerance curves, hyper surfaces or regions.

3.2.2. Estimation

Non-parametric conditional quantiles estimation is usually based on kernel or local polynomial estimation methods (see for instance [33], [31].) and suffers, like local smoothing methods, from what is called the curse of dimensionality. Indeed, when the dimension p of the covariate X increases, the dispersion of the data increases and the quality of the estimation decreases. Another drawback is that graphical representation is possible only when the dimension of X is equal to 1 or 2: tolerance curves are obtained in 2D when $X \in \mathbb{R}$ and tolerance hyper surfaces are obtained in 3D when $X \in \mathbb{R}^2$.

To avoid these two drawbacks, semi-parametric modeling can be used. The following two-step (one parametric and one non-parametric) methodology for conditional quantiles estimation is proposed. First of all, the Euclidean parameter β used to reduce X to $X'\beta$ is estimated. Next, the functional parameters used in the non-parametric conditional quantile estimation are estimated. More precisely the semi-parametric approach combines the SIR (sliced inverse regression) method and the kernel estimation of the conditional quantile. This methodology allows graphical representation of the tolerance curves in 2D ($X'\beta \in \mathbb{R}$) or surfaces in 3D ($X'\beta \in \mathbb{R}^2$), with the index $X'\beta$ easy to interpret.

In this project, we will focus our attention on non-parametric and semi-parametric estimation of tolerance curves and hyper-surfaces. Moreover, because physical measures are usually non-independent, the problem of breakdown detection will also be studied. Another point of interest will be the introduction of recursive methods in the estimation process in order to be able to manage the data stream. To our knowledge, the use of recursive methods has never been envisaged in semi-parametric model estimation.

4. Application Domains

4.1. Application Domains

Keywords: *dependability and safety*, *dynamic reliability*, *quality control*.

The three following examples illustrate the importance of dependability and safety in various fields of industry.

A first example concerns oil production in deep water. We have already worked with IFREMER on the reliability of oil rigs and with IFP (French Oil Institute) on risk assessment and control for extraction of hydrocarbon substances from submarine deposits hard to work due to their depth.

A second example in the military field concerns combat aircraft with "relaxed static stability". These aircraft are slightly aerodynamically unstable by design: they will quickly depart from level and controlled flight unless the pilot constantly works to keep it in trim. While this enhances maneuverability, it is very wearing on a pilot relying on a mechanical flight control system. Hence, the aircraft is highly vulnerable to sensors or on-board calculator breakdown.

The third example deals with quality control linked with biomedical and biometric studies led by CERIES (Centre de Recherches et Investigations Epidermiques Sensorielles): the research center of CHANEL on human skin. The knowledge of tolerance curves for numerous skin biophysical parameters is crucial for CERIES in so far as it enables CHANEL chemists to develop new cosmetic products better adapted to the aimed target: elderly women on the Asian market, young Caucasian or African-American women. Thus, knowing the skin features of a person is enough to decide whether or not they fit in the reference limits of the various CHANEL cosmetic products.

5. Software

5.1. Software

We produced a piece of software for IFP (French Oil Institution) for which the elementary model is a PDMP. This program enables the user to evaluate the availability, the production of hydrocarbon substances and the probability of feared events of an offshore rig where exploitation is rendered delicate due to a hostile environment : high pressure and low temperature.

6. New Results

6.1. Stability and Ergodicity of Piecewise Deterministic Markov Processes

Participants: Oswaldo Costa, François Dufour.

The following results have been obtained in collaboration with Oswaldo Luis Do Valle Costa from Escola Politécnica da Universidade de São Paulo, Brazil. Our main goal is to investigate conditions under which a PDMP is Harris-recurrent and ergodic.

Over the last decades a great deal of attention has been given to the stability properties and related ergodic theory of Markov processes. One of the main approaches to deal with these problems is to show that the recurrence properties of the Markov process under consideration are related to the recurrence properties of an associated discrete-time Markov chain obtained from a sampling of the original process, so that the well known discrete-time Markov chains results could be used (see for example the books [36], [39], [40] and the references therein).

In the continuous-time context, J. Azéma *et al* [23], [24] showed that a general Markov process and its associated resolvent admit the same recurrence properties. It was proved by P. Tuominen and R. Tweedie [42] that the recurrence structure of a Markov process $\{X(t)\}$ with transition semigroup $\{P^t\}$ and the Markov chain with kernel $K_F = \int P^t F(dt)$, where F is a distribution on $[0, \infty)$, are essentially equivalent, provided that a continuity assumption on $\{P^t\}$ is satisfied, an assumption later suppressed in a fundamental paper by S. Meyn and R. Tweedie [37]. It must be pointed out that these results are related to the sampling of a continuous-time process $\{X(t)\}$, sampled at random times defined by an independent undelayed renewal process. This idea of randomized sampling was generalized to state dependent sampling to provide some more powerful state dependent drift criterions in order to ensure stability of the original Markov process. Within this context, V. Malyšev and M. Men'šikov [35] derived a modified Foster-Lyapunov criterion to establish recurrence properties for discrete-time Markov chains with countable state space. S. Meyn and R. Tweedie [38] generalized this work to discrete-time Markov chains with a general state space and furthermore obtained state-dependent drift conditions to get geometric ergodic properties. The generalization to continuous-time models has been established by J. Dai and S. Meyn [26] in the context of general state space Markovian queueing models. In particular, they provided sufficient conditions for the existence of bounds on the long-run average moments and rates of convergence of the p^{th} moments to their steady-state values. Another paper related to this subject is [25].

Our main goal is to establish some equivalence results on stability, recurrence and ergodicity between a PDMP and a discrete-time Markov chain generated by a kernel G that can be explicitly characterized in terms of the three local characteristics of the PDMP leading to tractable criteria results. It should be noticed that the results developed in [24], [37], [42] are hard to be applied for the PDMP's from the practical point of view because the transition semigroup of the PDMP as well as its associated resolvent kernel cannot be explicitly calculated from its local characteristics, as opposite to the kernel G. We have established very recently the following result: G generates a Markov chain that corresponds to a state dependent sampling of the PDMP $\{X(t)\}$ providing an interesting parallel between our work in the continuous-time context and the results obtained in [38] in the discrete-time setting. However, it must be stressed that [38] provides general sufficient conditions to ensure that stability of the sampled chain implies stability of the Markov process, but not the converse. We would like to show the converse for PDMP's and, in fact, that the PDMP and the discrete-time Markov chain generated by this tractable kernel G have an equivalent recurrence structure. This is an important feature that would distinguish our work from [38]. In particular, it would be interesting to show the following equivalence results:

(i) The PDMP $\{X(t)\}$ is irreducible if and only if the Markov chain $\{\Theta_n\}$ associated to G is irreducible.

(ii) There is a one to one correspondence between the set of invariant measures for the PDMP $\{X(t)\}$ and the set of invariant measures for the Markov chain $\{\Theta_n\}$.

(iii) The PDMP $\{X(t)\}$ is recurrent if and only if the Markov chain $\{\Theta_n\}$ is recurrent.

(iv) The PDMP is Harris recurrent if and only if the Markov chain associated to G is Harris recurrent.

(v) The PDMP is positive recurrent (respectively, positive Harris recurrent) if and only if the Markov chain associated to G is recurrent (respectively Harris recurrent) with invariant measure satisfying a suitable boundedness condition.

These results would generalize those of [29] in several directions.

6.2. Conditional quantiles and quality control

Keywords: *Dimension reduction*, *conditional quantile*, *conditional spatial quantile*, *data analysis*, *nonparametric estimation*, *sliced inverse regression*.

Participants: Mohamed Chaouch, Marie Chavent, Vanessa Kuentz, Benoit Liquet, Jérome Saracco.

Concerning the dimension reduction framework which is a useful tool for the quality control part of the project, some results have been obtained for various approaches. For Sliced Inverse Regression (SIR) methods, a bootstrap criteria allowing to determine the dimension and the parameter associated with the SIR method has been proposed and implemented in R. The study of multivariate sample selection models via SIR has been made and the estimation of the euclidean and functional parts of the model has been implemented in R. A new method, named Cluster-based SIR, has been developped from the theoretical and practical points of view (including the implementation in the software R), the method is more flexible than the usual one concerning the underlying linear condition of SIR. Some others applied and methodological works have been developped on air pollution data.

Concerning the conditional quantiles framework which is an important tool for the estimation of tolerance curves in the quality control part of the project, the generalization in the multidimensional case has been studied with nonparametric estimation of spatial conditional quantile. Moreover, a comparison of kernel estimators of conditional distribution function and quantile regression under censoring has been made in order to select the most appropriate one for the rest of the study.

7. Contracts and Grants with Industry

7.1. EADS Astrium

Keywords: *propagation of cracks*, *tiredness of structures*.

Participants: François Dufour, Yves Dutuit, Anne Gégout-Petit, Benoîte de Saporta, Huilong Zhang.

The goal of this project is to propose and study an approach to evaluate the probability of occurrence of events defined by the crossing of a threshold. The example of the theory of propagation of cracks will be used as a basis for this project. The key problem will be to show that at the end of the lifetime of the structure, the probability that the crack exceeds the acceptable threshold is in adequacy with the specified need for safety. Applications in the field of the tiredness of structures will be considered.

8. Other Grants and Activities

8.1. National actions

Jérome Saracco has obtained a ï¿½Projet Région Aquitaine 2007, volet Recherche named *Estimation recursive pour des modèles semiparamétriques en Statistique* with a total amount of 120 000 euros including a PhD-grant.

8.2. International actions

B. Bercu is the leader of an ECOS cooperation program between France and Mexico, dealing with breakdown problems and adaptive control for linear regression models. Twenty researchers are involved in this program, from Bordeaux, Toulouse, Besançon, Paris 5, Mexico and Puebla Universities. The duration of this program is four years.

9. Dissemination

9.1. Animation of the scientific community

B. Bercu belongs to the MAS thematic group of the SMAI (industrial and applied mathematical society). The main purpose of this group is to promote probability and statistics in the applied mathematic community.

B. Bercu is a regular reviewer for Annales de l'IHP, ESAIM PS, Stochastic Processes and their Applications, SIAM J. Control and Optimization, IEEE Transactions on Automatic Control, Electronic Journal of Probability.

B. Bercu is a member of the scientific council of Bordeaux Institut of Mathematics, and a member of the Commission de Spécialistes, section 26, of the University of Bordeaux 1.

M. Chavent is a member of the scientific commitee of the following conferencesï¿½: EGC' 07 and SFC' 07.

M. Chavent is a member of the administration council of the SFDS (Sociétéï¿½Française de Statistique).

M. Chavent is a member of the Commission de Spécialistes, section 26, of the University of Bordeaux 1.

M. Chavent is in charge of the seminary statistic, probabilitity and operational reserach, of Bordeaux Institute of Mathematics.

M. Chavent is a reviewer for Computational Statistics and Data Analysis, Advances in Data Analysis and Classification, Pattern Recognition Letters.

F. Dufour is a regular reviewer SIAM J. Control and Optimization, IEEE Transactions on Automatic Control, System & Control Letters, Journal of Applied Probability.

F. Dufour is a member of the Commission de spécialistes, section 26, of the University of Bordeaux 1.

F. Dufour is the head of the second year cursus of the engineering school MATMECA and the head of the cursus of probability, statistics and reliability of the master in applied mathematics at University of Bordeaux 1.

F. Dufour is a member of the administration council of the engineering school MATMECA.

A. Gégout-Petit is in charge to promote the "Licence MASS" (Applied mathematics degree) of the University of Bordeaux 2 to the secondary school pupils.

A. Gégout-Petit was member of the Organization Committee of the "Journée Math-Info en fête". The aim of this journey was to prompt pupils to study informatics and mathematics. `http://www.u-bordeaux1.fr/math_info_fete/`

B. de Saporta is a regular reviewer for *Mathematical Reviews*.

J. Saracco is a member of the administration council of the SFDS (Sociétéï¿½Française de Statistique).

J. Saracco is a member of theï¿½Commission de Spécialistes, section 26, of the University of Bordeaux 2.

J. Saracco is a reviewer for Computational Statistics and Data Analysis, Journal of Multivariate Analysis, The Annals of Statistics, Statistica Sinica, Biometrika, Comptes Rendus de l'Académie des Sciences.

9.2. Workshop organisation

B. Bercu was an organizer of a conference on Toeplitz operators, probability and random matrices in Bordeaux 1 University, June 20, 2007. More information is available via the web-page http://www.math.u-bordeaux1.fr/JTPM2007/

9.3. Teaching

B. Bercu teaches postgraduate probability and statistics in the University of Bordeaux 1 . He also gives a postgraduate course on martingale theory, stochastic algorithm, with several examples of applications. He has written a book [7] with D. Chafai on Stochastic modelling and simulation, published by Dunod in September 2007.

M. Chavent teaches data analysis in master MSRO of university Bordeaux 1 and Statistic in licence MASS of University of Bordeaux 2.

F. Dufour teaches postgraduate courses in probability, stochastic calculus, finance and reliability at University of Bordeaux 1 and at the engineering school MATMECA.

A. Gégout-Petit teaches under graduate and graduate probability and statistics especially in the cursus "Satistique et Fiabilité" (Statistic and Reliability) of the master "Ingénierie Mathématique Statistique et Economique" of the Bordeaux 1, 2 and 4 Universities.

B. de Saporta teaches undergraduate mathematics and postgraduate probability and finance in the university of economics Montesquieu Bordeaux 4.

J. Saracco teaches applied statistics in Master MSRO of University Bordeaux 1, scoring in Master 2 pro IRE (Ingénierie des risques économiques) of University Bordeaux 4, statistics in Magistère d'Economie et de Finance Internationale (MAGEFI), University Bordeaux 4 and linear algebra and Statistics in Licence of Economics, University Bordeaux 4.

9.4. PhD Theses

9.4.1. Theses started in 2007

Victor Vasquez started his PhD thesis with B. Bercu on asymptotical results for ARX models in adaptive tracking.

Thi Mong Ngoc Nguyen started her PhD thesis with B. Bercu and J. Saracco on recursive estimation for semi-parametric models with statistical applications.

9.5. Participation to congresses, conferences, invitations

B. Bercu has given a conference in April 2007 at the Chinese Academy of Sciences, Beijing, China, on exponential inequalities for autoregressive processes in adaptive tracking.

B. Bercu has given a conference in April 2007 at the Universidad Autonoma Metropolitana, Mexico, on exponential inequalities for self-normalized martingales with applications.

M. Chavent gave a contributed talk at EGC 07, Namur, January 2007.

M. Chavent gave a contributed talk at 39èmes journées de Statistique, Angersï¿½, June 2007.

M. Chavent gave a contributed talk at ASMDA 07, Chania, Crete, Greece, May 2007.

M. Chavent gave a contributed talks SFC 07, Paris, September 2007.

B. de Saporta made two research stays in INRIA team TOSCA in Sophia Antipolis in january (4 days) and june (2 days). Another stay is scheduled for december.

B. de Saporta has given a seminar at Université Bordeaux 1 in february.

B. de Saporta has given a seminar at Université Rennes 1 in march.

B. de Saporta has given a seminar at Université Bordeaux 4 in april.

J. Saracco gave 3 contributed talks at 39èmes journées de Statistique, Angersï¿½, June 2007.

J. Saracco gave 2 contributed talks at ASMDA 07, Chania, Crete, Greece, May 2007.

J. Saracco gave a contributed talk at SFC 2007, Paris, September 2007.

10. Bibliography

Major publications by the team in recent years

[1] B. BERCU. *On the convergence of moments in the almost sure central limit theorem for martingales with statistical applications*, in "Stochastic Process. Appl.", vol. 111, n^o 1, 2004, p. 157–173.

[2] B. BERCU, E. GASSIAT, E. RIO. *Concentration inequalities, large and moderate deviations for self-normalized empirical processes*, in "Ann. Probab.", vol. 30, n^o 4, 2002, p. 1576–1604.

[3] O. L. V. COSTA, F. DUFOUR. *On the Poisson equation for piecewise-deterministic Markov processes*, in "SIAM J. Control Optim.", vol. 42, n^o 3, 2003, p. 985–1001 (electronic).

[4] P. DEL MORAL. *Feynman-Kac formulae*, Probability and its Applications (New York), Genealogical and interacting particle systems with applications, Springer-Verlag, New York, 2004.

[5] A. GANNOUN, J. SARACCO, A. YUAN, G. E. BONNEY. *Non-parametric quantile regression with censored data*, in "Scand. J. Statist.", vol. 32, n^o 4, 2005, p. 527–550.

[6] J. SARACCO. *Asymptotics for pooled marginal slicing estimator based on* SIR_α *approach*, in "J. Multivariate Anal.", vol. 96, n^o 1, 2005, p. 117–135.

Year Publications

Books and Monographs

[7] B. BERCU, D. CHAFAÏ. *Modélisation stochastique et simulation Cours et applications*, Dunod, 2007.

Articles in refereed journals and book chapters

[8] L. BARREDA, A. GANNOUN, J. SARACCO. *Some extensions of multivariate sliced inverse regression*, in "Journal of statistical computation and simulation", vol. 77, 2007.

[9] B. BERCU, W. BRYC. *Asymptotic results for empirical measures of weighted sums of independent random variables*, in "Electron. Comm. Probab.", vol. 12, 2007, p. 184–198 (electronic).

[10] M. CHAVENT, Y. LECHEVALLIER, O. BRIANT. *DIVCLUS-T: A monothetic divisive hierarchical clustering method*, in "Computational Statistics and Data Analysis", vol. 52, n^o 2, 2007, p. 687–701.

[11] D. COMMENGES, A. GÉGOUT-PETIT. *Likelihood for generally coarsened observations from multi-state or counting process models*, in "Scand. J. of Statist.", vol. 34, n^o 2, 2007, p. 432-450.

[12] D. COMMENGES, A. GÉGOUT-PETIT, P. JOLY, B. LIQUET. *Choice between semi-parametric estimators of markov and non-markov multi-states model from generally coarsened observations*, in "Scand. J. of Statist.", vol. 34, n^o 1, 2007, p. 33-52.

[13] P. DEL MORAL, L. MICLO. *Strong propagations of chaos in Moran's type particle interpretations of Feynman-Kac measures*, in "Stoch. Anal. Appl.", vol. 25, n^o 3, 2007, p. 519–575.

[14] F. DUFOUR, B. MILLER. *Necessary conditions for optimal singular stochastic control problems*, in "Stochastics", vol. 79, n^o 5, 2007, p. 469-504.

[15] B. LIQUET, J. SARACCO. *Application of the bootstrap approach to the choice of the dimension and the* α *parameter in the* SIR_α *method*, in "Communications in Statistics – Simulation and Computation", to appear, 2007.

Publications in Conferences and Workshops

[16] H. ZHANG, F. DUFOUR, I. FARES, Y. DUTUIT. *Piecewise Deterministic Markov Processes and Dynamic Reliability*, in "Proceedings of Mathematical Methods in Reliability: Methodology and Practice, Glasgow, Ecosse, July", 2007.

Miscellaneous

[17] B. AGUILANIU, J. MAITRE, A. GÉGOUT-PETIT, S. GLÉNET, H. GUÉNARD. *CO and NO lung transfer, membrane conductance and capillary lung volume in a wide healthy european population : effects of age*, to appear, 2007.

[18] M. CHAVENT, H. GUÉGAN, V. KUENTZ, B. PATOUILLE, J. SARACCO. *Air pollution sources apportionment in a french urban site*, to appear, 2007.

[19] M. CHAVENT, V. KUENTZ, J. SARACCO. *Analyse en Facteurs : présentation et comparaison des logiciels SAS, SPAD et SPSS*, to appear, 2007.

[20] M. CHAVENT, J. SARACCO. *On central tendency and dispersion measures for intervals and hypercubes*, to appear, 2007.

[21] A. GANNOUN, J. SARACCO, K. YU. *Comparison of kernel estimators of conditional distribution function and quantile regression under censoring*, to appear, 2007.

References in notes

[22] T. AVEN, U. JENSEN. *Stochastic Models in Reliability*, Springer Verlag, New York, 1999.

[23] J. AZÉMA, M. DUFLO, D. REVUZ. *Mesure invariante sur les classes récurrentes des processus de Markov*, in "Z. Wahrscheinlichkeitstheorie verw. Gebiete", vol. 8, 1967, p. 157-181.

[24] J. AZÉMA, M. DUFLO, D. REVUZ. *Propriétés relatives des processus de Markov récurrents*, in "Z. Wahrscheinlichkeitstheorie und Verw. Gebiete", vol. 13, 1969, p. 286–314.

[25] J. G. DAI. *On positive Harris recurrence of multiclass queueing networks: a unified approach via fluid limit models*, in "Ann. Appl. Probab.", vol. 5, n^o 1, 1995, p. 49–77.

[26] J. G. DAI, S. P. MEYN. *Stability and convergence of moments for multiclass queueing networks via fluid limit models*, in "IEEE Trans. Automat. Control", vol. 40, n^o 11, 1995, p. 1889–1904.

[27] M. DAVIS. *Markov Models and Optimization*, Chapman and Hall, London, 1993.

[28] P. DEL MORAL, J. GARNIER. *Genealogical particle analysis of rare events*, in "Ann. Appl. Probab.", vol. 15, n^o 4, 2005, p. 2496–2534.

[29] F. DUFOUR, O. COSTA. *Stability of Piecewise-deterministic Markov Processes*, in "SIAM Journal of Control and Optimization", vol. 37, n^o 5, 1999, p. 1483-1502.

[30] F. DUFOUR, Y. DUTUIT. *Dynamic Reliability: A new model*, in "Proceedings of $\lambda\mu$13-ESREL2002, Lyon, France, Mars", 2002.

[31] W. HENDRICKS, R. KOENKER. *Hierarchical spline models for conditional quantiles and the demand for electricity*, in "Journal of the American Statistical Association", vol. 99, 1992, p. 58-68.

[32] P.-E. LABEAU, DUTUIT. *Fiabilité dynamique et disponibilité de production : un cas illustratif*, in "Proceedings of $\lambda\mu$14, Bourges, France, October", 2004, p. 431-436.

[33] L. MAGEE, J. BURBIDGE, A. ROBB. *Computing kernel-smoothed Conditional Quantiles from Many Observations*, in "Journal of the American Statistical Association", vol. 86, 1991, p. 673-677.

[34] J. MALATRONAS, J. PERKINS, R. SMITH. *The availability of a system of two unreliable machines connected by an intermediate storage tank*, in "IIE Transactions", vol. 15, n^o 3, 1983, p. 195-201.

[35] V. A. MALYŠEV, M. V. MEN'ŠIKOV. *Ergodicity, continuity and analyticity of countable Markov chains*, in "Trans. Moscow Math. Soc.", vol. 1, 1982, p. 1-48.

[36] S. MEYN, R. TWEEDIE. *Markov Chains and Stochastic Stability*, Springer-Verlag, Berlin, 1993.

[37] S. P. MEYN, R. L. TWEEDIE. *Generalized resolvents and Harris recurrence of Markov processes*, in "Doeblin and modern probability (Blaubeuren, 1991), Providence, RI", Contemp. Math., vol. 149, Amer. Math. Soc., 1993, p. 227–250.

[38] S. P. MEYN, R. L. TWEEDIE. *State-dependent criteria for convergence of Markov chains*, in "Ann. Appl. Probab.", vol. 4, n^o 1, 1994, p. 149–168.

[39] E. NUMMELIN. *General irreducible Markov chains and non-negative operators*, Cambridge University Press, Cambridge, 1984.

[40] D. REVUZ. *Markov chains*, North-Holland Mathematical Library, Second, vol. 11, North-Holland Publishing Co., Amsterdam, 1984.

[41] A. SCHORNAGEL. *Optimum preventive maintenace for complex systems with interdependent equipment units*, in "Amsterdam, The Netherlands: Shell Res. Lab.", 1987.

[42] P. TUOMINEN, R. TWEEDIE. *The Recurrence Structure of General Markov Processes*, in "Proc. London Math. Soc.", vol. 39, n^o 3, 1978, p. 554-576.

[43] H. ZHANG, F. DUFOUR, I. FARES, Y. DUTUIT. *Fiabilité dynamique: Outils analytiques et numériques*, in "Proceedings of $\lambda\mu$15, Lille, France, October", 2006.