ERNSI 2017 PROGRAM

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ERNSI Workshop 2017 Program

Sunday, September 24

16h00: registration

19h00: welcome drink (*court yard*)

20h00: dinner *(room 08, ground floor)*

Monday, September 25

Breakfast from 07h00 *(room 05, ground floor)*

08h50-09h00 (*amphitheater, 2nd floor*): ERNSI Workshop 2017 opening

09h00-10h00 (*amphitheater, 2nd floor*): discussion talk 1: **Bayesian methods in system identification: equivalences, differences, and misunderstanding**, Johan Schoukens (Vrije Universiteit Brussel) and Carl Edward Rasmussen (University of Cambridge), [Chair: Alessandro Chiuso (University of Padova)]

10h00-10h20 (*amphitheater, 2nd floor*): poster teasers [Chair: Guillaume Mercère (University of Poitiers)]

10h20-10h40 (*ground floor*): coffee break

10h40-12h00 (*ground floor, room 02 and 03*): poster session A [Chair: Guillaume Mercère (University of Poitiers)]

12h00-13h30: lunch (*room 08, 2nd floor*)

13h30-14h30 (*amphitheater, 2nd floor*): invited talk 1: **Beyond stochastic gradient descent for large-scale machine learning**, Francis Bach (INRIA), [Chair: Laurent Bako (Ecole Centrale Lyon)]

14h30-14h45 (*amphitheater, 2nd floor*): discussion

14h45-15h05 (*amphitheater, 2nd floor*): poster teasers [Chair: Guillaume Mercère (University of Poitiers)]

15h05-15h25 (*ground floor*): coffee break

15h25-16h45 (*ground floor, room 02 and 03*): poster session B [Chair: Guillaume Mercère (University of Poitiers)]

16h45-17h15 (*amphitheater, 2nd floor*): regular talk 1: **Canonical Correlation Analysis based identification of LPV systems**, Roland Tóth (TU Eindhoven), [Chair: Martin Enqvist (Linköping University)]

17h15-17h45 (*amphitheater, 2nd floor*): regular talk 2: **Multi-armed bandit formulations for identification and control**, Cristian R. Rojas (KTH Royal Institute of Technology), [Chair: Martin Enqvist (Linköping University)]

17h45-18h00 (*amphitheater, 2nd floor*): discussion

18h00-18h30 (*amphitheater, 2nd floor*): regular talk 3: **Direct data-driven control of constrained linear systems**, Simone Formentin (Politecnico di Milano), [Chair: Tomas McKelvey (Chalmers University of Technology)]

18h30-19h00 (*amphitheater, 2nd floor*): regular talk 4: **Inverse source estimation problems in magnetostatics**, Juliette Leblond (INRIA)**,** [Chair: Tomas McKelvey (Chalmers University of Technology)]

19h00-19h15 (*amphitheater, 2nd floor*): discussion

20h00: dinner (*room 08, ground floor*)

Tuesday, September 26

Breakfast from 07h00 (*room 05, ground floor*)

09h00-10h00 (*amphitheater, 2nd floor*): invited talk 2: **System identification applications in power system stability monitoring, modeling and control**, Luigi Vanfretti (Rensselaer Polytechnic Institute), [Chair: Xavier Bombois (CNRS)]

10h00-10h15 (*amphitheater, 2nd floor*): discussion

10h15-10h35 (*amphitheater, 2nd floor*): poster teasers [Chair: Guillaume Mercère (University of Poitiers)]

10h35-10h55 (*ground floor*): coffee break

10h55-12h15 (*ground floor, room 02 and 03*): poster session C [Chair: Guillaume Mercère (University of Poitiers)]

12h15: lunch (*room 08, ground floor*)

14h15-18h30: social program

20h00: social dinner (*room 08, ground floor*)

Wednesday, September 27

Breakfast from 07h00 (*room 05, ground floor*)

9h00-09h30 (*amphitheater, 2nd floor*): regular talk 5: **Distribution-free prediction: perspectives from a recovering bayesian**, Dave Zachariah (Uppsala University), [Chair: Roland Tóth (TU Eindhoven)]

09h30-10h00 (*amphitheater, 2nd floor*): regular talk 6: **Are right half-plane zeros necessary for inverse response?**, Jan Maciejowski (University of Cambridge), [Chair: Roland Tóth (TU Eindhoven)]

10h00-10h15 (*amphitheater, 2nd floor*): discussion

10h15-10h45 (*ground floor*): coffee break

10h45-11h15 (*amphitheater, 2nd floor*): regular talk 7: **From structurally independent local LTI models to LPV model** , Qinghua Zhang (INRIA), [Chair: Carl Edward Rasmussen (University of Cambridge)]

11h15-11h45 (*amphitheater, 2nd floor*): regular talk 8: **Compactification of reachability row spaces and global likelihood optimization for linear systems**, Bernard Hanzon (University College Cork), [Chair: Carl Edward Rasmussen (University of Cambridge)]

11h45-12h15 (*amphitheater, 2nd floor*): regular talk 9: **Estimating effective connectivity in linear brain network models**, Giulia Prando (University of Padova), [Chair: Carl Edward Rasmussen (University of Cambridge)]

12h15-12h30 (*amphitheater, 2nd floor*): discussion

12h30: lunch (*room 08, ground floor*)

Title: BEYOND STOCHASTIC GRADIENT DESCENT FOR LARGE-SCALE MACHINE LEARNING
Author and presenter: Francis Bach (INRIA)
Time slot: Monday, September 25, 13h30-14h30
Abstract: Many machine learning and signal processing problems are traditionally cast as convex optimization problems. A common difficulty in solving these problems is the size of the data, where there are many observations ("large n") and each of these is large ("large p"). In this setting, online algorithms such as stochastic gradient descent which pass over the data only once, are usually preferred over batch algorithms, which require multiple passes over the data. In this talk, I will show how the smoothness of loss functions may be used to design novel algorithms with improved behavior, both in theory and practice: in the ideal infinite-data setting, an efficient novel Newton-based stochastic approximation algorithm leads to robustness to ill-conditioning, while in the practical finite-data setting, an appropriate combination of batch and online algorithms leads to unexpected behaviors, such as a linear convergence rate for strongly convex problems, with an iteration cost similar to stochastic gradient descent. (joint work with Nicolas Le Roux, Eric Moulines and Mark Schmidt)
Short biography: Francis Bach is a researcher at Inria, leading since 2011 the machine learning project-team, which is part of the Computer Science Department at Ecole Normale Supérieure. He graduated from Ecole Polytechnique in 1997 and completed his Ph.D. in Computer Science at U.C. Berkeley in 2005, working with Professor Michael Jordan. He spent two years in the Mathematical Morphology group at Ecole des Mines de Paris, then he joined the computer vision project-team at Inria/Ecole Normale Supérieure from 2007 to 2010. Francis Bach is primarily interested in machine learning, and especially in graphical models, sparse methods, kernel-based learning, large-scale convex optimization, computer vision and signal processing. He obtained in 2009 a Starting Grant and in 2016 a Consolidator Grant from the European Research Council, and received in 2012 the Inria young researcher prize. In 2015, he was program co-chair of the International Conference in Machine learning (ICML).

Title: SYSTEM IDENTIFICATION APPLICATIONS IN POWER SYSTEM STABILITY MONITORING, MODELING AND CONTROL
Author and presenter: Luigi Vanfretti (Rensselaer Polytechnic Institute)
Time slot: Tuesday, September 26, 09h00-10h00
Abstract: Across the world, electrical power systems are undergoing an unprecedented transition from their conventional energy transmission and distribution model where energy flows had well established seasonal power transfer corridors from production (sources) to distribution/consumption (sinks). The transition is largely due to the adoption of Renewable Energy Sources (RES) at different voltage levels and with different power production capabilities whose production variability characteristics can alter energy flows in short time-scales, and for which the electrical grid was not designed nor it is it well equipped to control. Naturally, electrical grid dynamics, even those that existed since the first interconnections and that raise due to energy exchanges between production zones, are become increasingly active and ever-more complex. At the same time, in places where grid dynamics where not of a concern due to grid over-dimensioning, they are now introducing new challenges for the overall operation of a large and widely geographically spread network such as the power systems in North America and Europe.
Evidently, the application of system identification techniques offers a unique toolset allowing engineers to characterize important grid properties that can be used to monitor and alarm operators to unwanted dynamics, while at the same time to improve the ability of power system models to capture grid dynamics. This talk gives an overview of over 10 years of work in the speaker's career of applying system identification methods and tools in electrical power networks across continents. From initial experiences in estimating the overall system modal response using elementary signal processing methods, through the application of least-costly input design methods and the development of models and tools for automated calibration of power system models, to the development of actual control systems to stabilize power networks, the talk aims to give an understanding of one of the most relevant stability characteristics of large interconnected grids, i.e. inter-area oscillations, and how system identification gives a unique toolset for understanding, monitoring and controlling electrical grid dynamics.
As electrical grids continue their transition towards complex cyber-physical systems, the system identification community can bring unprecedented value to help different societies to develop cleaner and greener electrical networks, the aim of this talk is not only to show that the development of advanced system identification techniques is important, but the availability of relevant tools and models that enables their application is also of great significance. Examples of these results include real-time monitoring and power system model validation tools that have been released as open source software, that will be briefly presented in the talk, and are available at: https://github.com/ALSETLab
Short biography: Luigi Vanfretti (IEEE S'03–M'10–SM'13) received the Electrical Engineering degree from Universidad de San Carlos de Guatemala, Guatemala City, Guatemala, in 2005. He was also a Visiting Researcher with The University of Glasgow, Glasgow, Scotland, in 2005. He obtained the M.Sc. and Ph.D. degrees in electric power engineering from Rensselaer Polytechnic Institute, Troy, NY, USA, in 2007 and 2009, respectively. For his research and teaching work toward his Ph.D. degree, he was awarded the Charles M. Close Award from Rensselaer Polytechnic Institute. He was with KTH Royal Institute of

Technology, Stockholm, Sweden, as Assistant 2010-2013), and Associate Professor (Tenured) and Docent (2013-2017/August); where he established the SmarTS Lab and research group. During this period, he was also with Statnett SF, the Norwegian electric power transmission system operator, as consultant (2011 - 2012), and Special Advisor in Strategy and in R&D (2013 – 2016). He joined Rensselaer Polytechnic Institute, Troy, NY in August 2017, to continue to develop his research agenda which aims to apply system identification through the model-based system engineering approach in cyber-physical power systems. He is currently developing his new laboratory and research team ALSETLab: http://alsetlab.com/. Dr. Vanfretti, served from 2009 to 2016 in the IEEE Power Engineering Society (PES) PSDP Working Group on Power System Dynamic Measurements, in different capacities, including as Chair from 2014-016. In addition, from 2009 to 2014, he served as Vice-Chair of the IEEE PES CAMS Task Force on Open Source Software. He is an advocate and evangelist for free/libre and open-source software, member of the Open Source Modelica Consortium (OSCM) and Associate Member of the Free Software Foundation. His research interests are in synchrophasor technology applications; and cyber-physical power system modeling, simulation, stability and control.

Discussion Talk

Title: BAYESIAN METHODS IN SYSTEM IDENTIFICATION: EQUIVALENCES, DIFFERENCES, AND MISUNDERSTANDING
Authors: Carl Edward Rasmussen and Johan Schoukens
Presenters: Carl Edward Rasmussen (University of Cambridge) and Johan Schoukens (Vrije Universiteit Brussel)
Abstract: The goal of this presentation is to connect the system identification activities in the machine learning community and the control community. We will cover/connect different aspects of the 'classical' system identification approach and the 'alternative' Bayesian inference approach. Topics like use of prior knowledge, optimization and marginalization, point estimators/posterior distributions and model complexity control will be discussed and illustrated on simple examples. The plan is to have a lively discussion with the audience, starting from joint presentation.

Regular Talks

Title: CANONICAL CORRELATION ANALYSIS BASED IDENTIFICATION OF LPV SYSTEMS
Author: Roland Tóth
Presenter: Roland Tóth (TU Eindhoven)
Abstract: Canonical Correlation Analysis (CCA) corresponds to a stochastic branch of subspace identification for linear systems. Its extensions in the form of Kernel CCA methods offer non-parametric estimators of the state-evolution associated with a Linear Parameter-Varying (LPV) data-generating system. In this talk, application of KCCA in formulating a novel LPV subspace method is discussed, showing maximum likelihood property of the estimator and favourable computational load compared to existing methods.

Title: MULTI-ARMED BANDIT FORMULATIONS FOR IDENTIFICATION AND CONTROL
Author: Cristian R. Rojas
Presenter: Cristian R. Rojas (KTH Royal Institute of Technology)
Abstract: The multi-armed bandit (MAB) problem is a well studied area in statistics and machine learning in relation to the so-called exploration-exploitation dilemma, where the actions taken by an agent on an unknown system not only affect the the rewards she obtains, but also impact the amount of information collected from the system. From a control perspective, the algorithms developed in this field provide asymptotically optimal solutions to dual adaptive control problems. In this talk we will provide a tutorial introduction to the MAB problem and its existing solution methods. Also, potential applications and extensions to identification for control, such as the estimation of the H_inf norm of a system, will be discussed.

Title: DIRECT DATA-DRIVEN CONTROL OF CONSTRAINED LINEAR SYSTEMS
Author: Simone Formentin
Presenter: Simone Formentin (Politecnico di Milano)
Abstract: In many control applications, nonlinear plants can be modeled as linear parameter-varying (LPV) systems. In such a model class, the dynamic behavior is modeled as a linear relationship dependent on some measurable signals describing the operating conditions. When a measured data set from a plant is available, LPV identification may provide low complexity linear models that embed the underlying nonlinear behavior of the plant. For such models, powerful control synthesis tools are available, but the way the modeling error and the conservativeness of the embedding affect the control performance is still largely unknown. Therefore, it appears to be attractive to directly synthesize a LPV controller directly from data without first modeling the plant. In this talk, a direct data-driven synthesis approach is introduced within a stochastic framework to provide a practically applicable solution to the above problem. It will be also shown that an outer model predictive control loop can also be synthesized from data to robustify the control and handle input/output constraints.

Title: INVERSE SOURCE ESTIMATION PROBLEMS IN MAGNETOSTATICS
Authors: Juliette Leblond, Laurent Baratchart, S. Chevillard, D. Ponomarev
Presenter: Juliette Leblond (INRIA)
Abstract: We will discuss some inverse problems for Laplace-Poisson partial differential equations (PDE) with source term in divergence form. We consider situations where incomplete (noisy) Cauchy data are given in some restricted region of the space (accessible to measurements) from which the unknown source term is to be recovered, at least partly. These issues are ill-posed inverse problems, that need first to be analysed from the mathematical point of view, next regularized, then algorithmically and computationaly solved. We will show how do harmonic analysis tools, function and operator theories, together with approximation techniques allow to set assumptions for well-posedness (uniqueness, smoothness, stability) and to constructively solve for these issues, and provide numerical illustrations. The above issues arise in many physical problems related to non-destructive inspection, in particular for electromagnetic phenomenon modelled by Maxwell's equations, under quasi-static assumptions. We will more specifically con

sider problems from planetary sciences and paleomagnetism, concerning magnetization recovery from magnetic data.

Title: FROM STRUCTURALLY INDEPENDENT LOCAL LTI MODELS TO LPV MODEL
Authors: Qinghua Zhang and Lennart Ljung
Presenter: Qinghua Zhang (INRIA)
Abstract: The local approach to linear parameter varying (LPV) system identification consists in interpolating individually estimated local linear time invariant (LTI) models corresponding to fixed values of the scheduling variable. When state-space LTI models are interpolated, they should be first made coherent, i.e., with compatible local state bases for the purpose of interpolation. It is shown in this paper that, without any global structural assumption of the considered LPV system, individually estimated local state-space LTI models do not contain sufficient information for determining similarity transformations making them coherent. Nevertheless, it is possible to estimate such similarity transformations from input-output data under appropriate excitation conditions.

Title: ARE RIGHT HALF-PLANE ZEROS NECESSARY FOR INVERSE RESPONSE?
Author: Jan Maciejowski
Presenter: Jan Maciejowski (University of Cambridge)
Abstract: Everyone knows that right-half plane zeros are associated with inverse response of (continuous-time) linear systems. It is known that the presence of a real right-half plane zero is sufficient for inverse response to exist. It is easy to demonstrate that complex right-half plane zeros are not sufficient to produce inverse response. So the question arises: are right-half plane zeros even necessary for inverse response to exist? It seems that the answer is not known. It is surprisingly difficult to prove that they are necessary (whereas various sufficient conditions are obtained easily) - at least for me. So I am pursuing two parallel paths: (1) Trying to prove that RHP zeros are necessary, (2) Searching for a counter-example. To make the search reasonably efficient and well-behaved I use the Levinson-Durbin parametrisation of Schur-stable polynomials together with a standard bilinear transformation. The presentation will motivate the question by giving various examples of inverse response in real systems, will summarise what is known in the literature, and will report on my progress so far - hopefully culminating with a YES/NO answer. This is a contribution to System Modelling rather than System Identification.

Title: DISTRIBUTION-FREE PREDICTION: PERSPECTIVES FROM A RECOVERING BAYESIAN
Authors: Dave Zachariah, Petre Stoica and Thomas Schön
Presenter: Dave Zachariah (Uppsala University)
Abstract: We consider the problem of predicting the output of a system and producing measures of prediction uncertainty. The problem is viewed both from a frequentist and subjectivist-Bayesian point of view, which highlights important conceptual and practical issues when the model class is misspecified. We present a model-robust distribution-free prediction approach with performance guarantees and valid measures of uncertainty even when the model class is misspecified. An important feature of the approach is that it is implemented online with a computational cost that scales linearly in the number of samples, while the memory requirement remains constant. The resulting predictor is illustrated using econometric and climate data sets.

Title: COMPACTIFICATION OF REACHABILITY ROW SPACES AND GLOBAL LIKELIHOOD OPTIMIZATION FOR LINEAR SYSTEMS
Authors: Bernard Hanzon (this talk is partially based on joint work with Wolfgang Scherrer)
Presenter: Bernard Hanzon (University College Cork)
Abstract: System Identification algorithms for linear Gaussian systems are well-established. However, as far as we know, the problem of finding the Maximum Likelihood Estimator, i.e. finding the global optimum of the likelihood function is still not fully solved. Here we describe a geometrical approach to try to solve this problem. We use an innovations form of the model in which the parameters are assumed to be time-invariant. However no assumptions on stability or minimum phase properties are made. First the likelihood function is optimized partially wrt some of the parameters. What results is a criterion function that depends on only on the row space of a finite reachability matrix. The family of such row spaces can be viewed as a subset of a Grassmannian manifold. The closure of the family in the Grassmannian turns out to be a compact differentiable manifold without boundary for which we obtain an explicit finite atlas [building on a finite atlas for balanced lossless systems as developed in collaboration with R. Peeters and M. Olivi] . The idea is now to construct an extension of the likelihood function to the extended space. IF the extension is continuous then it will attain a maximum. If it is also Lipschitz with a known Lipschitz constant then the maximum value can be found (at least in principle) with arbitrary precision, by using appropriate subdivisions of the compact space. However we do encounter some “obstacles” when trying to work out this approach. One of the obstacles is the surprising (to us at least) result that the maximum likelihood problem for our model class is ill-posed, as the supremum of the likelihood is plus infinity! We propose a relaxation of the problem to overcome the obstacles encountered and will discuss the effects of the relaxation.

Title: ESTIMATING EFFECTIVE CONNECTIVITY IN LINEAR BRAIN NETWORK MODELS
Authors: Giulia Prando, Mattia Zorzi, Alessandra Bertoldo and Alessandro Chiuso
Presenter: Giulia Prando (University of Padova)
Abstract: Contemporary neuroscience has embraced network science to study the complex and self-organized structure of the human brain; one of the main outstanding issues is that of inferring from measure data, chiefly functional Magnetic Resonance Imaging (fMRI), the so-called effective connectivity in brain networks, that is the existing interactions among neuronal populations. This inverse problem is complicated by the fact that the BOLD (Blood Oxygenation Level Dependent) signal measured by fMRI represent a dynamic and nonlinear transformation (the hemodynamic response) of neuronal activity. In this talk, we consider resting state (rs) fMRI data; building upon a linear population model of the BOLD signal and a stochastic linear DCM model, the model parameters are estimated through an EM-type iterative procedure, which alternately estimates the neuronal activity by means of theRauch-Tung-Striebel (RTS) smoother, updates the connections among neuronal states and refines the parameters of the hemodynamic model; sparsity in the interconnection structure is favoured using an iteratively reweighting scheme. Experimental results using rs-fMRI data are shown demonstrating the effectiveness of our approach and comparison with state of the art routines (SPM12 toolbox) is provided.

Poster Sessions

Poster session A
Time slot: Monday, September 25, 10h00-12h00

P2	***Title***: Local rational modelling - Can Bootstrapped Total Least Squares improve the FRF estimate? ***Authors***: Dries Peumans, Cedric Busschots, Gerd Vandersteen and Rik Pintelon ***Abstract***: Mechanical systems predominantly exhibit strong resonant behaviour which must be accurately characterised to prevent potential catastrophies in real world applications. Measuring the Frequency Response Function (FRF) of these systems allows to effectively assess the severity of the resonant behaviour but remains challenging due to long transient phenomena and spectral leakage. Advanced local modelling techniques such as the Local Polynomial Method (LPM) and the Local Rational Method (LRM) were introduced in the past to remedy these challenges but they do not use an appropriate model structure or introduce a bias in the FRF estimate. We resolved these issues by developing a local rational modelling technique which removes the bias on the frequency response function measurement. This technique involves the use of the Bootstrapped Total Least Squares (BTLS) estimator which achieves nearly Maximum Likelihood (ML) properties by iteratively updating its estimate. Additionally, we applied a model order selection technique which limits the occurence of pole-zero cancellations in the local model as much as possible. The performance of the proposed technique was verified by measuring the flexural vibrations of a steel beam.
P3	***Title***: Frequency response measurements with local parametric modeling ***Authors***: Dieter Verbeke and Johan Schoukens ***Abstract***: The concept of local parametric modeling has sparked renewed attention in frequency response function (FRF) measurements. Essentially, these approaches assume a particular parametric structure and approximate the FRF and the leakage errors in a small-frequency band around the frequency of interest. Following the successful application of the idea in the local polynomial method (LPM), the local rational method (LRM) was developed, replacing polynomial by rational approximating functions. The power of the LRM has previously been demonstrated in both simulations and experiments. At the cost of increased computation, the LRM reduces the leakage errors with several orders of magnitude w.r.t. its alternatives while the sensitivity to disturbing noise remains comparable to that of the standard procedures. In this paper we seek to provide an explanation for the observed virtues of the proposed method.
P4	***Title***: Input design for data perturbation methods in linear regression problems ***Authors***: Sándor Kolumbán and Balázs Csanád Csáji ***Abstract***: There have been successful attempts to define hypothesis testing methods without exact knowledge about the distribution of the randomness corrupting the measurements. One example is the family of Data Perturbation (DP) hypothesis testing algorithms, which have a few building blocks that can be customized according to the given prior knowledge about the distribution of the noise. The confidence level of these tests can be selected arbitrarily, so it is independent of the available data. However the power of the tests depend heavily on the input data. This opens up the possibility of improving statistical power by input design. We develop an algorithm to design the regressors for linear regression problems based on the volume of the resulting confidence region. The resulting procedure is consistent with the classical theory in the sense that the classical input design results emerge. There are many different input sequences that have the same performance from the point of view of the classical perspective. Selection from these is possible to further optimize the power of the tests.
P5	***Title***: Maximum likelihood identification of dynamic networks with rank-reduced noise ***Authors***: Harm H. M. Weerts, Paul M. J. Van den Hof, Arne Dankers ***Abstract***: A typical assumption in multivariable and dynamic network system identification is that process noise is full rank. When many sensors are placed physically close to each other, process noises will become correlated, and possibly fully linearly dependent on each other. In such a case the process noise is rank-reduced. Many of the typical steps in a prediction error identification framework can not immediately be taken in case noise is rank-reduced, so some generalizations are made to make prediction error methods suitable for rank-reduced situations. Recently we have shown that both a weighted least squares and a constrained least squares criterion can lead to consistent estimates of the network in case noise is rank-reduced. Now we can now show that the maximum likelihood estimate is also a constrained optimization criterion, which under some conditions is equal to the constrained least squares criterion. The maximum likelihood criterion reaches minimum variance, but an analysis of the variance is not standard due to the rank-reduced noise. Due to the constraint, the covariance matrix of the estimated parameters is singular. By appropriately treating the constraint, the variance of the estimate can be determined. The lower-bound of the variance is obtained, and can be shown to be given by a singular matrix.
P6	***Title***: Generalized Sinkhorn iterations for regularizing inverse problems using optimal mass transport ***Authors***: Johan Karlsson and Axel Ringh ***Abstract***: The optimal mass transport problem gives a geometric framework for optimal allocation, and has recently gained significant interest in application areas such as signal processing, image processing, and computer vision. Even though it can be formulated as a linear programming problem, it is in many cases intractable for large problems due to the vast number of variables. A recent development to address this builds on an approximation with an entropic barrier term and solves the resulting optimization problem using Sinkhorn iterations. In this work we extend this methodology to a class of inverse problems. In particular we show that Sinkhorn-type iterations can be used to compute the proximal operator of the transport problem for large problems. A splitting framework is then used to solve inverse problems where the optimal mass transport cost is used for incorporating a priori information. We illustrate the method on problems in computerized tomography. In particular we consider a limited-angle computerized tomography problem, where a priori information is used to

	compensate for missing measurements.
P7	***Title***: MAXIMUM LIKELIHOOD IDENTIFICATION OF WIENER-HAMMERSTEIN SYSTEMS IN PRESENCE OF PROCESS NOISE ***Authors***: Giuseppe Giordano ***Abstract***: The Wiener-Hammerstein model is a block-oriented model consisting of two linear blocks and a static nonlinearity in the middle. Several identification approaches for this model structure rely on the fact that the best linear approximation of the system is a consistent estimate of the two linear parts, under the hypothesis of Gaussian excitation and Gaussian output noise. In this poster, we consider the presence of a disturbance entering before the nonlinearity (process noise), see Figure 1. In this case, the best linear approximation is still a consistent estimate of the underlying linear dynamics. However, a standard prediction error method approach normally leads to biased results, when estimating the overall parameters of the model. Hence, a Maximum Likelihood estimate is derived in order to obtain unbiased estimation. The derivation of the likelihood function requires numerical integration, which is solved via importance sampling. The samples are generated via the Metropolis-Hastings technique and the maximization of the likelihood is solved in an optimization-resample scheme. The method is tested on simulation and benchmark data.
P8	***Title***: USING LINEAR PREDICTORS AND PEMS FOR NONLINEAR IDENTIFICATION ***Authors***: Mohamed Abdalmoaty and Håkan Hjalmarsson ***Abstract***: Nonlinear stochastic parametric models are widely used in various fields. However, for these models, the problem of maximum likelihood identification is very challenging. Recently, several methods have been developed to approximate the maximum likelihood estimator/optimal MSE predictor using Monte Carlo methods. Albeit asymptotically optimal, these methods come with several computational challenges. In this poster, we consider the use of predictors that are linear in the observed outputs but may be nonlinear in the (assumed known) input. Given the nonlinear model, we derive the optimal linear predictor and construct a corresponding prediction error estimator that relies only on the first two moments of the model. The resulting estimator is consistent and asymptotically normal. The performance of the resulting estimator is demonstrated on numerical examples.
P9	***Title***: A STOCHASTIC MULTI-ARMED BANDIT APPROACH TO NONPARAMETRIC H_∞-NORM ESTIMATION ***Authors***: Matias I. Müller, Patricio E. Valenzuela, Alexandre Proutiere and Cristian R. Rojas ***Abstract***: We study the problem of estimating the largest gain of an unknown linear and time-invariant filter, which is also known as the H_∞ norm of the system. By using ideas from the stochastic multi-armed bandit framework, we present a new algorithm that sequentially designs an input signal in order to estimate this quantity by means of input-output data. The algorithm is shown empirically to beat an asymptotically optimal method, known as Thompson Sampling, in the sense of its cumulative regret function. Finally, for a general class of algorithms, a lower bound on the performance of finding the H_∞ norm is derived.
P10	***Title***: DATA-DRIVEN IMPULSE RESPONSE ESTIMATION USING DEEP LEARNING ***Authors***: Carl Andersson, Niklas Wahlström, Thomas Schön ***Abstract***: Estimating a Finite Impulse Response (FIR) of a stable linear system given input-output measurements is a problem that has a well-known linear solution using the prediction error method. Chen et al. (2012) made some improvements on the classical solution by making use of a prior for the FIR model. This prior is motivated by the assumption that the impulse response can be modeled as a Gaussian Process. By using this prior a regularized least square approach is obtained which yields a better one-step ahead prediction. In our case we instead use a regularization matrix that is modeled using Deep Learning. By simulating numerous systems (N = 100 000) generated from a common distribution, a function to map the input-output measurements to a regularization matrix can be trained. The function is parameterized as a neural network and it is trained to minimize the norm between the estimated impulse resopnse and the true impulse response, ie. the impulse response estimation error. The systems are generated using a slightly modified version of MATLABs rss function with 30 states and an SNR of 10. The systems are then sampled using a sample frequency proportional to the bandwidth of the simulated systems. Using this regularization we achieve a performance that is comparable to that of the regularization matrix induced by a Gaussian Process. The performance measure is calculated as the ratio between the impulse response estimation error for our model and for the classical model.
P11	***Title***: BIAS-VARIANCE TRADE-OFF FOR HIGH-DIMENSIONAL PARTICLE FILTERS USING ARTIFICIAL PROCESS NOISE ***Authors***: Anna Wigren, Fredrik Lindsten, Lawrence Murray ***Abstract***: Particle filters are methods used for sequential inference in non-linear and non-Gaussian systems by representing the involved probability densities using a set of weighted particles. For high-dimensional systems the particle filter suffers from degenerated particle weights both when using the standard and the optimal proposal density . However, in many practical applications the optimal proposal can significantly outperform the standard proposal and provide competitive results for fairly high-dimensional systems. Furthermore, the benefit of using the optimal proposal has been shown to increase when the magnitude of the process noise increases. The optimal proposal is, however, difficult to use in practice since it is only possible to sample from it for a few specific types of models, such as the linear Gaussian model, but the system model can be approximated to enable the use of the optimal proposal. Here the aim is to approximate by first propagating according to the standard proposal and then adding artificial process noise. This introduces a bias but will also reduce the variance since it is possible to use the optimal proposal for the additional artificial noise step. The magnitude of the variance of the artificial noise can be varied to find the trade-off between bias and variance which gives the best overall performance. Simulation results show that a clear improvement in performance is possible.
P12	***Title***: SCALABLE IDENTIFICATION OF STABLE POSITIVE SYSTEMS ***Author***: Jack Umenberger ***Abstract***: This poster considers identification of internally positive systems, which have the property that nonnegative inputs lead to nonnegative internal states and outputs. Such systems frequently arise in applications

	in which physical constraints imply that the quantities of interest are nonnegative. Internally positive systems enjoy substantially simpler stability and performance analysis, compared to general the LTI case. Specifically, a Lyapunov function that is linear, rather than quadratic, in both the state variable and the number of parameters is necessary and sufficient to verify stability. We exploit these simplified linear stability conditions to derive a polytopic parametrization of all stable positive systems. Furthermore, due to ease of decomposability compared to LMIs, these linear constraints are readily amenable to distributed optimization, suitable for identification of large-scale dynamical systems. To access these benefits, we also derive convex quality-of-fit metrics based on Lagrangian relaxation, and demonstrate superior performance over existing approaches based on weighted equation error.
P13	***Title***: A TIME SERIES CLUSTERING ALGORITHM BASED ON INVERSE MODELLING ***Authors***: Olivier Lauwers, Thomas Devenyns and Bart De Moor ***Abstract***: In many time series clustering applications - especially in those concerning traditionally system identification-oriented areas -, it is important to take into account the underlying dynamics of the time series. Examples are anomaly detection in process industry, finding similar user profiles in the electricity grid or fraud detection. We present a novel algorithmic approach to do so. This technique is based on inverse modelling of time series. Given a dataset, the first signal is modelled with a linear stochastic model. All other signals are put through the inverse of this model. If what comes out is close to white noise, it is clustered together with the first signal and the signal dissapears from the dataset. If not, the signal is retained in the dataset without cluster label. The algorithm then repeats over the resulting dataset. Some preliminary results on synthetic datasets are shown. The connection between this technique and a weighted cepstrum distance is given. Several open research questions with the technique are discussed, possible solutions presented. A real-life dataset is needed to strengthen the results.
P14	***Title***: DYNAMIC MODELS FOR BIRD POPULATION - PARTIAL DIFFERENTIAL EQUATION IDENTIFICATION ***Authors***: Régis Ouvrard, Lauriane Mouysset, Frédéric Jiguet ***Abstract***: The main goal of this collaboration is to improve the population dynamic models of birds for the development of ecological indicators in the context of global changes such as the climate change, the agriculture evolution or the urbanization. These models will help to take into account biodiversity goals into public policies. The considered model is a partial differential equation and the parameter estimation is based on common bird database for 2002-2014 provided by the national French Breeding Bird Survey. In a first step, the system identification tools developed are: partial moment approach, Galerkin's method and proper orthogonal decomposition.
P15	***Title***: REAL TIME MONITORING OF ROAD FRICTION CHANGE: STILL AN OPEN AND CHALLENGING QUESTION! ***Author***: Jérémy Vayssettes ***Abstract***: To be able to take advantage of all the adherence potential of the tires, control algorithms of autonomous cars need to know the road-tire friction coefficient, named . However, this coefficient depends on both tire and road characteristics, it means that . Currently, control algorithms usually estimate the resultant value. This implies that these classical approaches are hardly able to know if monitored variations are due to road friction change or to tire friction change due to rubber state variations. Thus, it cannot take into account friction change of the road to adapt vehicle commands so as to be as most as possible at the tire limit of adherence for any usage conditions. In this poster, main principles of Tyre modeling will be recalled, showing why the friction coefficient knowledge is essential in order to get correct predictions of tyre efforts. Different solutions considered to estimate road friction changes will be introduced as well as how system identification inspired approaches can help bridging the gap between simulations and reality.
P16	Title: GENOME-WIDE DYNAMICAL DATA ANALYSIS AND NETWORK INFERENCE OF THE GENE REGULATORY NETWORK OF THE HUMAN T CELLS Authors: Rucha Sawlekar, Stefano Magni and Jorge Gonçalves Abstract: Despite the enormous advance in understanding the biological functions of individual genes, proteins and metabolites, the core question - how different molecules interact with each other to regulate certain physiological and pathological processes of different cellular types still largely remain unknown. Understanding of such integrated molecular networks can pinpoint the exact genetic pathogenesis of diseases and suggest new therapies to guide us through the medical treatment. In response to this question, our work aims to contribute to reconstruct the gene regulatory network of two types of CD4 T cells: regulatory T cells (Tregs) and effective T cells (Teffs), and understand the underlying precise molecular mechanisms. The time-series data of Tcells includes causality information, thus containing information on whom is regulating whom. This information is extracted and analyzed using the network inference methods. One of such linear methods ‘all to all' has been applied to the time series data of T cells in order to realize the network. The difference between the gene regulatory network of Treg and Teff is the main focus, but also the variability within the population of the same cell type is of interest. For the genes that are known to be responsive in either Tregs or Teffs, their possible upstream regulation can be observed in the reconstructed regulatory network.
P17	***Title***: A FUNCTIONAL APPROACH TO STABILITY ANALYSIS OF LINEAR SYSTEMS ***Authors***: Adam Cooman, Fabien Seyfert, Martine Olivi, Sylvain Chevillard and Laurent Baratchart ***Abstract***: Frequency domain simulation methods have become very popular in modern simulators for RF and microwave electronic circuits. These methods, like Harmonic Balance or DC, constrain the frequency grid of the circuit solution. This constraint can lead the simulator to find unstable solutions of the electronic circuit's differential equations. A stability analysis is therefore required once the solution has been found. To test the stability of these steady-state solutions, the circuit is linearised around the solution and several non-parametric frequency response functions of the linearised circuit are determined. The stability analysis therefore boils down to determining whether a given non-parametric frequency response of a linear system is stable or not. The high-

	frequency circuits under study contain distributed elements, which causes the frequency responses to be non-rational. The presented approach to analyse the stability of a frequency response (∈ L2) is to split it into a stable and unstable part. The stable part is a function in the Hardy space H2 while the unstable part lies in its orthogonal complement H2 = L2 ⊖ H2. The stable and unstable parts are obtained by projecting the frequency response onto the bases of H2 and H2 respectively. With this non-parametric approach, we can easily determine whether a given frequency response has poles in the right half-plane or not.
P18	***Title***: CIRCADIAN GENE REGULATORY NETWORK INFERENCE AND CHARACTERISATION BY LINEAR TIME INVARIANT SYSTEMS IDENTIFICATION ***Authors***: Laurent Mombaerts and Jorge Goncalves ***Abstract***: Most organisms have developed the capability of synchronizing their life cycle to the environment. As regards to plants, the circadian clock regulatory network controls diverse biological processes, such as growth, photosynthesis and flowering. This self-sustaining central oscillator consists in a complex network of interlocking genes regulations that incorporates environmental inputs. Our project is focused on the identification of the regulatory structure of the central clock system of (yet not) investigated species (e.g. plants or crops) together with the quantification of dynamical changes potentially caused by a biological alteration, such as a drug or a mutation. In the context of circadian microarray data, the identification of the dynamical properties connecting individual or novel components is challenging, due on one hand to the complexity of the interlocked network and on the other, on the partial knowledge of the biological mechanisms and species involved in the system of interest. Therefore, we considered a strategy that relies on very limited observations and provides meaningful and comparable dynamical traits while being unbiased towards any putative topology or specific dynamics of the whole system. The introduced methodology is computationally cost-effective, flexible and readily allows its extension to whole genome analysis. Theoretically, we use a combination of established and newly developed mathematical modelling tools from control systems and graph theory. Namely, the Linear Time Invariant (LTI) system identification framework relies on the identification of potential causal functions between pair of genes through low order models (typically first or second order) derived from transcriptional time course data. Additionally, when provided with various datasets, the performances of the inference methodology can be sharpened by simultaneously identifying biological alterations and biochemical pathways with a high confidence level. Despite inevitably overlooking some regulatory links due to a number of intrinsic nonlinearities, the practical efficiency of this approach has been already demonstrated in several clock studies (Dalchau et al., 2010; Herrero et al., 2012, Mombaerts et al., 2016).
P19	***Title***: LPV MODEL IDENTIFICATION OF AERODYNAMIC COEFFICIENTS BASED ON FREE-FLIGHT DATA ***Authors***: D. Machala, M. Albissier, S. Dobre, S. Theodoulis, F. Collin and M. Gilson ***Abstract***: Characterization of the behavior of a vehicle in flight, through the use of aerodynamic coefficients, allows to analyses the vehicle's static and dynamic stability. Several complementary methods able to quantify the aerodynamic coefficients exist in the literature, such as wind tunnel experiments, empirical or semi-empirical codes and free-flight tests. The latter one allows the aerodynamics to be revealed under real experimental conditions through measurements and system identification techniques. The poster is related to the topic of Linear Parameter Varying (LPV) model identification of aerodynamic coefficient based on free flight data. The nonlinear model, describing the behavior of a vehicle in free flight, is constructed by Newton/Euler laws of a rigid body motion and by considering the output signals associated to measured data. The LPV model is going to be derived from the known nonlinear state-space model and by considering polynomial and spline functions for the description of the aerodynamic coefficients. The poster will conclude with initial results obtained in terms of LPV model development in the formulated framework.
P20	***Title***: DERIVATIVE-FREE ONLINE LEARNING OF INVERSE DYNAMICS MODELS ***Authors***: Diego Romeres, Mattia Zorzi, Raffaello Camoriano, Silvio Traversaro and Alessandro Chiuso ***Abstract***: This talk discusses online algorithms for inverse dynamics modelling in robotics. Several model classes are placed in a common framework that allows to include possible prior information, e.g. that obtained from rigid body dynamics (RBD) equations. While model classes used in the literature exploit joint velocities and acceleration, which need to be approximated resorting to numerical differentiation schemes, in this paper a new “derivative-free” framework is proposed that does not require this preprocessing step. An extensive experimental study with real data from the right arm of the iCub robot is presented, comparing different model classes and estimation procedures

P1	***Title***: DETECTING AND QUANTIFYING NONLINEARITY IN A DYNAMIC NETWORK THROUGH THE BLA ***Authors***: M. Schoukens, P.M.J. Van den Hof ***Abstract***: This work extends the definition of the Best Linear Approximation (BLA) framework from the closed loop to the networked setting. It is shown how the nonlinear behavior can be quantified and located in a network using the BLA framework. The developed framework is illustrated on a simulation example and compared with the results obtained by the MIMO BLA approach.
P2	***Title***: IDENTIFICATION FROM A "SMALL" NUMBER OF SAMPLES ***Authors***: Ivan Markovsky and Guillaume Mercère ***Abstract***: Subspace identification methods may produce unreliable model estimates when a small number of noisy measurements are available. In such cases, the accuracy of the estimated parameters can be improved by using prior knowledge about the system. The prior knowledge considered in this work is constraints on the impulse response. It is motivated by availability of information about the steady-state gain, overshoot, and rise time of the system, which in turn can be expressed as constraints on the impulse response. The method proposed has two steps: 1) estimation of the impulse response with linear equality and inequality constraints, and 2) realization of the estimated impulse response. The problem on step 1 is shown to be a convex quadratic programming problem. In the case of prior knowledge expressed as equality constraints, the problem on step 1 admits a closed form solution. In the general case of equality and inequality constraints, the solution is computed by standard numerical optimization methods. We illustrate the performance of the method on a mass-spring-damper system.
P3	***Title***: COMPUTING THE D-OPTIMAL ZERO-ORDER-HOLD INPUT SIGNAL FOR WIENER SYSTEMS WITH A KNOWN POWER NONLINEARITY ***Authors***: Alexander De Cock and Johan Schoukens ***Abstract***: The field of optimal input design (OID) considers the problem of finding an input signal that leads to the most informative experiment, given some prior knowledge about the system, while respecting the physical limitations of the measurement setup. Mathematically, the OID problem can be formulated as an optimization problem in which a scalar measure of the Fisher information matrix is maximized with respect to the parametrization of the input sequence. In this study, the OID is computed for a Wiener model that consists of a combination of a linear time invariant system, followed by power nonlinearity of known order, while the class of inputs is restricted to zero-order-hold signals with fixed range or fixed total energy. To facilitate the computation of the Fisher information matrix, the linear system is parameterized with its poles and residues instead of the more classical rational form representation. Due to the nonlinearity of the system, the resulting optimization problem is a nonconvex and nonlinear. The optimization problem is solved using the fmincon solver in Matlab and a custom made sequential optimization algorithm.
P4	***Title***: NONLINEAR SYSTEM IDENTIFICATION: FINDING STRUCTURE IN NONLINEAR BLACK-BOX MODELS **Authors**: Philippe Dreesen, Koen Tiels, Mariya Ishteva, Johan Schoukens ***Abstract***: The use of black-box models is wide-spread in signal processing and system identification applications. However, often such models possess a large number of parameters, and obfuscate their inner workings, as there are nonlinear connections between all inputs and all outputs (and possibly internal states) of the model. Although black-box models have proven their success and wide applicability, there is a need to shed a light on what goes on inside the model. We have developed a tensor-based method that aims at pinpointing the nonlinearities of a given nonlinear model into a small number of univariate nonlinear mappings, with the advantageous side-effect of reducing the parametric complexity. In this contribution we will discuss how the method is conceived, and how it can be applied to the task of finding structure in black-box models. We have found that the tensor-based decoupling method is able to reconstruct up to high accuracy a given black-box nonlinear model, while reducing the parametric complexity and revealing some of the inner operation of the model. Due to their universal use, we will focus the presentation on the use of nonlinear state-space models, but the method is also suitable for other model structures. We validate the method on simulation results and highlight several case studies in nonlinear system identification.
P5	***Title***: TWO-EXPERIMENT APPROACH TO WIENER SYSTEM IDENTIFICATION ***Authors***: Giulio Bottegal, Ricardo Castro-Garcia, and Johan A. K. Suykens ***Abstract***: We propose a new methodology for identifying Wiener systems using the data acquired from two separate experiments. In the first experiment, we feed the system with a sine signal at a prescribed frequency and use the steady state response of the system to estimate the static nonlinearity. In the second experiment, the estimated nonlinearity is used to identify a model of the linear block feeding the system with a persistently exciting input. We discuss both parametric and nonparametric approaches to estimate the static nonlinearity. In the parametric case, we show that modeling the static nonlinearity as a polynomial results into a fast least-squares based estimation procedure. In the nonparametric case, least squares support vector machines (LS-SVM) are employed to obtain a flexible model. The effectiveness of the method is demonstrated through numerical experiments.
P6	***Title***: GRAY-BOX IDENTIFICATION USING DIFFERENCE-OF-CONVEX PROGRAMMING ***Authors***: Chengpu Yu, Lennart Ljung and Michel Verhaegen ***Abstract***: Identification of structured state-space (gray-box) model is popular for modeling physical and network systems. Due to the non-convex nature of the gray-box identification problem, good initial parameter estimates are crucial for successful applications. In this paper, the non-convex gray-box identification problem is reformulated as a structured low-rank matrix factorization problem by exploiting the rank and structured properties

	of a block Hankel matrix constructed by the system impulse response. To address the low-rank optimization problem, it is first transformed into a difference-of-convex (DC) formulation and then solved using the sequentially convex relaxation method. Compared with the classical gray-box identification methods like the prediction-error method (PEM) and the expectation maximization (EM) method, the new approach turns out to be more robust against converging to local.
P7	***Title***: INFERENCE AND LEARNING IN NON-LINEAR GAUSSIAN PROCESS STATE-SPACE MODELS ***Authors***: Alessandro Ialongo, Mark van der Wilk, Carl Edward Rasmussen ***Abstract***: We propose and examine a novel inference method to apply state space models with Gaussian process dynamics (GPSSM) in system identification and time-series modelling. Inference in noisy, or stochastic, non-linear systems is intractable, hence flexible approximations are required. Our approach combines inducing point approximations with variational inference, giving us an analytic lower bound on the data's marginal likelihood as well as computational efficiency in the presence of large amounts of data. In particular, we exploit the markovian structure of our posterior distribution over the system's latent states and fit a Gaussian distribution with block-tridiagonal precision matrix. This leads to a closed form update for the posterior over our Gaussian process transition function, derived by calculus of variations. In contrast to previous approaches, no monte carlo sampling is required. We are thus able to model arbitrary, non-linear dynamics in the presence of both process and observation noise as well as automatically inferring missing information (e.g. velocities from raw positions through time) and the underlying dimensionality of the system (by comparing marginal likelihood values). We test our model on standard non-linear system identification problems and compare favourably with the autoregressive Gaussian Process model. We also evaluate the quality of predictions obtained by optimising the variational objective as opposed to moment matching.
P8	***Title***: COMPLEMENTARY AND EXTENDED KALMAN FILTERS FOR ORIENTATION ESTIMATION ***Authors***: Manon Kok and Thomas B. Schön ***ABSTRACT***: IT IS POSSIBLE TO ESTIMATE THE ORIENTATION OF AN OBJECT USING MEASUREMENTS FROM AN ACCELEROMETER, A GYROSCOPE AND A MAGNETOMETER. A LARGE VARIETY OF ALGORITHMS CAN BE USED FOR THIS. TWO OF THE MOST COMMONLY USED ARE EXTENDED KALMAN FILTERS AND COMPLEMENTARY FILTERS. THE RELATIONSHIP BETWEEN THE (STATIONARY) KALMAN FILTER AND THE COMPLEMENTARY FILTER IS WELL-KNOWN IN THE CASE OF LINEAR MODELS. HOWEVER, THIS RELATIONSHIP IS MORE INTRICATE IN THE CASE OF ORIENTATION ESTIMATION BECAUSE OF THE NONLINEARITY OF THE PROBLEM, THE PARAMETRISATION OF THE ORIENTATION AND THE FACT THAT ORIENTATION IS NOT DIRECTLY MEASURED BY ANY OF THE SENSORS. WE EXPLORE THE RELATION BETWEEN THESE TWO ESTIMATION ALGORITHMS IN MORE DETAIL AND PRESENT A VERSION OF THE COMPLEMENTARY FILTER THAT CLEARLY HIGHLIGHTS SIMILARITIES AND DIFFERENCES BETWEEN THEM.
P9	***Title***: AN ADAPTIVE APPROACH TO CHANGE POINT DETECTION AND CLUSTERING FOR ELECTRICITY SPOT MARKET DATA ***Authors***: Othmane Mazhar, Cristian R. Rojas, Carlo Fischione and Mohammad Reza Hesamzadeh ***Abstract***: Price forecasting is of prime importance for the electricity market, as better forecasts permit to uncover hidden patterns, correlations and other insights for more confident decision making. An important problem that faces the forecaster is determining the type of price regimes and when the change from one regime to the other happens. The aim of this study is to provide a change point detection algorithm for certain type of data that exhibit the property of switching between a small number of regimes; smaller than the number of changes. Specifically we reduce the problem to a penalized least square problem and build a penalty for choosing the number of change points and regimes starting from a BIC estimator. This penalty makes the resulting estimator adaptive to both parameters. We prove a non-asymptotic oracle inequality for the proposed least square estimator. And a minimax rate for this new problem using Birge's Lemma and a new family of hypotheses. Numerical evaluation using electricity market data illustrate the accuracy of our method using a dynamic programming algorithm.
P10	***Title***: DISTRIBUTED NONPARAMETRIC IDENTIFICATION OF ACYCLIC DYNAMIC NETWORKS. ***Authors***: Riccardo Sven Risuleo and Håkan Hjalmarsson ***Abstract***: In this research, we study the identification of linear modules interconnected in a network without feedback loops. Such networks may be used to model water distribution systems, chemical processes, and industrial production lines, among others. We model the impulse responses of the modules as zero-mean independent Gaussian processes where the covariance matrices are used to encode prior information, such as stability and smoothness. To estimate the network, we approximate the joint posterior distribution of the impulse responses using a variational Bayes approach. In particular, using a mean field approximation, we assume that the impulse responses of the modules are a posteriori independent. This allows us to devise a distributed algorithm where the identification of each impulse response can be performed locally at the module, using only information passed by neighboring modules. We evaluate the performance of the proposed identification prodecure in a simulation experiment where we compare it to other kernel-based appraches.
P11	***Title***: LEARNING AN OPTIMIZATION SOLVER FOR A CLASS OF INVERSE PROBLEMS ***Authors***: Jonas Adler, Johan Karlsson, Axel Ringh and Ozan Öktem ***Abstract***: System identification methods can often be cast as optimization problems, where the optimal solution characterizes an approximation of the sought system. In this work we consider methods for solving large scale optimization problems based on machine learning. In particular, we consider the problem of reconstructing an object (system) based on partial measurements using L1 -regularization and apply this to inverting the Radon transform using a total variation (TV) regularization, a problem often considered in Computerized Tomography. We specify a class of optimization algorithms using only linear operations and applications of proximal operators, which can be interpreted as a recurrent neural network. This class is general enough to span modern first-order solvers like Douglas-Rachford and Chambolle-Pock. We then apply unsupervised learning in order to find the best solver in this class of solvers for the family of TV-problems, which de facto can be seen as learning a generalized inverse. Finally, stability of the trained solver is investigated and the solver is also compared to state-of-the-art solvers.

P12	***Title***: Another particle-filter based approach to maximum likelihood parameter estimation in nonlinear state-space models ***Authors***: Andreas Svensson, Fredik Lindsten and Thomas B. Schön ***Abstract***: The particle filter algorithm is a Monte Carlo tool to compute the posterior for the unobserved states in a nonlinear state-space model. For system identification purposes, the result from the particle filter can be used to estimate the likelihood of the parameters in the state-space model, since the expression for the likelihood contains an integral over the state posterior. Since the particle filter algorithm is stochastic, the likelihood estimate is also stochastic, which prohibits its use in a generic optimization scheme to find the maximizum likelihood parameters. To this end, several method have been proposed, based on various optimization schemes tailored for noisy function evaluations, pseudo-marginal Metropolis-Hastings, etc. We will explore a different approach, where we re-use the state samples generated within the particle filter algorithm. By, intuitively, walking thorugh the particle filter algorithm and answer the counterfactual question "what had happaned, if another parameter value had been used" we arrive at an estimator which retains the unbiasedness property. Furthermore, this estimator is a deterministic function of the parameters, for a fixed Monte Carlo "noise realization", which allows for a numerical optimization scheme to be applied. We demonstrate the effectiveness of the proposed approach on a few simulated cases.
P13	***Title***: A decision-theoretic approach to system identification ***Authors***: Johan Wågberg, Dave Zachariah and Thomas B. Schön ***Abstract***: Traditionally, methods that identify a parametric model of a dynamical system are based on the frequentist paradigm. Computational advances have more recently enabled identification methods based on the Bayesian paradigm. The underlying philosophies and their practical interpretations of both paradigms differ radically. Here, however, we propose a way to bridge both seemingly different approaches in a decision-theoretic framework for system identification. Specifically, by viewing the identification of a specific parametric system model as a decision, we can unify classical frequentist and modern Bayesian identification approaches. To illustrate the findings we consider simple examples previously studied in the literature. We hope that this will be useful in making the implications clear and explicit.
P14	***Title***: Model reduction for linear Bayesian System Identification ***Authors***: G. Prando and A. Chiuso ***Abstract***: Bayesian estimation methods have recently been introduced in the system identification community. When applied in this context, they allow to estimate the unknown system in terms of its impulse response coefficients, thus returning a model with high (possibly infinite) McMillan degree. In this paper we discuss how these Bayesian estimation techniques can be equipped with a completely automatic model reduction procedure, in order to obtain a low McMillan degree model as the final zstimate. Besides being more suitable for filtering and control applications, these low-order models seem also to better capture the dynamics of the systems to be identified, as demonstrated by the extensive Monte Carlo experiments which are included in the presentation.
P15	***Title***: Grey-box identification for active vibration control of a flexible structure with piezo patches ***Authors***: P. Wang, C. Wang, A. Korniienko, G. Scorletti, X. Bombois and M. Collet ***Abstract***: For satisfactory active vibration control of flexible structures, an accurate model of the to-be-controlled system is crucial. In this poster, we design a data-based model of a specific cantilever beam present in the premises of the LTDS lab at ECL and we validate this model by the design of satisfactory vibration controller. This beam is a free-free cantilever beam with a number of piezo patches that can be used as actuators and/or sensors and that are distributed over the beam except in its central part. The control objective is in turn to reduce the vibrating energy in this central part. First, a finite-element analysis is used to get a physical model of the overall system (beam and piezo patches). Due to the uncertainty in a number of important parameters, this first model was found to be relatively inaccurate (especially in the frequency band of interest for vibration control). Grey-box identification is therefore used to obtain better estimates of those uncertain parameters with special attention to the frequency band of interest for control. The identified model is subsequently used to design a satisfactory vibration controller using H_∞ framework. The whole procedure is validated by applying the designed controller on the cantilever beam in the LTDS lab. The experimentally observed vibration reduction is similar to the one predicted on the model.
P16	***Title***: Parametrizing mechanical systems using Matrix Fraction Descriptions ***Authors***: Robin de Rozario, Robbert Voorhoeve, Tom Oomen ***Abstract***: Mechanical motion systems are position-varying due to flexible mechanics. An important challenge lies in the control of these mechatronic systems, including the inference of possibly unmeasured performance variables. A successful grey-box strategy to obtain accurate models through a local approach is to directly identify canonical mechanical systems, whose parameters can subsequently be interpolated in a physically motivated manner. Estimating these generally nonlinear-in-the parameter modal models from Frequency Response Function data through gradient-based techniques suffers from the potential of converging to sub-optimal estimates. In this research proposes a novel Matrix-Fraction Description parametrization that is shown to be equivalent to the relevant class of modal mechanical systems. This parametrization enables the formulation of the Sanathanan-and-Koerner and Instrumental Variables estimators which are known to attain the global optimum upon convergence. The proposed parametrization is successfully employed to directly estimate a large set of local mechanical models of various position-dependent motion systems, thereby confirming that proposed the identification method is well-suited for practical applications. In related work (de Rozario, R., Oomen, T., & Steinbuch, M., Iterative Learning Control and Feedforward for LPV Systems: Applied to a Position-Dependent Motion System, Amer. Control. Conf., 2017), it is shown that these models can be cast in an LPV framework, and the potential of LPV control is shown.

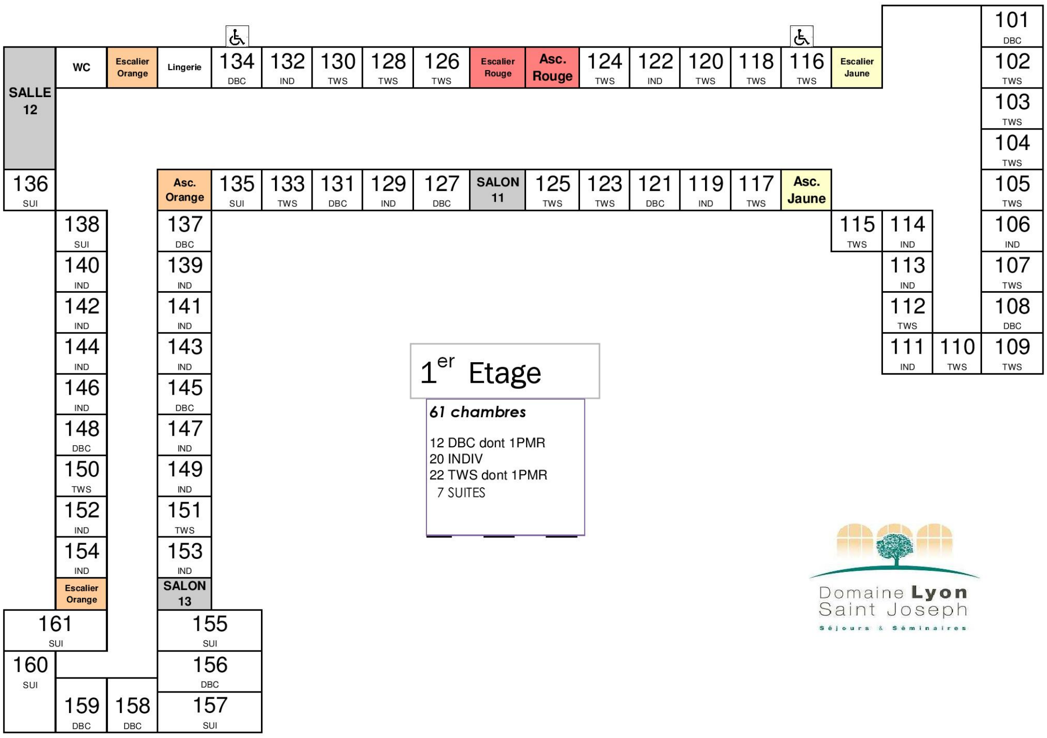
P17	***Title***: DYNAMIC NETWORK RECONSTRUCTION WITH LOW SAMPLING FREQUENCIES: A STATE-SPACE-BASED BAYESIAN APPROACH ***Authors***: Zuogong Yue, Johan Thunberg, Jorge Goncalves ***Abstract***: Dynamic network reconstruction has been shown to be challenging due to the requirements on sparse network structures and the satisfaction of network identifiability. Moreover, the low sampling frequency makes identification problems more difficult and forces to rely on continuous-time models to infer networks. It also leads to particular difficulties on the calculation of gradients for optimization in parameter estimation. This paper uses the Expectation Minimization (EM) algorithm to bypass this issue, in which the M-step turns to be a full-state measurement case. The E-step is calculated via Kalman filter and Kalman smoother. Parameters in each iteration are estimated by the maximum a posteriori (MAP), where the prior is constructed using the Frechet derivative of matrix logarithm in the framework of Sparse Bayesian Learning (SBL) to enhance network sparsity. To solve the SBL problem, another EM algorithm is used, in which we apply the constraints of network identifiability heuristically. In a sum, this paper manages to offer a solution using Bayesian approaches to reconstruct dynamic networks from low-sampling-frequency data.
P18	***Title***: PREDICTION OF HIGH-DIMENSIONAL TIME-SERIES WITH EXOGENOUS VARIABLES USING EXTENDED KOOPMAN OPERATOR FRAMEWORK IN REPRODUCING KERNEL HILBERT SPACE ***Authors***: Jia-Chen Hua, Farzad Noorian, Philip H.W. Leong, Gemunu Gunaratne, and Jorge Goncalves ***Abstract***: We propose a novel methodology to predict high-dimensional time-series with exogenous variables using Koopman operator frame- work, by assuming that the time series are generated by some under- lying unknown dynamical system with input as exogenous variables. In order to do that, we first extend and generalize the definition of the original Koopman operator to allow for input to the underlying dynamical system. We then obtain a formulation of the extended Koopman operator in reproducing kernel Hilbert space (RKHS) and a new derivation of its numerical approximation methods. We also obtain a probabilis- tic interpretation of this numerical method developed for deterministic Koopman operator by using the connection between RKHS and Gaus- sian processes regression, and relate it to the stochastic Koopman and Perron-Frobenius operator. In applications, we found that the prediction performance of this methodology is very promising in forecasting real world high-dimensional time-series with exogenous variables, includ- ing energy consumption data and financial markets data. We believe that this methodology will be of interest to the community of scientists and engineers working on quantitative finance, econometrics, system bi- ology, neurosciences, meteorology, oceanography, system identification and control, data mining, machine learning, computational intelligence, and many other fields involving high-dimensional time series and spatio- temporal data.
P19	***Title***: GAUSSIAN PROCESS DYNAMICAL MODEL APPROACH TO GENE REGULATORY NETWORK INFERENCE ***Authors***: Atte Aalto and Jorge Goncalves ***Abstract***: We present a novel approach for inferring the regulatory network structure of a nonlinear system from time series data that consists of sampled measurements. A regulatory network is a directed graph whose nodes represent different state variables of the system and a directed edge from one node to another signifies that the state variable corresponding to the first node has a direct effect on the dynamics of the state variable corresponding to the second node. The method is based on modelling the nonlinear time evolution function as a Gaussian process. A probability measure for the continuous time trajectory is formed, and it is used in a Bayesian framework utilizing a MCMC sampling scheme for estimating the hyperparameters of the chosen covariance function for the Gaussian process. These hyperparameters (called input relevance parameters) yield the regulatory network structure. As a prior for the hyperparameters, we use a global part that depends on the sparsity pattern of the network structure, and a separate prior probability density for each non-zero relevance parameter. The motivation for the work arises from gene regulatory network estimation, where taking into account the continuous time nature of the underlying system is vital due to low temporal resolution of the available time series data.
P20	***Title***: ON PERFORMANCE ANALYSIS FOR STOCHASTIC WIENER SYSTEM IDENTIFICATION ***Author***: Bo Wahlberg ***Abstract***: we analyze the statistical performance of identification of stochastic dynamical systems with non-linear measurement sensors. This includes stochastic Wiener systems, with linear dynamics, process noise and measured by a non-linear sensor with additive measurement noise. There are many possible system identification methods for such systems, including the Maximum Likelihood (ML) method and the Prediction Error Method (PEM). The focus has mostly been on algorithms and implementation, and less is known about the statistical performance and the corresponding Cram\'er-Rao Lower Bound (CRLB) for identification of such non-linear systems. We derive expressions for the CRLB for certain Gaussian Wiener system approximations to show how a non-linear sensor affects the accuracy compared to a linear sensor with the same gain. The key idea is to take second order statistics into account by using ML and PEM with a common parametrization of the mean and the variance of the output process. The analysis is supported by numerical simulations.

P1	***Title***: COMPARISON OF PARTICLE FILTERING + EM AND OPTIMIZATION FOR NONLINEAR STATE-SPACE IDENTIFICATION ***Authors***: Koen Tiels, Andreas Svensson and Thomas B. Schön ***Abstract***: Nonlinear state-space models are flexible model structures that can capture many nonlinear dynamic behaviors. When estimating these models from measured data, inevitably, noise is present. The noise can be present both as measurement noise on the output, and as process noise on the states. In this work, we compare two approaches to estimate nonlinear state-space models: a particle filter based method and an optimization based method. The particle filter based method can intrinsically deal with process noise, while the optimization based method works in an output error framework. In the presence of low process noises, preliminary work on a simulation example shows that the optimization based method is still able to estimate a good model. The particle filter method can be slow to converge in that case. At higher process noises, the particle filter method performs better than the optimization based method. The optimization based method solves the wrong problem as it assumes only output noise. The particle filter method solves the right problem and with enough process noise, it does not run into trouble with propagating the particles.
P2	***Title***: VOLTERRA SERIES OF THE BRAIN RESPONSE TO IMPOSED WRIST MOTION ***Authors***: Georgios Birpoutsoukis, Martijn P. Vlaar, John Lataire, Maarten Schoukens, Alfred C. Schouten, Johan Schoukens, and Frans C. T. van der Helm ***Abstract***: Analysing the human sensorimotor system is crucial in order to better understand, diagnose and treat movement disorders. Describing the relation between the wrist joint motion and the electroencephalography (EEG) signals in the brain is an important tep in this direction. It has been shown that a linear model can capture only 10% (in terms of Variance Accounted For, VAF) of the characteristics of the wrist joint - brain system while more than 70% is attributed to even nonlinear behavior. In this work, the Volterra series, combined with a regularization technique to impose exponentially decay and smoothness on the estimated Volterra kernels, is used to model the even nonlinear system behavior. The obtained model achieves a VAF of 55% on a validation data set. Conclusions on the system behavior are drawn both in time and in the frequency domain.
P3	***Title***: NON-LINEAR SINGULAR VALUE DECOMPOSITION ***Authors***: Mariya Ishteva and Philippe Dreesen ***Abstract***: In data mining, machine learning, and signal processing, among others, many tasks such as dimensionality reduction, feature extraction, and classification are often based on the singular value decomposition (SVD). As a result, the usage and computation of the SVD have been extensively studied and well understood. However, as current approaches take into account the non-linearity of the world around us, non-linear generalizations of the SVD are needed. We present our ideas on this topic. As it turns out, the so-called decoupling problem is a promising non-linear generalization of the SVD, and can be solved by tensor techniques. We briefly discuss the potential of this approach for inverting nonlinear functions and for defining a nonlinear modal canonical form in the context of state-space modeling.
P4	***Title***: IDENTIFICATION OF INVERSE MODELS FOR FEEDFORWARD CONTROL: THE ROLE OF NON-CAUSAL BASIS FUNCTIONS AND AN OPTIMAL IV APPROACH ***Authors***: Lennart Blanken and Tom Oomen ***Abstract***: System identification of inverse models for feedforward control is investigated. The estimation of the parameters of a feedforward controller is reformulated as the estimation of an inverse model of a dynamical system operating in closed-loop. The aim of this poster is to enhance feedforward tuning methods by using (closed-loop) identification techniques, tailored towards their use in feedforward control. First, a regression method based on instrumental variables is presented that leads to unbiased estimates with optimal accuracy for feedforward control. Second, non-causal rational orthonormal basis functions in L2 are proposed to identify inverse models. These functions are then utilized to generate non-causal feedforward control actions, and enable exact solutions for non-minimum phase systems. Experimental results on a motion system confirm the effectiveness of the proposed approach, including the benefits of non-causal feedforward control.
P5	***Title***: DATA-DRIVEN MODEL COMPLETION USING SYMBOLIC REGRESSION ***Authors***: Dhruv Khandelwal, Paul Raaijmakers, Roland Tóth, Siep Weiland ***Abstract***: In this submission, a new black-box approach to model completion is presented. The model completion problem refers to the problem of augmenting an existing continuous-time dynamical model that does not sufficiently capture the dynamics of the real system, such that the new augmented model better reflects the true system, as per some user-defined metric. In the black-box setting, the augmentation is to be estimated based on data inferred from the true system. The main challenge of the model completion problem is two-fold: firstly, the unknown augmentation function must be estimated from data, and secondly, one must also determine how the augmentation function enters the existing model, for example, in additive form, output multiplicative form, and so on. The approach used and the main contributions of the submission are the following. A framework based on Fractional Representations (FR) is proposed that allows to encapsulate the two estimation problems into a single estimation problem. Subsequently, Genetic Programming (GP), a meta-heuristic optimization method, is used to solve the resulting estimation problem. GP typically uses several thousand function evaluations in order to find a solution, an aspect that can be prohibitively expensive in terms of computation time. Additionally, the augmentation functions could vary in terms of their mathematical properties, for example, they could be static or linear or non-linear or singular models. In order to deal with the computational demands, a kernel-based LS-SVM method is used in order to approximate the solutions of the augmented function.

P6	***Title***: Multidimensional Rational Covariance Extension with application to Wiener system identification and texture generation ***Authors***: Axel Ringh, Johan Karlsson and Anders Lindquist ***Abstract***: The rational covariance extension problem is an inverse problem where one tries to find a rational power spectral density that matches a finite set of covariances. A solutions to this problem can be seen as identifying a stochastic linear time-invariant system that matches an observed finite realization of a stochastic process. Moreover, the problem can in fact be solved using variational regularization, i.e., by posting it as an optimization problem with a regularizing functional that “promotes a rational form of the solution spectrum”. Recently we extended results in the literature from a one-dimensional to a multidimensional setting, where we use rational systems to model multidimensional stochastic processes. We apply the theory to texture generation by modeling the texture as the output of a Wiener system. The static nonlinearity in the Wiener system is assumed to be a thresholding function and we identify both the linear dynamical system and the thresholding parameter. This presentation builds on and extends these results.
P7	***Title***: Probabilistic line searches using quintic spline models ***Authors***: Manon Kok and Carl Edward Rasmussen ***Abstract***: We consider the problem of optimising a function in cases where we only have access to noisy evaluations of the function values. Optimisation algorithms typically first determine a search direction after which a line search algorithm determines a step length along this search direction. In the case of noisy function evaluations, the performance of standard line search algorithms degrades because the function evaluations no longer directly give information about the increase or decrease of the function itself. To overcome these issues, we build a joint Gaussian process model of the function and its gradient projected along the search direction. We model the function using a quintic spline kernel hich imposes an inherent smoothness in the function as well as in its projected gradient. Contrary to former works, we assume that the variance of the noise on the evaluations is not known and consider it to be a hyperparameter to be estimated. We present preliminary results based on simulations with varying signal to noise ratios. In future work we plan to extend our approach to also consider the case of noisy gradients. Using our current method it is possible to learn a model of the function also for this case. However, additional challenges include determining an appropriate search direction because the evaluated gradient no longer directly provides information about how to choose the next search direction. Standard optimisation methods such as steepest descent, conjugate gradient and Broyden-Fletcher-Goldfarb-Shanno (BFGS) therefore all come with their own specific challenges.
P8	***Title***: Krylov methods for low-rank commuting generalized Sylvester equations ***Authors***: Elias Jarlebring, Giampaolo Mele, Davide Palitta, and Emil Ringh ***Abstract***: Sylvester and Lyapunov equations play a key role for computations in linear systems theory and generalized versions can be formulated for several nonlinear systems. For large-scale problems such computations can be intractable and efficient methods are needed. Here we consider a certain generalized Sylvester equation $AX + XB^T + \sum_{i=1}^m N_i X M_i^T = C_1 C_2^T$. (1) This equation appears naturally for bilinear- and stochastic linear- control systems, as well as for some partial differential equations on rectangular domains. We show low-rank approximability of the solution for a class of problems on the form (1), i.e., for these problems X can be approximated by a matrix of low rank. Furthermore, we propose a new projection method for solving (1), under the additional assumption that the commutator of the matrix coefficients has low rank. Our method is based on the extended Krylov subspace method for Sylvester equations, for which a constructive choice of the starting vector/block is derived from the low-rank commutators. We illustrate the effectiveness of our method by solving large-scale matrix equations.
P9	***Title***: Recursive identification based on weighted null-space fitting ***Authors***: Mengyuan Fang, Miguel Galrinho, Håkan Hjalmarsson ***Abstract***: Algorithms for online system identification consist in updating the estimated model while data are being collected. A standard method for online identification of structured models is the recursive prediction error method (PEM). The problem is that PEM does not have an exact recursive formulation, and the need to rely on approximations makes recursive PEM prone to convergence problems. In this paper, we propose a recursive implementation of weighted null-space fitting (WNSF), an asymptotically efficient method for identification of structured models. Consisting only of (weighted) least-squares steps, the recursive version of the algorithm has the same convergence and statistical properties of the off-line version. We illustrate these properties with a simulation study, where the proposed algorithm always attains the performance of the off-line version, while recursive PEM often fails to converge.
P10	***Title***: Inverse Filtering for hidden Markov models ***Authors***: Robert Mattila, Cristian R. Rojas, Vikram Krishnamurthy, Bo Wahlberg ***Abstract***: We consider three related inverse filtering problems for hidden Markov models (HMMs). Given a sequence of state posteriors and the system dynamics: i) estimate the corresponding sequence of observations, ii) estimate the observation likelihoods, iii) jointly estimate the observation likelihoods and the observation sequence. These problems have potential applications in autonomous sensor calibration and estimation, fault detection, and revealed-preference problems in microeconomics. Firstly, we demonstrate how it is possible to avoid a computationally expensive mixed integer linear program (MILP) by exploiting the inherent structure of the HMM filter. Secondly, we provide conditions for when the quantities can be uniquely recovered. And finally, we consider the case where the posteriors are corrupted by noise. It is shown that this problem can be naturally posed as a clustering problem on the unit sphere. The proposed algorithm is evaluated on real-world polysomnographic data used for automatic sleep tracking.
P11	***Title***: Quantifying human balance control using Gaussian process regression and inertial sensors ***Authors***: Fredrik Olsson and Kjartan Halvorsen. ***Abstract***: Quantification of the underlying mechanisms in human balance control can assist with assessing

	balance performance or design targeted interventions for individuals with balance impairment disorders, but is something that is not provided by commonly used clinical balance tests. The main objective is to identify the neuromuscular feedback mechanism (controller), which allows humans to maintain a stable posture in upright standing. We present a work in progress in which we study the possibility for Gaussian process regression (GPR) to meet this objective. Previous studies have used a variety of methods; from non-parametric identification, describing the frequency response function of the controller, to parametric identification, which assumes a certain model structure for the controller and fits a finite set of parameters to the measured data. The benefits of using GPR is that the model is non-parametric (determined by measured data), so no model structure for the controller has to be assumed. Moreover, it quantifies the uncertainty of the predictions made by the model. The model is trained and validated using simulated inertial sensor measurements and a double inverted pendulum as a biomechanical model of a standing human moving in the sagittal plane. The use of inertial sensors is central to our project, since they are small and cheap and would allow for identification to be done outside the lab. However, practical challenges still exist for out-of-the-lab assessment of balance control to be possible, which will be discussed further in this work.
P12	***Title***: LINEARLY CONSTRAINED GAUSSIAN PROCESSES ***Authors***: Carl Jidling, Niklas Wahlström, Adrian Wills, Thomas B. Schön ***Abstract***: We consider a modification of the covariance function in multivariate Gaussian processes to correctly account for known linear operator constraints. By modeling the target function as a transformation of an underlying function, the constraints are explicitly incorporated in the model such that they are guaranteed to be fulfilled by any sample drawn or prediction made. We also propose a constructive procedure for designing the transformation operator and illustrate the result on both simulated and real-data examples.
P13	***Title***: CANCELLATION OF NONLINEARITIES USING INDIRECT INPUT MEASUREMENTS ***Authors***: Jonas Linder and Martin Enqvist ***Abstract***: The interest for system identification in dynamic networks has increased recently with a wide variety of applications. The power of the dynamic network formulation is that it breaks down and describes complex interconnected systems with a simple representation. By only estimating a model for a part of the network dynamics, the complexity and hence, the need for large amounts of data and sensors, can be decreased. The same idea can also be applied to complex systems that are not a network in the traditional sense, for instance, by considering that the dynamics of each degree of freedom of a mechanical system is a module in a network. This approach might be beneficial if only some properties of the system are desirable to estimate and a limited set of sensors is available. However, unlike the common assumption of linear modules in dynamic network literature, many mechanical systems exhibit some kind of nonlinear behavior. In this contribution, some initial results for cancellation of these nonlinearities using additional measurements, here called indirect input measurements, will be discussed. The resulting model is linear in the inputs and has a larger operational domain than when relying on linearization of the original model.
P14	***Title***: MODELING PARTIAL DIFFERENTIAL EQUATIONS WITH STATE SPACE MODELS ***Authors***: Bob Vergauwen, Oscar Mauricio Agudelo and Bart De Moor ***Abstract***: The relation between one dimensional (1D) state space models and ordinary differential equations is a well-know result in systems theory. In this work we study the relation between partial differential equations and multidimensional (nD) state space models. A couple of nD state space models have been proposed in the past, Givone and Roesser, Roesser, Attasi, Fornasini and Marchesini and Kurek, for which dedicated realization theories exist. These models were all derived in the domain of signals and image processing. Hence they were not intended to model dynamical systems mathematically described by partial differential equations (although some of them have been used for this purpose, e.g., Roesser model). In this work we intend to create multidimensional models to represent physical partial differential equations. At the basis we use the state space model derived in P. Dreesen, “Back to the roots: polynomial system solving using linear algebra,” Ph.D. dissertation, 2013. The link between autonomous partial differential equations and input-output systems is shown. This is done in a constructive way using the language and methodology of partial differential equations and one-dimensional system theory. Based on the properties of the model, a dedicated realization algorithm for the autonomous systems is described. This realization technique is based on the work of P. Van Overschee and B. De Moor, Subspace identification for linear systems: Theory Implementation and Applications. Springer Science & Business Media, 2012. We show that most of the concepts and ideas from one-dimensional systems can be carried over to multidimensional systems.
P15	***Title***: OPTIMAL LPV IDENTIFICATION EXPERIMENT FOR CONTROL ***Authors***: D. Ghosh, X. Bombois, J. Huillery and G. Scorletti ***Abstract***: We consider the problem of optimally designing the identification experiment leading to a model of a Linear Parameter Varying (LPV) system when this model will be used for LPV control. A LPV system is a system whose parameters vary as a function of an external variable, the so-called scheduling variable. When the scheduling variable is kept constant, the LPV system reduces to a Linear Time-Invariant (LTI) system whose dynamics depend on the chosen value for the constant scheduling variable. We consider here the local LPV identification framework. In local LPV identification, a number of local LTI models of the LPV system are identified by performing identification experiments for fixed values of the scheduling variable. These local LTI models are then interpolated in order to yield a LPV model of the LPV system. In this talk, we are looking at ways to optimally choose the values of the scheduling variables at which the local identification experiments have to be performed as well as the excitation signals that have to be applied to the system during these local identification experiments. The objective of this optimal experiment design problem is to obtain, with the least injected power, a sufficiently accurate LPV model for the design of a satisfactory LPV controller.
P16	***Title***: NONPARAMETRIC TIME-VARYING OPERATIONAL MODAL ANALYSIS ***Authors***: Péter Zoltán Csurcsia, Johan Schoukens and Bart Peeters

	Abstract: The project deals with the time variations of (vibrational) mechanical structures described by the nonparametric Operational Modal Analysis (OMA). OMA is a special identification technique for estimating the modal properties (e.g. resonance frequencies, damping) of structures based on vibration data collected when the structures are under real operating conditions without having access to the excitation signals. The main issue is that the dynamics of underlying systems may vary significantly when operating in real-life conditions. In this case, advanced modeling is needed taking into account the time-varying (TV) behavior because the unmodeled time variations might lead to instability and structural failures. It is already shown that (linear) TV systems can be nonparametrically described in the time domain with a two dimensional impulse response function or equivalently with a two dimensional frequency response function (FRF). Similarly to these cases, using the OMA framework, the underlying time-varying systems can be uniquely represented by their scaled 2D FRF. The scaling in this case originates from the fact that the input excitation is not known exactly but it is assumed to be white. The problem lies in the fact that due to unknown input signal, the high number of parameters and the underdetermined system of linear equations, the estimation procedure is not trivial. Using nonparametric modeling, these equations will have very high degrees of freedom. Additional user selected properties, e.g. smoothness, will be imposed to select a unique model. The main challenge is to build accurate models which can track the varying dynamics of these systems, while using as few experiments as possible.
P17	***Title***: SYSTEM IDENTIFICATION FOR ATTITUDE CONTROL OF SATELLITES ***Authors***: C. Nainer, M. Gilson, H. Garnier, C. Pittet ***Abstract***: High fidelity satellite simulators are required for the validation of attitude control algorithms. For these simulators accurate and reliable satellite and orbital environment models are necessary. However, some parameters cannot be easily identified on ground (disturbing torques, satellites inertia, flexible modes characteristics, …) and identification methods must be used during the satellite operation. This poster provides an overview on this topic and invites the workshop attendants for a discussion regarding which identification strategies may improve the estimate of the desired parameters with respect to the current solutions adopted. Starting from the problem definition, the system dynamics are described together with the limitation of the measurements; the main research challenges are highlighted. Finally, the poster ends with a couple of identification strategies that may be viable for the actual problem solution.
P18	***Title***: SYNTHESIS METHODS FOR MATCHING FILTERS ***Authors***: M. Olivi, D. Martinez Martinez, F. Seyfert, S. Bila, F. Torres, J. Sence ***Abstract***: In the fifties and sixties Bode, Fano and Youla pioneered their broad-band matching theory based on the use of the Darlington two port equivalent and extraction procedures. Despite its undeniable elegance this approach did not result in massive practical applications, mainly because of its complexity and the relative rigidity of its induced practical implementations. This approach was therefore progressively replaced by the optimization based "real frequency" technique of Carlin which is more oriented to practical applications. These methods however focuses only on matching requirement of the designed network and do not allow to impose rejection specifications in specified frequency bands. Moreover, like any non-convex optimization approach,they do not guarantee the optimality of the obtained transducer gain function. Based on Youla's matching theory and convex optimization, the guaranteed optimal synthesis technique we propose, yields the best possible matching filter for a given single band antenna. This technique allows to handle the matching and filtering requirements in a single filter, rendering superfluous the use of an extra matching network.
P19	***Title***: RECENT PROGRESS ON KERNEL-BASED REGULARIZATION METHODS: ASYMPTOTIC ANALYSIS AND INPUT DESIGN ***Authors***: Biqiang Mu, Tianshi Chen and Lennart Ljung ***Abstract***: The kernel-based regularization method involves some core issues: kernel design, hyperparameter estimation, and input design. In contrast with the numerous results on kernel design, there are however few results on hyperparameter estimation and input design. In this talk, we report some recent progress on the asymptotic properties of several hyperparameter estimators including the empirical Bayes (EB) estimator, two Stein's unbiased risk estimators (SURE) and the input design issue. For the hyperparameter estimation, we show that as the number of data goes to infinity, the two SUREs converge to the best hyperparameter minimizing the corresponding mean square error, respectively, while the more widely used EB estimator converges to another best hyperparameter minimizing a different function. Surprisingly, the convergence rate of two SUREs is slower than that of the EB estimator. For the input design problem, we first derive the optimization criteria in the Bayesian perspective and then an effective two-step method is proposed to solve the optimization problem, which avoids the drawback of directly solving the non-convex optimization problem and can find all the globally optimal inputs. In particular, the property of the optimal input is also investigated for some special kernels.



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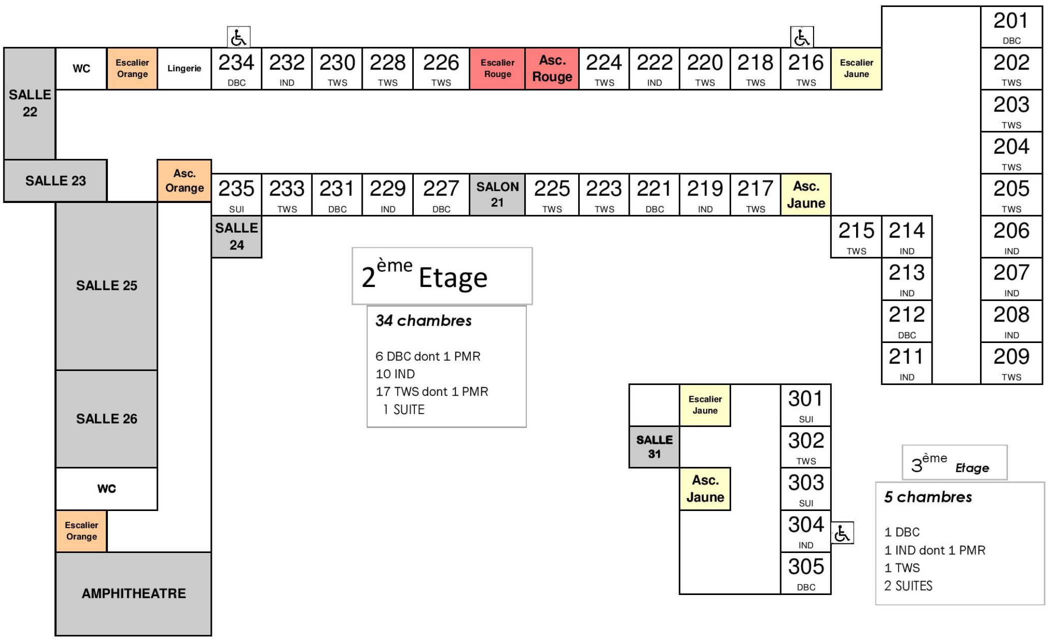

2ème Etage

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3ème *Etage*

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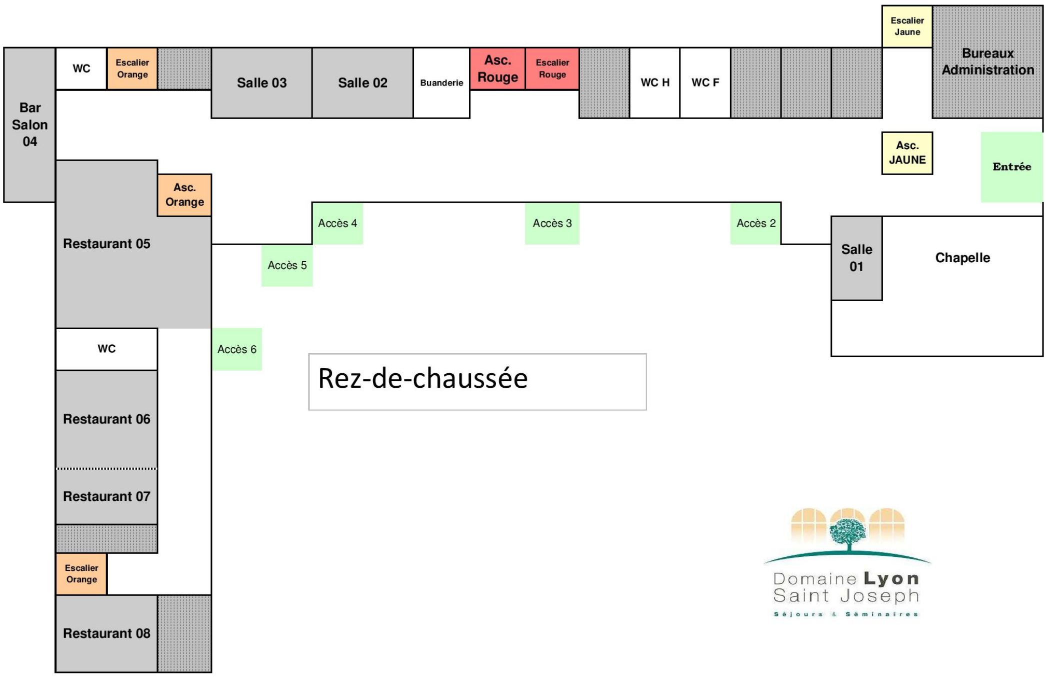

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