2018 ERNSI WORKSHOP

Location: Pembroke College, Cambridge, UK

Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre

Co-Chair: Martin Enqvist

Information for Participants

Dear Participant,

Welcome to the ERNSI Workshop 2018 and to Pembroke College.

The below contains some practical information regarding arrangements during the Workshop.

Meeting Rooms:

All Talks: The Old Library (beside the main entrance to the College).

Poster sessions: The Nihon Room (Staircase AA at the back of the College) – please note that this room is only open at certain times only, please consult the programme for times.

Other areas available for discussion, private work, etc.: Thomas Gray Room (Staircase I, first floor), Outer Parlour (from Monday afternoon onwards, Staircase J, Ground floor), The Junior Parlour/Café Pembroke, Bar area (Staircase N).

Meals: All meals will be in the Hall. In the evening, **dinner** is served at the table. For **breakfast and lunch**, please enter the Buttery (between The Old Library and Staircase E), select what you want, show your conference badge to the person at the checkout and take your meal into the Hall. **You do not** need to pay at the checkout if you have registered for the Workshop. Breakfast is served from 8am.

Coffee/tea breaks: These will be held in the Dining Hall in the mornings and in the Nihon Room in the afternoons with the Poster Sessions.

The Bar: will be open in the evenings after dinner until about 22:00. **Café Pembroke** is open in the middle of the day for snacks and drinks. Both of these are on Staircase N, ground floor.

Team Leaders or their representatives will have a separate lunch on Monday in the Outer Parlour (Staircase J).

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre

Co-Chair: Martin Enqvist

All the rooms referred to above are shown on the plan of the College that is in your Welcome Pack.

Internet access: Wi-Fi at Pembroke is 'Pembroke Guest'. The password is RogerRabbit1983. The *eduroam* service (www.eduroam.org) is available in all the public areas of the College, but not in all bedrooms.

Social Event: For recreation, we have arranged a historical walking tour, mostly of Pembroke College but also some of the sights in Cambridge. Each tour is limited to about 20 people so there will be 4 tours on Monday, 2 at 17:00 – 18:00, and 2 at 18:00 – 19:00. Please sign up for the one you prefer – sign-up sheets will be available in the Old Library on Monday. Those who are not on a tour could try punting if it is warm enough, or there are several museums nearby (please note that these close at either 16:30 or 17:00).

Problems or requests, etc.: Please ask Catherine Munn.

Departure: You are kindly asked to vacate your rooms by 10:00 on the day of departure. Luggage can be left with the Porters and/or in the Old Library – we will have more specific instructions on the day.

A note on dinner in Hall: We will have dinner in Hall at 19:30 each evening. There is a little ritual associated with this. We will have dinner in the main body of the Hall. At the far end there is the 'High Table' at which Fellows of the College, in Academic Dress, and their guests sit. We stand while they come in, and the senior Fellow present says grace – usually very sort. At the end of the meal a gong is sounded, which is the signal for all to stand, while the senior Fellow says another brief grace (*Laus Deo*, to which the response is *Deo gratias*) and the Fellows leave. We can leave either before or after the final grace if we wish. It is polite for us to be in place at the start of the meal, however, so please try to be there a few minutes before 19:30

There is no formality associated with either breakfast or lunch.

We hope you all have a fruitful and enjoyable Workshop.

Jan Maciejowski, Carl Edward Rasmussen & Rodolphe Sepulchre.

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchr

Co-Chair: Martin Engvi

Programme Sunday 23 September

Session	Event
Afternoon	Delegates arrive and collect welcome pack from Porter's Lodge
Evening	7.30pm: Welcome Dinner in the Dining Hall

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre
Co-Chair: Martin Enqvist

Programme Monday 24 September

Session	Time	Event	Speaker	Title
Morning	9am	Plenary Talk	Dr Roderich Gross – University of Sheffield.	Robots, swarms, and Turing Learning.
	10am	Presentation 1	Simone Garatti	Sample size tuning for reliable data driven modelling
	10.30am	Coffee in the Dining Hall		
	11am	Presentation 2	Thomas Schon	Assembling stochastic quasi-Newton algorithms using GPS.
	11.30am	Presentation 3	Kévin Colin	Joint identification and control of MEMS sensors.
12 – 1.30pm: Lunch in Dining Hall				
12 – 1.30pm: Team Leaders Lunch in the Outer Parlour (Staircase J)				
Afternoon	1.30pm	Presentation 4	Atte Alto	Gaussian process dynamical models for system identification: application on gene regulatory network inference.
	2pm	Poster Spotlight: Chaired by Dr Alessandro Ialongo in the Old Library		
	2.30pm	Poster Session in Nihon Room		
	4pm	Presentation 5	Bart de Moor	Least squares optimal identification of LT1 dynamical models is an eigenvalue problem.
	4.30pm	Presentation 6	Thiago Burghi	Identification of excitable neuronal systems.
Evening	5pm	Pembroke Tour – Groups 1 & 2		
	6pm	Pembroke Tour – Groups 3 & 4		
7.30pm: Dinner in Dining Hall				

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre

Co-Chair: Martin Enqvist

Programme Tuesday 25 September

Session	Time	Event	Speaker	Title
Morning	9am	Presentation 1	Diogo Rodrigues	Incremental model identification of reaction systems
	9.30am	Presentation 2	Ben Hanzon	Positivity and zero locations of LTI impulse response functions, generalized Gaussian mixtures and more.
	10am	Presentation 3	Simone Formentin	CoRe: Control-Oriented Regularisation for System Identification
	10.30am	Coffee in the Dining Hall		
	11am	Plenary Talk	Professor Ioannis Kontoyiannis – University of Cambridge.	Variable-dimensional models for discrete time series.
12 – 1.30pm: Lunch in Dining Hall				
Afternoon	1.30pm	Presentation 4	Kim Batselier	Lifting the curse of dimensionality in nonlinear system identification with tensor networks.
	2pm	Poster Spotlight: Chaired by Dr Alessandro Ialongo in the Old Library		
	2.30pm	Poster Session in Nihon Room		
	4pm	Presentation 5	Michel Gevers	A miscellany of results on the identification of dynamical networks.
	4.30pm	Presentation 6	Manfred Deistler	High frequency linear time series models and mixed frequency data
7.30pm: ERNSI Workshop Dinner in Dining Hall				

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre
Co-Chair: Martin Enqvist

Programme Wednesday 26 September

Session	Time	Event	Speaker	Title
Morning	9am	Presentation 1	Mirko Mazzeloni	Advances in manifold regularization for system identification
	9.30am	Presentation 2	Ines Lourenco	Temporal perspectives: Exploring robots' perception of time.
	10am	Presentation 3	Christian Gerhards	Source Estimation and Separation in Geomagnetic Potential Field Problems.
	10.30am	Coffee in the Dining Hall		
	11am	Presentation 4	Manon Kok	Scalable magnetic field SLAM in 3D using Gaussian Processes maps
	11.30am	Presentation 5	Ivan Markovsky	Dynamic measurement: an application of system identification in metrology.
12pm: Lunch in Dining Hall				

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre

Co-Chair: Martin Enqvist

Monday 24 September

Plenary Talk

Author: Dr Roderich Gross

Title: Robots, swarms, and Turing Learning.

Abstract: In this talk, we study the behavior of autonomous agents, with particular emphasis on systems comprising of numerous embodied agents (e.g., swarms of robots). First, we consider the problem of designing behavioral rules for robots of extreme simplicity. We show among others how "computation-free" robots, with only 1 bit or trit of sensory information, can accomplish tasks such as multi-agent rendezvous, cooperative object manipulation and collective choice. Second, we consider the problem of inferring the behavioral rules or morphology of robots. We use Turing Learning – a generalization of Generative Adversarial Networks. In Turing Learning, the discriminators are allowed to "interrogate", similar to their human counterparts in the Turing test. We present two case studies where this active learning approach helps improve model accuracy, and discuss applications to robotics and beyond.

Presentation 1

Authors: Simone Garatti and Mirko Campi

Title: Sample size tuning for reliable data driven modelling.

Abstract: In system identification and machine learning, it is important to avail of methods for a correct sizing of the data set. Indeed, the data set must be informative enough but collecting more data than necessary may be costly and time-consuming. In this work, we focus attention on classification problems based on compression schemes, which include separating hyperplanes and Support Vector Machines (SVM). We present a new theory that links the probability of misclassification to the complexity of the classifier, and introduce a new learning scheme where the size of the data set is iteratively tuned during the training procedure depending on the complexity of the current solution. This new scheme implies a better exploitation of the available resources and allows one to achieve a prescribed level of misclassification probability with a substantial saving of data as compared to standard one-shot learning schemes.

Presentation 2

Authors: Thomas Schon

Title: Assembling stochastic quasi-Newton algorithms using GPs.

Abstract: In this talk I will focus on one of our recent developments where we show how the Gaussian process (GP) can be used to solve stochastic optimization problems. Our main motivation for studying these problems is that they arise when we are estimating unknown parameters in nonlinear state space models using sequential Monte Carlo (SMC). The very nature of this problem is such that we can only access the cost function (in this case the likelihood function) and its derivative via noisy observations, since there are no closed-form expressions available. We start from the fact that many of the existing quasi-Newton algorithms can be formulated as learning algorithms, capable of learning local models of the cost functions. Inspired by this we can start assembling stochastic quasi-Newton-type algorithms, applicable in situations where we only have access to noisy observations of the cost function and its derivatives. We will show how we can make use of the GP model to learn the Hessian allowing for efficient solution of these stochastic optimization problems. Additional motivation for studying the stochastic optimization problem stems from the fact that it arise in almost all large-scale supervised machine learning problems, not least in deep learning. I will very briefly mention some ongoing work where we have removed the GP representation and scale our ideas to high(er) dimensions (both in terms of the size of the dataset and the number of unknown parameters).

Presentation 3

Authors: Kévin Colin, Fabricio Saggin, Federico Morelli, Xavier Bonbois, Laurnet Bako & Anton Korniiekno.

Title: Joint identification and control of MEMS sensors.

Abstract: In mechanical control of moving objects one has to decide which sensors to use. This choice is always based on the trade-off measurement-accuracy/cost. Optical sensors can be used but they are very cumbersome and expensive. A less cumbersome, less expensive but also less accurate way to measure a motion is to use MEMS (Microelectromechanical systems) technologies. There is an active research on this type of sensors to improve their efficiency of measurement by using automatic control techniques. This is the aim of the PSPC lab project NEXT4MEMS. To develop these control techniques, a model of these sensors is needed. In this talk, we present our first results on the data-based modelling of the MEMS gyroscope considered in the NEXT4MEMS project. In the literature, one can find a majority of papers using simple linear grey-box models, based on mechanical equations and on information from experimental data to calibrate unknown parameters. The angular rate of a moving system is then deduced by using these models and control techniques. However, these papers do not take account the parasite effects present in a MEMS gyroscope and which can deteriorate the angular rate measurement. This issue motivates the use of a black-box Prediction-Error (PE) approach to obtain the model of the considered MEMS gyroscope. In this gyroscope, the parasite effects depend directly on the applied input voltage while the main dynamics depend on the square of this input voltage. We develop an identification methodology to separate both contributions based on a multisine excitation. For validation purposes, the identified model has been used to design a control loop for the considered MEMS gyroscope. The control loop is made up of an ??? designed controller based on the identified model of the main dynamics of the gyroscope. In addition, the parasite effects are compensated using their model. We observe a good correspondence between simulation and experimental results and the parasite effect compensation increases the performance. These observations validate our identification methodology.

Presentation 4

Authors: Atte Alto, Lauri Viitasaari, Pauliina Ilmonen & Jorge Goncalves

Title: Guassian process dynamical models for system identification: application on gene regulatory network inference.

Abstract: Gaussian processes are widely used in machine learning where they provide a probabilistic setup for nonlinear regression problems. We bring this data into nonlinear regression problems. We

bring this idea into nonlinear system identification by introducing the continuous-time Gaussian process dynamical model. The dynamics of this system are governed by a nonlinear stochastic differential equation whose dynamics function is modelled as a Gaussian process. The input of the Gaussian process is the system state, and the output is the time derivative of the state. The probabilistic nature of this framework allows the trajectories of this system to be considered as stochastic processes. Their properties are characterized by the chosen covariance function for the Gaussian process and the process noise model The probability measure for the trajectories can be derived, and a Bayesian approach can then be taken to obtain a system model from time series data. Finally, we introduce a MCMC sampling scheme for the system trajectories, based on Crank-Nicolson sampling. The motivation for this work arises from the problem of gene regulatory network inference, where the task is to determine how the abundances of different species effect the dynamics of each other. In the introduced setup, this inference is based on estimating the hyperparameters of the covariance function of the Gaussian process.

Poster Spotlight & Poster Session

Presenters:

Giulia Prando: System Identifiation in neuroscience: whole-brain networks models.

Mohamed Abdelmoaty: Consistent estimators of stochastic MIMO Wiener models based on suboptimal predictors.

Guillaume Mercere: Combining linear algebra and numerical optimization for structured state-space model identification.

Robin de Rozario: A global approach to frequency response function identification of LPV systems: with application to motion-systems.

Georgios Birpoutsoukis: Identification for prediction and alerts.

Adriá Garriga Alonso: Joint variational uncertain input Gaussian processes.

Giuseppe Giordano: A Newton-based method for Maximum Likelihood estimation from incomplete.

Laurent Baratchart: Checking the stability of amplifiers via identification of the Harmonic 'Transfer Function'.

Maarten Schoukens: Identification of nonlinear LFR systems.

Bob Vergauwen: Order estimation of two-dimensional systems.

Tomas van Pottelbergh: Identification of reduced biological neuron models.

Fredrik Ljunberg: Closed-loop identification using instruments simulated from non-linear models.

EMM Kivits: On representations of linear dynamic networks.

Dries Peumans: Exposing resonances using the Bootstrapped Total Least Squares estimator.

Othmane Mazhar: Hankel penalized least squares for linear model estimation problems.

Tom Steentjes: A recursive estimation approach to distributed identification of large-scale multi-input-single-output FIR systems.

Piet Bronders: Enhancing envelope tracking power amplifier understanding using the wonderful properties of LPV.

Axel Ringh: Learning to solve inverse problems using Wasserstein loss.

Manon Kok: Directing PILCO's exploration with epistemic uncertainty.

John Lataire: Identification of a class of nonlinear systems through an LTV approach – Application to an RRR robot.

Koen Tiels: Hamiltonian Monte Carlo to sample from Gaussian mixture models.

Stefano Magni: Inference of the Gene Regulatory Network of human T celss from time-series data by dynamical systems modelling.

Jan Decuyper: Retrieving highly structured models starting from black-box nonlinear state-space models using polynomial decoupling.

Presentation 5

Author: Bart de Moor

Title: Least squares optimal identification of LT1 dynamical models is an eigenvalue problem.

Abstract: The last 50 years, we have witnessed tremendous progress in model-based control design and applications. Both the solution to the steady state LQR problem and the Kalman filter, ultimately reduce to an eigenvalue problem (which is hidden in the matrix Riccati equations involved). The same observation applies to the H-infty framework, with different Riccati equations. Even with other or additional objectives in minds, models are used as constraints in (preferably convex) numerical optimization problems.

But what about the models? What do we know about their optimality? Either they are obtained from first principles (white-box), from a black box point of view (e.g. using machine learning approaches) or from a so-called grey box approach, in which first a parametrization is put forward and next, from data records, one sets up an identification problem to identify numerically the unknown parameters.

But, are these models optimal in any sense? We will show how least squares optimal models for LTI SISO systems, derive from an eigenvalue problem, hence achieving an important landmark on optimal identification for this type of models.

In this talk, we concentrate on LTI SISO models, with at most one observed input and/or output data record, and at most one ‘unobserved’ (typically assumed to be white) noise input (called ‘latency’). In the most general case, also the inputs and outputs are corrupted by additive measurement noise (called ‘misfit’). This class of models covers a lot of special cases, like AR, MA, ARMA, ARMAX, OE (Output-Error), Box-Jenkins, EIV (Errors-in-Variables), dynamic total least squares, and also includes models that up to now have not been described in the literature (such as e.g. ARMA with 'noisy' outputs, but many others as well).

The results we will elaborate on, are the following:

- Firstly, we show that, using Lagrange multipliers, the least squares optimal model parameters, and the estimated latency and noise sequences, constitute a stationary point of the derivatives of the Lagrangean, which is equivalent to a (potentially large) set of multivariate polynomials. One (or some) of these stationary points provide the global minimum.
- We show that all stationary points of such multivariate polynomial optimization problems, correspond to the eigenvalues of a multi-dimensional (possibly singular) autonomous (nD-)shift invariant dynamical system.
- These eigenvalues can be obtained numerically by applying nD-realization theory in the null space calculated from a so-called Macaulay matrix. This matrix is built from the data, is a highly structured, quasi-Toeplitz matrix and in addition sparse. Revealing the number of stationary points that are finite, their structure and the solutions at infinity, requires a series of rank tests (SVDs) and eigenvalue calculations.
- The estimated misfit and latency sequences can be shown to be eigenvectors of an eigenvalue problem. This fact implies a serious reduction in computational complexity: we show how the parameters of the models are the eigenvalues of a multi-valued eigenvalue problem, in which the eigenvectors are the misfit and latency sequences.

- Finally, we show how also this multi-valued eigenvalue problem ultimately reduces to a 'ordinary' eigenvalue problem (i.e. in one variable, which is e.g. the minimal value of the least squares objective function).

Our results also put a lot of identification methods that have been described in the signal processing and identification literature, in a new perspective (think of VARPRO, IQML, 'noisy' realization, PEM (Prediction-Error-Methods), Riemannian SVD, ….): all of them generate (often very good) 'heuristic' algorithms, but what they really aim for is to try to find the minimal eigenvalue of a large matrix.

The algorithms we come up with are guaranteed to find the global minima, using the machinery of eigenvalue solvers and singular value decomposition algorithms, the machinery for which has also undergone a real revolution the last 50 years. We will elaborate a bit on the computational challenges (e.g. the fact that we only need to compute 1 eigenvalue-eigenvector pair of a large matrix, namely the one corresponding to the global optimum).

We will also elaborate on some preliminary system theoretic interpretation of these results (e.g. that misfit and latency error sequences are also highly structured in a system theoretic sense), and on some ideas on how to incorporate a priori information (e.g. power spectra) into these methods.

Presentation 6

Authors: Thiago Burghi & Rodolphe Sepulchre

Title: Identification of excitable neuronal systems.

Abstract: The pioneering work of Hodgkin and Huxley [1] to model the excitability of neurons is grounded in the voltage clamp experiment. In system theoretic terms, the success of the voltage clamp experiment rests on the fact that the *inverse* dynamics of excitable models is simple: it has a fading memory and a steady-state input-output characteristic, properties which generalize the behavior of stable LTI systems. This is in sharp contrast to the *direct* dynamics from applied current to voltage, which exhibits highly nonlinear behavior, including bifurcations and rest-spike bistability. This fundamental difference exists in any conductance-based model, where the inverse system, from voltage to total current, has an architecture reminiscent of a parallel one layer continuous-time artificial neural network. It is amenable to estimation using standard techniques from the field of systems identification.

In this work, we explore those structural properties by developing a procedure for quasi-black box identification of excitable systems which assumes that the inverse dynamics is exponentially contractive [2]. We propose a simple technique based on convex optimization to automatically identify the dynamics of a single compartment neuron model from membrane potential and applied current traces only. As an initial model, we use a large set of simple parallel branches composed of static nonlinearities and linear time-invariant filters, chosen so as to span a large space of dynamic behaviors. We then keep in our model only those few branches which capture the excitable properties of the neuron at the right amplitude and frequency ranges [3]. To illustrate our approach, we estimate the dynamics of conductance-based models from the literature using voltage and applied current data obtained numerically.

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre

Co-Chair: Martin Enqvist

Tuesday 25 September

Presentation 1

Authors: Diogo Rodrigues & Hakan Hjalmarsson.

Abstract: The identification of reaction kinetics represents the main challenge in building models for reaction systems. The identification task can be performed via either simultaneous model identification (SMI) or incremental model identification (IMI).

In SMI, a rate law must be postulated for each reaction, and all parameters are estimated simultaneously. The procedure must be repeated for all combinations of rate candidates. This approach is computationally costly when there are several candidates for each reaction, and the number of parameters is large.

In IMI, the task is decomposed into sub-problems, one for each reaction. Since IMI investigates each reaction individually, only the rate candidates for that reaction need to be compared. In addition, only the parameters of a single reaction rate are estimated simultaneously. In extent-based IMI, the simulated rates are integrated to yield extents, and the simulated extents are fitted to the experimental extents obtained by transformation of measured concentrations. The number of parameters to identify via optimization can be reduced to the ones that appear nonlinearly in the rate law.

The concept of extents will be presented, and we will show how extents can be obtained from concentrations via linear transformation. Then, the decoupling provided by the extents will be applied to IMI of reaction systems, allowing correct model discrimination and accurate parameter estimation.

In particular, an extent-based IMI scheme that guarantees convergence to globally optimal, maximum-likelihood estimates will be presented. The problem is reformulated as a convex problem, namely a semidefinite program, which converges to global optimality. The approach is demonstrated via a simulated example.

ERNSI 2018 WORKSHOP

Location:	Pembroke College, Cambridge, UK
Date:	23 – 26 September 2018
Local Organisers:	Jan Maciejowski Carl Edward Rasmussen Rodolphe Sepulchre
Co-Chair:	Martin Enqvist

Presentation 2

Authors: Ben Hanzon

Title: Positivity and zero locations of LTI impulse response functions, generalized Gaussian mixtures and mores.

Abstract: This talk is based on joint work with Stefano Bonaccoris (Univ. Trento) & Giulia Lombardi (Suedtirol Bank, Bolzano).

In earlier work (B.H. & F. Holland {2010, 2012}; B.H. & O. Mason {2014}), an algorithm was constructed to determine the zero location of LTI-system impulse response functions on any finite interval of the non-negative real half-line. Here we put these findings in a more general framework, which (1) makes it easier to explain why the method works for impulse response functions (aka exponential-polynomial-trigonometric {EPT} functions); (2) allow rather far-reaching generalizations; (3) cover the case of (univariate) generalized finite Gaussian mixtures with signed weights.

The results can be used for various purposes. In the case of EPT functions and generalized finite Gaussian mixtures they can be used to check non-negativity of the function. This is important when we want to use these functions as probability density functions. In the case of generalized finite Gaussian mixtures this will allow (certainly mathematically) much more flexible families than the classical finite Gaussian mixtures with non-negative weights.

The results can also be used to determine (isolate) zeros in the complex pane of the functions treated (cf. BH & O. Mason MTNS2014). In the context of probability theory it also allows one to compute various distance measures (including Wasserstein distance) of probability densities of this type.

In the talk we will present the main ideas behind the algoith, which we call a Generalized Budan-Fourier (GBF) algorithm. The new framework of these results relies on a very useful formula of Polya (1922) and a nice treatment of this in Ristroph (1972).

Presentation 3

Authors: Simone Formentin & Alessandro Chiuso.

Title: CoRe: Control-Oriented Regularisation for System Identification.

Abstract: In this talk, we shall discuss a novel theoretical framework for control-oriented identification, based on a Bayesian perspective on modelling. Specifically, we show that closed-loop specifications can be incorporated within the identification procedure as a prior of the model probability distribution via suitable regularization. The effectiveness of the proposed strategy against state-of-the-art regularized identification is illustrated on a benchmark example for digital control system design.

Plenary Talk

Author: Professor Ioannis Kontiyiannis

Title: Variable-dimensional models for discrete time series.

Abstract: One of the main obstacles in the development of effective algorithms for inference and learning from discrete time series date, is the difficulty encountered in the identification of useful temporal structure in the data. We will discuss a class of novel methodological tools for effective Bayesian inference and model selection for general discrete time series, which offer promising results on both small and big data. Our starting point is the development of a rich class of Bayesian hierarchical models for variable-memory Markov chains. The particular prior structure we adopt makes it possible to design effective, linear-time algorithms that can compute most of the important features of the resulting posterior and predictive distributions without resorting to MCMC. We have applied the resulting tools to numerous application-specific tasks, including on-line prediction, segmentation, classification, anomaly detection, entropy estimation, and causality testing, on data sets from different areas of application, including data compression, neuroscience, finance, genetics, and animal communication. Results on both simulated and real data will be presented.

Presentation 4

Author: Kim Batseliar

Title: Lifting the curse of dimensionality in nonlinear system identification with tensor networks.

Abstract: In this talk, a brief overview will be given on how tensor networks can be used to lift the curse of dimensionality in nonlinear system identification. In particular, the case of multiple-input-multiple-output Volterra systems will be discussed. It will be shown how using tensor networks reduces the number of model parameters from an exponential dependence on the degree of the polynomial to a linear one. Next, a system identification algorithm will be presented that exploits the tensor network representation of the nonlinear model.

Poster Spotlight & Poster Session

Presenters:

Daniele Alpago: A scalable strategy for the identification of latent-variable graphical models.

Mina Ferizbegovic: Weighted null-space fitting of cascade networks with arbitrary location of sensors and excitation.

Federico Morelli: Optimal experiment design for the identification of one module in the interconnection of locally controlled systems.

Lennart Blanken: Kernel-based regression of non-causal systems of inverse model feedforward estimation.

Ivan Markovsky: Identification of autonomous Wiener systems.

Alessandro Ialongo: Entropy preserving transformations for variational inference in state-space-models.

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre

Co-Chair: Martin Enqvist

Rodrigo Gonzalez Vidal: An asymptotically optimal indirect approach to continuous-time system identification.

David Martinez: Matching filters using convex relaxation and Nevanlinna-Pink interpolation.

Dhruv Khandlwal: Grammar based representation and identification of nonlinear dynamical systems.

Christof Vermeesch: Globally optimal ARMA identification is an eigenvalue problem.

Isabel Haasler: Using optimal mass transport for direction of arrival estimation.

Robert Mattila Riquelme: A multiple-lag method of moments for hidden Markov estimation.

Karthik Raghaven Ramaswamy: Local module identification in dynamic networks using regularized kernel-based methods.

Olivier Lauwers: Cepstral system identification.

Axel RIngh: Lower bounds on the maximum delay margin by analytic interpolation.

Shengling Shi: Topology identification of dynamic networks.

John Lataire: Time-variant frequency response function measurement in the presence of missing data.

Emil Ringh: Residual-based iterations and Rational Krylov for generalized Lyapunov equations.

Zuogong Yue: An MCMC approach to simultaneous element and group sparsity.

Matias Muller: Gain estimation under bandit feedback.

Mingliang Wang: A mutli-linear Gaussian process for model selection of nonlinear kinetics in bio-reactions.

Laurent Mombaerts: Circadian Gene Regulatory Network Inference (GRN) and characterization by Linear Time Invariant (LTI) Systems identification and non-parametric noise models.

Presentation 5

Authors: Julien Hendrickx, Michel Gevers (presenting) & Alex Bazanella.

Title: A miscellany of results on the identification of dynamical networks.

Abstract: This talk will focus on dynamical networks in which the nodes are connected to one another by scalar, linear, causal transfer functions, and are also subject to possible external excitation by either measured signals or unmeasured noises. The recent work on the identification of such networks has been mainly concerned with identifiability and experiment design questions. In this talk we will present recent solutions to two such questions. The first are necessary and sufficient path-based conditions for the identifiability of the whole network, or a part of the network, when the network topology is known and when either all nodes are excited or all nodes are measured. The second is a solution to the problem or identifying a single embedded module within the network, that is based on local information about the topology of the network; the solution tells us which nodes to measure, which nodes to excite and hot to compute the unknown transfer function from these measured and excited nodes.

Presentation 6

Authors: Manfred Deistler, BDO Anderson & A Braumann.

Title: High frequency linear time series models and mixed frequency data.

ERNSI 2018 WORKSHOP

Location: Pembroke College, Cambridge, UK
Date: 23 – 26 September 2018

Local Organisers: Jan Maciejowski
Carl Edward Rasmussen
Rodolphe Sepulchre

Co-Chair: Martin Enqvist

Wednesday 26 September

Presentation 1

Authors: Mirk Mazzoleni, Matteo Scandella, Simone Formentin & Fabio Prevedi

Title: Advances in manifold regularization for system identification.

Abstract: This work introduces the application of the concept of manifold regularization for learning nonlinear dynamical systems. The approach, based on nonparametric kernel methods, draws inspiration from the semi-supervised learning literature. A graph is employed to approximate the manifold where regressors lie. The introduced regularization term, as opposite to the standard Tikhonov one, enforces local smoothness of the function along the manifold, by penalizing variations of the output between connected components of the graph. The hyperparameters of the method, along with the order of the system, are estimated from the available data. Numerical results on benchmark dynamical systems show how the proposed approach can perform better than the nonparametric methods proposed in the literature.

Presentation 2

Author: Ines Lourenco

Title: Temporal perspectives: Exploring robots' perception of time.

Abstract: Time perception is a concept used to represent the phenomenological experience of time by an individual, present in every activity of our daily lives. Amongst other variables, sensory information has been proven to have an impact in the way we perceive the passage of time. Artificial agents, however, perform their actions based on functions that assume a linear metric of time given by a clock, and lack a variable sense of time that is so prevalent in animals.

This work aims at studying whether an artificial agent can estimate time, through the second-order statistics of the natural environment, assuming these behave like gaussian processes with an Ornstein-Uhlenbeck covariance function. Multiple experiments were conducted to check which characteristics of sensory information could be used in order to get the most realistic possible approach to these kinds of processes, but, by using a numerical approach, a lack of similarity in their statistics was found. Other covariance functions should therefore be studied in order to find one that more accurately represents the statistics of the natural environment, collected by the agent's sensors.

If successfully obtained, the resulting time estimate could be used as a time basis for the robotic tasks. This means that the artificial agent would no longer be dependent on a clock, and could instead use that estimate to perform its functions.

Presentation 3

Author: Christian Gerhards

Title: Source estimation and separation in geomagnetic potential field problems.

Abstract: Similar to other geophysical modalities, the use of potential field data for the study of subsurface structures often suffers from severe non-uniqueness and instability. We give an overview on various inverse problems in that directions, e.g., the reconstruction of magnetization, susceptibility, density, of the identification of oceanic and crustal signals in magnetic and gravity field data. Geomagnetic problems are governed by Maxwell's equations, but in many situations, they can be reformulated as integral equations on the sphere with harmonic convolution kernels. Therefore, tools for the study of uniqueness and stability typically stem from functional and harmonic analysis. We try to present a general framework for some of these problems, but a particular focus is given to the reconstruction of magnetization and the identification of the crustal magnetic signal. For the problem of identifying the crustal magnetic signal, we approximate each Fourier coefficient separately rather than approximating the signal as a whole. This leads to a procedure similar to the method of approximate inverse. Numerical approaches are discussed and some examples are presented.

Presentation 4

Authors: Manon Kok & Arno Solin.

Title: Scalable magnetic field SLAM in 3D using Gaussian Processes maps.

Abstract: Based on our recent work, we present a method for scalable and fully 3D magnetic field simultaneous localization and mapping (SLAM) using local anomalies in the magnetic field as a source of position information. These anomalies are due to the presence of ferromagnetic material in the structure of buildings and in objects such as furniture. We represent the magnetic field map using a Gaussian process model and take well-known physical properties of the magnetic field into account. We build local maps using three-dimensional hexagonal block tiling. To make our approach computationally tractable we use reduced-rank Gaussian process regression in combination with a Rao-Blackwellised particle filter. We show that it is possible to obtain accurate position and orientation estimates using measurements from a smartphone, and that our approach provides a scalable magnetic field SLAM algorithm in terms of both computational complexity and map storage.

Presentation 5

Authors: Ivan Markovsky

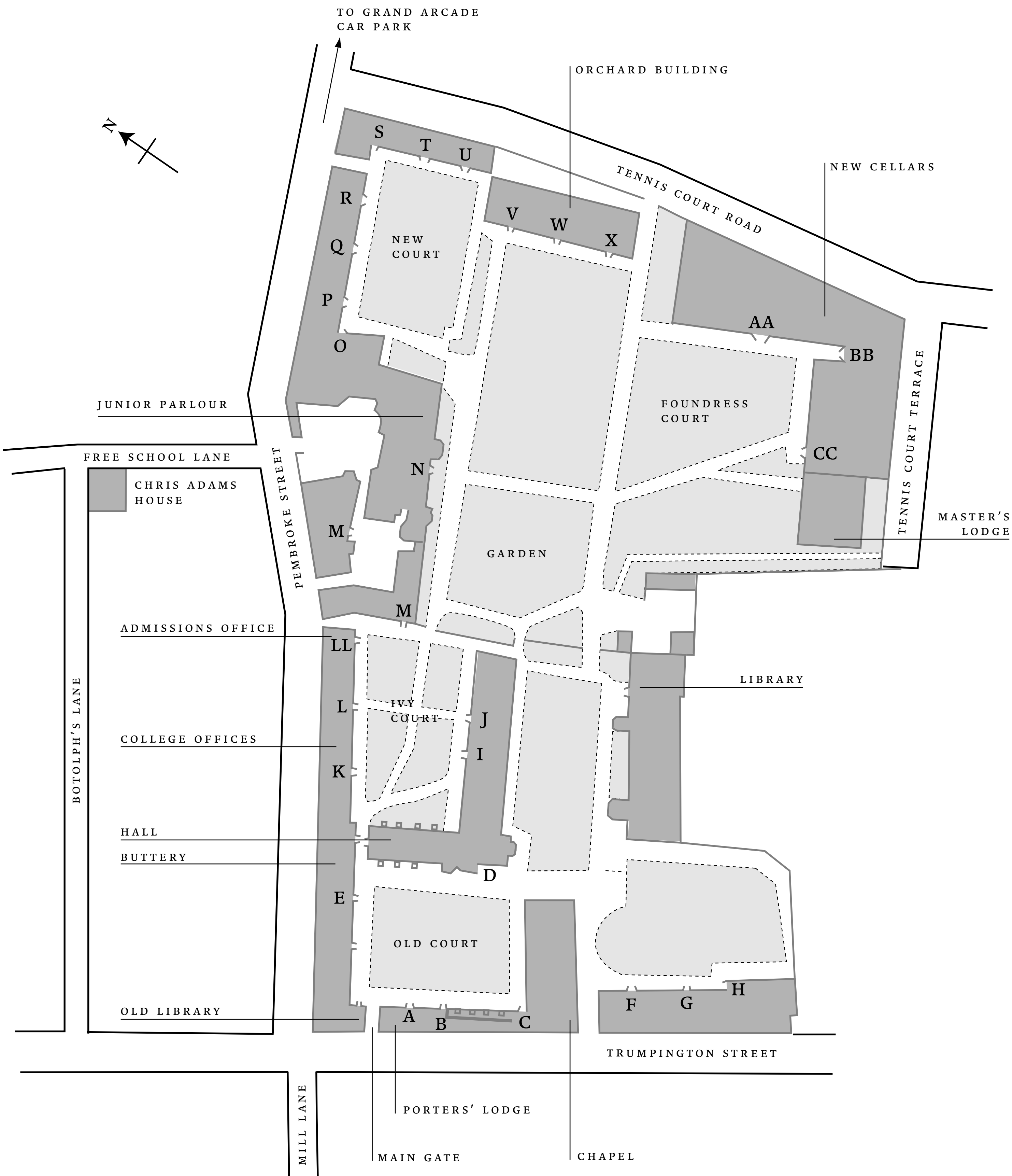
Title: Dynamic measurement: an application of system identification in metrology.

Abstract: On a suitable time-scale, all measurement devices exhibit a transient response. Assuming that the measured value is a constant, of interest in metrology is the steady-state value of the response. The transient is a (deterministic) disturbance that has to be taken into account along with the measurement noises and other (stochastic) disturbances. This motivates the development of methods for estimation of the steady-state value from transient response data.

In practice, the measurement process dynamics is often unknown, however it can be assumed to be a finite-dimensional linear time-invariant. Also, the dimensional noise can often be assumed to be a zero mean, white, Gaussian stochastic process. The task then is to develop a maximum likelihood estimator for the steady-state value under the assumptions of finite-dimensional linear time-invariant dynamics and the zero mean, white, Gaussian measurement noise.

We show that the maximum likelihood estimation problem for the steady-state value is equivalent to a generalized Hankel structured low-rank approximation problem. We don't model the unknown measurement process dynamics and derive the optimal estimator from the identified model (model-based approach). Instead, we estimate directly the parameter of interest from the measured data, avoiding the parameter estimation for the measurement process model (model-free approach).

Pembroke College
CAMBRIDGE



october 2008