IAP VI/4 DYSCO
Dynamical systems
control and optimization
Study Day

28–29 October 2010
Château-Ferme de Profondval
Time Schedule

Thursday 28 October 2010

09:30 Registration and Welcome Desk

10:15 Plenary lecture 1
   Stochastic Reconstructibility and Optimal Control
   Prof Robert Bitmead, University of California, San Diego

11:00 Coffee break

11:15 Plenary lecture 2
   Control Challenges in a Couple of Large Scale Applications
   Prof Keith Glover, University of Cambridge

12:00 Address by Prof Bruno Delvaux, Rector of UCL

12:15 Lunch

13:45 Poster session I

15:00 Plenary lecture 3
   Sum-of-Norm Regularization in Estimation Problems
   Prof Lennart Ljung, Linköping University

15:45 Coffee break

16:00 Celebratory talks
   Profs Manfred Deistler (Vienna University of Technology), Håkan Hjalmarsson (KTH Stockholm), Rodolphe Sepulchre (University of Liège)

17:00 End
Friday 29 October 2010

09:30 Registration and Welcome Desk

10:15 Plenary lecture 1

A Fast Algorithm for Approximating the Pseudospectral Abscissa and Pseudospectral Radius of a Matrix
Prof Michael Overton, New York University

11:00 Poster session II and coffee break

12:30 Lunch

14:00 Plenary lecture 2

A Schur-Padé Algorithm for Fractional Powers of a Matrix
Prof Nick Higham, University of Manchester

14:45 Celebratory talks

Profs Patrick Dewilde (TU Munich), Bart De Moor (K.U.Leuven), Dan Sorensen (Rice University)

16:05 Coffee

16:30 End
Practical Information

Château-Ferme de Profondval
Chemin de Profondval
1490 Court-Saint-Etienne
Plenary Lectures

Stochastic Reconstructibility and Optimal Control

Robert Bitmead, University of California, San Diego

Abstract

Observability and reconstructibility require careful definitions for stochastic systems, and more so for nonlinear stochastic systems. Some candidate definitions will be presented and discussed and then interpreted in terms of their importance for optimal control using output feedback. The example will be concerned with the reconstructibility of a hidden Markov model describing internet traffic control and reconstructibility will be shown to be necessary in order to benefit from the output measurements.

Michel Gevers has devoted considerable talents and efforts to the study of coupled identification and control. Observability and identifiability are synonymous (or at least congruent) for parameter estimation. Accordingly, the results to be presented should connect with his works in optimal control based on identified models.

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Control Challenges in a Couple of Large Scale Applications

Keith Glover, University of Cambridge, Department of Engineering

Abstract

Two control application areas will be described and discussed. Firstly automotive engine management systems have to meet very stringent performance, emissions and efficiency specifications over an extremely wide operating range. Secondly wellbore drilling in the oil and gas industry has to perform in extraordinarily harsh, varied and often sensitive environments. Our group has been engaged in these areas and the control issues will be outlined and their intersection with currently available theories and design methodologies discussed.

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Sum-of-Norm Regularization in Estimation Problems

Lennart Ljung, Linköping University

Abstract

Regularization has long been used in estimation problem to curb the flexibility of models, and to provide reliable and numerically sound estimates. During the past 15 years the power of l-1 regularization has been especially appreciated, mainly due to the introduction of efficient convex programming techniques. l-1 regularization favors solutions which have many elements exactly equal to zero, and has been very successful in, for example, regressor selection (LASSO) and compressed sensing. This presentation shows how the related sum-of-norm regularization works well for some system identification and estimation-related problems compared to conventional techniques. We apply it to segmentation of ARX-models, identification of hybrid piecewise affine models, to state smoothing with abrupt disturbances and to path generation.

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Fast Algorithms for the Approximation of the Pseudospectral Abscissa and Pseudospectral Radius of a Matrix

Nicola Guglielmi (University of L’Aquila) and Michael L. Overton (Courant Institute, NYU)

Abstract

The $\epsilon$-pseudospectral abscissa and radius of an $n \times n$ matrix are respectively the maximal real part and the maximal modulus of points in its $\epsilon$-pseudospectrum, defined using the spectral norm. Existing techniques compute these quantities accurately but the cost is multiple singular value decompositions and eigenvalue decompositions of order $n$, making them impractical when $n$ is large. We present new algorithms based on computing only the spectral abscissa or radius of a sequence of matrices, generating a sequence of lower bounds for the pseudospectral abscissa or radius. We characterize fixed points of the iterations, and we discuss conditions under which the sequence of lower bounds converges to local maximizers of the real part or modulus over the pseudospectrum, proving a locally linear rate of convergence for $\epsilon$ sufficiently small. The convergence results depend on a perturbation theorem for the normalized eigenprojection of a matrix as well as a characterization of the group inverse (reduced resolvent) of a singular rank-one perturbation of a matrix, both of which seem to be new. The total cost of the algorithms is typically only a constant times the cost of computing the spectral abscissa or radius, where the value of this constant increases with $\epsilon$, and may be between 2 and 10 in many practical cases of interest.

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A Schur–Padé Algorithm for Fractional Powers of a Matrix

Nicholas J. Higham, School of Mathematics, The University of Manchester, Manchester, M13 9PL, UK (higham@ma.man.ac.uk, http://www.ma.man.ac.uk/~higham).
Joint work with Lijing Lin.

Abstract

A new algorithm is developed for computing arbitrary real powers $A^p$ of a matrix $A \in \mathbb{C}^{n \times n}$. The algorithm starts with a Schur decomposition, takes $k$ square roots of the triangular factor $T$, evaluates an $[m/m]$ Padé approximant of $(1 - x)^p$ at $I - T^{1/2k}$, and squares the result $k$ times. The parameters $k$ and $m$ are chosen to minimize the cost subject to achieving double precision accuracy in the evaluation of the Padé approximant, making use of a result that bounds the error in the matrix Padé approximant by the error in the scalar Padé approximant with argument the norm of the matrix. This enables algorithmic parameters to be pre-computed that ensure a result fully accurate to double precision. The Padé approximant is evaluated from the continued fraction representation in bottom-up fashion, which is shown to be numerically stable. In the squaring phase the diagonal and first superdiagonal are computed from explicit formulae for $T^{p/2}$, yielding increased accuracy. Since the basic algorithm is designed for $p \in (-1, 1)$, a criterion for reducing an arbitrary real $p$ to this range is developed, making use of bounds for the condition number of the $A^p$ problem. How best to compute $A^k$ for a negative integer $k$ is also investigated. In numerical experiments the new algorithm is found to be superior in accuracy and stability to several alternatives, including the straightforward use of an eigendecomposition.

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Poster Session I

Active Noise Control in Hearing Aids

Romain Serizel, Marc Moonen, Katholieke Universiteit Leuven, ESAT-SCD/SISTA (KUL1)

Abstract

The usage of hearing aids with an open fitting has become more common over the past years mainly owing to the availability of more efficient feedback control schemes and fast signal processing units. Whereas removing the earmold reduces the occlusion effect and improves the physical comfort, one major drawback is that the noise leakage through the fitting cannot be neglected anymore. Conventional Noise Reduction (NR) systems do not take this contribution into account. Combined with the attenuation in the acoustic path between the loudspeaker and the tympanic membrane (the so-called secondary path), the noise leaking through the fitting can override the action of the processing done in the hearing aid. One efficient way to cancel this undesired noise leakage is to use Active Noise Control (ANC). The principle of ANC is to generate a zone of quiet, in this case at the tympanic membrane, cancelling the effect of noise leakage. In the hearing-aid framework, ANC then has to be performed together with a NR algorithm. This presentation introduces a scheme integrating ANC and NR in a single set of filters. Its performance are analyzed and different evolutions of the primary scheme are presented.

Convex Multilinear Estimation with Tensors

Marco Signoretto, Johan Suykens, Katholieke Universiteit Leuven, ESAT-SCD/SISTA (KUL1)

Abstract

Tensors are a powerful way to represent and analyze the most diverse type of data with applications in image and video recognition, EEG and fMRI, text analysis and recommendation systems, to name a few. In this presentation we touch four points:

A) What are tensors? Why are they useful?

B) Tensor based techniques are mostly based on generalization of the singular value decomposition. In this work we take a different perspective and rely on convex optimization. We study a broad class of non-smooth convex optimization problems for tensors. A penalty based on nuclear norms is used to enforce solutions with small (multilinear)
ranks. A simple yet effective algorithm, termed Convex MultiLinear Estimation (CMLE), is proposed.

C) We show how this algorithm can be specialized to accomplish different data-driven modeling tasks. Extending the existing taxonomy of learning to the case where input (and possibly output) patterns are represented as tensors, we can called these problems unsupervised or supervised. This generalization is instrumental to deal with important aspects - often overlooked in the tensor literature - such as the choice of loss functions, model selection, regularization and out-of-sample extensions.

D) We present concrete examples ranging from image completion to low rank denoising and classification.

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Segmenting time series from nonlinear dynamical models using sum-of-norms regularization

Tillmann Falck, Henrik Ohlsson, Johan Suykens, Lennart Ljung, Bart De Moor, Katholieke Universiteit Leuven, ESAT/SCD (SISTA) (KUL1)

Abstract

Segmentation of time series data is of interest in many applications like for example fault detection. In the area of convex optimization the sum-of-norms formulation has been successfully used for trend estimation [Kim et al., 2009] and segmentation of ARX models [Ohlsson et al., 2010]. We extend these formulations to handle nonlinear dynamics by integrating the sum-of-norms regularization with a least squares support vector machine (LS-SVM) core model.

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A product developer’s approach to KitePower

Reinhart Paelinck, Moritz Diehl, Katholieke Universiteit Leuven, ESAT/SCD (SISTA) (KUL1)

Abstract

(Airborne) Wind Energy tends to be mainly driven by technological innovations and engineering. One of the qualities of a product developer is the ability to implement all relevant technological, economical as well as customer-driven specifications into the (early stages of the) design process. This integral approach to solving the problem generally leads to a shorter development process and a higher succes-rate of the final product. This methodology has been applied in the master thesis project “KitePower”, and will be applied in the PhD thesis “Optimization based design of high altitude wind power generators”. This PhD thesis will generate optimal designs and configurations for the launching and landing systems and wing constructions in a kitepower-plant. A part of this research will focus on the development of the so-called “Balanced Kite”-method.
A toolkit for multi-objective optimal control in bioprocess engineering

F. Logist, B. Houska, M. Diehl, J.F. Van Impe (KUL1)

Abstract

Many practical (bio)chemical engineering problems involve the determination of optimal trajectories given multiple and conflicting objectives. These conflicting objectives typically give rise to a set of Pareto optimal solutions. To enhance real-time decision making efficient approaches are required for determining the Pareto set in a fast and accurate way. Hereto, the current paper integrates efficient multiple objective scalarisation strategies (e.g., Normal Boundary Intersection and Normalised Normal Constraint) with fast deterministic simultaneous approaches for dynamic optimisation (e.g., Multiple Shooting). All techniques have been implemented as an add-on to the freely available automatic control and dynamic optimisation toolkit ACADO (www.acadotoolkit.org).

Estimation of inactivation model parameters using a Bayesian approach

P. Busschaert, E. Velliou, E. Van Derlinden, M. Uyttendaele, A. Geeraerd, J. Van Impe (KUL1)

Abstract

Introduction. In this research, a Bayesian model is applied to determine parameters of an inactivation model for E. coli in the presence of molecular chaperones. This approach allows to obtain specific distributions representing uncertainty about the estimated values for these parameters, which can be used subsequently in quantitative risk assessment.

Methods. A data set containing measurements of E. coli in function of time for two different temperatures, i.e., 54°C and 58°C and 4 different concentrations of the molecular chaperone trimethylamine-N-oxide (TMAO), i.e., 0M (control), 0.5M, 1M and 2M, is used to determine model parameters of the Geeraerd et al. (2000) inactivation model. The Bayesian model is solved with Markov Chain Monte Carlo (MCMC); 3000 iterations are run after discarding 500 values as burn-in. The simulation is performed in JAGS, and R is used for pre- and processing of data and outcomes.

Results. Distributions are obtained representing uncertainty for each parameter and condition. The majority of conditions results in good estimates with small uncertainty; for some conditions, uncertainty of the shoulder parameter appears to be very large, which can be explained by the absence of a clear shoulder transition in the original data.

Conclusions. Obtained results are comparable with confidence intervals obtained by the inverse Fisher information matrix, when it is assumed that parameters are distributed
as a Student-t distribution. Applying a Bayesian model to determine parameter values has as a main advantage that a full distribution for uncertainty is obtained for each estimated variable, as a consequence of the limited availability of measurements. This helps determining if collecting additional measurements would be beneficial or redundant, and if different conditions imply significant differences between variables such as shoulder length or inactivation rate. Furthermore, especially in the context of microbiological risk assessment, it is of major importance to characterize uncertainty as adequately as possible. The Bayesian model can easily be extended to include variability such as between strains or other covariates, which offers a way for complete separate characterization of variability and uncertainty in a two-dimensional QMRA.

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Modeling and identification of distillation columns using optimized excitations

Diana Ugryumova and Gerd Vandersteen (VUB)

Abstract

The aim of this research is to enhance the performance of a distillation column through a better modeling and control strategy. This is done by optimizing the different accessible inputs of the column and by improving the system identification techniques used. A distillation column is, as such, a highly non-linear Multiple-Input Multiple-Output (MIMO) system that suffers from drift, due to changes of e.g. the environment temperature, and long transient effects, due to huge time constants in the column. In addition, specific constraints on the excitations and operation of the distillation column have to be taken into account. This implies that practical identification techniques should be robust to non-linearities and drift, overriding the applied excitation (for safety reasons) and possible missing data. The starting point is to use (orthogonal) multisine excitations for MIMO systems. These excitations make it possible to remove transients and to separate the additive (measurement) noise from the non-linearities. Using these excitations, the so-called Local Polynomial (LP) method is used to determine a non-parametric model for the linear behavior and the additive noise covariance matrix. This method also enables the identification of the so-called Best Linear Approximation (BLA) of the distillation column. The non-parametric model is then used to extract a rational model in the Laplace-domain with a delay term. This model can be used for the design of a model predictive controller (MPC) for the distillation column. Measurements from a pilot binary distillation column at KUL-BioTeC are available and will be used to verify the results. In a later stage of the research, all the mentioned identification techniques will be extended to enable the modeling and control of periodically forced distillation columns.

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Parametric identification of parallel Hammerstein and parallel Wiener systems

Maarten Schoukens, Yves Rolain (VUB)

Abstract

This poster proposes a parametric identification method for parallel Hammerstein and parallel Wiener systems. In this modelling approach, the static nonlinearities are represented by a linear combination of basis functions, and the linear dynamic systems by a parametric rational function in the z-domain. A three-step identification procedure is used to obtain a set of starting values for the parameters. In the first step, the FRF of the best linear approximation is estimated for different input excitation levels. In the second step, the varying dynamics are decomposed over a number of parallel branches using a singular value decomposition (SVD) of the combined dynamic behaviour. In the last step, the static nonlinearities are estimated using a linear least squares estimation. In the case of parallel Hammerstein systems, this results in one nonlinear function for each branch of the model. For parallel Wiener systems, one nonlinear function with multiple inputs and a single output is obtained. Furthermore, an iterative identification scheme is introduced to further reduce the model errors. This iterative scheme alternately estimates updated parameters for the linear dynamic systems and the static nonlinearities that are present in the parallel Hammerstein and parallel Wiener systems starting from the initial three-step estimates. The iterative method is fully implemented for the parallel Hammerstein systems, but is still work in progress for the case of parallel Wiener systems. The method is illustrated on a series of simulations and experiments, both for the parallel Hammerstein and parallel Wiener case.

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Nonparametric modelling of a linear time varying system

Widanage W. D., Lataire J. and Schoukens J. (VUB)

Abstract

Consider a time-varying system that is a sum of two parallel branches, one being a linear time invariant (LTI) branch and the other an LTI followed by a time-varying gain. A method is presented that shows how such a system can be modelled nonparametrically. It estimates the frequency response functions when excited by an arbitrary input signal. The kernel idea is the observation that the frequency response of a linear system and the transient error that arise when using arbitrary signals to model the input-output behaviour are smooth functions of frequency. By a polynomial approximation of these functions and considering the time varying effect, a model that is linear in the parameters is obtained. The method is evaluated on a simulated system showing the level of the modelling error, along with the estimated frequency responses, their variances and the variance of any disturbing noise at the output.
Real-time synchronization feedbacks for single-atom frequency standards: V- and Lambda-structure systems

Alain Sarlette (ULg)

Abstract

This paper proposes simple feedback loops, inspired from extremum-seeking, that use the photon emission times of a single quantum system following quantum Monte-Carlo trajectories in order to lock in real time a probe frequency to the system’s transition frequency. Two specific settings are addressed: a 3-level system coupling one ground to two excited states (one highly unstable and one metastable) and a 3-level system coupling one excited to two ground states (both metastable). Analytical proofs and simulations show the accurate and robust convergence of probe frequency to system transition frequency in the two cases.

Observer-based Control of Nonlinear Bilateral Teleoperators

Ioannis Sarras*, Emmanuel Nuño**, Michel Kinnaert*, Luis Basanez**

* SAAS, ULB
** Institute of Industrial and Control Engineering, Technical University of Catalonia

Abstract

This work considers the problem of designing an observer for a bilateral teleoperation scheme with no time-delays in order to estimate the unmeasured velocities. Moreover, it is proved that the interconnection of the recently proposed Immersion and Invariance (I&I) observer with the nonlinear bilateral teleoperator and a PD-like controller is globally stable. Furthermore, in the case where there is no interaction with the human and the environment global asymptotic convergence of the velocities and of the position tracking error to zero is achieved.
Automatic K-complexes Detection in Sleep EEG Recordings using Likelihood Thresholds

Stéphanie Devuyst, Thierry Dutoit, Patricia Stenuit and Myriam Kerkhofs (UMONS)

Abstract

In this poster, we present an automatic method for K-complexes detection based on features extraction and the use of fuzzy thresholds. The validity of our process was examined on the basis of two visual K-complexes scorings performed on 5 excerpts of 30 minutes. Results were investigated through all different sleep stages. The algorithm provides global true positive rates of 61.72% and 60.94%, respectively with scorer 1 and scorer 2. The false positive proportions (compared to the total number of visually scored K complexes) are of 19.62% and 181.25%, while the false positive rates estimated on a one second resolution are only of 0.53% and 1.53%. These results suggest that our approach is completely suitable since its performances are similar to those of the human scorers.

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ECLIPSE, a research program devoted to voice pathology assessment

Thomas Dubuisson, Thierry Dutoit, Bernard Gosselin (UMONS)

Abstract

ECLIPSE is a research program funded by Wallonia and conducted by the Circuit Theory and Signal Processing Laboratory (UMONS). It gathers laboratories from Université Libre de Bruxelles (ULB) and Université Catholique de Louvain (UCL). The goal of this project is twofold: developing algorithms to process voice signals and images of the vocal folds in order to detect voice disorders; developing a clinical station and a portable device in order to provide help to the clinicians in their everyday work. This poster presents the main results obtained in the development of the algorithms, the clinical station and the portable device. Demonstrations will also be provided to the audience.

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Predicting the effect of mutations on the thermal stability of proteins with statistical potentials and artificial neural networks

Benjamin Folch, Marianne Rooman and Yves Dehouck (ULB)

Abstract

We present a new method to predict changes in melting temperature induced by mutations in proteins. It relies on a set of statistical potentials and a neural network, and outperforms predictions based on estimations of the thermodynamic stability.

MOTIVATION: Proteins are exploited in applications such as the design of therapeutic agents, or in the agro-food or biotechnology sector. To improve yield or specificity, it is interesting to tune their properties via amino acid substitutions. In particular, maintaining its activity in unusual temperature conditions is often crucial. Although several methods have been designed to predict changes in thermodynamic stability at room temperature upon mutation (DDG), there is still a stringent need for predictive models that focus specifically on the effect of mutations on the thermal resistance of proteins.

MATERIALS AND METHODS: Our method relies on a set of statistical potentials, extracted protein structures, describing the couplings between four protein descriptors (sequence, distance, torsion angles and solvent accessibility). Terms accounting for volume variations upon mutation are also considered. The change in melting temperature is expressed as a linear combination of these potentials, whose weights are functions of the solvent accessibility of the mutated residue, identified with the help of a neural network. The network is trained and validated on a dataset on 1601 experimentally characterized mutations.

RESULTS: We used a 5-fold validation procedure to assess the performances of our model. The correlation coefficient (R) between computed and measured changes in melting temperature (DTm) is 0.73, for 90% of the mutations. In contrast, when DDG predictions are used to estimate DTm values, the performances drop significantly (R=0.67). Interesting differences are observed between DTm and DDG predictors. In particular, to predict thermal stability changes, local interactions are more important in the core than on the surface, although the opposite trend is observed for DDG predictions.

DISCUSSION: We showed that accurate predictions of thermal stability changes (DTm) upon mutation can only be achieved through predictive models specifically focused on thermal stability. Indeed, even though thermodynamic stability changes (DDG) are related to thermal stability changes, DDG predictions only allow a poor evaluation of DTm values. Moreover, our model reveals that for some types of interactions, the weighting functions strongly differ between DDG and DTm predictors. This indicates differences between the mechanisms that rule protein stability at room temperature and at higher temperatures.
Nearest Stable System using Successive Convex Approximations

François-Xavier Orban de Xivry (UCL)

Abstract

Stability is a crucial property for dynamical systems. We are interested in finding a practical algorithm that would find the nearest stable system to an unstable one in the sense of the Frobenius norm and without computing its eigenvalues. This problem is not easy due to the non-convex nature of the set of solutions and one cannot find a global solution to the problem. Here, we present an iterative algorithm that produces successive convex approximations of the stable set of systems. The goal is to obtain a locally optimal solution in reasonable computational time. The convex approximations are based on the Lyapunov characterization of the set of stable systems on which we apply a barrier function.

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First-order Methods for Convex Optimization with Inexact Oracle

Olivier Devolder, François Glineur and Yurii Nesterov (UCL, CORE and INMA)

Abstract

In this poster, we analyze the effect on first-order methods of smooth convex optimization (classical and fast gradient methods) if only inexact first-order informations are available. We introduce a notion of approximative first-order oracle. For each method, we develop complexity results and study the link between the desired accuracy on the objective function and the needed accuracy for the oracle. We obtain that in this inexact case, the superiority of the fast gradient method over the classical one is no more so clear. The optimal scheme suffers from an accumulation of errors contrarily to the classical gradient method and the choice between these two kinds of methods depends on the complexity of the computation of the inexact first-order informations. We prove that this accumulation of errors does not come from our analysis but from the fast gradient method itself, more precisely it is an intrinsic property of any first-order method with optimal convergence rate. We present applications of our results to smooth convex-concave saddle point problems and to the obtention of a universal optimal method for smooth, weakly-smooth and non-smooth convex problems.

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Complexity of Low-Rank Matrix Approximation with Weights and Missing Data

Nicolas Gillis (UCL)

Abstract

Weighted low-rank approximation (WLRA) is a dimensionality reduction technique for data analysis which has been successfully used in several applications, e.g., in collaborative filtering to design recommender systems or in computer vision to recover structure from motion. In this work, we study the computational complexity of WLRA and prove that it is NP-hard to find an approximate solution even in the rank-one case. The proof is based on a reduction of the maximum-edge biclique problem, and applies for both positive and binary weights (the latter corresponding to missing data).

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Energy-Aware Consensus Algorithms in Networked Sampled Systems

Jean-Charles Delvenne (UCL)

Abstract

This work presents a method to analyze the convergence to consensus of a network of first order linear systems, when the signals associated to the interconnections are sampled from the continuous time systems. In order to minimize the energy consumed in the process of communication, we will look for the optimal sampling time such that the consensus is reached in a minimum number of iterations (communications). The analysis is performed by minimizing several objective functions that take into account a measure of the convergence rate to reach a consensus. These objective functions mainly depend on the eigenvalues of the sampled transition matrix of the system. Finally, we present a case study based on the torus topology, where a simple case of communication is analyzed and the optimal sampling time to reach a consensus is obtained.

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Characterizing the set of coherent lower previsions with a finite number of constraints or vertices

Erik Quaeghebeur (UGent)

Abstract

The standard coherence criterion for lower previsions is expressed using an infinite number of linear constraints. For lower previsions that are essentially defined on some finite set of gambles on a finite possibility space, we present a reformulation of this criterion that only uses a finite number of constraints. Any such lower prevision is coherent if it lies within the convex polytope defined by these constraints. The vertices of this polytope are the extreme coherent lower previsions for the given set of gambles. Our reformulation makes it possible to compute them. We show how this is done and illustrate the procedure and its results.

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Modelling and control of tethered airplanes for wind energy harvesting

Kurt Geebelen, Joris Gillis, Jan Swevers, Moritz Diehl (KUL2)

Abstract

A novel approach for harvesting wind power makes use of tethered airplanes. An airplane, anchored to the ground, transmits power to a ground-based generator by periodically pulling out the tether. Automatic control of these systems remains a challenging task. The research focuses on developing dynamic models, estimation techniques and optimal control techniques (nonlinear model predictive control) for tethered airplanes. The poster demonstrates some basic ideas about the topic.

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A reference-free iterative learning strategy and its application to wet clutch control

*Bruno Depraetere, Gregory Pinte, Jan Swevers (KUL2)*

**Abstract**

This paper proposes a method to iteratively learn optimal control signals for mechatronic applications that perform similar or repetetive tasks, but for which reference trajectories to be tracked can not readily be derived. Instead, the specifications are used directly to formulate a numerical optimization problem, which is solved before each trial to find the next control signal. Learning is included by using the measured response data to update the models and constraints used by the optimization problem. This learning process makes it possible to find control signals close to the optimal one, yet without detailed a priori knowledge and without complex models. By operating during normal machine operation, it also allows compensation of variations in the system behavior and operating conditions. To demonstrate the validity of the proposed approach it is applied to the engagement of wet clutches. For this application, a fast convergence is obtained towards the desired specifications, and a demonstration of the robustness to variable operating conditions is provided.

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Chebyshev lattices: cubature qualities and fast implementation

*Koen Poppe, Ronald Cools (KUL2)*

**Abstract**

We have introduced Chebyshev lattices as framework for well known near-optimal point sets for interpolation and integration in two and three dimensions. This also extends the idea of Clenshaw-Curtis quadrature to higher dimensions. In this context, two special cases are important: rank-1 rules, which originate from computer searches for good Chebyshev lattices, and the full rank Chebyshev lattice rules described by Godzina. Both methods allow for a very efficient FFT-based implementation. We compared the two types of rules in terms of function evaluation and actual run times and observed good behaviour for integration of oscillatory functions.

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Algorithms for the rank-$(L_t, L_t, 1)$ Block Term Decomposition

Laurent Sorber en Lieven De Lathauwer (KUL2)

Abstract

Block Component Analysis is a technique to decompose a tensor into a sum of tensors of low multilinear rank. One way of doing BCA is with the rank-$(L_t, L_t, 1)$ Block Term Decomposition. We show how existing CP decomposition algorithms can be extended to perform this decomposition and also present a new algorithm in which the mode-one and mode-two rank $L_t$ of each block term is automatically estimated.

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Sparse spectral clustering method based on the incomplete Cholesky decomposition

Katrijn Frederix, Marc Van Barel (KUL2)

Abstract

A novel sparse spectral clustering method using linear algebra techniques is proposed. Spectral clustering methods solve an eigenvalue problem containing a graph Laplacian. The proposed method exploits the structure of the Laplacian to construct an approximation, not in terms of a low rank approximation but in terms of capturing the structure of the matrix. It selects a sparse data set which is a good representation of the full data set. With this approximation, the size of the eigenvalue problem can be reduced. To obtain the indicator vectors a pivoted LQ factorization of the eigenvector matrix is computed. This formulation also gives the possibility to extend the method to out-of-sample points.

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A parallelizable element-by-element multilevel block-ILU preconditioner

Nick Vannieuwenhoven and Karl Meerbergen (KUL2)

Abstract

Current preconditioning techniques for Krylov-subspace methods do not focus on computational efficiency. We propose a new preconditioner that successfully combines a high-quality multilevel factorization with computational efficiency both during construction as during application. Both theoretical and numerical experiments demonstrate its effectiveness.
List of participants

**UCL**
Abouzaid Bouchra
Absil Pierre-Antoine
Bastin Georges
Ben-Naoum Kouider
Borckmans Pierre
Browet Arnaud
Casenave Céline
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Chang Chia-Tche
Coppe Sébastien
David Bob
Dehaye Jérémy
Delhaye Benoît
Delvenne Jean-Charles
Devolder Olivier
Dochain Denis
Ego Caroline
Gevers Michel
Glineur François
Hendrickx Julien
Hollander Romain
Ishteva Mariya
Ivanov Tzvetan
Jungers Raphaël
Krings Gautier
Leclercq Guillaume
Lefèvre Philippe
Maclean Heather
Melchior Samuel
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Rentmeesters Quentin
Simon Emile
Trefois Maguy
Van Dooren Paul
Wertz Vincent
Winkin Joseph
Wolsey Laurence
Batselier Kim
Bernaerts Kristel
Bonilla Julian
Boons Kathleen
De Batselier Kim
De Moor Bart
Deprez Mimi
D’Huys Pieter-Jan
Diehl Moritz
Domanov Ignat
Dreesen Philippe
Falck Tillmann
Gil-Cacho Pepe
Gins Geert
Kozma Attila
Langone Rocco
Logist Filip
Lule Ivan
Moonen Marc
Paelinck Reinhart
Schuddinck Pieter
Serizel Romain
Signoretto Marco
Sima Diana
Suykens Johan
Telen Dries
Tran Dinh Quoc
Valerio Mattia
Van den Kerkhof Pieter
Vanderlinden Eva
Vandewalle Joos
Van Huffel Sabine
Van Impe Jan
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**UGent**
Aeyels Dirk
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Loccufer Mia
Marinica Nicolae
Muresan Bogdan
Petit Frits
Pop Cristina
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De Coster Diane
De Locht Ludwig
Lataire John
Lauwers Lieve
Louaroudi Ebrahim
Monteyne Griet
Pintelon Rik
Schourens Johan
Schouens Maarten
Thorsell Mattias
Ugruyanova Diana
Vandersteen Gerd
Van Moer Wendy
Widanage Dhammika

KUL2
Bultheel Adhemar
Depraetere Bruno
De Vlieger Jeroen
Gawad Jerzy
Geebelen Kurt
Ghysels Pieter
Gumussoy Suat
Humeat Matthias
Huybrechs Daan
Jarlebring Elias
Lasaro Andrea
Mazzi Giacomo
Meerbergen Karl
Michiels Wim
Mohaghhe Kasra
Nuyens Dirk

Poppe Koen
Roose Dirk
Saadvandi Maryam
Sorber Laurent
Swevers Jan
Van Barel Marc
Vandereycken Bart
Vannieuwenhoven Nick
Wu Zhen
Yue Yao

ULg
Aristidou Petros
Bullinger Eric
Collard Anne
Defourny Boris
Drion Guillaume
Fabozzi Davide
Guillaume Bryan
Mahachie John Jestinah
Mauroy Alexandre
Meyer Gilles
Mishra Bamdev
Rousseaux Patricia
Sacre Pierre
Safadi Firas
Saint-Pierre David
Saive Benjamin
Sarlette Alain
Sepulchre Rodolphe
Trotta Laura
Van Cutsem Thierry

ULB
Bogaerts Philippe
Buttafuoco Angelo
Dehouck Yves
Galvez Manuel
Janssens Jérôme
Jaroslav Albert
Kajdan Rudy
Kinnaert Michel
Rooman Mariam
Sarras Ioannis
Verspecht Jonathan
UMons
Almeida Pedro
Castermans Thierry
Devuyst Stéphanie
Dewasme Laurent
Donoso Andres
Dubuisson Thomas
Duvinage Matthieu
Mailier Johan
Retamal Cristina
Saraiva Ines
Sbarciog Mihaela
Suvarov Paul
Vande Wouwer Alain
Zamorano Francisca

Guest Speakers
Bitmead Robert (University of California, San Diego)
Deistler Manfred (Vienna UT)
Delvaux Bruno (UCL)
De Moor Bart (KUL)
Dewilde Patrick (TU Munich)
Glover Keith (University of Cambridge)
Higham Nick (University of Manchester)
Hjalmarsson Håkan (KTH Stockholm)
Ljung Lennart (Linköping University)
Overton Michael (New York University)

Sepulchre Rodolphe (ULg)
Sorensen Dan (Rice University)

Guests
Alves Pereira Luis Fernando (Universidade Federal do Rio Grande do Sul)
Bazanella Alexandre (Universidade Federal do Rio Grande do Sul)
Bombois Xavier (Delft UT)
Chahlaoui Younes (University of Manchester)
Codrons Benoît (Laborelec)
De Bruyne Franky (Triphase NV)
Ferreira Coutinho Daniel (Universidade Federal do Rio Grande do Sul)
Feys Véronique (BELSPO)
Gallivan Kyle (Florida State University)
Hildebrand Roland (Université Joseph Fourier, Grenoble)
Ho Diep (Mediaxim)
Lejour Corinne (BELSPO)
Maciejowski Jan (University of Cambridge)
Mastronardi Nicola (National Research Council of Italy, Bari)
Solari Gabriel (Dalmine R&D)
Tempo Roberto (Politecnico di Torino)
Tisseur Françoise (University of Manchester)
Vandendorpe Antoine (BNP Paribas)
Van den Hof Paul (Delft UT)
Verhaegen Michel (Delft UT)