PAI VI/4 DYSCO
Study Day

27 November 2009
Thermotechnisch Instituut
Kasteelpark Arenberg 41
Leuven-Heverlee

IAP VI/4
DYSCO

Katholieke
Universiteit
Leuven

Time Schedule

09:30 Registration

10:00 Plenary Lecture I

Continuation of periodic solutions directly in an experiment
Prof. Bernd Krauskopf, Department of Engineering Mathematics, University of Bristol, UK

11:00 Poster Session 1

12:00 Status of the IAP project and future of the DYSCO network

12:30 Lunch (In Alma III)

14:00 Poster Session 2 (New PhD researchers)

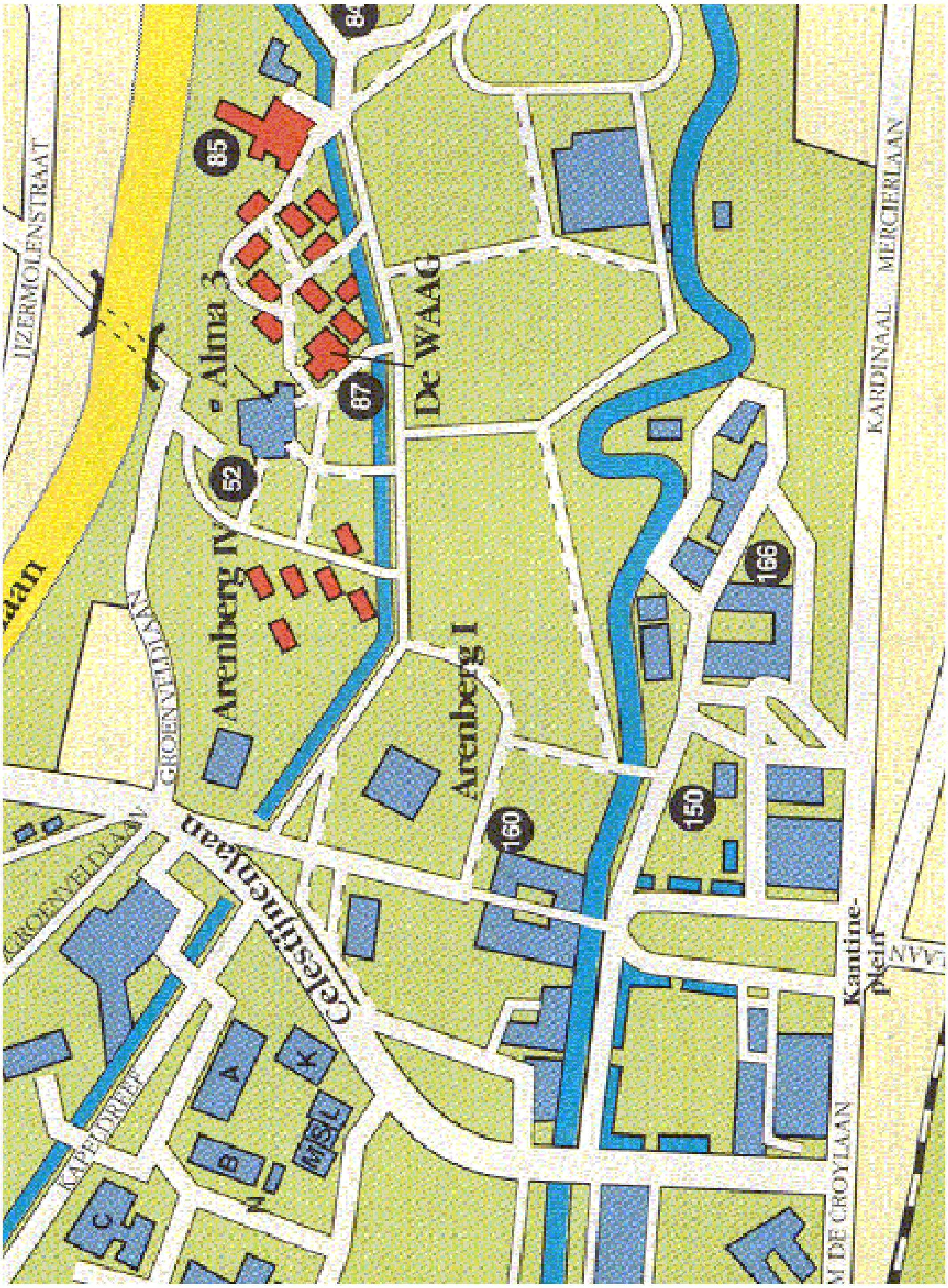
14:50 Poster Session 3 (New PhD researchers)

15:45 Plenary Lecture 2

The thermodynamics of control: Maxwell's demon and Carnot engines
Dr. Jean-Charles Delvenne, UCL/INMA team

16:45 End

Practical Information (Location of Alma 3)



Plenary Lectures

Continuation of periodic solutions directly in an experiment

Prof. Bernd Krauskopf, Department of Engineering Mathematics, University of Bristol, UK. Joint work with Jan Sieber, University of Portsmouth, and Alicia Gonzalez-Buelga, Simon Neild and David Wagg, University of Bristol

Abstract

When a mathematical model is available, for example, in the form of a system of ordinary differential equations, then it is possible to find and follow equilibria, periodic solutions and their bifurcations in system parameters. Numerical continuation is today a well-established tool that is implemented in software packages such as AUTO, DsTool and Content. However, in many situations it is impractical or even intractable to derive a mathematical model of the system under consideration. A particular example are hybrid engineering tests, where a test specimen of interest (for example, a bridge cable) is tested in the laboratory as if it were part of the entire structure (the bridge). To this end, the tested part is coupled dynamically via sensors and actuators to a computer simulation of the remainder of the structure (such as the bridge deck). The talk presents a continuation method that enables one to continue branches of solutions, including periodic orbits, directly in an experiment. A control-based setup in combination with Newton iterations ensures that the periodic orbit can be continued even when it is unstable. Our method is demonstrated with the continuation of initially stable rotations of a vertically forced pendulum experiment through a fold bifurcation to find the unstable part of the branch.

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The thermodynamics of control: Maxwell's demon and Carnot engines

Dr. Jean-Charles Delvenne, UCL/INMA team.

Abstract

"Every mathematician knows it is impossible to understand an elementary course in thermodynamics", said Vladimir Arnold. This should not prevent us from trying, of course.

The main results of thermodynamics, including the emergence of irreversibility from microscopic reversible laws, Maxwell's demon and Carnot's theorem, will be formulated in linear control theory. This will be applied to the impossibility of perfect measurement.

Poster Session 1

Non-parametric instantaneous FRF of a class of Time-Varying systems

John Lataire en Rik Pintelon, VUB

Abstract

Slowly time-varying systems can be informally seen as systems with slowly evolving instantaneous transfer functions. This poster proposes a definition of an instantaneous transfer function, based on 'frozen' models of time-varying systems. It is demonstrated how the use of multisines as excitation signals provide insight into the nature of the time variation by simple inspection of the resulting output spectrum. Furthermore, a non-parametric estimate of the evolving instantaneous FRF (Frequency Response Function) is extracted from data of a single experiment.

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Reduction of polynomial nonlinear state-space models by means of nonlinear similarity transforms

Anne Van Mulders, Laurent Vanbeylen, Johan Schoukens, VUB

Abstract

A state-space representation of a system is not unique. By means of a state (similarity) transform, a new model with the same input-output behaviour can be obtained. For nonlinear models, such as the polynomial nonlinear state-space (PNLSS) model, both linear and nonlinear transformations can be used to create a new model that fits within the same model class (i.e. preserving the same nonlinear degrees and model order). The benefits of these transformations can be to generate parsimonious representations for (non-parsimonious) PNLSS models obtained from systems of block-oriented type (e.g. Wiener-Hammerstein). Finding the right nonlinear transformation can greatly reduce the number of parameters. Up to now, we are not aware of an existing solution (in literature). We will present our ideas by means of a simple example.

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Selecting multiple epistatic models using MB-MDR

Cattaert T., Mahachie John J.M., Van Steen K.,Ulg

Abstract

When searching for epistasis (gene-gene interaction), parametric regression approaches have severe limitations when there are many independent variables compared to the number of observed outcome events. Alternatively, one can use the non-parametric Multifactor Dimensionality Reduction method (MDR, Ritchie et al., 2001), which tackles the dimensionality problem by pooling multi-locus genotypes into two risk groups: a high and a low risk set. The MDR method and its numerous extensions are all extremely computer-intensive. Models are evaluated on the basis of cross-validation and prediction accuracy. Only the best model is singled out and its significance assessed through permutation testing. We recently proposed FAM-MDR (Cattaert et al., 2009, in preparation), a novel unified MDR strategy for epistatic association analysis capable of handling both unrelateds and families of any structure, different outcome types (e.g. categorical, continuous or survival type). It allows for adjustment for lower order effects or confounding factors. In comparison with MDR, it is less computationally intensive since its core is based on Model-Based MDR (MB-MDR, Calle et al., 2007). The latter is a semi-parametric MDR method to detect epistasis in unrelated individuals. Models are evaluated via association tests on the final one-dimensional construct. In this work, we address the issue of identifying several good models using MB-MDR methodology and borrowing ideas from FAM-MDR. To this end, alternatives for the identification of high and low multi-locus risk cells are discussed, because optimal definitions may substantially improve the power of our method and may dramatically reduce computation time. Furthermore, we validate and evaluate our epistasis detection method in a simulation study, by computing power and type I error under a variety of scenarios. Emphasis will be placed on multiple co-occuring epistatic models.

Calle, M. L.; Urrea, V.; Malats, N. & Van Steen, K. (2007), Tech. Rep. n.24. Department of Systems Biology. Universitat de Vic.
Cattaert, T.; Urrea, V.; Naj, A. et al. (2009), in preparation.
Ritchie, M.D.; Hahn, L.W.; Roodi, N. et al. (2001), Am. J. Hum. Gen. 69:138–147.

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Dynamic Treatment Regimes using Reinforcement Learning: a Cautious Generalization Approach.

Raphaël Fonteneau, Ulg

Abstract

The treatment of chronic-like illnesses such has HIV infection, cancer or chronic depression implies long-lasting treatments that can be associated with low quality outcome, painful side effects and expensive costs. To enhance these treatments, clinicians often adopt what we call Dynamic Treatment Regimes (DTRs). DTRs are sets of sequential decision rules defining what actions should be taken at a specific instant to treat a patient based on information observed up to that instant. Ideally, DTRs should lead to treatments which result in the most favorable clinical outcome possible. Since a few years, a growing research community is working on the development of formal methods (mainly issued from mathematics, statistics and control theory) that allow to infer from clinical data high-quality DTRs.

We propose in this framework an algorithm of quadratic complexity that infer from clinical data a sequence of treatment actions. The algorithm (called CGRL for Cautious Generalization for Reinforcement Learning) has cautious generalization properties, i.e. it avoids taking treatment actions for which the sample of clinical data is too sparse to make safe generalization. The algorithm also has consistency properties, which means that when the sparsity of the set of clinical data decreases to zeros, the inferred sequence of treatment actions is actually optimal. Moreover, in some favorable cases, some tight performance guarantees on the inferred sequence of treatment actions can be computed. The algorithm is illustrated using some simulated data dealing with the HIV infection.

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A PDE viewpoint on basic properties of coordination algorithms with symmetries

Alain Sarlette, ULg

Abstract

Several recent control applications consider the coordination of subsystems through local interaction. Often the interaction has a symmetry in state space, e.g. invariance with respect to a uniform translation of all subsystem values. The present paper shows that in presence of such symmetry, fundamental properties can be highlighted by viewing the distributed system as the discrete approximation of a partial differential equation. An important fact is that the symmetry on the state space differs from the popular spatial invariance property, which is not necessary for the present results. The relevance of the viewpoint is illustrated on two examples: (i) ill-conditioning of interaction matrices in coordination/consensus problems and (ii) the string instability issue.

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Detection of the development stages of higher eukaryotes from DNA microarray time series data

Alexandre Haye, Yves Dehouck, Marianne Rooman, ULB

Abstract

DNA microarray techniques provide snapshots of the simultaneous expression levels of thousands of genes in a cell sample. We focus here on DNA microarray time series of two model multicellular eukaryotes across their development stages, Drosophila melanogaster and Ciona intestinalis. Comparing the expression profiles with simple polynomial curves, we show that they present some ?discontinuities? at time points that are close to the transitions between development phases. This result is exploited to set up a simple but efficient clustering method, which classifies the genes on the basis of their expression profile within each development stage. This approach provides some clues about the gene regulatory network, which will be used in further analyses.

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Modeling of the interaction force between the instrument and the trocar in minimally invasive surgery

J. Verspecht, T. Delwiche, A. Buttafuoco, L. Catoire, S. Torfs, and M. Kinnaert, ULB

Abstract

Trocars used in Minimally Invasive Surgery (MIS) are equipped with a sealing mechanism. During the motion of an instrument through a trocar, the sealing mechanism deforms itself. None of the friction models presented in the literature capture the macroscopical deformation of the seal mechanism. Therefore a specific hybrid model is developed to describe the movement of an instrument through a trocar. Two operating modes are distinguished, corresponding to the deformation of the sealing mechanism on the one hand, and to the sliding phase through the trocar on the other hand. The model is identified and validated using experimental data recorded on a dedicated test setup.

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Fixed-Order H-infinity Optimization of Time-Delay Systems

Suat Gumussoy and Wim Michiels, KUL2

Abstract

H-infinity controllers are frequently used in control theory due to their robust performance and stabilization. Standard H-infinity controller synthesis for finite dimensional LTI MIMO plants via Riccati or LMI approaches results in a controller order same as the plant order. Therefore fixed-order H-infinity controller design is desirable for practical implementations. Recently fixed-order H-infinity controllers are successfully designed for finite dimensional LTI MIMO plants using a non-smooth, non-convex optimization method (Gumussoy et.al., 2009). In our work, we design fixed-order H-infinity controllers for a class of time-delay systems based on this optimization method and a recently developed H-infinity norm computation by authors.

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Nonlinear eigenproblems and delay systems

Elias Jarlebring, Wim Michiels, Joris Vanbiervliet, KUL2

Abstract

The nonlinear eigenvalue problem is a very general class of problems with important applications in numerous fields. The results presented here are a combination of results applicable to general nonlinear eigenvalue problems and specializations. In particular we present result related to stability and the H_2-norm of time-delay systems

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Iterative optimization of wet-plate clutch control

Bruno Depraetere, KUL2

Abstract

Industrial wet-plate clutches are controlled using feedforward signals, determined during time consuming, experimental calibrations, often followed by periodic recalibrations to account for varying operating conditions. An alternative control strategy is presented to learn and vary the optimal control signals during normal operation. On a low level the control signal is found by numerically solving an optimal control problem. On a higher level the constraints for this optimization problem are iteratively updated, consisting of a controller to learn appropriate values for the end-point constraints and a recursive identification algorithm to model the system dynamics.

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MATMOL: a user-friendly library for the solution of PDE models

Carlos Vilas, Filip Logist, Philippe Saucez and Alain Vande Wouwer, UMons

Abstract

In this presentation, we report on the development of a Matlab-based library for the numerical solution of partial differential equations. The underlying approach follows a method of lines strategy, i.e., spatial discretization followed by time integration of the resulting semi-discrete differential-algebraic equations. The spatial discretization techniques include classical finite difference and finite element methods, spectral methods, slope limiters, and adaptive gridding. Time integration is based on available solvers, for instance from the Matlab ODE suite, as well as on a few home-made solvers (mostly developed for introductory and teaching purposes). Besides the method of lines, an operator splitting method useful for convection-diffusion-reaction problems with dominant convective phenomena, is also included. A library of typical application examples is provided as illustration and as templates for the development of new applications. MatMol is in a development stage and, as such, is regularly updated (www.matmol.org).

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Improving Continuous - Discrete Interval Observers - Application to the Monitoring of Cultures of Phytoplankton

Guillaume Goffaux, Alain Vande Wouwer, Olivier Bernard, Umons

Abstract

Based on intervals bounding the uncertain initial conditions, inputs, model parameters and measurements, interval observers provide guaranteed intervals for the state trajectory. However, most of the published studies focus on methods relying on continuous-time on-line measurements, or at least, relatively fast sampling. In this study, interval state estimation methods are proposed in the situation where measurements are only available at discrete, and possibly rare, times. The attention is focused on defining a bundle of predictors preserving the boundedness of the state variables between two measurement times assuming bounded uncertainties. The methods are tested with Droop model simulating data from continuous cultures of phytoplankton.

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The Information Inequality on Function Spaces: A tight lower Bound for the Auto-covariance.

Tzvetan Ivanov, UCL

Abstract

In this work we extend the scope of classical information inequalities from Euclidean to function spaces. The novel inequalities are applicable to unbiased function estimation and serve as a lower bound for the auto-covariance function of the random process corresponding to the estimator. The results are shown to have strong consequences for many natural applications in the context of system identification of discrete-time, finite dimensional, LTI systems for which the function space consists of real rational transfer functions. The development is based on the coordinate free approach of information geometry. This results in a key advantage for the user which makes it possible to work with performance specification directly - without the need to translate back and forth to some parameter space.

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The brain accounts for 3D eye kinematics in the visuomotor transformation of velocity signals in manual tracking

Guillaume Leclercq, Gunnar Blohm, Philippe Lefèvre, UCL

Abstract

Visually guided arm movements are common actions carried out each day in our everyday life, like reaching our cup of coffee, playing tennis, driving a car. When performing visually guided arm movements, the brain needs to transform the visual information (the tennis ball, an obstacle) into an appropriate motor plan for the arm (i.e. a command to give to the arm?s muscles). It is known that for arm movements, the brain accounts for the 3D eye-head-shoulder geometry when transforming position or velocity signals (position and velocity signals are known to be processed separately in the brain).

In these experiments, the eyes and head were static during the task. But new implications arise if the eye and/or head is moving during the task. Here, we investigate if the brain accounts for the 3D eye kinematics in the visuomotor transformation of velocity signals for manual tracking movements.

A visuomotor transformation model taking into account the complete 3D eye-head-shoulder kinematics was developed using dual quaternions. Model predictions show that 3D eye velocity signals are needed in order to transform the retinal velocity input into a spatially accurate motor plan. Specifically, the model predicts that the brain must compensate non-linearly for differences in eye and target 1) directions and 2) velocities.

To test our predictions, human subjects performed manual tracking movements while pursuing another target with the eyes while the head was upright and fixed. We compared the arm initial direction with the predictions provided by the model.

For each subject, we performed a linear regression analysis on the observed compensation versus the predicted full compensation accounting for the eye kinematics. No compensation would result in a regression slope of zero. If the observed compensation is perfect, the slope of the compensation must be one. For each subject, the slope of the regression line ranges from 0.80 to 0.95 and is significantly different from 0 (R ¿ 0.75). This suggests that the brain uses eye velocity and directions signals to account for the eye kinematics in the visuomotor transformation of velocity signals for manual tracking movements.

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Predictive oculomotor behavior in patients with frontotemporal lobar degeneration

Sebastien Coppe, Demet Yuksel, Adrian Ivanoiu, Philippe Lefèvre, UCL

Abstract

In normal subjects, saccades compensate for the variability of the smooth pursuit eye movements during blanking of the target. Several studies suggest that predictive pursuit relies on frontal and temporal lobes (Frontal and Supplementary Eye Fields, Temporal areas). In this study, we tested whether an impairment of these cortical areas would damage the predictive pursuit and/or its saccade compensation.

Frontotemporal lobar degeneration (FTLD) is a neurodegenerative disorder that is associated with degeneration of the frontal and/or anterior temporal lobes with relative sparing of more posterior cortical regions. We recorded eye movements of two patients with frontotemporal dementia (FTD-patient) presenting as a behavioral/dysexecutive syndrome (frontal lobe variant) and one patient with progressive non-fluent aphasia (PA-patient) presenting with poor articulation (temporal lobe variant). Diagnosis was confirmed by the clinical assessment, neuropsychological evaluation, magnetic resonance imaging and functional imagery.

Previous studies (Meyniel et al 2005, Boxer et al 2006, Garbutt et al 2008) have shown abnormalities in smooth pursuit and in anti but not reflexive saccades for FTD-patients. PA-patients showed normal oculomotor behavior compared to control subjects for saccades and smooth pursuit in all the tested conditions.

We tested anticipatory smooth pursuit eye movements before target onset and predictive pursuit during occlusion (blanking of the target). In addition, the degree of impairment of either the saccadic system and/or the pursuit system was compared in order to test if there is a coupling between the two pathways for compensation to the deficit. The experiment was the following; after fixation and a gap period, the target started moving at

constant velocity before blanking and reappearance (random direction, gap and blanking duration, target velocity).

Anticipatory and predictive pursuit for PA-patient showed no major impairment. In contrast, pursuit gain was slightly decreased for one FTD-patient during visually-guided tracking and the deficit was even more severe during target blanking (especially for target velocity 10 deg/s). In this condition, the saccadic system could not compensate for the predictive pursuit deficit.

Results will be discussed in order to correlate the predictive eye movements with the lobar degeneration in order to bring insight to the role of the frontal and temporal cortical regions in this process. Moreover, the observed abnormalities may serve as sensitive indicators to guide the clinician in the early diagnosis, and to follow the evolution of the disease.

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Discrete-Time Stochastic Optimal Control via Occupation Measures and Moment Relaxations

Carlo Savorgnan, KUL1

Abstract

We consider discrete-time nonlinear stochastic optimal control problems for which all the data are polynomial. For this class of problems we derive a hierarchy of linear matrix inequality relaxations which is based on occupation measures and moment theory. The dual of the convex problem obtained, which can be interpreted in terms of the Bellman equation, is then used to derive an almost optimal control law.

Model Predictive Control of a Spark Ignition Engine

Matus Kopacka, KUL1

Abstract

Nowadays, model predictive control is more and more applied in different fields thanks to its advantages and available cheap and powerful computational units. One of these fields is the automotive industry with its complex control tasks involving fast dynamic systems. My aim is to control selected processes, originally controlled by PID controllers or by look-up tables, necessary for the run of an SI engine (air/fuel ratio, spark advance, throttle valve position...) using MPC. The poster will also introduce basic SI engine control principles and my tasks at KU Leuven.

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Design and control of a river power plant

Carlo Romani, KUL1

Abstract

An Hydro Power Valley (HVP) is an interconnection of several reaches and storages. By manipulating the water flow through their facilities (turbines and weirs), the power plants affect the rivers natural water level and flow. Unless the power plants are controlled properly, excessive variations in flow and level can result, which may have an adverse impact on the flora and fauna within the river and at the riverbank. Additionally, water discharge variations are unfavorable for navigation. These facts must be considering in the design of the controllers, so the use of a MPC technique grant the possibility to consider the constraints on the water level and on the water flow. Here I present an implementation of the model and the design of a MPC control.

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Sequential Convex Programming and Applications

Quoc Tran Dinh, Moritz Diehl, KUL1

Abstract

Consider the following non-convex optimization problem

$$\begin{cases} \min\limits_{x\in\mathbf{R}^n} & f(x) := c^T x \\ \text{s.t.} & g(x) = 0,\ x \in \Omega \end{cases} \tag{P}$$

where $c \in \mathbf{R}^n$, $g : \mathbf{R}^n \to \mathbf{R}^m$ is nonlinear, continuously differentiable, and $\Omega \subset \mathbf{R}^n$ is a nonempty closed convex subset.

In this poster, an iterative method for solving non-convex optimization problem (P) is proposed, which we call sequential convex programming (SCP). The main contribution of this poster includes two parts. The first part presents a *full-step SCP algorithm* and investigates its local convergence based on the *strong regularity assumption* introduced in the landmark paper of Robinson [1] (see, also [2]). We prove that under acceptable assumptions the SCP method converges linearly to a KKT point of (P). The second part shows applications of the SCP algorithm in optimization and optimal control. Computational results are reported in this poster.

References

[1] S. M. Robinson, Strong regularity generalized equations, *Mathematics of Operation Research*, Vol. 5, No. 1, pp. 43-62 (1980).
[2] R. T. Rockafellar and R. J-B. Wets, *Variational Analysis.* Springer-Verlag, New York (1997).

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ACADO Toolkit - An Open-Source Framework for Automatic Control and Dynamic Optimization

Boris Houska, KUL1

Abstract

ACADO Toolkit is an open-source software environment and algorithm collection for automatic control and dynamic optimization that is currently developed within OPTEC. It provides a general framework for using a great variety of algorithms for direct optimal control, including model predictive control and state/parameter estimation. ACADO Toolkit is implemented as self-contained C++ code providing a very user-friendly syntax for setting up optimal control problems. The object-oriented design allows for convenient coupling of existing optimization packages and for extending it with user-written optimization routines. In this poster we discuss several of ACADO Toolkit's key features and demonstrate how it can be used to solve optimal control problems.

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Poster Session 2 (New PhD researchers)

Identification of periodically time-varying systems

Ebrahim Louarroudi, Rik pintelon and John Lataire, VUB

Abstract

In the last century, the LTI (Linear Time Invariant) assumption and the corresponding system identification techniques have been utilized successfully in practice. However, in some applications the considered real-life systems do not satisfy the time invariant condition. For that reason it is convenient to extent the framework of LTI-systems to theories whereby system properties might evolve over time. There exist a width range of applications where the treatment of time-varying systems is indispensable. Consider for instance structures that are subject to increasing damage, pitting corrosion of metals, metal deposition, biological systems or even time invariant systems with a time-varying setpoint. All these examples cannot be treated in the classical LTI framework. Therefore, we need a more systematic approach that is able to handle such time-varying processes. Two fundamental principles exist that underlie this time variation. Namely:

- The time behavior is dictated by the random nature of the system. Hence, the system properties change actually witch time. Concrete examples are: pitting corrosion in metal structures, (bio)chemical process, etc.
- The time variation is caused by external parameters, the so-called scheduling parameters. Examples are: flight flutter analyses with the flight speed as scheduling parameter, a moving robot with the length of the robot axis as external parameter, etc.

When the time variation is forced experimentally (see ii), one can choose between periodically, arbitrary (non- periodically) or hold (piecewise constant time variation) configurations for the scheduling parameter(s). In this poster a rough introduction is given on linear time-varying (LTV) systems with (periodically) time-varying scheduling parameters. The advantage of the hold configuration for the external parameter is the shrinking of the complex modeling process (only LTI-models must be identified), at a cost of an increase in experimental time against the first two approaches. The purpose of using non-constant piece time variation (periodically or non- periodically) is to reduce the experimental time, with the drawback that a more complex system model should be identified with respect to LTI-systems.

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Performance criteria and robustness in biological bistable models at the example of the apoptotic process.

Laura Trotta, Eric Bullinger and Rodolphe Sepulchre, ULg

Abstract

Apoptosis is the programmed cell death used by multicellular organisms to remove damaged or potentially harmful cells and involved in cellular processes such as development of embryos, neurogenesis or regulation of the immune system (Hengartner, 2000). Defective apoptosis can lead to severe pathologies: while repressed apoptosis is found in most of cancers, enhanced apoptosis is present in developmental defects, autoimmune and neurodegenerative diseases.

Two ODE models of the extrinsic pathway of apoptosis (Eissing et al., 2004, Schliemann et al., 2007) have been proposed. These models present the apoptotic process as a system which can switch between two states, the survival and the death, in function of a pro-apoptotic input signal. Moreover, these models reproduce the main features of the extrinsic apoptotic pathway: the resistance of the survival state to external perturbations, the transition between the survival and the death for a sufficiently strong pro-apoptotic stimulus and the time-delay between the pro-apoptotic input signal and the effective activation of effector caspases.

The systems proposed by T. Eissing and M. Schliemann are bistable systems which means that they have two stable equilibrium points. Both models present, in addition, one saddle node. In order to understand switch mechanism in apoptosis, performance and robustness of bistable systems were investigated. Performance was defined as the capacity of the system to present a typical response to a signal input while robustness was related to its capacity to preserve this response in face of perturbations. It was shown that the main properties of the apoptotic switch can be expressed as performance specifications of particular bistable systems.

Although there have been several studies of the models of apoptosis, especially of the one proposed by T. Eissing et al., the saddle nodes have barely been analysed. However, this node has a special characteristic in the models of Eissing and Schliemann: it presents only one positive eigen value which is, in modulus, the smallest one of all the eigen values of the node. We called the bistable models having this characterisitc "Retarding Switch Models" (RSM). Sensitivity analyses and parametric perturbations were performed on two different RSM, the two-dimensional model of Griffith (Griffith, 1971) and the eight-dimensional model of apoptosis proposed by T. Eissing (Eissing et al., 2004). Our results suggest that the performance of RSM is influenced by properties of their saddle node equilibrium point.

In biology, bistable models have been used to describe physiological decision-making processes not only in apoptosis but also in cell cycle progression, development and differentiation (Tyson et al., 2008, Yan et al., 2009). Further investigation of these models could reveal if they present a similar structure and the part of RSM systems in biological switches.

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Robustness and entrainment of the Drosophila circadian clock: an analysis based on the phase response curve

Pierre Sacré, Marc Hafner and Rodolphe Sepulchre, ULg

Abstract

Robustness is a ubiquitously observed feature of biological systems. Broadly speaking, this property allows a system to maintain its function despite external and/or internal perturbations. Currently, it is widely believed that the specific structural characteristics of a biological control network is responsible for its dynamic behavior and its robust performance. However, the actual mechanisms are still not clear, even in genetic circuits of moderate complexity. Understanding of those molecular and cellular mechanisms is crucial to advances in systems biology.

Here, we develop a method to identify the region of a high-dimensional parameter space where a circuit displays an experimentally observed behavior. This global analysis is refined by a local analysis, in which the parameter sets sampled in the global analysis are analyzed individually to separate the viable parameter sets in particular subsets (sensitivity, stability, etc.) [1]. The combination of those global and local analysis helps to derive properties linked to network structure.

Autonomous oscillations provided by circadian clock architectures have been widely studied in the literature in terms of local and global sensitivity analysis [2, 3]. Nevertheless, the main feature of circadian clocks is their capacity to adapt to the imposed day-night rhythm. In this context, a very common and useful tool for studying the phase shift induced by a particular input is the phase response curve (PRC). We currently investigate whether this tool can be used as a discriminant criterion for the model selection. Our comparative analysis focuses on two moderately complex models of circadian rhythms in Drosophila. The simpler model contains a single negative feedback loop [4] and the more complex model describes both branches of negative feedback [5]. We found that the addition of a second loop allows the system to be globally more robust and more resilient to parameter variations.

References

[1] Marc Hafner, Heinz Koeppl, Martin Hasler, and Andreas Wagner. 'Glocal' robustness analysis and model discrimination for circadian oscillators. PLoS Comput Biol, 5(10):e1000534, 10 2009.

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Real-Time Moving Horizon Estimation for Advanced Motion Control

Max Boegli, KUL2

Abstract

In this project real-time moving horizon estimation (MHE) algorithms will be developed and experimentally validated to improve the accuracy of motion control systems. Moving horizon estimation is a class of optimal control problems that aims at finding the system state and disturbances that are most consistent with current and past system input and output data and the available system model or at finding model parameters if all other data is available. Real-time MHE algorithms will be developed to optimally estimate the parameters of advanced friction models in order to optimally compensate the effect of friction in model-based motion control systems. The developed algorithms will be experimentally validated on a dedicated linear motor based test setup. Also MHE of speed based on position measurements, which can then be used in traditional motor controllers will be considered, as well as other applications where MHE is expected to improve performance such as: active orthoses, sensor based robotics, and GPS navigation systems.

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Analyse en berekening van de eigenwaarden van symmetrische onzekere matrices

Jeroen De Vlieger and Karl Meerbergen, KUL2

Abstract

Deterministische computersimulaties van allerhande wiskundige modellen uit de ingenieurswetenschappen worden al jaren gebruikt om het ontwerp van nieuwe technologieen te ondersteunen. De laatste jaren is het belang van het bestuderen van onzekerheid in de parameters toegenomen. Het is namelijk zo dat een groot aantal parameters een ontwerp sturen en deze moeten optimaal worden bepaald. Sensitiviteitsanalyses helpen de ontwerper bij de goede keuze van de parameters.

Dit project bestudeert de berekening van eigenwaarden van een trillend systeem onderhevig aan onzekere ontwerpparameters. Hierbij zal gebruik gemaakt worden vage parameters, die de laatste jaren een nuttig hulpmiddel zijn gebleken bij de studie van onzekerheden. Daarbij moet zoveel mogelijk gebruik gemaakt worden van de specifiieke wiskundige structuur van de eigenwaardenproblemen om de algoritmische complexiteit te drukken.

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1-D FFT for n-D Clenshaw Curtis integration

Koen Poppe and Ronald Cools, KUL2

Abstract

We introduce Chebyshev lattices as an extension of some well known near-optimal point sets in two and three dimensions. These points are well suited for hyperinterpolation with product Chebyshev polynomials and, because of the construction, the coefficients in the polynomial basis can be calculated fairly efficient: only one univariate fast Fourier transformation (FFT) is required, even for high dimensional functions.

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Parameter varying fault-tolerant control Application to wind turbines

Benoît Galloy, Michel Kinnaert, ULB

Abstract

A Fault-tolerant control system is a control system that is able to accommodate system components faults automatically, with or without performance degradation. The aim of this work is to contribute to obtaining a complete methodology for fault-tolerant control systems design. This will be based on a case study which is fault-tolerant control of a wind turbine connected to the electrical grid. Expenses for wind turbines maintenance are particularly large, especially for the offshore wind turbines. Fault-tolerant control applied to wind turbines could reduce these maintenance expenses

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Mathematical modelling and optimal control of hybridoma cell cultures in perfused bioreactors

Zakaria Amribt, ULB

Abstract

Monoclonal antibodies may be produced, in biopharmaceutical industries, on the basis of hybridoma cell lines within bioreactors. In order to reach high cell densities in these bioreactors, cultures may be performed in perfused mode, i.e. with a feeding of fresh culture medium and a withdrawal of the culture medium poor in substrates and containing metabolites which are growth inhibitors. The aim of this research is to maximize the productivity of monoclonal antibodies thanks to a dynamic optimization of the culture medium (feeding and withdrawal rates, medium composition). To attain this goal, it will

first be necessary to identify mathematical models on the basis of biomass, substrates, product and metabolites concentration measurements. These models will be used to build software sensors (state observers) allowing to estimate some key signals for the controllers but hard to obtain with hardware sensors (at least providing admissible expenses). Finally, these models will also be used for developing robust controllers allowing, on the basis of some hardware sensors and/or of the above mentioned software ones, to maximize the productivity of the monoclonal antibodies.

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Fluid Petri net models for urban traffic control

Herman Sutarto, UGent

Abstract

Coordination of traffic streams in an urban network, controllable by switching traffic lights, requires a global macroscopic model of the evolution of the flows of vehicles. We propose to use fluid Petri nets as modeling tools. For the design of on-line controllers for traffic lights we study the network-wide effects of different local perturbations of the traffic light switching times via fast simulation. The infinitesimal perturbation analysis can under certain conditions lead to optimal closed loop performance.

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From EEG signals towards human locomotion : a first attempt

Matthieu Duvinage, UMons

Abstract

Current prostheses dedicated to disabled people or amputees do not integrate the latest advances in neurophysiology, microelectronics and informatics. In partnership with other Walloon research teams, the TCTS lab is developing the brain computer interface of an original lower limb prosthesis driven by the brain waves. In this poster, we present preliminary results showing how it is possible to establish a direct mapping between EEG signals and the kinematics of a human walking on a treadmill at constant speed.

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Derivative-Free Optimization : Swarm Intelligence and Multimodal problems

Borckmans Pierre, UCL

Abstract

Classical optimization often rely on the use of the derivatives of the objective function. Since this is not always suitable in practice, several derivative-free methods have been developed. Among these DFO methods, I will focus on Particle Swarm Optimization (PSO). PSO is a stochastic population-based algorithm, using social influence and learning to detect optimal regions. Since PSO is still in its infancy, there is ample room for improvement. In my work, I will explore two main axes : multimodal problems and genericity. For dealing with multimodal problems, I will consider options such as niching, and function stretching. I will also consider extending PSO to other search spaces than the cartesian space, such as manifolds. Among the many applications showing these characteristics, I will present the 3D-Oriented Bounding Box problem (OBB). This problem is multimodal and can be expressed on the rotation matrices manifold (SO(3)) and is therefore relevant to explore in this context. It will be shown that PSO outperforms state of the art algorithm for the OBB problem.

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The joint spectral radius: from computation problems to continuous switching systems

Chang Chia-Tche, UCL

Abstract

The joint spectral radius characterizes the maximal asymptotic growth rate of a set of matrices. This quantity appears in many applications such as system theory, graphs and networks, wavelets, coding theory or combinatorics on words, but has been proven to be NP-hard to approximate. Many algorithms have been designed to tackle this problem, either in the general case or for restricted sets such as nonnegative or integer matrices, e.g., branch-and-bound methods, semidefinite and conic programming, geometric algorithms... We would like to investigate the joint spectral radius computation problem in a general framework. In this poster, we will show several methods to compute the joint spectral radius and give some applications.

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Analysis and Control of Convection-Diffusion-Reaction Systems

Dehaye Jérémy, UCL

Abstract

this thesis project has it roots in control theory and its applications to engineering and applied mathematics. The main framework will be briefly explained, which is essentially the analysis and control of distributed parameter systems modelled by nonlinear partial differential equations, and more particularly by convection-diffusion-reaction infinite-dimensional nonlinear operators. (e.g. based on Arrhenius' law or Haldane's kinetics for chemical and biochemical processes respectively).

Achieving some interesting results could lead to the use of efficient tools in order to design robust feedback control laws for applications in engineering. For example, such tools are required for the optimal control of nonisothermal tubular reactors with axial dispersion or biochemical reactors.

Here is a list of some of the main questions that could be studied in order to achieve these goals : asymptotic behaviour of state trajectories, multiple equilibrium profiles and linearization, reachability, observability optimal control with constraints and boundary control. The latter can be needed in view of physical constraints when controlling the system (e.g. when the control can only be applied at one end of the reactor). Optimal control with constraints is essentially used in order to guarantee that the state and entries of the system remain in some physically feasible domain. It can be useful to avoid unexpected behaviour of the mathematical model or simply for efficiency reasons (e.g. to keep the energy required below some previously determined bound).

Spectral properties of the involved linear operators will also be studied by means of some useful theoretical results of functional analysis, such as properties of Riesz spectral operators and Sturm-Liouville operators, as well as some other results linking these two fields. The first main objective, which will be briefly introduced here, is to find a unified framework for the description of both chemical and biochemical processes, independently of the physical law that is used for modelling the reaction dynamics of the system. Such a framework could require some conditions on the nonlinearities of the infinite dimensional operator describing the dynamics of the system, which are due to the reaction term given by the aforementioned physical law.

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Solving Infinite-dimensional Optimization problems by Polynomial Approximation

Devolder Olivier, UCL

Abstract

Considering optimization problems in infinite-dimensional spaces, in particular in functional spaces, is not a new idea: calculus of variations, for example, is a very rich area studied since the 17th century and motivated by a lot of problems occuring in physics.

Nowadays, infinite-dimensional optimization problems appear in a lot of different fields such as PDE-constrained Optimization, Optimal Control or Shape and Topology Optimization. From the algorithmic point of view, the classical approach based on discretization is often used (either discretization of the problem or discretization of the algorithm).

In this work, we consider a different method of resolution that does not rely at all on discretization: we restrict the decision variables to (a sequence of) finite-dimensional linear subspaces of the original infinite-dimensional space, each corresponding to a set of polynomials of bounded degree. This approach is applied to a specific class of convex infinite-dimensional problems obtained by generalizing the linear programming problem in primal standard form to an infinite-dimensional framework.

The main results obtained so far are the following:

- under some reasonable assumptions, the sequence of optimal values of the polynomial problems with increasing degree converges to the optimal value of the infinite-dimensional problem, with in some cases a guaranteed convergence speed,
- in certain situations, each polynomial problem can be expressed as a structured convex problem in finite-dimension that is efficiently solvable using interior point methods.

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Plant Growth Modelling

Maclean Heather, UCL

Abstract

Plant growth models have a wide range of purposes, including improving agricultural practices, increasing our understanding of plants, and for the purpose of optimization and control of greenhouses or other plant growth operations. Existing plant models are mostly semi-empirical and do not fully consider the mechanisms underlying plant growth. Therefore, although simple, these models are typically not applicable over a wide range of conditions. In contrast, complex metabolic models give a more complete description of

reactions taking place within the plant, but are typically over-parameterized and unidentifiable. There is a need for simple, robust models for plant growth that are based on important biological mechanisms.

The research project aims to develop such a model within the context of a life support system project that has been developed by the European Space Agency. The MELiSSA (Micro-Ecological Life Support System Alternative) project aims to develop technology for a future regenerative life support system for long term manned space missions. The concept is to use microorganisms and plants to regenerate the atmosphere, recycle water, and to produce food for the crew on such missions.

An important part of the MELiSSA loop is the production of higher plants in a controlled greenhouse environment. A model of plant growth is required for the prediction and eventual control of this compartment. The main control objective will be to provide a certain desired flow of biomass output from the plant chamber to continuously provide food for the crew. Both quantity and quality (nutritional requirements, etc) will need to be maintained.

A first principle model based on mass balances of important states is currently being developed. A simple model structure has been selected and identification of parameters is ongoing.

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Geometric data fitting and subspace tracking

Rentmeesters Quentin, UCL

Abstract

In many applications related to signal processing and image processing, a filtering technique is required to reduce the influence of perturbations on the measurements. In this poster, we will see different approaches to implement such a filtering technique when the measurements belong to a nonlinear space. We will illustrate these techniques on subspace tracking problems and will show some applications.

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Reputation dynamics in evolution of cooperation

Traag Vincent, UCL

Abstract

Several mechanisms for the evolution of cooperation have been suggested. One such mechanism, indirect reciprocity, works through reputation. Most studies assume that reputation is an objective global variable. However, reputation is usually constructed locally, and the reputation can diverge among various agents. This research tries to explain and analyse a mechanism for reputation dynamics within this context.

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Enhanced line search for blind channel identification based on the Parafac decomposition of cumulant tensors

Ignat Domanov and Lieven De Lathauwer, KUL1

Abstract

We are interested in recovering the impulse response of a complex valued SISO-FIR channel from the Parafac decomposition of a 3rd-order tensor composed of 4th-order output cumulants. With an enhanced line search procedure we improve a recently proposed iterative single-step least-squares Parafac-based blind channel identification algorithm.

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The Fourth Generation DSL broadband concept

Rodrigo Moraes, KUL1

Abstract

DSL technology provides broadband service over twisted pair copper wires of the existing telephone network. Unfortunately, electromagnetic coupling between twisted pairs in the same bundle leads to crosstalk and therefore a degradation in performance. Dynamic spectrum management and crosstalk cancellation techniques can partially compensate for this effect. This project will perform a theoretical investigation into how the exploitation of common-mode signals could compensate substantially for the performance reduction and even lead to a significant increase in capacity.

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Dynamiek van Complexe systemen met toepassingen in socio-economische modellering

Dries Geebelen, KUL1

Abstract

In this doctoral thesis we study the concept of modelling socio-economic applications (f.e. the internal mechanism behind a recession). This modelling exists out of two steps: first we identify relevant variables, second we identify the relation between the variables. The relation between two variables will be a priori knowledge or will be learned using system identification techniques. Once the model is ready we can study and simulate the effect of decisions made within this model.

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Poster Session 3 (New PhD researchers)

Behavioral modeling of the thermal dynamics of borefields for geothermal applications

Griet Monteyne, Gerd Vandersteen, VUB

Abstract

This work is related to geothermal heat pumps. This central heating and/or cooling system pumps heat from or to the ground. It is one of the most recommendable methods for heating buildings via so called green energy.

Current controllers don't explicitly take the dynamic behavior of the source-side into account. The object of this work is to model the thermal dynamic behavior of the surrounding geology. This model can then be used to develop an optimal control strategy that also prevents the exhaustion of the heat from the soil on short and long term.

It is important that the slow dynamic behavior of the soil is well modeled. The system dynamics of a ground coupled heat pump is characterized by very diverse time constants. The conductive heat transport between the soil and the fluid is characterized by small time constants (with an order of magnitude of several minutes). On the other hand, the thermal diffusion in the soil is characterized by large time constants (with an order of magnitude of years). An additional problem is that diffusion phenomena can only be approximately described by a rational form in the s-domain (with s the Laplace variable). In order to get more accurate results rational models in the s-domain have to be used.

There are more challenges to be faced. Only a limited amount of measured quantities are easily accessible for the user. The measurement time is limited as well as the possible excitations. Several other identification problems have to be considered, for example, MIMO identification of the thermal diffusion in multiple borefield installations, dealing with missing data, ...

The model will be validated by use of simulations as well as measurements on an operational thermal installation.

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Prediction of genetic interactions in Yeast using machine learning

Marie Schrynemacker (with Pierre Geurts, Louis Wehenkel, M. Madan Babu), ULg

Abstract

The inference of the genetic interaction network of an organism is an important challenge in systems biology. An interaction (epistasis) exists between two genes when the presence or the absence of one gene modifies the effect of the other genes. The knowledge of these interactions is very important to understand the functions of the genes and their products. In Yeast S.Cerevisiae, the "Epistatic miniarray profile" (E-MAP) technique allowed to measure some interaction subnetworks on two subsets of respectively 424 and 743 genes (Schuldinger et al. 2004, Collins et al., 2007). For the time being, it remains however impossible to test experimentally the 18 millions potential interactions between the 6000 yeast genes. In this work, we propose to use computational techniques based on machine learning to complete the experimentally confirmed interactions.

From a machine learning point of view, the goal is, from the known subnetwork, to infer a model able to predict the presence or absence of an interaction between two genes from some features of those genes. We proposed several strategies to transform this problem into one or several standard supervised classification or regression problems and exploited tree-based ensemble methods to learn the models. To validate the approach, we used the two available E-MAPs as our training subnetwork and considered as input gene features several expression data and chemo-genomic profiles (Hillenmeyer et al., 2008).

The evaluation of the models by cross-validation shows that we are able to predict new interactions with a reasonable accuracy. Through feature relevance ranking, the approach should also shed new light on the biology behind the interactions. Future works will consider the addition of new input features and a thorough analysis of genome-wide predictions.

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Enzymatic protein prediction from structure using a segment and combine approach

Julien Becker, Louis Wehenkel, Pierre Geurts, ULg

Abstract

Numerous applications in bioinformatics exploit complex objects often represented by graphs, in which nodes correspond to elementary components and vertices correspond to relations between these components. The study of macroscopic properties of these objects aims to understand the relation that exists between the topology of the graph and the target property. In this work, we are interested in using supervised machine learning

techniques to automatically build a predictive model for some target property of a class of graphs from a database of graphs of this class for which this property is known. As an example application, we consider the problem of predicting the function of a protein from its 3D structure.

The proposed method is a first attempt to apply the "Segment and Combine" principle to graphs . It consists of four steps: (i) each protein in the learning sample is converted to a graph using the 3D positions of its amino acids (ii) each graph is segmented into one or more pieces that can be represented by equal-size vectors (iii) a standard supervised learning method is applied on the sample of segments to build a model for predicting the label of each segment (which is directly derived from the label of its parent protein) (iv) Finally, a class prediction for a new protein is computed from the classifications of all its segments by the classifier.

We have explored several alternatives at each of these four steps and compared them with existing methods on a benchmark problem aiming at distinguishing enzymatic and non-enzymatic proteins. Our results in terms of accuracy show that the proposed approach is promising.

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Statistical processing of images defined on nonlinear spaces and application to brain diffusion tensor imaging

Anne Collard and Rodolphe Sepulchre, ULg

Abstract

Diffusion Tensor Imaging (DTI) is a relatively new technique of brain imaging, producing a diffusion tensor for each voxel of the brain. This technique is emerging as an important tool in medical image analysis of the brain, and notably of brain connexions. Diffusion tensors give information about anisotropy of the matter, and, in case of white matter, about the directions of axons. These informations can be exploited to reconstruct nervous fibers (a technique called tractography) and study connexions between different areas of the brain.

This work will be part of a study which implies MRI and DTI measures of 500 subjects. While many techniques are available to process and compare MRI images, relatively little work has been done on statistical processing of DTI images. So far, many of the processing techniques developed for DTI images are applied on only one subject, and registration of subjects is either limited to the case of 2 subjects or time-consuming.

For our population study, the question arises of how to compare DTI images of different subjects in a fast and efficient way. A main difficulty to answer this question is that the space of diffusion tensors (the space of symmetric, positive-definite matrices) does not form a vector space. Some groups avoided this difficulty by using a scalar approximation (e.g. FA, Fractional Anisotropy). In this study, we want to keep all information given by the tensors and must then do the calculus on the diffusion tensor space. This space is in fact a

type of curved manifold known as a Riemannian symmetric space. Therefore, methods for the processing (i.e. filtering, registration, and statistical analysis) of diffusion tensor images have to be developed in this particular space, by using the general theory of optimization on manifolds.

******

One-shot multigrid for the optimal control of time-periodic partial differential equations

Dirk Abbeloos, Stefan Vandewalle, Moritz Diehl, KUL2

Abstract

We present a one-shot multigrid method for the optimal boundary control of time-periodic, linear, parabolic partial differential equations. We focus on optimal control problems of the tracking type, i.e., we try to steer the PDE solution such that it matches a prescribed periodic trajectory, or segment thereof, as closely as possible. To that end we derive the optimality conditions of such problems. We develop a multigrid method for solving the resulting coupled system of forward and backward time-periodic equations.

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Learning control of mechatronic systems

Pieter Janssens, KUL2

Abstract

In ILC, a feedforward signal is learned iteratively using error information from previous trials. The goal of this research is to develop iterative learning control (ILC) algorithms for linear systems such that the ILC technique can be applied to a broader class of control problems. The aim is to tackle some of the remaining challenges in the field of iterative learning control such as taking into account model uncertainty and actuator constraints and learning nonidentical reference trajectories.

******

Rational design of proteins with modified stability and solubility

Malik Dhanani, Benjamin Folch, Yves Dehouck, Marianne Rooman, ULB

Abstract

The project aims at developing a program for predicting the change in thermal stability and solubility of proteins upon mutations. This program will allow proposing very rapidly a series of sequence mutations likely to have the required thermostability and solubility properties, and will be of valuable help in the rational design of modified proteins - a challenge of fundamental and applied research. The basic ingredients of the program will consist of temperature-dependent statistical potentials derived from proteins of known structure and melting temperature, as well as a neural network model for the identification of the parameters so as to minimize the difference between prediction and measurement on a set of mutations for which the change in melting temperature is known.

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Modelling, optimization and control of yeasts fermentation processes in food industry

Anne Richelle, ULB

Abstract

The global aim is to propose, in the context of yeast fermentations in food industry, methods for determining operational conditions optimizing objective criteria (productivity, reproducibility, compliance with the product specifications: activity, stability, ability of the yeast to be dried) and closed loop controllers allowing to maintain these optimal conditions on line. Command signals (influencing these objective criteria) and measured signals (witnesses of the commands impact on the process behavior and on these criteria) will be selected, being sure that they are indeed available in the industrial context. In order to quantify that impact, microscopic models describing the yeast metabolism will be used. Due to their complexity (leading to problems regarding parameter estimation and use for the controller synthesis), model reduction techniques will be used so as to obtain macroscopic models (biomass and extracellular components). The optimal conditions and the controllers will be deduced from these mathematical models. The fermentation experiments for the parameter estimation of the models and for the optimal conditions and controllers validation, will be realized with the pilot bioreactor of the 3BIO department and in the fermentation R&D department or our industrial partner Beldem. Besides the increase of quality and reproducibility at the level of the production, the proposed solutions will lead to a higher flexibility and to a time and costs reduction at the level of the process development.

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A platoon based model for urban traffic networks: identification, modeling and distributed control

Nicolae Marinica, UGent

Abstract

Urban traffic control poses a challenging problem in terms of coordinating the different traffic lights that can be used in order to influence the traffic flow. The goal of this approach is to identify and to develop hybrid system models of controlled and uncontrolled intersections and links in urban traffic networks based on formation of platoons. The other purpose is to develop a feedback control algorithm that optimizes the signal timing plan based on the strategy of platoons formation estimated via the vehicle re-identification technology.

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Distributed Voltage Control in Electrical Power Systems

Mohammad Moradzadeh, UGent

Abstract

Voltage instability stems from the attempt of load dynamics to restore power consumption beyond the capability of the combined transmission and generation system. Discrete event controllers such as load tap changing transformers (LTCs), electronically controlled HVDC lines and switched capacitor banks can locally maintain the voltage but following a major disturbance that causes a strong decrease in the voltages, there are some interaction between LTCs action and up to now there has been relatively little attention paid to coordination between important components in voltage stability using message exchange between them and applying distributed control and taking discrete events into account. So, this study aims at voltage stability enhancement by using coordinated control of the discrete event controllers by using message exchange between the different local control agents. Various approaches for coordinating local controllers (e.g. distributed model predictive controllers) will be investigated. The influence of the discrete event driven local voltage controllers on remote locations of the network has to be investigated in a hybrid systems model framework.

******

Control of Animal Cell Cultures

Ines Saraiva, UMons

Abstract

The objective of this new project is to develop on-line monitoring and control tools for cultures of animal cells operated in perfusion mode. This project is motivated by the fact that most of the currently available culture media include all the necessary components in large excess, which are wasted due to partial use only. In order to reduce the operating costs, and to optimize the process productivity, it is appealing to develop the concept of "dynamic growth medium", in which a multivariable controller would allow to act on several component concentrations simultaneously, in agreement with the estimated cell metabolism. In turn, this implies the development of adequate metabolic models, estimation and control schemes.

******

Image segmentation and Video tracking

Browet Arnaud, UCL

Abstract

Computer vision has been a very active topic in the last few decades but there is still progress needed in robust, reliable and stable algorithms (for handling problems such as noise, occlusion, deformable objects, etc..). We will focus on the real-time video tracking problem and explore different image segmentation techniques from a wide variety of domains such as graph cuts, community detection in graphs, snakes or active contours, partial differential equation solutions for energy minimization. We plan to adapt those techniques and develop new ones to address real-time video tracking in various fields such as remote sensing for collision detection and video surveillance.

******

Dextrous Manipulation in Microgravity: Motor Planning and Interaction with Robots

Dasnoy Thibaut, UCL

Abstract

this thesis will investigate the neural mechanisms underlying the control of movements of the upper limb. An experimental approach will address the adaptation of subjects to different gravity levels induced by parabolic flights and to external perturbations induced by robotic devices. These experiments aim at modelling the internal representations of the limb dynamics, movement control and object manipulation mechanisms within the central nervous system.

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Dexterous Manipulation in Microgravity: Mechanical properties of the fingertip-object contact.

Delhaye Benoît, UCL

Abstract

The aim of the project is to study the mechanical properties of the fingertip and their influence on the control of grip force when manipulating objects. More specifically, we will study how information from skin afferent s allows characterising the properties of an object when grasping it. This information is of prime importance to prevent the object from slipping with a minimal grip force as a function of the friction properties of the fingertip-object interface. Moreover, we will focus on the influence of a change in gravity on these mechanisms.

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Visual tracking in cerebral-palsied children: influence on learning and exploration of new avenues for rehabilitation

Ego Caroline, UCL

Abstract

Cerebral palsy (CP) is a group of permanent disorders of movement and posture due to a non-progressive lesion of the fetal or infant brain. The motor disorders in cerebral-palsied children are often accompanied by several disabilities including sensation, perception or cognition impairments. In particular, previous studies showed a high prevalence of learning disorders in cerebral-palsied children. The goal of the present study is to point out subclinical deficits in oculomotor performances of children with low level of severity of CP by comparing their performances to those recorded in age-matched control children between 6 and 14 years. Indeed, subtle oculomotor deficits such as impaired saccade pursuit interaction or poor anticipation and prediction skills in oculomotor strategies may be an important cause of learning disabilities. The underlying purpose of this study is to investigate new paths for rehabilitation in cerebral-palsied children.

******

Nearest Stable Continuous Time System using Convex Optimization

Orban de Xivry François-Xavier, UCL

Abstract

Stability is a crucial feature for dynamical systems. In the literature researchers have focused on keeping their system stable under perturbations and have developed various theories to find the smallest perturbation that would drive the system to instability. In this work, we do the opposite reasoning. From a unstable system under matrix form, we aim at finding the nearest stable system to it in the sense of the Frobenius norm. The problem is formulated as a non-linear optimization problem over convex approximations of the stable set. From a point inside the stable region, we built successive ellipsoidal approximations of the stable set and project the unstable system onto that ellipsoid. The theory calls for different aspects of both numerical analysis, matrix theory and non-linear optimization over convex sets.

******

Flood control of the Demer with Model Predictive Control in combination with Moving Horizon Estimation

Maarten Breckpot, KUL1

Abstract

River floodings are worldwide a recurring phenomenon with often disastrous injuries to people and large scale damage on their properties, public infrastructure and the economy. The Demer, a river in Belgium, has a history of large floodings. As a countermeasure to prevent floodings in the future, the regional water authority embanked the river and installed hydraulic structures and flood basins. This reduced the number and the impact of floodings significantly, although the current controller system could not prevent new disasters during periods of heavy rainfall in 1998 and 2002. This research investigates whether these floodings could have been prevented with Model Predictive Control (MPC). Because the river models behave strongly nonlinear, nonlinear model predictive control will be used. It is also necessary to incorporate a state estimator as only some of the states of the Demer are measured in practice. For this research a Moving Horizon Estimator (MHE) will be used.

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Signal processing for multimodal perinatal monitoring

Alexander Caicedo Dorado, KUL1

Abstract

the aim pof this phD project is the development of novel multimodal signal processing techniques based on multi-way signal and 3D canonical correlation analysis in order to extract the common dynamics among multiple neonatal recordings (cerebral oxygenation, EEG, ECG, EOG, EMG, respiration, saturation, etc...) in order to monitor and detect risk situations in an automated way.

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Epileptic Seizure Detection

Borbala Hunyadi, KUL1

Abstract

Epilepsy is a neurological disorder, where abnormal electrical discharges in the brain cause seizures. The abnormal brain activity appears on EEG recordings, therefore it can be used for epileptic seizure detection.

This project is aiming at developing a mimetic detection algorithm, inspired by an existing method for neonatal seizure detection. According to the preliminary results, the method looks promising. However, there are significant differences between neonatal and adult siezures; moreover, several artifacts, such as blinking, muscle or chewing artifacts contaminate adult recordings. The above mentioned factors have to be taken account when developing an optimal algorithm for adult epileptic seizure detection.

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Perceptually optimal clipping of audio signals

Bruno Defraene, KUL1

Abstract

Clipping consists of confining the amplitude of an audio signal to the audio systems available amplitude range, while maximally preserving sound quality. This operation is of utmost importance in small, portable audio devices such as cell phones, MP3 players and hearing aids. The goal of this project is to design, implement and evaluate novel algorithms that perform clipping of an audio signal in a perceptually optimal way. The proposed approach is to formulate clipping as a constrained optimization problem. This calls upon principles of psychoacoustics, the study of human perception of sounds. A significant improvement of sound quality as compared to state-of-the-art clipping algorithms is aimed at. Moreover, algorithms should be executable in real time.

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