IAP VII/19 DYSCO

Dynamical systems

control and optimization

Château-Ferme de Profondval

8 October 2012

DYSCO Study Day, Kickoff of phase VII (2012-2017)

9 October 2012

JojoFest, Celebration of Georges Bastin
becoming Emeritus professor

IAP VII/19
DYSCO

Université catholique
de Louvain

The DYSCO Network 2012-2017

Belgian Partners

- Université catholique de Louvain (UCL)
  Promoter: Professor Vincent BLONDEL
  Web: http://www.uclouvain.be/inma

- Katholieke Universiteit Leuven (KUL)
  Promoter: Professor Joos VANDEWALLE
  Web: http://www.kuleuven.be/optec/

- Universiteit Gent (UGent)
  Promoter: Professor Dirk AEYELS
  Web: http://www.systems.ugent.be/

- Vrije Universiteit Brussel (VUB)
  Promoter: Professor Rik PINTELON
  Web: http://wwwir.vub.ac.be/elec/

- Université de Liège (ULg)
  Promoter: Professor Rodolphe SEPULCHRE
  Web: http://www.montefiore.ulg.ac.be

- Université de Mons (UMons)
  Promoter: Professor Alain VANDE WOUWER
  Web: http://www.umons.ac.be/Polebiosys/

- Université de Namur (FUNDP)
  Promoter: Professor Joseph WINKIN
  Web: http://www.fundp.ac.be/en/sci/naxys

International Partners

- Stanford University (Stanford)
  Promoter: Professor Stephen BOYD
  Web: http://stanford.edu/group/isl/cgi-bin/wordpress/

- Princeton University (Princeton)
  Promoter: Professor Naomi LEONARD
  Web: http://www.princeton.edu/mae/

- Massachusetts Institute of Technology (MIT)
  Promoter: Professor John TSITSIKLIS
  Web: http://lids.mit.edu/

Time Schedule

Monday 8 October 2012 - DYSCO Study Day, Kickoff of phase VII (2012-2017)

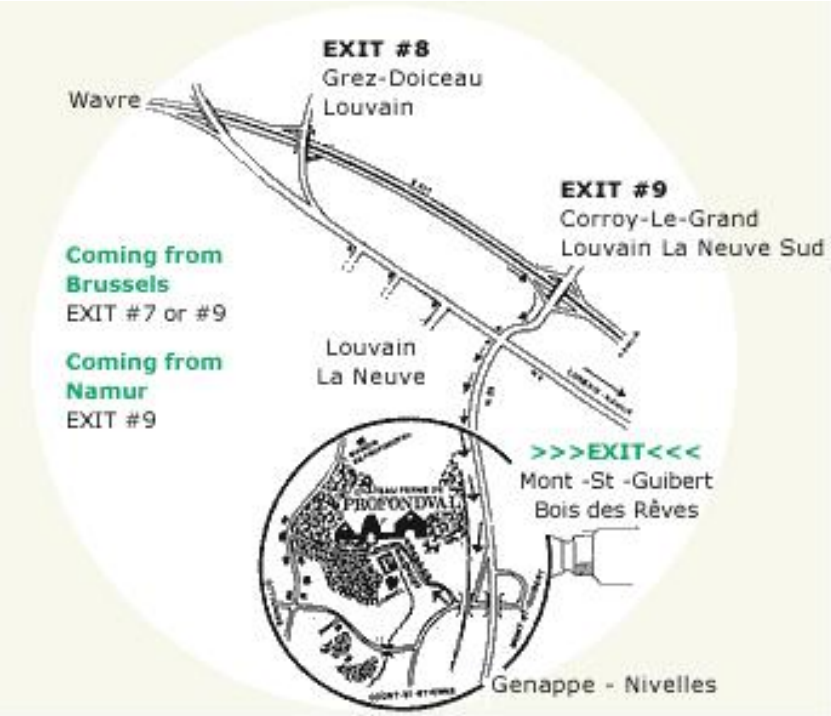
09:00 Welcome breakfast & coffee
09:30 Registration at the Welcome Desk
10:00 Welcome and introduction by **Vincent Blondel**, DYSCO coordinator
10:10 Introduction of the new partners : Stanford University, Princeton University, Massachussetts Institute of Technology, FUNDP University of Namur, UGent University of Ghent
10:45 Poster spotlights (1 page and 1 minute per poster)
11:00 Poster session 1 & Coffee break
12:00 **Philippe Mettens** (Director of the Belgian Science Policy): "Science and Society"
12:30 Lunch
13:45 **Paul Van Dooren** (UCL): Science in the news : "On the Sparse Fast Fourier Transform"
Source article : "Nearly Optimal Sparse Fourier Transform" by Haitham Hassanieh, Piotr Indyk, Dina Katabi, and Eric Price
14:00 Plenary talk, Francqui lecture by **Yurii Nesterov** (UCL): "Algorithmic Optimization: new challenges in the old field"
14:45 Poster spotlights (1 page and 1 minute per poster)
15:00 Poster session 2 & Coffee break
16:00 Plenary talk by **Jean-Jacques Slotine** (MIT, USA): "Synchronization and Controllability in Biological Systems"
17:00 End of the scientific program (meeting of the DYSCO academics at 17:15)

Tuesday 9 October 2012 - JojoFest, Celebration of Georges Bastin becoming Emeritus professor

09:00 Welcome breakfast & coffee
10:00 Introduction
10:10 **Iven Mareels** (University of Melbourne, Australia): "An Introduction to Extremum Seeking: 1922-2012"
10:50 **Miroslav Krstic** (University of California at San Diego, USA): "Stochastic Extremum Seeking"
11:30 Coffee break
11:50 **Jean-Michel Coron** (Institut Universitaire de France): "On the control of 1-D hyperbolic systems"
12:30 Lunch
14:00 **Laurent Praly** (Ecole des Mines de Paris, France): "Necessary conditions convergence for observer convergence"
14:40 **Olivier Bernard** (INRIA, France): "From hydrodynamics to metabolism: modelling and analyzing the fast time scale response of microalgae to light"
15:20 **Jan Van Impe** (KU Leuven, Belgium): "The Tree of Life: a Systems Biology approach to Bioprocess Optimization"
16:00 Coffee break
16:30 **Rodolphe Sepulchre** (Université de Liège, Belgium): "Contraction analysis: a late attempt to answer early questions by Jojo"
17:10 **Brigitte d'Andréa-Novel** (Ecole des Mines de Paris, France): "Estimation and control of wind instruments : a meeting between science and music"
17:50 End of the scientific program, group picture
18:00 Banquet (on invitation)

Practical Information

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



Plenary Lectures

On the "Sparse Fast Fourier Transform"

Paul Van Dooren, UCL

Abstract

In this talk we will try to explain the basic ideas behind the recent development of a "superfast" version of the Fast Fourier Transform that runs in $O(k \log n)$ time when the n-dimensional signal has at most k non-zero Fourier coefficients and in $O(k \log n \log(n/k))$ time for almost all n-dimensional signals.
Ref : H. Hassanieh, P. Indyk, D. Katabi, E. Pryce, Nearly Optimal Sparse Fourier Transform, ArXiv.

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Algorithmic Optimization: new challenges in the old field

Yurii Nesterov, UCL

Abstract

During the last decades, Optimization Theory was one of the most developing fields of Computational Mathematics. Now it consists of several powerful approaches, which can treat problems of very big size up to a high accuracy. In many cases, an intelligent use of problem structure allows to overcome the efficiency bounds of the standard optimization theory. At the same time, new randomized algorithms open a possibility of solving problems of practically unlimited dimension. Theoretical complexity analysis of optimization methods became a powerful tool for designing the new schemes, which are able to prove their superiority both in theory and in practical computations. Awareness of all these developments is important for people interested in different applications of optimization technique.

In this lecture, we describe the state of art in Convex Optimization. We start from discussion of general principles of complexity analysis and explain the key elements of classification of optimization problems and efficiency of optimization schemes.

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Synchronization and Controllability in Biological Systems

Jean-Jacques Slotine, Massachusetts Institute of Technology

Abstract

Issues of synchronization, control, measurement, and composability are pervasive in complex networks, such as e.g. those encountered in systems biology and systems neuroscience. We show that dynamic systems analysis tools yield simple but highly non-intuitive predictions about such questions. The development makes extensive use of nonlinear contraction theory and of recent work on network controllability.

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An Introduction to Extremum Seeking: 1922-2012

Iven Mareels, University of Melbourne
joint work with Ying Tan, University of Melbourne

Abstract

We review extremum seeking as a form of adaptive control from its early inception in 1922 to its widespread use across many different engineering applications in 2012. The insightful contributions made by Prof Bastin are highlighted.

The first survey paper (going back to 1966) on extremum seeking describes extremum seeking as "a control system which is used to determine and to maintain the extremum value of a function". If one allows this function to be a steady state input-output map associated with a family of asymptotically stable equilibria of a dynamical system, then this description captures the idea of extremum seeking very well. It also reveals the difficulty one faces to establish a comprehensive design framework, as the domain of applicability for extremum seeking is indeed rather dauntingly large. As with much of adaptive control, extremum seeking is a tool, with a loose design framework, to be clarified in the particular application at hand.

In extremum seeking control, the extremum has to be found and maintained, without necessarily having a description of the steady state map of interest. Rather, all that is assumed is that the steady state map exists, and possesses some sensible stability and attractivity properties, and that it attains an extremum for some input value in a given operational range of this input. These conditions are typically met in engineering applications.

The extremum seeking approach is to probe the steady state input-output map through a small dither superimposed on the slowly adjusted input. Correlating the effect of this dither in the output with the dither itself, leads to a particular estimate of the gradient of the steady state map with respect to the input. Integrating this gradient in the appropriate direction, a steepest ascent or steepest descent, algorithm can be envisaged to locate an

extremal input and its corresponding output. A small dither persisting in the input and output, is the price one pays for locating the "best" operational point in the input-output map.

The basic idea can be traced back to the 1922 patent application by Leblanc. He describes a mechanism to maintain maximum power transfer in an air-transformer subject to a variable air-gap between the secondary and primary transformer windings. Leblanc explains what essentially is the first extremum seeking algorithm, using a sinusoidal dither function.

During World War II, extremum seeking became an important topic of research and application in Russia. Probably the first, English literature paper describing a form of extremum seeking control described MIT initiated research in 1951. In their paper Draper and Li seek to optimize an internal combustion engine to achieve maximum power using an extremum seeking approach. Due to the inherent complexity of the associated steady state behaviour, extremum seeking remains to this date a very popular approach in the management of internal combustion engines.

Whilst great progress has been made on the theory of extremum seeking, especially in the last two decades, the practice of extremum seeking has grown much more rapidly. New application domains are constantly being added. Often extremum seeking is even practiced where theory fails to explain the actual behaviour of the algorithms in sufficient detail. Indeed although the general principles are well understood, there is still much work to be done before a reliable, and relatively comprehensive design framework for extremum seeking control is established.

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Stochastic and Infinite-Dimensional Extremum Seeking

Miroslav Krstic, University of California at San Diego

Abstract

Extremum seeking (ES) employs periodic or stochastic perturbation signals to estimate the gradient and/or Hessian of a cost map whose functional form is unknown. Jojo was an early partner in this endeavor, introducing me to opportunities for extremum seeking algorithms in the area of biochemical processes, where ES has to cope with bifurcations, and stimulating the work of other leading researchers on ES. I will present recent ES designs that provably converge to Nash equilibria in finitely- and infinitely-many player noncooperative games. A Newton-based ES scheme will be presented, which removes the dependence of the algorithm's convergence rate on the unknown Hessian. Stochastic analogs of standard ES algorithms will be presented, along with a new stochastic averaging theory in continuous time and free of global Lipschitz restrictions, which enables the proofs of the algorithms' convergence.

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On the control of 1-D hyperbolic systems

Jean-Michel Coron, Institut Universitaire de France

Abstract

This talk concerns the control of 1-D hyperbolic systems. We first study the controllability issue (Li Tatsien and Rao theorem). Then we move to the stabilization problem. We show how the use of "localized control Lyapunov functions" can be used to construct stabilizing feedback laws. We also give an explicit limitation of this method in the case of 2x2 balance laws and then show how Krstic's backstepping approach can be used to overcome this difficulty. Most of the results of this talk are joint works with Georges Bastin.

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Necessary conditions convergence for observer convergence

Laurent Praly, Ecole des Mines de Paris

Abstract

Usually we restrict our attention to observers with a very specific structure. But then designing them to guarantee convergence may be quite difficult. Hence the question how much of this structure is necessary ? We answer this question indirectly by giving necessary conditions on the system to guarantee the existence of a convergent observer with the given structure which is that the observer has a state dimension smaller or equal to the one of the system.

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From hydrodynamics to metabolism: modelling and analyzing the fast time scale response of microalgae to light

Olivier Bernard, INRIA

Abstract

Microalgae are often considered as one of the potential major source of biofuel for the future. These photosynthetic microorganisms can be cultivated in a high rate pond, where a paddle wheel agitates the culture medium in a raceway shaped shallow pond. The solutions of the Navier-Stockes equations describing the hydrodynamics of the system are approached by a multi layer Saint-Venant framework (Sainte-Marie, 2011), providing an estimation of the velocity field in the raceway. The trajectories of individual cells are then reconstructed using Lagrangian approach. Since light is exponentially decreasing with depth, it turns out that the cells experiment a succession of dark and light phases. Such

realistic light pattern was used to feed a physiological model (Han, 2002), where the key metabolic reactions of the photosynthesis are represented. In particular, the dynamical effect of inhibition by an excess of light (photoinhibition) is explicitly represented. This model involves two different time scales. We study the response of this model to fluctuating light with different frequencies by slow fast approximations. Therefore, we identify different regimes for which a simplified expression for the model can be derived. The dynamics of a microalgal cell, when it is submitted to a realistic light pattern is then used to predict the overall photosynthesis efficiency of the production system. The frequency of the light pattern, and therefore the overall photosynthetic yield, can be computed as a function of the paddle wheel agitation speed. It is then shown that there exists an optimal agitation velocity, which maximises the net bioenergy produced.

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The Tree of Life: a Systems Biology approach to Bioprocess Optimization

Jan Van Impe, Katholieke Universiteit Leuven

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Contraction analysis: late answers to early questions by Jojo

Rodolphe Sepulchre, Université de Liège

Abstract

As a PhD student and as a postdoc, I used to be regularly challenged by Jojo with questions that I was never fully sure to interpret as semi-jokes or semi-serious scientific questions. Those that I remember all turned to be deep and fundamental. But it often took me many years to properly understand them. In this talk, I will describe two of them. The first one is about the existence of a positive observer for positive linear systems. The second one is about the construction of a Lyapunov function for a pendulum with non-zero constant forcing.

I will discuss the importance of those questions and why I now consider that contraction analysis is the right framework to address them. Although I read my first contraction paper at about that same time, the connection of contraction to Jojo's early questions is based on recent work with Silvre Bonnabel and Fulvio Forni.

S. Bonnabel, A. Astolfi, R. Sepulchre, Contraction and Observer Design on Cones, Proceedings of the 50th IEEE Conference on Decision and Control and European Control Conference, Orlando, Florida, pp. December 2011.

A differential Lyapunov framework for contraction analysis F. Forni and R. Sepulchre, arXiv:1208.2943.

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Estimation and control of wind instruments : a meeting between science and music

Brigitte d'Andréa-Novel, Ecole des Mines de Paris

Abstract

In this talk, we are interested in music instruments represented by two hyperbolic PDEs of conservation laws. Two examples of wind instruments will illustrate how systems control theory can be applied in the context of music applications both for control and estimation problems.
Wind instruments are usually made of a linear acoustic resonator (the pipe) coupled with a nonlinear oscillator (the mouth of the instrument). The resonator can be modeled through two hyperbolic wave equations. We will consider two kinds of instruments: the first one is a slide flute, namely a kind of recorder without finger holes but which is ended by a piston mechanism to modify the length of the resonator. The control problem is here to stabilize a periodic orbit corresponding to a desired note. Taking into account a realistic model of the air jet obtained by blowing through a flue channel and formed by flow separation at the flue exit, and finally directed towards a sharp edge called the labium, the resulting structure can then be seen as a nonlinear oscillator with delay coupled with the resonator, which can be seen itself as a time delay system. A modal analysis is performed using the linearized boundary conditions which can also be used to compute the suitable blowing pressure (linked to the mouth delay) and the suitable pipe length (linked to the pipe delay) to obtain a desired fundamental frequency or equivalently a desired pitch. This will constitute the feedforward part of our control algorithm which has to be completed by closed-loop terms, the length of the piston being measured as well as the pressure in the mouth.
The second example will concern the case of a simplified trumpet-like instrument composed of a valve (including the mechanics of the lips), an air jet coupled with the valve dynamics and an acoustic pipe excited by the jet and radiating in the air. The problem is here to construct an asymptotic observer of the whole state of the system which can be described by a so-called nonlinear neutral state space system, the state of which being the position and velocity of the valve aperture and the ingoing wave of the pressure at the entrance of the pipe. The measured output is the pressure at the open end of the resonator and the control is the mouth pressure. We elaborate a local asymptotic observer of the state, the stability of which being proved using Lyapunov techniques.

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Poster Session I

LS-SVM approximate solution to linear time varying descriptor systems

Siamak Mehrkanoon, Johan Suykens (KUL)

Abstract

This paper discusses a numerical method based on Least Squares Support Vector Machines (LS-SVMs) for solving linear time varying initial and boundary value problems in Differential Algebraic Equations (DAEs). The method generates a closed form approximate solution. The results of numerical experiments on different systems with index from 0 to 3, are presented and compared with analytic solutions to confirm the validity and applicability of the proposed method.

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The model-free control methodology : from theory to applications

L. Michel and W. Michiels (KUL)

Abstract

The model-free control methodology that has been recently developed in the previous years, has been successfully applied experimentally and in simulation to many multidisciplinary non-linear engineering problems. This control law is now known as robust against most dynamical disturbances of the controlled process. In particular, input or internal time-delays, switching state-spaces, strong uncertainties or model changes can be considered without significant loss of performances. Some theoretical studies provide basic stability results as well as a possible derivation to robustify and simplify the original model-free control.

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Genetic ideas in optimizing the engagement of a wet clutch system

Yu Zhong, Bart Wyns, Abhishek Dutta, Clara-Mihaela Ionescu, Wim Symens, Gregory Pinte, Julian Stoev, Robin De Keyser (UGent)

Abstract

A wet clutch system is a typical system such that its working principle can be easily explained but very hard to obtain a model for control propose. By now, a wet clutch system is usually controlled by sending a pre-defined parameterized signal. The values of the parameters are usually set empirically. Towards a more efficient control propose, we will first implement genetic algorithms to optimize the parameterized signal. The genetic algorithms are representative implementation of the genetic ideas in the engineering optimization. It uses the idea of Darwin's fittest survive philosophy. By giving more possibilities to the more fitted parents to generate the off spring, the global optimal can be achieved with the evolution process. After we obtain the global optimal by using genetic algorithms at the experiment condition, we notice that the temperature of the oil also plays an important role in the engagement. So that we introduce the Fibonacci algorithm, another genetic inspired optimization algorithm, to adapt the temperature variance online based on the results we get from the genetic algorithms. The results are satisfactory. And the combination of these two algorithms can solve the engineering optimization problem efficiently.

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Accuracy-complexity trade-off of some nonlinear identification methods: benchmark case studies

Anne Van Mulders, Laurent Vanbeylen, Anna Marconato (Dept. ELEC, VUB)

Abstract

This poster shows a comparison of the results of several nonlinear system identification techniques on a number of benchmark examples. An effective graphical representation is used to evaluate the trade-off between model quality and number of parameters. An interpretation of the results allows one to group the families of the considered nonlinear models: block-oriented, nonlinear state-space, neural networks models, ... Some theoretical open issues need still to be addressed and will be raised during the discussion.

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Determining the Dominant Nonlinear Contributions in a multistage Op-amp in a Feedback Configuration

Adam Cooman, Gerd Vandersteen (VUB)

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Learning exploration/exploitation strategies for single trajectory reinforcement learning

Michael Castronovo and Damien Ernst (ULg)

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A unicellular mechanism to switch a network behavior from tonic activity to synchronous oscillations

Julie Dethier, Guillaume Drion, Alessio Franci, Rodolphe Sepulchre (ULg)

Abstract

Parkinson's disease (PD) is a neurodegenerative disorder affecting the basal ganglia (BG), a set of small subcortical nervous system nuclei. The hallmark of the disease is a dopaminergic denervation of the input stage of the BG, altering information patterns along movement-related ganglia-mediated pathways in the brain, inducing therefore movement disorders such as tremor at rest, bradykinesia, akinesia, and rigidity. It is still unclear how dopamine depletion causes those motor symptoms. Experimental studies have shown that abnormally synchronized oscillatory activities - rhythmic bursting activity at the neurocellular level and beta frequency band oscillations at the network level - emerge in PD at multiple levels of the BG-cortical loops and are correlated with motor symptoms. We propose a computational model of the BG using a novel unicellular mechanism to explain the induction of bursting activity and beta band oscillations in the network. We show how a single change in the dopaminergic level at the input stage of the BG can switch the model from its physiological state to the pathological state. This computational model also proposes a simple mechanism for high-frequency deep brain stimulations.

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Nitrogen and oxygen control in a recirculating aquaculture system: Classical versus model-based control

Pedro Almeida, Andres Donoso-Bravo, Anne-Lise Hantson, Marcel Remy, Alain Vande Wouwer (Université de Mons)

Abstract

Due to the growth of world population and change in food consumption habits, the aquaculture industry has become one of the world's fastest growing sectors in food production (FAO, 2007). Recirculating aquaculture systems (RAS) result from the need of more intensive practices, growing environmental constraints on water consumption and effluent quality, as well as the possibility to supply fish in places where it would be otherwise difficult (Gutierrez-Wing and Malone, 2006; Rijn et al. 2006). The main drawback of these systems is the accumulation of some toxic compounds, such as ammonia, when there is no proper treatment. Biofilters are the most commonly used technique for ammonia removal in aquaculture recirculation units because of their low energy consumption, ease of use, compactness and efficiency. They are also the most commonly used technique for the subsequent nitrate removal resultant from the nitrification process (Gutierrez-Wing, 2006; Rijn et al., 2006). Since the mortality of the fish due to excessive levels of ammonia and nitrate represents a decrease in the production income, it is interesting to develop control strategies that can keep these compounds at the desired concentration levels. As with what happens in common wastewater treatment plants incorporating nitrification and denitrification, recirculating aquaculture systems have usually a number of interacting control loops. This interaction, aided by the nonlinear nature of the system makes the implementation of common control strategies such as PID controllers difficult (Wahab et al. 09). Model predictive control resorts to a dynamic model of the system and solves an optimization problem in order to determine the best manipulated variables configuration while taking into account process variables targets and limits, leading to a more robust and efficient control. In this work, a comparison is made between both control strategies applied to a simulator of a recirculating aquaculture system developed in the MATLAB platform that mimics a large scale rearing facility. The model is composed of fish rearing tanks, physical filtration systems and nitrification and denitrification biofilters taking into account fish feeding, growth and excretion as well as the biological removal of the nitrogen compounds in a closed loop system. In order for the denitrification reaction to occur, an external carbon source is added in the denitrification biofilter. The considered controlled variables are the ammonia, nitrate and oxygen concentrations in the fish rearing tanks and the manipulated variables are the oxygen supplied to the nitrification basin, the carbon source added in the denitrification reactor and the flowrates of both the system and in the denitrification reactor.

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Follies subdued: Informational Efficiency under Adaptive Expectations and Confirmatory Bias

Timoteo Carletti, Gani Aldashev and Simone Righi (Namur Center for Complex Systems (naXys), University of Namur)*

Abstract

We study the informational efficiency of a market with a single traded asset. The price initially differs from the fundamental value, about which the agents have noisy private information (which is, on average, correct). A fraction of traders revise their price expectations in each period. The price at which the asset is traded is public information. The agents' expectations have an adaptive component and a social-interactions component with confirmatory bias. We show that, taken separately, each of the deviations from rationality worsens the informational efficiency of the market. However, when the two biases are combined, the degree of informational inefficiency of the market (measured as the deviation of the long-run market price from the fundamental value of the asset) can be non-monotonic both in the weight of the adaptive component and in the degree of confirmatory bias. For some ranges of parameters, two biases tend to mitigate each other's effect, thus increasing informational efficiency.

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Role Detection: Network Partitioning and Optimal Model of the Lumped Markov Chain

Maguy Tréfois (UCL)

Abstract

Nowadays, complex networks are present in many fields (social science, chemistry, biology, ...) as they allow to model systems with interacting agents. In many cases, the number of interacting agents is large (from hundreds to millions of nodes). In order to get information about the functionality of the underlying system, we are interested in studying the structure of the network. One way to do that is by partitioning the nodes of the network. In this poster, we present a method in order to detect a relevant partition of the network such that the dynamics of a random walker on the clustered network is a good prediction of the dynamics of a random walker on the original network.

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Dynamical Models Explaining Social Balance and Evolution of Cooperation

Vincent Traag (UCL)

Abstract

Social networks with positive and negative links often split into two antagonistic factions. Examples of such a split abound: revolutionaries versus an old regime, Republicans versus Democrats, Axis versus Allies during the second world war, or the Western versus the Eastern bloc during the Cold War. Although this structure, known as social balance, is well understood, it is not clear how such factions emerge. An earlier model could explain the formation of such factions if relationships were assumed to be symmetric initially. We show this is not the case for non-symmetric initial conditions. We propose an alternative model which (almost) always leads to social balance, thereby explaining the tendency of social networks to split into two factions. In addition, the alternative model may lead to cooperation when faced with defectors, contrary to the earlier model. The difference between the two models may be understood in terms of gossiping: whereas the earlier model assumed people talk about what they think of others, we assume people talk about what others did.

Poster Session II

Nonlinear loudspeaker compensation through embedded convex optimization

Bruno Defraene, Toon van Waterschoot, Moritz Diehl and Marc Moonen (KUL)

Abstract

In this poster, a novel nonlinear loudspeaker compensation technique is presented which is based on embedded convex optimization. The aim is to compensate for the linear as well as for the nonlinear perceptible distortions incurred in the loudspeaker. To this end, a psychoacoustic model is adopted and a convex optimization based problem formulation is set up. In order to solve the resulting convex optimization problems in a fast and reliable way, a projected gradient optimization method is proposed. From comparative objective evaluation experiments, it is concluded that the proposed nonlinear loudspeaker compensation technique indeed improves the average audio quality scores.

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Time-Optimal Path Following for Robots with Convex-Concave Constraints using Sequential Convex Programming

Frederik Debrouwere, Wannes Van Loock, Goele Pipeleers, Tran Dinh Quoc, Moritz Diehl, Joris De Schutter and Jan Swevers (KUL)

Abstract

Time-optimal path following considers the problem of moving along a predetermined geometric path in minimum time. In the case of a robotic manipulator with simplified constraints a convex reformulation of this optimal control problem has been derived previously. However, many applications in robotics feature non-convex constraints. We propose an efficient sequential convex programming (SCP) approach to solve the corresponding non-convex optimal control problems by writing the non-convex constraints as a difference of convex (DC) functions, resulting in convex-concave constraints.

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Parametric Dominant Pole Algorithm for Parametric Model Order Reduction

M. Saadvandi, K. Meerbergen, W. Desmet (KUL)

Abstract

Standard model order reduction (MOR) techniques attempt to build reduced order models of large scale systems, e.g, arising from mechanical modeling, with similar input-output behavior over a wide range of input frequencies as the full system. However, capturing dependency of the system's behavior w.r.t. variations of other factors is of crucial importance as well. Factors that need to be considered may be design or geometric parameters as well as influence of variations within the design process on the design's performance. The dominant pole algorithm is used for reducing the first and second order linear dynamical systems as well as nonlinear time-delay systems.The dominant poles and corresponding eigenvectors lead to a reduced system. In this poster, we present the dominant pole algorithm to find the dominant poles for the parametric system. In each iteration, we represent the solution by a subspace which spans the solutions of all parameter values of interest. This subspace converges to the dominant eigenvectors for all parameter values. We present various choices of such subspaces and show their use in applications.

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Stochastic analysis of traffic junctions

Willem Mélange, Dieter Claeys, Joris Walraevens (Department of Telecommunications and Information Processing, Ghent University - UGent)

Abstract

In traffic, it often happens that vehicles are hindered by other vehicles that have another destination. For instance on a junction, vehicles heading for destination A may be hindered or even blocked by vehicles with destination B, even when the road to destination A is free. This is simply because they have to wait in line in a first-come-first-served (FCFS) manner on the road leading to the junction. Our objective is to study junctions in terms of throughput, stability and other performance measures, among which the mean delay of vehicles. These results aid in determining the optimal length of a filter lane, i.e. a lane reserved for those making a specific destination at the next junction. As traffic is not deterministic, we develop and analyze appropriate queueing models. These models are extremely suited to incorporate specific stochastic features of the application at hand.

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Dealing with Correlated Errors in Least-Squares Support Vector Machine Estimators

John Lataire (Vrije Universiteit Brussel), Dario Piga (Technische Universiteit Delft), Roland Toth (Technische Universiteit Eindhoven)

Abstract

Least-squares support vector machines (LS-SVM's) are known to be versatile estimators of static functions. They are stochastically unbiased in an output error framework, even if the output noise is correlated. However, they require the calibration of a set of hyper parameters to avoid overmodelling (to minimize the variance), which can be hampered if the output noise is correlated. In this poster, a frequency-domain formulation of the LS-SVM estimator of a static function is proposed to deal with correlated output noise. It relies on the fact that correlated noise, if it is stationary, is not correlated in the frequency domain. This ensures efficient function estimation via sound calibration of the hyper parameters. The method is shown to be applicable to the identification of time-varying FIR filters, where the output signal is disturbed by correlated measurement noise.

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Combining the best linear approximation and dimension reduction to identify the linear blocks of parallel Wiener systems

Maarten Schoukens, Christian Lyzell, Martin Enqvist (VUB)

Abstract

A Wiener model is a fairly simple, well known, and often used nonlinear block-oriented black-box model. A possible generalization of the class of Wiener models lies in the parallel Wiener model class. This poster presents a method to estimate the linear time invariant blocks of such parallel Wiener models from input/output data only. The proposed estimation method combines the knowledge obtained by estimating the best linear approximation of a nonlinear system with a dimension reduction method to estimate the linear time invariant blocks present in the model. The estimation of the static nonlinearity is fairly easy once the linear blocks are known.

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A computationally efficient algorithm for the provision of a day-ahead modulation service by a load aggregator

Sébastien Mathieu and Damien Ernst (ULg)

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Control of a lower limb prosthesis by means of eye movement sequences: a concept

Matthieu Duvinage, Thierry Castermans (Université de Mons)

Abstract

For a few years, Brain-Computer Interfaces (BCIs) based on electroencephalographic (EEG) signals have grown up at an impressive speed. These systems allow communication through direct measures of brain activity and allow their users to control a computer or any electronic device with thought alone. However, BCIs are limited in terms of information transfer rates and may suffer from a lack of reliability. Brain Neural Computer Interaction systems (BNCIs) are similar but rely on indirect and easier measures of brain activity, like electrooculographic (EOG) signals for example. In this poster, we explain how these signals can be exploited to drive a lower limb prosthesis during locomotion. Firstly, two algorithms are presented: on the one hand the detection of specific eye movement sequences, which will be translated as high-level commands to the prosthesis actuator. On the other hand, a simulator of the human walk kinematics a Programmable Central Pattern Generator (PCPG) which is stable and whose parameters like stride length or stepping frequency can be modulated smoothly. We finally explain the concept of combining both tools to control the prosthesis thanks to the eye movements.

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Efficient Control for Accelerator Maps

Jehan Boreux and Timoteo Carletti (Namur Center for Complex Systems (naXys), University of Namur)*

Abstract

Hamiltonian Control Theory is used to increase the dynamic aperture of a ring particle accelerator having a localized thin sextupole magnet. We present these results including a simplified version of the obtained general control term leading to significant improvements of the dynamic aperture of the uncontrolled model. In order to exhibit the numerical results the following tools are used : the chaos indicator SALI, the Frequency Map Analysis and the Normal Form theory.

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"Late for good", sensing mobility of train users

Renaud Lambiotte and Vsevolod Salnikov (Namur Center for Complex Systems (naXys), University of Namur)*

Abstract

Human mobility has attracted much attention in the last few years. This trend has been driven by the availability of large electronic datasets capturing our exact location whenever we make a phone call or check in using online services. Unfortunately, most data-sets are proprietary and, when made available, focus on past time periods. To overcome these limitations, we are developing a mobile app tracking human mobility and offering proper incentives for train users to adopt our service.

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Intermediate gradient methods for smooth convex optimization problems with inexact oracle

Olivier Devolder (UCL)

Abstract

Between the slow but robust gradient method and the fast but sensitive to errors fast gradient method, we develop new intermediate gradient methods for smooth convex optimization problems. We show that these new intermediate first-order methods can be used in order to accelerate the minimization of a smooth convex function when only inexact first-order information is available. Joint with François Glineur and Yurii Nesterov.

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