Special Session 24: Optimization and Optimal Control with Applications

K.L. Teo, Curtin University of Technology, Australia
L. Caccetta, Curtin University of Technology, Australia
C.C. Lim, The University of Adelaide, Australia

It is our great pleasure to organize this special session: Optimization and Optimal Control with Applications for the 6th AIMS International Conference on Dynamical Systems, Differential Equations & Applications, to be held in Poitiers, France during June 25-28, 2006. It is well recognised in the importance of optimization and optimal control in dealing with the ever increasingly complicated real life decision making problems. These problems can arise in natural resource utilization, financial operations, control of complex systems, and supply chain co-ordination, just to name a few. It is thus a great pleasure for us to make this special session a forum for the experts and practitioners to exchange ideas and information on multi-disciplinary approaches to optimization and optimal control. We believe that we would all benefit from the cross-fertilization of these ideas and information. It is our hope that this special session will play some small part in stimulating the future development of optimization and optimal control and their applications.

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An Address Sequencer for Matrix Computing Machines

Adam Burdeniuk
The University of Adelaide, Australia
aburdeni@eleceng.adelaide.edu.au
Cheng Chew Lim and Mike Liebelt

This paper describes an address sequencer that has been optimized for low overhead access to matrix structures. In addition to producing regular data access sequences suited to block matrix algorithms, it is also capable of generating a limited set of irregular patterns sufficient for addressing triangular (and some banded) matrix structures. This is an improvement over sequencers that lack features for accessing triangular and banded matrices, and must either be reprogrammed between each row/column access or throw away up to 50% of the fetched data, resulting in large overheads. The sequencer has been modelled as a behavioural System-C model, and correct operation verified.

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Optimal Paths in Time Constrained Networks

Louis Caccetta
Curtin University of Technology, Australia
caccetta@maths.curtin.edu.au

The design of efficient routes for moving products, resources and information through a specified network or region which may be discrete or continuous arises in many applications. The objective may be expressed in terms of minimizing risk, cost or time or maximizing reliability. Usually the routes must satisfy a variety of constraints that may include : distance travelled; total transit time; delivery/pick up deadlines; need to visit or avoid specific nodes of the network; and a variety of resource restrictions. The classical shortest path problem (SPP) of finding in a given weighted network a minimum weight (length or cost) path between a specified pair of nodes is solved by efficient procedures such as the label-setting algorithm of Dijkstra. A variation of the SPP involves additional constraints such as time and resource limitations. This paper considers variations involving time constraints. Several models and algorithms for this computationally difficult problem will be discussed.

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A Nash Bargaining Solution for Partition of Jobs between Two Manufacturers

Xiaoqiang Cai
The Chinese University of Hong Kong, Hong Kong
xqcai@se.cuhk.edu.hk
Quanle Chen

We consider the problem where two manufacturers are negotiating to partition a set of jobs that they have jointly obtained from a customer. Each manufacturer has his own processing capacity and setting, and thus has to look at the best schedule for his processing given any subset of jobs that he may be allocated by the negotiation. We formulate the utility function of each manufacturer, and cast the partition problem into a two-stage decision model: (i) The two parties perform the division of the job set based on the Nash bargaining solution; and (ii) For each given subset of jobs, each of them calculate their respective backend processing schedule to evaluate their corresponding utility function value. We develop

a pseudo-polynomial dynamic programming algorithm, and show that it can derive the best solution to partition the jobs in a mutually acceptable and beneficial manner.

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Optimality and Controllability of Complex Systems with Distributed Parameters

David Y. Gao
Virginia Tech, USA
gao@vt.edu

Complex systems are usually governed by nonconvex/nonsmooth differential equations with distributed parameters. Due to the nonconvexity and nonsmoothness of the cost functions, these systems are very sensitive to the parameters and numerical methods used. Very small perturbations of these parameters may lead the system to different output with significantly different performance, i.e. the so-called chaos. In order to control complex systems, the chaotic (or bifurcation) criteria will play a fundamental role. In this talk, the speaker will present a potentially useful canonical dual transformation method and the associated triality theory for solving optimization and control problems in complex systems governed by nonconvex/nonsmooth cost functions and constraints. He will show that by using the canonical dual transformation, many nonconvex/nonsmooth problems in n-dimensional space can be converted into certain smooth canonical (either convex or concave) dual problems in m-dimensional space with m ¡ n, therefore, a large class of nonconvex/nonsmooth optimization problems can be solved completely, including the well-known nonconvex quadratic minimization with box constraints, nonconvex integer programming, and a class of polynomial minimization problems, etc. Applications will be illustrated by some interesting problems in nonconvex dynamics with distributed parameters. A chaotic criterion is proposed which can be used to against chaotic behavior of the system. Finally, the speaker will present some newest progress (jointed work with S.C. Fang) on global optimization of generalized logarithmic-exponential functions in information theory.

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Stabilization of Vibration of Rotating Timoshenko Beam System

Shui hung Hou
Hong Kong Polytechnic University, Hong Kong
mahoush@polyu.edu.hk

The problem of stabilizing the vibration of a rotating Timoshenko beam system using feedback control is considered. It is shown by means of nonlinear semigroup theory that the closed loop system decays exponentially.

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Hopf bifurcation and structural instability in an open economy with Keynesian rigidity

Edgardo D. Jovero
Universidad Complutense de Madrid, Spain
edgardojovero@yahoo.es

This paper attempts to contribute to the debate in macroeconomic dynamics by presenting the neoKeynesian challenge. Proof is presented regarding the behavior of an open-economy two-sector growth model in the neoKeyenesian tradition of non-market clearing. It has been shown that there possibly exists a Hopf-bifurcation type of structural instability in a nonlinear dynamical model of the macroeconomy by which a stable region is connected to an unstable region situated in a center manifold in the state space of the resulting dynamical system. The Keynesian view that structural instability globally exists in the aggregate economy is put forward, and therefore the need arises for policy to alleviate this instability in the form of dampened fluctuations is presented as an alternative view for macroeconomic theorizing.

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Keywords: Hopf bifurcation, structural instability, neoKeynesian economics

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Optimal Control of Oscillatory Systems by Iterative Dynamic Programming

Rein Luus
University of Toronto, Canada
luus@chem-eng.utoronto.ca

Oscillatory inputs have been observed to increase the yield of chemical reactors beyond the level possible by steady inputs. To obtain the optimal inputs, iterative dynamic programming is well suited, because very large number of time stages can be used without encountering computational problems. To observe the benefits of oscillatory inputs, the effects of the initial state and the final state can be eliminated by normalizing the average yields with respect to the yield from a shorter final time. Two

examples show that optimal oscillatory can improve the yield substantially. The third example shows that there are situations where oscillatory behaviour is optimal, but the benefits are negligible. The optimal control policies can be readily established with iterative dynamic programming with the use of a large number of time stages of flexible length.

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Optimization methods applied to bang-bang and singular control problems

Helmut Maurer
Universität Mñster, Germany
maurer@math.uni-muenster.de
Georg Vossen

We consider optimal control problems with control appearing linearly. In this class of control problem, the optimal control is composed by bang–bang and singular arcs. It is shown that the control problem induces a finite-dimensional optimization problem where the optimization variable essentially consists of the switching and junction times between bang-bang and singular arcs. We present a numerical method for solving the induced optimization problem which uses the arc-parametrization method to determine the arc durations. This approach allows also to verify second-order sufficient optimality conditions (SSC) for the induced optimization problem and to compute parametric sensitivity derivatives of optimal solutions.Then SSC for bang-bang control problems can be obtained from the SSC for the induced optimization problem and an additional property of the switching function. SSC for singular control problems require stronger conditions which are currently under investigation. We discuss two numerical examples: (1) bang-bang and singular control for a van der Pol oscillator, (2) bang-singular-bang control in the GODDARD problem.

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Applications of the fourth order Cumulant to Direction Finding with a Circular Array

Julian Sorensen
Defence Science and Technology Organisation, Australia
julian.sorensen@dsto.defence.gov.au

A number of direction finding algorithms exploit the signal/noise subspaces that arise from the eigen-decomposition of the covariance matrix. Higher order cumulants can also be used to generate matrices with this signal/noise subspaces property. Moreover, higher order cumulants can be used to make virtual elements. In this paper we will show three applications of the fourth order cumulant to an experimental uniform circular array, which has 7 elements on the circumference and 1 element in the centre. The first application is the creation of a number of different virtual linear arrays that circumvent the need for a full 2d spectral search. The second application is the creation of virtual elements that more than double the aperture of the array. The third application is the creation of virtual elements that double the number of elements lying on the circumference of the circle, which along with reducing the ambiguities in the array, could also be used by the direction finding algorithm UCA ESPRIT.

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A Global Computational Approach to Impulsive Optimal Control Problems

Kok-lay Teo
Curtin University of Technology, Australia
K.L.Teo@curtin.edu.au
C.Z. Wu

Abstract In this paper, we develop a global computational approach to solve a class of optimal control problems governed by impulsive dynamical systems and subjected to continuous state inequality constraint. We show that this problem is equivalent to an optimal control problem governed by ordinary differential equations with periodic boundary conditions as well as the continuous state inequality constraint. For this equivalent optimal control problem, a con- straint transcription method is used in conjunction with the concept of penalty function to construct an appended new cost functional. This leads to a sequence of approximate optimal control problems subject only to periodic boundary conditions. Each of these approximate problems can be solved as an optimization problem using gradient-based optimization tech- nique, which are, however, for finding a local optimal solution. Thus, a filled function method is introduced to supplement the gradient-based optimization method. This leads to a com- bined method for finding a global optimal solution. A numerical example is solved using the proposed approach.

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Controlling Nonlinear Evolution Equations into Stationary Solutions

Karsten Theissen
University of Muenster, Germany
tbb@math.uni-muenster.de

Helmut Maurer

In many applications, the problem arises of steering a dynamic process optimally to a stable or unstable stationary solution. In this talk, we consider dynamic processes described by evolution equations. We will formulate the problem as an optimal control problem with an appropriate tracking functional. The control variable appears linearly in the control system which leads to bang-bang and singular control functions. The optimal control problem is treated by a instantaneos control approach where a sequence of local optimization problems is solved. We present the solution for two practical problems: (1) control of an activator-inhibitor reaction-diffusion system simulating dissipative solitons in a gas discharge system, (2) control of the feed velocity in abrasive water-jet cutting to avoid ripple formation.

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Knot-Optimizing Spline Networks (KOSNETS) for Nonparametric Regression

Song Wang
The University of Western Australia, Australia
swang@maths.uwa.edu.au
Q.X. Shao and X. Zhou

In this talk we present a novel method for short term forecast of time series based on Knot-Optimizing Spline Networks (KOSNETS). The time series is first approximated by a nonlinear recurrent system. The resulting recurrent system is then approximated by feedforward B-spline networks, yielding a nonlinear optimization problem. In this optimization problem, both the knot points and the coefficients of the B-splines are decision variables so that the solution to the problem has both optimal coefficients and partition points. To demonstrate the usefulness and accuracy of the method, numerical simulations and tests using various real time series are performed. The numerical simulation results are compared with those from a well-known regression method, MARS. The comparison shows that our results are superior to MARS for nonlinear problems.

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Optimal control of Maxwell's system in Quasi-stationary electromagnetic field with the temperature effect

Wei Wei
Guizhou University, Peoples Rep of China
wei66@yahoo.com
Yuyang Kuang

In this paper, we study an optimal control problem of system governed by Maxwell's equations the coupled a heat equation. The system is considered in a quasi-stationary state field. The new existence theorem of an optimal control problem is presented.

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Second Order Nonlinear Impulsive Time-Variant Systems with Unbounded Perturbed and Optimal Control

Xiaoling Xiang
Department of Mathematics, Guizhou University, Peoples Rep of China
pengyf0803@163.com
Y. Peng

In this paper, the second order nonlinear impulsive evolution differential equations perturbed by unbounded operator on Banach space is considered. Discussing the perturbation of time-varying operator matrix and constructing the corresponding evolution system generated by operator matrix we introduce the reasonable mild solution of second order nonlinear impulsive evolution differential equations and prove the existence of the mild solutions. Existence of optimal controls for a Lagrange problem of systems governed by the second order nonlinear impulsive evolution equations is also presented. An example is given for demonstration.

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Optimal portfolios under a risk constraint with applications to inventory control in supply chains

Cedric Yiu
The University of Hong Kong, Hong Kong
cedric@hkucc.hku.hk
S.Y. Wang and K.L. Mak

In risk management, the Value-at-Risk (VaR) is a useful measure of market risks. The risk of a portfolio can be controlled by restricting the level of VaR. If the expected utility of wealth or consumption is maximized over a certain period of time without considering risks, the optimal allocation to the risky asset might violate the VaR restriction at some points and fall short of the regulatory requirement. In this article, we impose the VaR as a dynamic constraint to the optimal portfolio problem. The optimal portfolio problem is formulated as a constrained maximization of the expected utility, with the constraint being the VaR level. Dynamic programming

is applied to reduce the whole problem to solving the Hamilton-Jacobi-Bellman equation coupled with the VaR constraint, and the method of Lagrange multiplier is then applied to handle the constraint. A numerical method is proposed to solve the problem. By applying the VaR constraint continuously over time, we find that investments in risky assets are reduced whenever the VaR constraint becomes active. We also demonstrate how this approach can be applied to certain inventory control problems in supply chains.

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An Unified Model for State Feedback of Discrete Event Systems I: Framework and Maximal Permissive State Feedback

Wuyi Yue
Konan University, Japan
yue@konan-u.ac.jp
Chen Xu and Qiying Hu

This paper presents a new basis model based on automaton for the state feedback control of discrete event systems (DES). It includes the (repeated) concurrent DES. So, it unifies Ramadge-Wonham framework and the controlled Petri nets with and without concurrency. We study the relationship between the concurrent models and the basis model. Based on this, we shown that the uniqueness of the maximal permissive state feedback (PSF) of a predicate P is equivalent to the weakly interaction of P, which is also equivalent to that the set of PSF, $F(P)$, is closed under the operation $\vee$ (disjunction). These results are also true for the concurrent systems but the WI may be difficult to be verified. Hence, we try to simplify the weakly interaction by introducing concepts such as cover, transitivity and local concurrently well-posedness (CWP). We show that the local CWP is to ensure the set of PSF for the concurrent systems equals that for the basis system. At the same time, it is pointed out that the concurrent Ramadge-Wonham framework differs from the controlled Petri nets.

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