Embedded Feature Selection for High Dimensional Data Sets

Panos Pardalos
University of Florida

High Dimensional datasets are currently prevalent in many practical applications. Classification and feature selection are common tasks performed on such datasets. In this talk, a new embedded feature selection method for high dimensional datasets is introduced by incorporating sparsity in Proximal Support Vector Machines (PSVMs). Our method called Sparse Proximal Support Vector Machines (sPSVMs) learns a sparse representation of PSVMs by first casting it as an equivalent least squares problem and then introducing the $l1$-norm for sparsity. An efficient algorithm based on alternate optimization techniques is proposed. Numerical experiments on several publicly available datasets show that our proposed method can obtain competitive or better performance compared with other embedded feature selection methods. Moreover, sPSVMs remove more than 98% features in many high dimensional datasets without compromising on generalization performance and also show consistency in the feature selection process. Additionally, sPSVMs can be viewed as inducing class-specific local sparsity instead of global sparsity like other embedded methods and thus offer the advantage of interpreting the selected features in the context of the classes.

GPOPS-II: A MATLAB Software for Solving Multiple-Phase Optimal Control Problems Using hp-Adaptive Gaussian Quadrature Collocation Methods and Sparse Nonlinear Programming

Michael Patterson
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A general-purpose MATLAB software program called GPOPS-II is described for solving multiple-phase optimal control problems using variable-order Gaussian quadrature collocation methods. The software employs a Legendre-Gauss-Radau quadrature orthogonal collocation method where the continuous-time optimal control problem is transcribed to a large sparse nonlinear programming problem (NLP). An adaptive mesh refinement method is implemented that determines the number of mesh intervals and the degree of the approximating polynomial within each mesh interval to achieve a specified accuracy. The software can be interfaced with either quasi-Newton (first derivative) or Newton (second derivative) NLP solvers, and all derivatives required by the NLP solver are approximated using sparse finite-differencing of the optimal control problem functions. The key components of the software are described in detail and the utility of the software is demonstrated on five optimal control problems of varying complexity. The software described in this paper provides researchers a useful platform upon which to solve a wide variety of complex constrained optimal control problems.

Source Transformation via Operator Overloading for Automatic Differentiation in MATLAB

Anil Rao
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A source transformation via operator overloading method is presented for computing derivatives of mathematical functions defined by MATLAB computer programs. The transformed derivative code that results from the method computes a sparse representation of the derivative of the function defined in the original code. As in all source transformation automatic differentiation techniques, an important feature of the method is that any flow control in the original function code is preserved in the derivative code. Furthermore, the resulting derivative code relies solely upon the native MATLAB library. The method is useful in applications where it is required to repeatedly evaluate the derivative of the original function. The method has been recently implemented in the ADiGator software.

A dual weighted Residual error estimation scheme for mesh refinement

Murat Engin Unal
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A Dual Weighted Residual (DWR) error estimation scheme is proposed for mesh refinement when solving an optimal control problem using collocation at Legendre-Gauss-Radau points. DWR error estimation has been used for finite element methods and indirect methods of solving optimal control problems in the past, but has yet to be applied to orthogonal collocation methods. This error representation has two important aspects. First, it incorporates deviations from all of the optimality conditions, instead of relying only on primal feasibility error. This requires calculation of control derivatives, which can be obtained by taking the time derivative of the first order necessity conditions for optimality, then solving a linear system of equations; and co-state estimation which is readily available for orthogonal collocation methods. Second, this method emphasises the errors that have high effect on the objective function value. Although this might result in poor feasibility in optimization of systems governed by partial differential equations, no such effects are reported for systems governed by ordinary differential equation. A new mesh is generated based that has increased collocation points in regions of high error. It is expected that the error calculated using the DWR method will locate regions of high error faster than previous methods, therefor leading to fewer mesh iterations to solve the problem. This shall remove some of the responsibility of obtaining a solution which satisfies first order necessary conditions of the continuous optimal control problem, from the NLP solver. Preliminary results demonstrate improved performance for problems with continuous solutions.

High performance algorithm design for sensor fusion and target tracking on a smart grid of munitionsg

Alla Kammerdiner
New Mexico State University

Centralized sensor fusion and target tracking can be performed using a system of smart munitions as a distributed computational resource. To enable ?efficient use of limited memory and computational resources on a grid of munitions, we formulate a new class of optimization problems. This new class of problems allows one to make better decisions on how to store the data and share the computational load among multiple munitions. We demonstrate how that this can improve performance of parallel algorithms for solving computationally challenging data association problems that arise in multi-sensor multi-target data fusion.

Simultaneous Geometry and Weight Optimization for Electronically Scanned Wideband Planar Arrays

Serdar Karademir
University of Florida

Wideband phased arrays have a wide range of applications in defense, communication, and surveillance. In subarrayed implementations, two crucial factors defining array's performance are subarray architecture and element weighting. In this work, we present optimization approaches that tackle these challenges simultaneously.

Minimum Risk Network Coverage Problems

Konstantin Pavlikov
University of Florida

The network maximum coverage problem under uncertainty is considered. In this problem, network vertices are assumed to cover their adjacent nodes with some probability, independently of each other. The emphasis is put on minimizing the risk of losing coverage in the presence of random failures of "covering" components. We formalize the stochastic coverage problem, formulate and further investigate the corresponding combinatorial optimization problems.

Error Estimation in Nonlinear Optimization and Dual Active Set Constraints

William Hager
University of Florida

A semi-analytical split-Bernstein approach to chance constrained programs

Mrinal Kumar
University of Florida

A Graph Coarsening Method for KKT Systems Arising in Orthogonal Collocation of Optimal Control Problems

Begum Senses
University of Florida

A graph coarsening method is described for solving large sparse Karush-Kuhn-Tucker (KKT) linear systems associated with the nonlinear programming problem that arises from the discretization of a continuous optimal control problem using a Legendre-Gauss-Radau collocation method. The method matches the vertices of each state and defect constraint at a particular collocation point, represents each vertex pair using a single vertex in the coarsened KKT matrix and performs a fill-reducing ordering on the coarsened matrix. As a result of these steps the state and defect constraint corresponding to a particular collocation point are placed in adjacent rows in the reordered KKT matrix. It is demonstrated that the proposed method decreases both the number of delayed pivots and floating point operations during the numerical factorization phase, making it possible to solve KKT linear systems more efficiently and more robustly.

Minimum-Time Trajectory Optimization of Many Revolution Low-Thrust Earth-Orbit Transfers

Kathryn Graham
University of Florida

The problem of determining high-accuracy minimum-time Earth-orbit transfers using low-thrust propulsion is considered. The optimal orbital transfer problem is posed as a constrained nonlinear optimal control problem and is solved using a variable-order Legendre-Gauss-Radau (LGR) quadrature orthogonal collocation method. Initial guesses for the optimal control problem are obtained by solving a sequence of modified optimal control problems where the final true longitude is constrained and the mean square difference between the specified terminal boundary conditions and the computed terminal conditions is minimized. It is found that solutions to the minimum-time low-thrust optimal control problem are only locally optimal in that the solution has essentially the same number of orbital revolutions as that of the initial guess. A search method is then devised that enables computation of solutions with an even lower cost where the final true longitude is constrained to be different from that obtained in the original locally optimal solution. A numerical optimization study is then performed to determine optimal trajectories and controls for a range of initial thrust accelerations and constant specific impulses. The key features of the solutions are then determined, and relationships are obtained between the optimal transfer time and the optimal final true longitude as a function of the initial thrust acceleration and specific impulse. Finally, a detailed post-optimality analysis is performed to verify the accuracy of the solutions obtained.

Control Approximation for Switching Structure Identification in Gauss Collocation Methods

Joseph Eide
University of Florida

This paper provides a new method of mesh refinement for Gauss collocation methods in which the discrete control information provided by the NLP solver is utilized to create a control profile for regions of the solution and used in the next iteration of the NLP. This mesh refinement technique requires a minimum of three iterations. In the first iteration, the optimal control problem is solved on a coarse grid. A continuous time control profile is approximated based on the previously calculated discrete control. Then control dynamics are calculated and used on the second iteration of the problem as additional state dynamic constraints based on the continuous control approximation. If piecewise behavior is detected in the solution, then a multiphase control approximation will be used. If a region has a control behavior that cannot be mapped to a profile, then the control in that region is solved as usual on the new mesh. The final phase is a verification phase, where the control dynamics are removed and any phase start points will be replaced with the start of a mesh interval. This motivation for the development of such a technique is presented for two control profiles of classic optimal control problems: The step control of the lunar lander and the ramp-coast-ramp control of the Bryson-Denham problem. It will be shown that this method is able to find the switching structure of these two controller quicker than previous mesh refinement techniques, and will also provide continuous control as a function of time. Future work will focus on increasing the complexity of the control approximation that can be generated.

Adaptive Mesh Refinement Method for Optimal Control Using Nonsmoothness Detection and Mesh Size Reduction

Fengjin Liu
University of Florida

An adaptive mesh refinement method for solving optimal control problems is developed. The method employs orthogonal collocation at Legendre-Gauss-Radau points, and adjusts both the mesh size and the degree of the approximating polynomials in the refinement process. A previously derived convergence rate is used to guide the refinement process. The method brackets discontinuities and improves solution accuracy by checking for large increases in higher-order derivatives of the state. In regions between discontinuities, where the solution is smooth, the error in the approximation is reduced by increasing the degree of the approximating polynomial. On mesh intervals where the error tolerance has been met, mesh density may be reduced either by merging adjacent mesh intervals or lowering the degree of the approximating polynomial. Finally, the method is demonstrated on three examples from the open literature and its performance is compared against a previously developed adaptive method.

Adaptive BOSVS Algorithm for Ill-Conditioned Linear Inversion with Applications to Partially Parallel Imaging

Maryam Yashtini
University of Florida

An Accelerated Bregman Operator Splitting-Type Algorithm with Applications to Partially Parallel Imaging

XIanqi Li
University of Florida

In this paper, we propose an accelerated Bregman operator splitting-type algorithm for solving problems of the form $\min\{\frac{1}{2}||Au - f||_2^2 + \phi(Bu)\}$, where ϕ may possibly be nonsmooth. Instead of choosing a fixed stepsize, we employ a line search to improve the efficiency. Moreover, we incorporate a second 'stepsize' into our scheme and analyze its influence by choosing different numbers. In the numerical experiments, the proposed schemes are compared with other state-of-the-art algorithms on partially parallel magnetic image reconstruction. Numerical results show that the proposed methods perform effectively and efficiently in terms of image quality and CPU time, respectively.

Fast bundle-level method for multi-task learning

Wei Zhang
University of Florida

Comparing to single-task learning, multi-task learning has been introduced to improve generalization performance by learning multiple related tasks simultaneously and meanwhile exploiting their intrinsic relatedness. In this talk, we will present a new trace norm regularization model for multi-task learning, and extend our recently developed fast bundle-level method to solve the corresponding optimization problem. Some applications in classification and image recognition will also be discussed.

Multi-Channel Image Reconstruction

Hao Zhang
University of Florida

Multi-shot echo-planar imaging (EPI) based Diffusion weighted imaging (DWI) has the potential to provide higher spatial resolution results compared with the generally used Single-shot EPI method. However, there are motion-induced phase errors among different shots. We make use of the low-rank property of the magnitude of intensity matrices (In) of images from different shots and under-sampled data from multi-channel scans to jointly reconstruct images for each shot. Our proposed model is a combination of the data fitting, gradient weighted Total Variation regularization and low-rank decomposition of In, which is solved by an ADMM scheme. Other potential applications of this model will also be discussed.

Rendezvous with Scalar Control for Nonholonomic Robots

Chau Ton
NRC

Nonlinear scalar control methods for nonholonomic robots will be discussed. Specifically, scalar controls for a two-robots system are developed. The robots under consideration are Dubins cars that share the same scalar orientation control input. There are two cases under consideration: rendezvous and orientation without targeted location, and rendezvous with targeted location. The control method is based sliding mode control. The control structure is simple, requiring no estimation or adaptation. Numerical simulations are provided to demonstrate the performance of the control methods.

Fractional-order System based Human-Robot Network for Rendezvous Problems with Common Scalar Control

Zhen Kan
University of Florida

A human-robot network that consists of human operators and semi-autonomous robots is considered to navigate the robots to achieve rendezvous within a desired area. The human operators form a social network, where each operator is assumed to maintain an opinion and communicate with other operators in determining the rendezvous area where the robots should meet. Motivated by the non-local property of fractional-order systems, the social interaction among operators are modeled by fractional-order dynamics whose opinions depend on influences from social peers and past experiences. A decentralized influence method is developed to influence the social group to achieve consensus on the rendezvous area. The robots considered are semi-autonomous in the sense that the robots are assumed to have onboard intelligence that allows them to autonomously perform preassigned cooperative tasks by interacting and collaborating with other robots. In addition to the onboard intelligence, the robots are also capable of receiving commands from human operators, allowing operators to influence the behaviors of the robots when necessary. Distinguished from most existing works, all semi-autonomous robots receive an identical control input from an operator (i.e., common control). The key contribution of the developed control structure is that a single human operator can control multiple robots in the same manner the operator will control a single robot, thus significantly reducing cognitive workload and operator fatigue. The developed robust controller ensures rendezvous of the robots within the desired area by using the common input from an operator. The human-robot interface is developed and experimental results with different subjects are provided to demonstrate the designed control strategy.

An Attacker-Defender Game and A Cooperative Estimation Scheme

Neha Satak
University of Florida

An attacker-defender incomplete information game is solved. The attacker chooses between two equally important targets to attack. A Gaussian impact distribution is assigned to both agents. The attacker plays to minimize its distance from either of the targets. The success of the attack is measured by the position of the target in the impact radius of the attacker. The attacker is considered destroyed if the defender reaches within a certain impact radius of the attacker. The game is incomplete information as the defender does not know which target the attacker will attack. The attacker also does not know the defenders plan of defense. A second problem related to cooperative estimation is solved between two robots equipped with an odometer, a bearing sensor to features and a range & bearing sensor to the other robot. A brief discussion with preliminary results will be presented on this second topic.

The Stochastic Incremental Network Design Problem with Shortest Paths and Uncertain Build Times

Nathaniel Richmond
University of Iowa

The deterministic incremental network design problem (DINDP) refers to the task of choosing how to grow an existing network over a finite time horizon. A network optimization problem (i.e. shortest path problem) is solved on the existing network at each time epoch, and the objective is to minimize the total cost over the given horizon. We introduce the stochastic incremental network design problem (SINDP) with shortest paths and uncertain build times. We design and discuss the model and examine interesting properties of its solution.

Jammer Placement to Partition Wireless Network

Jixin Feng
University of Florida

Wireless communication systems are susceptible to jamming attacks, and the use of unmanned vehicles bring new opportunities for coordinated jamming attacks. At the same time, systems of autonomous vehicles that coordinate their movements over a wireless network may be particularly vulnerable to jamming attacks that disrupt the control information. Much research has been conducted on how to efficiently jam single communication links and how to protect such links from jamming. However, less research has focused on problems of jamming attacks on the overall network. In this paper, we consider the problem of determining how to efficiently position jammers so as to partition a wireless network. The communication network is represented as a graph with the vertices representing the radios, and the edges representing the communication links. Although there has been extensive research into the problem of efficiently partitioning a graph via edge separators, the action of a jammer in a wireless network is more closely analogous to blocking reception at one or more radios, which may be modeled as partitioning a graph via node separators. We formulate several optimization problems for jammer placement. Since the optimal solution to these problems are computationally complex, we develop suboptimal solutions using spectral partitioning followed by greedy jammer placement and also a harmony search. The results show that these algorithms offer a tradeoff between complexity and performance. In the scenarios where we were able to compare performance with the optimal solution, the harmony search algorithm offered performance close to that of the optimal solution while requiring a much lower complexity.

New analytical lower bounds for the maximum clique number of graphs

Vladimir Stozhkov
University of Florida

We propose three new analytical lower bounds for the maximum clique number. Two most effective of them are derived from the Motzkin-Straus formulation for the maximum clique problem. We also prove several theoretical results for them. Finally, we compare its performance with well-known maximum clique lower bounds and show superiority of our best new bound. We run our experiments on various random graph models that simulate graphs with different densities and assortativity coefficients.