The Third SIAM Gators Student Conference

March 27 to 29, 2014

University of Florida

DEPARTMENT OF MATHEMATICS

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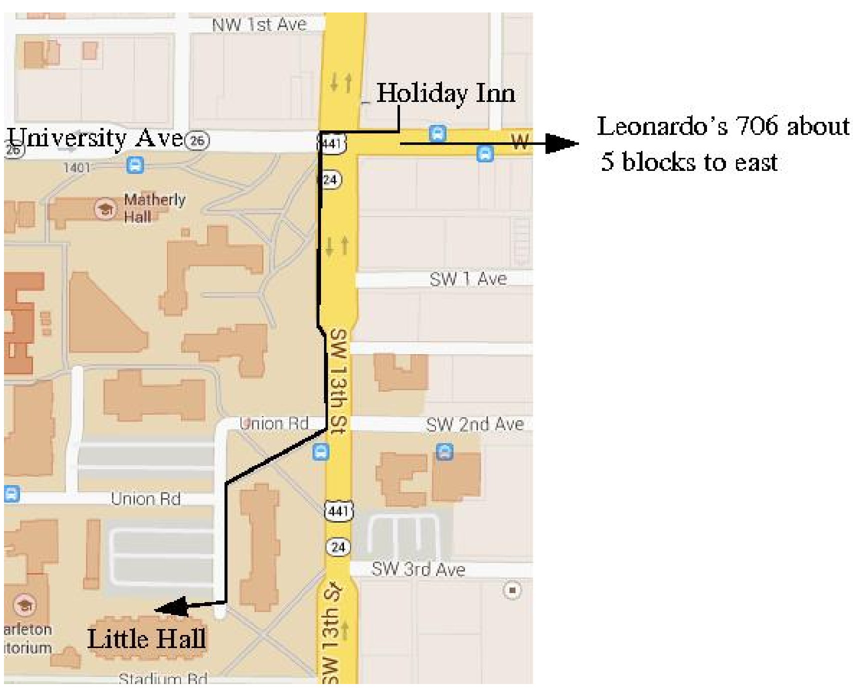
UNIVERSITY OF FLORIDA

The conference will be held in the Department of Mathematics at the University of Florida. The Mathematics Department is located in Little Hall, near 13th Street as shown in the map below. The main office and reception desk for the Mathematics Department are located on the third floor near the center of the building. All the talks will take place in room 339 of Little Hall, also known as the Little Hall Atrium. Breakfast is available for the conference participants in the Atrium, starting about 30 minutes before the first talk on each day of the conference. Dinner is provided for conference participants at the restaurant Leonardo's 706. The restaurant is located at 706 West University Avenue (about 5 blocks east of the Holiday Inn on University Avenue). The buffet style dinner is available from about 6:30pm to 8:30pm on each day of the conference.

Internet Access: Connect to ufvisitor under your computer's wireless connections, then open your browser and follow the instructions for getting a pin.



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SCHEDULE

March 27th:	Mathematical Biology and Modeling
March 28th:	Mathematical Algorithms in Imaging
March 29th:	Numerical Optimization and Application

Thursday, March 27, 2014

8:10–8:50a.m.	**Breakfast**
8:50–9:00a.m.	**Initial Welcome from the Chair, Dr. Douglas Cenzer**
Session T.1	**Chair: Omar Saucedo**
9:00–9:45a.m.	**Keynote Speaker:** **Prof. Juliet Pulliam** (UF) *Tailoring Models to Research Questions in Biology:* *An Example From Pathogen Invasion Dynamics*
9:45–10:15a.m.	**Coffee Break**
10:15–10:40a.m.	**Matthew Donahue** (FSU) *The Role of Biofilm Formation within Plant Diseases*
10:40–11:05a.m.	**Rui Gu** (FSU) *A Two-phase Field Method for Illustrating Vesicle-substrate Adhesion Process*
11:05–11:30a.m.	**Yougan Cheng** (Case Western) *Computational Analysis of Brain Energy Metabolism Model at Different Scales:* *Spatial Resolution and Beyond*
11:30–11:55a.m.	**Hayriye Gulbudak** (UF) *A Structured Avian Influenza Model with Imperfect Vaccination*
11:55–2:00p.m.	**Lunch Break**
Session T.2	**Chair: Hayriye Gulbudak**
2:00–2:45p.m.	**Keynote Speaker:** **Prof. Suzanne Lenhart** (UT) *Using optimal control of PDEs to investigate population questions*
2:45-3:15p.m.	**Coffee Break**
3:15–3:40p.m.	**Gordon Akudibillah** (OSU) *Optimizing HIV Treatment In A Hetrosexual Population*
3:40–4:05a.m.	**Abhishek Pandey** (Clemson) *The Introduction of Dengue Vaccine may Cause Temporary Spikes in Prevalence*
4:05–4:30a.m.	**Illyssa Summer** (ASU) *Oncolytic Virotherapy to Treat Cancer and the Effects from the Immune System*
4:30–4:55a.m.	**Rebecca Everett** (ASU) *Can Mathematical Models Predict the Outcomes of Prostate Cancer Patients* *Undergoing Intermittent Androgen Suppression Therapy?*

Friday, March 28, 2014

8:30–9:00a.m.	**Breakfast**
Session F.1	**Chair: Hao Zhang**
9:00–9:45a.m.	**Keynote Speaker:** **Prof. Thomas Mareci** (UF) *The Virtual Brain*
9:45–10:15a.m.	**Coffee Break**
10:15–10:40a.m.	**Xiaojing Ye** (GSU) *A Semi-implicit Curve Search Algorithm for Nonconvex Minimization*
10:40–11:05a.m.	**Yuyuan Ouyang** (REEF, UF) *An Accelerated Primal-dual Framework for Convex Composite Optimization with Linear Constraints*
11:05–11:30a.m.	**Qian Dong** (CAS) *Semi-Asynchronous Strategies in Distributed Optimization for Data Fitting Problem*
11:30–11:55a.m.	**Benjamin Berman** (Arizona) *Compressed Sensing for Magnetic Resonance Imaging of the Lungs during Forced Expiration*
11:55–2:00p.m.	**Lunch Break**
Session F.2	**Chair: Meng Liu**
2:00–2:45p.m.	**Keynote Speaker:** **Prof. Wotao Yin** (UCLA) *Distributed Optimization over Network*
2:45-3:15p.m.	**Coffee Break**
3:15–3:40p.m.	**Wei Zhang** (UF) *Fast Accelerated Bundle Level Type Methods*
3:40–4:05p.m.	**Jacob Grey** (LSU) *Asymptotic Convergence of Solutions for the BBM-KP and the BBM*
4:05–4:30p.m.	**Cuong Ngo** (UF) *Alternating Direction Approximate Newton Method for Partially Parallel Imaging*
4:30–4:55p.m.	**Feishe Chen** (SYR) *Composite Minimization and its Application to Image Deblurring*

Saturday, March 29, 2014

8:30–9:00a.m.	**Breakfast**
Session S.1	**Chair: Cuong Ngo**
9:00–9:45a.m.	**Keynote Speaker:** **Prof. Panos Pardalos** (UF) *Data Mining and Optimization Heuristics for Massive Networks*
9:45–10:15a.m.	**Coffee Break**
10:15–10:40a.m.	**Nguyenho Ho** (WPI) *Accelerated Uzawa Iteration for the Stokes Equations*
10:40–11:05a.m.	**Jun Lu** (Gatech) *A Fast Algorithm for Finding the Shortest Path by Solving Initial Value ODEs*
11:05–11:30a.m.	**Zachary Clawson** (Cornell) *Optimal Control with Budget Constraints and Resets*
11:30–11:55a.m.	**Alfredo Garbuno** (ITAM) *A Comparison between Two Fast Algorithms for Symmetric LCPs*
11:55–2:00p.m.	**Lunch Break**
Session S.2	**Chair: Maryam Yashtini**
2:00–2:45p.m.	**Keynote Speaker:** **Prof. Samuel Burer** (UI) *Copositive Optimization*
2:45-3:15p.m.	**Coffee Break**
3:15–3:40a.m.	**Guanglin Xu** (UI) *Solving a Partial Inverse Optimization Problem via QP-Based Branch and Bound*
3:40–4:05p.m.	**Damek Davis** (UCLA) *Convergence Rate Analysis of Several Convex Splitting Schemes*
4:05–4:30p.m.	**Shuxiong Wang** (CAS) *Feasible Method for Semi-Infinite Programs*
4:30–4:55p.m.	**Christopher Jarvis** (VT) *Parameter Dependent Model Reduction for Nonlinear Systems*

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ABSTRACTS of KEYNOTE TALKS

Tailoring models to research questions in biology: an example from pathogen invasion dynamics

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Abstract

I will discuss four models from my own research that were used to address distinct but related questions regarding the invasion and establishment of pathogens in novel host species. These models vary from simple, analytically tractable models to complex individual-based simulations, and I will describe the uses and outcomes of each of these models, and the relationships between them.

Using optimal control of PDEs to investigate population questions

Suzanne Lenhart
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Abstract

We use optimal control of partial differential equations to investigate conservation questions in population models. One example will address a question about resource allocation to increase population abundance with limited resources; the control represents the availability of resources. A second example is motivated by the question: Does movement toward a better resource environment benefit a population? The control is the advective coefficient in a parabolic PDE with nonlinear growth.

The Virtual Brain

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Abstract

Over the last 50 years, the science of brain measurement has advanced to the point where the tools are coming into place for the creation of a virtual model of the brain. Central to this work is the ability to mathematically analyze these measurements, which become input to computer models of the brain. This presentation will focus on the use of magnetic resonance imaging to measure the structure and function of the brain and the use of this data to model the brain as a complex network. The network model of the brain relies upon mathematical analysis of connectivity using graph theory, which can be used to view the organizational structure and function of the brain.

Distributed Optimization over Network

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Abstract

There has been considerable recent interest in solving optimization problems with data stored over a network. For these problems we need techniques that process data locally yet converge rapidly to an (approximate) solution across the entire network. This talk reviews primarily first-order algorithms for large-scale optimization of the distributed or decentralized types. We emphasize on recognizing separable structures in a large set of image processing, signal processing and statistical learning problems and demonstrate that, through skillful uses of gradient, proximal, duality, and splitting techniques, massively parallel algorithms can be developed. Numerical results are presented to demonstrate the scalability of the parallel codes on typical unix clusters and Amazon EC2.

Data Mining and Optimization Heuristics for Massive Networks

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Abstract

In recent years, data mining and optimization heuristics have been used to analyze many large (and massive) data-sets that can be represented as a network. In these networks, certain attributes are associated with vertices and edges. This analysis often provides useful information about the internal structure of the datasets they represent. We are going to discuss our work on several networks from telecommunications (call graph), financial networks (market graph), social networks, and neuroscience. In addition, we are going to present recent results on critical element selection. In network analysis, the problem of detecting subsets of elements important to the connectivity of a network (i.e., critical elements) has become a fundamental task over the last few years. Identifying the nodes, arcs, paths, clusters, cliques, etc., that are responsible for network cohesion can be crucial for studying many fundamental properties of a network

Copositive Optimization

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Abstract

In this talk, we survey the active area of copositive optimization, focusing on two key features: (i) its ability to model difficult problems as equivalent convex problems; (ii) its approximability by semidefinite optimization. We also discuss applications, computation, and connections with other research areas.

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ABSTRACTS of STUDENT TALKS

The Role of Biofilm Formation within Plant Diseases

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Abstract

Despite multiple bacterial diseases causing widespread damage to the citrus, wine, and other fruit industries, there has been little attention paid to modeling their development and progression. A multiphase modeling framework will be used to examine the dynamic behavior and fluid/structure interactions of the biological system. Perturbation analysis will be used to determine potential causes and tendencies of patterns discovered within the biofilm.

A Two-phase Field Method for Illustrating Vesicle-substrate Adhesion Process

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Abstract

A phase field model for simulating the adhesion of a cell membrane to a substrate is constructed. The model features two phase field functions which are used to simulate the membrane and the substrate. An energy model is defined which accounts for the elastic bending energy and the contact potential energy as well as, through a penalty method, vesicle volume and surface area constraints. Numerical results are provided to verify our model and to provide visual illustrations of the interactions between a lipid vesicle and substrates having complex shapes.

Computational Analysis of Brain Energy Metabolism Model at Different Scales: Spatial Resolution and Beyond

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Abstract

Brain energy metabolism has been approached in the framework of spatially lumped models, where the region of interest is represented as in terms of well mixed compartments representing different cell types, extracellular space and capillary blood [1, 2]. While these models shed some light on the brain metabolism, they overlook some potentially important factors including the locus of the synaptic activity in reference to capillaries, the effect of diffusion, pre- and postsynaptic neurons, and possible variations in mitochondrial density within the cells.

We develop a three-dimensional spatially distributed model [3] of brain energy metabolism and investigates how the locus of the synaptic activity in reference to the capillaries and diffusion affects the behavior of the model, a type of analysis which is impossible to carry out in spatially lumped models, which are shown to be consistent spatially averaged approximations of the distributed model. To avoid a geometrically detailed modeling of the complex structure of the tissue consisting of different cell types and the extracellular space, the distributed model is based on a novel multi-domain formulation of reaction-diffusion equations, accounting also for separate mitochondria. The model reduction relating the spatially distributed model and lower dimensional reduced models, including the well-mixed spatially lumped compartment model, is carefully explained. We illustrate the effects of losing the spatial resolution with a computed example which is based on a reduced one-dimensional distributed radial model, and looks into how the model behaves when the locus of the synaptic activity in reference to the capillaries is changed. By averaging the fluxes and concentrations in the distributed radial model to correspond to quantities in a lumped model, and further by estimating the parameters in the lumped, we conclude that varying the locus of the synaptic activity in reference to the capillaries alters significantly the lumped model parameters. This observation seems to be consequential for parameter estimation procedures from data when the spatial resolution is insufficient to determine the locus of the activity, indicating that the model uncertainty is an inherent feature of lumped models.

References

[1] Aubert A. and Costalat R., 2005. Interaction between astrocytes and neurons studied using a mathematical model of compartmentalized energy metabolism. *J. Cereb. Blood Flow Metab.* 25:1476-90.

[2] Calvetti D., Somersalo E., 2011. Dynamic activation model for a glutamatergic neurovascular unit. *J. Theor. Biol.* 274: 12-29.

[3] Calvetti D., Cheng Y. and Somersalo E., 2013. Computational analysis of brain energy metabolism model at different ccales. submitted.

A Structured Avian Influenza Model with Imperfect Vaccination

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Abstract

Vaccination of poultry is an important control strategy for avian influenza. In general, it is clear that vaccination does not induce perfect immunity in populations, instead producing partial protection from disease. The mech- anisms of this partial protection offered by vaccination include reducing the probability of infection and decreasing the severity of infection. In mathematical models of vaccination, the partial protection is usually modeled by considering reduction in probability of infection and loss of immunity is assumed to occur with constant per-capita rate. However, this may not capture all of the complexities of vaccination. We introduce a model of avian influenza in domestic birds with imper- fect vaccination and age-since-vaccination structure, which includes the two mechanisms of partial protection. The basic reproduction number, $\mathbf{R}_0$, is calculated. The disease-free equilibrium is found to be globally stable when $\mathbf{R}_0 < 1$ under certain conditions. When $\mathbf{R}_0 < 1$, existence of an endemic equilibrium is proved (with uniqueness for a special case), and uniform per- sistence of the disease is established. The inclusion of both mechanisms of partial protection from vaccination can have important implications for disease control. We analytically and numerically demonstrate that vacci- nation can paradoxically increase the total number of infected, resulting in the silent spread of the disease.

Optimizing HIV Treatment In A Hetrosexual Population

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Abstract

Progress toward the development of a safe and effective treatment for AIDS has been slow because the Human immunodeficiency virus has the ability to mutate its own structure. This mutation enables the virus to become resistant to previously effective drug therapies. Apart from the traditional role of preventing progression from HIV to AIDS Antiretroviral drugs have an additional clinical benefit of substantially reducing infectiousness thus making them an important strategy in the fight against HIV. Recent advances in drug therapy have seen the use of Antiretroviral medications as a prophylaxis. Administered either as post-exposure prophylaxis after high-risk exposure or as pre-exposure prophylaxis in those with ongoing HIV exposure. In this study, we constructed a compartmental heterosexual transmission model based on the dynamics of HIV in heterosexual population in Sub-Sahara. The model classifies the male and female populations by risk (low, medium and high) according to their sexual preferences. Data from South Africa was used to parameterize the model. For a finite amount of drugs we developed a numerical opti- mization algorithm to find optimal allocation of the drugs amongst risk groups, which minimizes objective functions such as Total Number of Deaths and Total Number of Infections. Preliminary results suggest that, the priority should be given to the high-risk females during drug allocations to minimize the number of deaths or infection per year. Significantly, the model provides the proportion of each risk group to be treated yearly in order to achieve the three objectives above. Given the limited health resources in African, this study will serve as a important guide to policy makers on how to optimally allocate scarce drugs to achieve the best results of using treatment as prevention.

The Introduction of Dengue Vaccine may Cause Temporary Spikes in Prevalence

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Abstract

A dengue vaccine is expected to be available within few years. Once vaccine is available, policy makers will need to find suitable vaccine-allocation policies. Mathematical models of dengue transmission predict complex temporal patterns in prevalence, driven seasonal oscillations in mosquito abundance, and may include a transient period immediately after vaccine introduction where prevalence can spike higher than in the pre-vaccine period. These spikes in prevalence could lead to doubts about the vaccination program among the public and among even decision makers, possibly hampering with the vaccination program. Using simple dengue transmission models, we show that the presence of transient spikes in prevalence is a robust phenomenon that occurs when vaccine efficacy and vaccination rate are not either both very high or both very low. Despite the presence of transient spikes in prevalence, the models predict that vaccination does always reduce the total number of infections in the 15 years after vaccine introduction. Policy makers should prepare for spikes in prevalence after vaccine introduction to mitigate the burden of these spikes and any resulting perception of inefficacy of the vaccine program.

Oncolytic Virotherapy to Treat Cancer and the Effects from the Immune System

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Abstract

Oncolytic viruses are a form of cancer treatment used to target tumor cells without harming healthy cells. These viruses have been engineered to specifically infect and kill cancer cells. Maximizing oncolytic potential of replicating viruses, however, has not been found to be an optimal strategy, as opposed to maximizing viral spread through the tumor. The ode model in this work includes interactions of uninfected tumor cells, tumor cells infected by the virus, and virus specific antigens, representing an immune response. Here , the thresholds between slow and fast replicating viruses are explored to find the most optimal outcome towards the minimization of tumor cells.

Can Mathematical Models Predict the Outcomes of Prostate Cancer Patients Undergoing Intermittent Androgen Suppression Therapy?

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Abstract

Prostate cancer is often treated by a hormone therapy called androgen deprivation therapy since both normal and cancerous prostate cells depend on androgens for proliferation and survival. Due to the side effects of this treatment, the quality of life decreases for the patients while on the therapy. Thus patients often choose intermittent androgen deprivation therapy, in which the patients alternate between durations of on and off treatment. We extend an existing model which used measurements of patient testosterone levels to accurately fit measured serum PSA levels. We test the model's predictive accuracy when only a subset of the data is used to find parameter values. The results are compared with those of an existing linear model which does not use testosterone as an input. Since actual treatment protocol is to re-apply therapy when PSA levels recover beyond some threshold value, we develop a second method for testing the first model's accuracy in predicting the duration of off-treatment periods.

A Semi-implicit Curve Search Algorithm for Nonconvex Minimization

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Abstract

We introduce a "curve" search algorithm in the semi-implicit numerical scheme for nonconvex optimization problems. The algorithm is particularly useful for imaging applications where semi-implicit scheme with adaptively large step sizes can significantly improve computation efficiency. Due to the structure of imaging problems, the semi-implicit scheme has only quasi-linear complexity per iteration, and the search trajectories of step sizes are curves rather than straight lines. The convergence of iterates to a local minimum in general nonconvex problem is guaranteed when modified Wolfe's conditions of step sizes are met. Application of the algorithm to several imaging problems is discussed.

An Accelerated Primal-dual Framework for Convex Composite Optimization with Linear Constraints

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Abstract

We present a novel scheme for convex composite optimization. The idea is to incorporate Nesterov's optimal scheme into linearized alternating direction method of multipliers. The proposed methods have better rates of convergence in terms of dependence on Lipschitz constant of the smooth component.

Semi-Asynchronous Strategies in Distributed Optimization for Data Fitting Problem

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Abstract

Many structured data-fitting applications require the solution of an optimization problem involving a sum over a potentially large number of measurements. We study some semi-asynchronous strategies for distributed optimization approaches to deal with the unbalance of computation loads. These strategies involve complicated communications among processors, instead of a simultaneous communication, by using the priori knowledge about the computation loads in different processors. Preliminary numerical experiments show that our semi-asynchronous strategies are promising.

Compressed Sensing for Magnetic Resonance Imaging of the Lungs during Forced Expiration

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Abstract

Compressed sensing (CS) is used in medical imaging to reconstruct images from very limited amounts of data. CS has especially improved magnetic resonance imaging (MRI), which is traditionally slow to acquire large amounts of data. One particular application is lung imaging, specifically during forced breathing maneuvers lasting less than 6 seconds. Current clinical standards rely on measurements made by a spirometer during exhalation, but these measurements contain no spatially specific information.

We have developed an imaging protocol and reconstruction framework to capture 4D (3D+time) images of the lungs with unprecedented temporal resolution during forced breathing. During the lung imaging experiment, data were collected in three phases: full lungs, forced expiration, and empty lungs. The data set from the forced expiration phase is highly under sampled, but can be reconstructed using sparse regularization across both space and time dimensions. Additionally, the full and empty lung images, both fully sampled, can help to resolve images from the forced expiration phase. A conjugate gradient method with total variation penalties is used to iteratively solve the image reconstruction inverse problem.

Preliminary correlation studies show that lung volume calculated from segmentation of the magnetic resonance images agrees with volume measured simultaneously by a spirometer.

Fast Accelerated Bundle Level Type Methods

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Abstract

It has been shown that the accelerated prox-level(APL) method and its variant, uniform smoothing level(USL) method, have optimal rate of convergence for smooth and non-smooth convex programming problems without requiring the input of any smoothness information. However, the efficiency of APL or USL algorithm fully relies on that of the two sub-problems involved in the algorithm, which are computationally expensive to solve and require the boundedness of the feasible set. This hindered the applicability of the algorithms in solving large scale or unconstrained optimization problems. Motivated by this, in this work, we propose a fast APL (FAPL) method and its variant: fast USL (FUSL) method for solving unconstrained convex minimization problems that have a wide range of applications in image/data analysis. The proposed algorithms can achieve the same optimal rate of convergence, but the numbers of the sub-problems involved reduced from two to one. Moreover, we introduced a non-iterative approach to solve the only sub-problem exactly, and the computational cost is almost dimensional independent. As a result, the proposed methods have improved the performance of the APL and USL in practice significantly in the sense of fast computing and high accuracy. Our experimental results on solving some large-scale least square problems and total variation based image reconstructions have shown great advantages of these fast accelerated bundle type methods comparing to APL, USL, and other state-of the-art first order optimal schemes.

Asymptotic Convergence of Solutions for the BBM-KP and the BBM

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Abstract

The BBM and BBM-KP equations cover the surface waves of long wavelength in liquids, hydromagnetic waves in cold plasma, acoustic waves in anharmonic crystals, and acoustic gravity waves in compressible fluids. It is shown that the solution of the Cauchy problem for the BBM-KP equation converges to the solution of the Cauchy problem for the BBM equation in a suitable function space whenever the initial data for both equations are close as the transverse variable $y \to \pm\infty$. Given a situation where it is easier to obtain a solution to the BBM-KP, provided the intial datum for the BBM is "'close"' to the intial datum of the BBM-KP for sufficiently large y, one could instead use the solution to the BBM which has one less spatial variable and, as a result, is more convenient in a numerical setting. This result contributes further to the understanding of two well-known, actively studied models in mathematical physics. Also, it attests to an interesting relationship between the BBM and the BBM-KP.

Alternating Direction Approximate Newton Method for Partially Parallel Imaging

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(joint work with William Hager, Maryam Yashtini, and Hongchao Zhang)

Abstract

An alternating direction approximate Newton method (ADAN) is developed for problems that arise in partially parallel magnetic resonance image reconstruction (PPI). The reconstruction amounts to solving a problem of the form $\min\{\phi(Bu) + 1/2\|Au - f\|_2^2\}$, where u is the image and ϕ is nonsmooth convex function corresponding to regularization. A is the matrix describing the imaging device, f is the measured data, and in total variation regularization, B corresponds to the derivative along the coordinate directions. It is shown that ADAN converges to a solution of the image reconstruction problem without a line search. It performs at least as well as the recent variable stepsize Bregman operator splitting algorithm (BOSVS), which requires a line search and a suitable choice for many algorithm parameters. Numerical experiments are presented based on PPI reconstruction.

Composite Minimization and its Application to Image Deblurring

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Abstract

In this talk, a composite minimization problem is considered. Fixed point iterative algorithms are proposed to solve the composite minimization problem. The convergence of the proposed algorithms is guaranteed under certain conditions. Application of the proposed algorithms to L2-TV and L1-TV deblurring problems will be shown.

Accelerated Uzawa Iteration for the Stokes Equations

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Abstract

The finite element discretization of the Stokes equations leads to a saddle point problem. Several different iterative methods have been used to solve this discrete problem, including preconditioned GMRES and CG. Here, we wish to reformulate the problem as a fixed point problem and explore the use of Anderson Acceleration (AA). Specifically, we use a P2/P0 finite element and solve a fixed point problem where the velocity and pressure have been set up using the Uzawa algorithm. It means, given an initial pressure, we solve for velocity, and then update the pressure using a relaxation parameter. We will show the results of a numerical study in which we compare the performance in several test cases of Uzawa iteration with and without AA as well as several alternative solution approaches.

A Fast Algorithm for Finding the Shortest Path by Solving Initial Value ODEs

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Abstract

We propose a new fast algorithm for finding a global shortest path connecting two points while avoiding obstacles in a region by solving an initial value problem of ordinary differential equations under random perturbations. The idea is based on the fact that every shortest path possesses a simple geometric structure. This enables us to restrict the search in a set of feasible paths that share the same structure. The resulting search set is a union of sets of finite dimensional compact manifolds. Then, we use a gradient flow, based on an intermittent diffusion method in conjunction with the level set framework, to obtain global shortest paths by solving a system of randomly perturbed ordinary differential equations with initial conditions. Comparing to the existing methods, such as the combinatorial methods or partial differential equation methods, our algorithm seems to be faster and easier to implement. We can also handle cases in which obstacle shapes are arbitrary and/or the dimension of the base space is three or higher.

Optimal Control with Budget Constraints and Resets

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Abstract

We consider both discrete and continuous control problems constrained by a fixed budget of some resource, which may be renewed upon entering a preferred subset of the state space. In the discrete case, we consider both deterministic and stochastic shortest path problems on graphs with a full budget reset in all preferred nodes. In the continuous case, we derive augmented PDEs of optimal control, which are then solved numerically on the extended state space with a full/instantaneous budget reset on the preferred subset. We introduce an iterative algorithm for solving these problems efficiently. The method's performance is demonstrated on a range of computational examples, including optimal path planning with constraints on prolonged visibility by a static enemy observer.

A Comparison between Two Fast Algorithms for Symmetric LCPs

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Abstract

Linear complementarity problems (LCPs) arise in a wide range of applications such as rigid body dynamics simulations and american options pricing among others. Machine learning models regularized with ℓ_1 norm can also be formulated as LCPs. Therefore, a good number of numerical methods have been proposed to efficiently solve instances of LCPs. In this work we study two methods based on two phases.

We first analyze the method described by Morales, Nocedal and Smelyanskiy. The method computes the solution by combining projected Gauss-Seidel iterations with subspace minimization steps; the recursive subspace minimization is designed to account for ill-conditioned problems. The second method in our study is the proposed by Hintermller, Ito and Kunisch. That method makes use of two-steps iterations; the first is designed to identify the active set by means a non-differentiable function whilst the second performs a Newton step to compute the direction for the update.

We present numerical results in a collection of 11 symmetric LCPs that arise in rigid body dynamics simulations.

Solving a Partial Inverse Optimization Problem via QP-Based Branch and Bound

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Abstract

This paper studies a particular partial inverse problem (PIP), which models a problem in statistics called instrumental variable quantile regression (IVQR). The PIP can be converted to a convex quadratic problem with complementarity constraints, which is generally NP-hard and we introduce a branch-and-bound algorithm to solve it globally. We compare our algorithm with two standard global optimization solvers on random, yet realistic, instances and show that our algorithm solves these efficiently and effectively.

Convergence Rate Analysis of Several Convex Splitting Schemes

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Abstract

In this talk, I will provide a general tool to analyze the convergence rate of several first order convex splitting schemes under inexact evaluation of operators and varying relaxation parameters. In the variational setting, we subsequently deduce ergodic and non-ergodic objective function value convergence rates of several Douglas-Rachford type splitting algorithms.

Feasible Method for Semi-Infinite Programs

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Abstract

Optimization problems involving finitely many decision variables and infinitely many constraints are referred to as semi-infinite programs. We present a novel approach to compute the feasible solution of standard semi-infinite programs. The key issue is to construct a proper upper bound function of constraint function with quadratic error bound on box domains. By replacing the original constraints with new approximate constraints, we obtain an inner approximation region in finitely many constraints. A feasible algorithm is proposed to obtain Karush-Kuhn-Tucker point of origin problem by solving the approximation problem and a refinement procedure is taken adaptively to improve the quality of solution. At each iteration, at most n new constraints are needed to add to guarantee convergence. In general, we prove that the solutions of approximation problems converge to that of the original problem if the subdivision of parameter set Y is exhaustive. Numerical experiment shows the performance of our algorithm.

Parameter Dependent Model Reduction for Nonlinear Systems

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Abstract

When applying optimization techniques, using full order models for the solution of parameter dependent PDE systems may simply be intractable. Surrogate models are used to provide an approximation to the high fidelity models while being computationally cheaper to evaluate. Typically, for time dependent nonlinear problems a reduced order model is built using a POD basis and Galerkin projection of the system dynamics. This talk will describe reduced order modeling techniques specifically designed for nonlinear parameter dependent systems. The focus will be on methods in which the projection basis also depends on the parameter through extrapolation and interpolation. Methods that utilize the sensitivity information of the projection basis will also be covered. Finally the methods will be demonstrated in a 1D optimization example problem.

The Third SIAM Gators Student Conference

March 27 to 29, 2014

Department of Mathematics
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ABSTRACTS of POSTERS

Stoichiometric Producer-Grazer Models

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Abstract

There has been important progress in understanding ecological dynamics through the development of the theory of ecological stoichiometry. For example, modeling under this framework allows food quality to affect consumer dynamics. While the effects of nutrient deficiency on consumer growth are well understood, recent discoveries in ecological stoichiometry suggest that consumer dynamics are not only affected by insufficient food nutrient content (low phosphorus (P): carbon (C) ratio) but also by excess food nutrient content (high P:C). This phenomenon is known as the stoichiometric knife edge, in which animal growth is reduced not only by food with low P content but also by food with high P content, and needs to be incorporated into mathematical models. Here we present Lotka-Volterra type models to investigate the growth response of Daphnia to algae of varying P:C ratios capturing the mechanism of the stoichiometric knife edge.

Accelerated Bregman Operator Splitting with Variable Stepsize

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Abstract

This paper develops a novel accelerated Bregman operator splitting with variable stepsize (ABOSVS) for solving problems of the type $\min\{\frac{1}{2}||Au - f||_2^2 + \phi(Bu)\}$, where ϕ may possibly be nonsmooth. The original Bregman operator splitting with variable stepsize (BOSVS) employed a line search to achieve high efficiency, while ABOSVS incorporates a multi-step acceleration scheme into BOSVS to improve the convergence rate. Our proposed algorithm is compared with BOSVS through partially parallel magnetic image reconstruction. The numerical results show that the proposed ABOSVS algorithm performs more efficiently in terms of image quality and CPU time.

Parallel MR Image Reconstruction for Multi-Shot Diffusion Weight Image

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Abstract

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 (I_n) 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 I_n, which is solved by an ADMM scheme.

Multi-Contrast Multi-Channel Parallel MR Image Reconstruction

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Abstract

In a clinical exam, multi-contrast images are often scanned by parallel coils with the same field of view (FOV) for complementary diagnostic information, such as T1 and T2 weighted. In this type of problems, we apply PPI with the most advanced compressive MRI techniques to multi-contrast multi-channel MR image reconstruction with significantly reduced data. This problem also involves big size of data, hence, we also need to develop optimization schemes with optimal rate of convergence to solve our models. In PPI, these images with different contrasts theoretically have sharable information, such as the same coil sensitivities and the same anatomical information, since the same patient is scanned in the same system using the same RF coil. Now we are developing the models that are able to share the information from multi-contrast and multi-channel images in a joint reconstruction.

Risk Factors for Hyperendemic Visceral Leishmaniasis in Two Eco-epidemiologically Distinct Countries: India and Sudan

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Abstract

Visceral leishmaniasis (VL) is a vector-borne parasitic disease caused by protozoan parasites and transmitted by the phlebotomine sand flies. India and Sudan together account for more than half of the world's VL burden. There are however some variations in vector and host characteristics between the two countries. The World Health Organization (WHO) aims to eliminate the disease by 2020, but various unknown risk factors and undetected high incidences of asymptomatic cases may pose a barrier in achieving the targeted objective. We have developed a vector-host epidemic model, for both asymptomatic and hospitalized individuals, to compare, and contrast the mechanisms that contribute to the level of risk posed by VL in the two countries. The dynamics of the model are uniquely determined by the basic reproductive number, $\mathcal{R}_0$, measuring the transmission potential of the *Leishmania donovani* parasite. Estimates of both ecological, epidemiological, and demographical parameters for both countries were determined from data sets of various of their respective public health departmental reports as well as from data from relevant literature reviews. The analyses of the endemic equilibrium reveal the existence of backward bifurcation and numerical solution with the real parameter estimates support this phenomenon. Using these estimates, a sample-based method of global sensitivity analysis is applied to identify key influential parameters affecting $\mathcal{R}_0$. Our analyses found that biting rate; the sand fly to human ratio; the transmission coefficients between sandflies and human; the disease related death rate for humans ; and the treatment rate are all sensitive to the predicting patterns of VL in both countries. The transmission potential from humans to sand flies was shown to also be a sensitive parameter but only for Sudan. The treatment rate per capita number of vectors was found to be the most influential factor contributing to high endemic levels of VL observed in both India and Sudan, respectively. Since our model incorporates and identify the impact of observable variations in demographical, epidemiological, and ecological factors on transmission dynamics of VL for both the countries its predictive outputs could be used to design effective control policies directly impacting VL risk factors for both India and the Sudan.

Assessing Temporal Rabies Dynamics in Three North American Carnivore Species

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Abstract

Rabies is a zoonotic infection that affects many wild and domestic mammals, as well as humans, throughout the world. Raccoons are currently considered the primary carnivore host in the northeast United States responsible for rabies virus maintenance. We use mechanistic transmission models to consider different hypotheses about rabies transmission dynamics in raccoons, skunks, and foxes in the northeast United States. To study the impact of birth process characteristics on transmission dynamics, we first develop a Susceptible-Exposed-Infectious model of rabies transmission for each species. Susceptible individuals are split into a juvenile compartment and an adult compartment. Seasonality in the birth rate is modeled using a periodic Gaussian function parameterized to represent the distinct birthing patterns.

We alter the model structure by incorporating raccoon spillover infections and eliminating within-species transmission for the fox and skunk populations. We compare the outputs from the alternative model structures with extensive time series data from the Centers for Disease Control and Prevention on the numbers of reported cases in raccoons, skunks, and foxes.

We are in the process of implementing an observation model to bridge the gap between the true ecological processes and the patterns we observe in surveillance data. Ultimately, we hope to implement a stochastic model and use an R package to fit unknown parameters and evaluate the predictive ability of each model. The initial model fitting will focus on a small geographic region in the northeast United States.

On a Non-linear Investigation of an Electrospinning Model under Combined Space and Time Evolving Instabilities

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Abstract

We study the nonlinear problem of axisymmetric electrically driven jets with applications to electrospinning. In our investigation we consider the model based on the governing electrohydrodynamic equations that unifies the two types of instabilities that occur during the fine fiber production due to spatial and temporal growing disturbances. The model is approached from a classical stability point of view in the early stage and then it is treated with a weakly nonlinear wave theory of certain dyad resonance modes that later involve the use of Newton's Method to solve a dispersion relation and finally the Method of Lines (MOL) to solve a system of PDEs that governs the combined time and space evolving amplitude instability functions. We found, in particular, that for certain parameter values of the jet flow system, there are some resonance modes that can dominate the jet for its temporal and spatial evolution. We were able to detect nonlinear properties in our investigation that allowed a favorable change in the dynamics of the jet flow from a thickening to a thinning jet. Our model was able to uncover new parameter regimes for both spatial and time modes in which instabilities were significantly enhanced and jet radius was reduced approaching to nano-scale size, which is the desired mechanism in the electrospinning process.