Program for the 2007 SIAM Front Range Applied Mathematics Student Conference

March 3rd, 2007

Breakfast and Registration: 8:30 - 9:00

Morning Session I - Room 1603
9:00 - 10:35

9:00 - 9:20	Brandon Booth, Ben Safdi, and Kye Taylor *CU - Boulder*	Ising Model Applied to Congressional Redistricting - MCM 2007
9:25 - 9:45	Sanghui Lee, John Villavert and Nathan Schill *CU - Colorado Springs*	The Kidney Exchange Problem - MCM 2007
9:50 - 10:10	Lee Rosenberg, Derlin Campbell, and Lydie Van Holland *CU - Denver*	Airplane Boarding Model - MCM 2007
10:15 - 10:35	Jisun Lim *CU - Boulder*	Stability of Solutions to a Reaction Diffusion System Based Upon Chemical Reaction Kinetics

Morning Session II - Room 1605
9:00 - 10:35

9:00 - 9:20	Jutta Bikowski *Colorado State University*	Electrical Impedance Tomography and the Pioneering Work of A. Calderon
9:25 - 9:45	Ethan Murphy *Colorado State University*	Reconstructions of Conductive and Insulating Targets Using the D-Bar Method on an Elliptic Domain
9:50 - 10:10	Mike Watson *CU - Boulder*	Fluid Dynamics in Cylindrical Geometries: Simplifying Navier-Stokes for Geophysically Relevant Problems
10:15 - 10:35	Benjamin Safdi *CU - Boulder*	Finite-Time Singularities in Coupled Nonlinear Schrödinger Equations with 4-wave Mixing

Break: 10:35 - 10:45

Plenary Address, Leslie Greengard: 10:45 - 11:45, North Classroom 1607

The Nonuniform FFT and Magnetic Resonance Image Reconstruction

Lunch: 12:00 - 1:00

Afternoon Session I - Room 1603
1:00 - 4:00

1:00 - 1:20	Lauren Anderson *CU - Boulder*	Isolation and Implementation of the Dynamical Core from the German Weather Service's Numerical Weather Prediction Model
1:25 - 1:45	Josh Nolting *CU - Boulder*	Local Adaptive Refinement (LAR)FOSLS
1:50 - 2:10	Kye Taylor *CU - Boulder*	Local Geometric Projection for Denoising M-Valued Data
2:10 - 2:20	Short Break	
2:25 - 2:45	Angela Harris *CU - Denver*	H-avoiding Hamiltonian Cycles
2:50 - 3:10	Geoffrey Sanders *CU - Boulder*	Using a Generalized Eigensolver Based on Smoothed Aggregation (GES-SA) to Initialize Smoothed Aggregation Multigrid
3:15 - 3:35	Eugene Vecharynski *CU - Denver*	Solution of Large Sparse Underdetermined Linear Systems with Embedded Network Structure for a Non-Homogeneous Network Flow Programming Problem
3:40 - 4:00	Keith Wojciechowski *CU Denver*	An Introduction to Spectral Methods via the Numerical Solution of a Fluid Transport Equation

Afternoon Session II - Room 1605
1:00 - 4:00

1:00 - 1:20	Gisella Kagy *CU - Boulder*	The Impact of Conditional Cash Transfers on Prenatal Health: Is It Just a Supply Effect?
1:25 - 1:45	Robert Engle *CU - Colorado Springs*	Jukes-Cantor DNA Probability Model
1:50 - 2:10	Jen-Mei Chang *Colorado State University*	Illumination Face Spaces are Idiosyncratic
2:10 - 2:20	Short Break	
2:25 - 2:45	Minjeong Kim *CU - Denver*	Mathematical and Numerical Modeling of Wildfire

2:50 - 3:10	Bedrich Sousedik *CU - Denver*	A Note on the Patch Test for the Bilinear Quadrilateral Finite Element
3:15 - 3:35	Jonathan Beezley *CU - Denver*	Predictor-Corrector and Morphing Ensemble Filters
3:40 - 4:00	McKenna Roberts *CU - Denver*	Evaluation of Parameter Effects in Estimating Non-linear Uncertainty Propagation

Plenary Speaker (10:45 - 11:45)

THE NONUNIFORM FFT AND MAGNETIC RESONANCE IMAGE RECONSTRUCTION

Leslie Greengard, Courant Institute, New York University

The nonuniform FFT arises is a variety of applications, from medical imaging to radio astronomy to the numerical solution of partial differential equations. In a typical problem, one is given an irregular sampling of N data points in the frequency domain with the goal of reconstructing the corresponding function at N points in the physical domain. When the sampling is uniform, the fast Fourier transform (FFT) allows this calculation to be carried out in O(N log N) operations. Unfortunately, when the data is nonuniform, the FFT does not apply. In the last few years, a number of algorithms have been developed which overcome this limitation and are often referred to as nonuniform FFTs. In this talk, we describe the basic algorithm and its application to magnetic resonance imaging.

About the speaker: Dr. Leslie Greengard received his B.A. in mathematics from Wesleyan University in 1979, his Ph.D. in computer science from Yale University in 1987, and his M.D. from Yale University in 1987. During 1987 – 89 he was a NSF Postdoctoral Fellow at Yale University in the Department of Computer Science. He is presently professor of mathematics and the Director of the Courant Institute of New York University. Much of his work has been in the development of analysis-based fast algorithms such as the Fast Multipole Method for gravitation and electromagnetics and the Fast Gauss Transform for diffusion. Among the many awards he received for his work is the 2001 Steele Prize in Mathematics.

Morning Session I

crete function involving distance, each passenger's boarding time, and other factors hindering the procession to a seat was utilized to simulate the abstract model of different airplanes. We devised a new method that airlines could implement that takes into account the many different variables that affect human behavior, such as age and air travel experience. This method uses the behavior scalar and sorts the passengers both by row number (rearmost to foremost row) and behavior scalar values. We devised a complex model for Southwest's random boardis implemented on an elliptic domain. The scattering transform is computed on an ellipse and the complete electrode model (CEM) for the

Afternoon Session I

ISOLATION AND IMPLEMENTATION OF THE DYNAMICAL CORE FROM THE GERMAN WEATHER SERVICE'S

H-AVOIDING HAMILTONIAN CYCLES

Angela Harris
University of Colorado at Denver
Room 1605, 3:15 - 3:35

A spanning cycle in a graph G is called a hamiltonian cycle and if such a cycle exists, we say that G is hamiltonian. For a subgraph H of G we say that G is H-avoiding hamiltoninan if there is a hamiltonian cycle in G that contains no edges of H or, in other words, if G - E(H) is hamiltonian. In this talk we will discuss some new results on H-avoiding hamiltonian graphs. In particular we will consider the case where H is a hamiltonian cycle, which will lead to a discussion of extending families of edge-disjoint hamiltoinian cycles.

USING A GENERALIZED EIGENSOLVER BASED ON SMOOTHED AGGREGATION (GES-SA) TO INITIALIZE SMOOTHED AGGREGATION MULTIGRID

Geoffrey Sanders
University of Colorado at Boulder
Room 1603, 2:50 - 3:10

Consider the linear system Ax=b, where A is a large, sparse and symmetric positive definite matrix. Solving this system for unknown vector x using a smoothed aggregation multigrid (SA) algorithm requires a characterization of the algebraically smooth error that is poorly attenuated by the algorithm's relaxation process. For many relaxation processes of interest, algebraically smooth error corresponds to the near null-space of A. An eigenvector corresponding to the smallest eigenvalue of A, or minimal eigenvector, is an essential part of the near-nullspace of A. Therefore, having an approximate minimal eigenvector can be useful to characterize the algebraically smooth error when forming the SA method. This talk discusses the details of a generalized eigensolver based on smoothed aggregation (GES-SA) that is designed to produce an approximation to a minimal eigenvector of A. GES-SA might be very useful as a stand-alone eigensolver for applications that desire an approximate minimal eigenvector, but the intention here is to use GES-SA to produce an initial algebraically smooth eigenvector that can be used to initialize SA or an adaptive version of SA.

SOLUTION OF LARGE SPARSE UNDERDETERMINED LINEAR SYSTEMS WITH EMBEDDED NETWORK STRUCTURE FOR A NON-HOMOGENEOUS NETWORK FLOW PROGRAMMING PROBLEM

Eugene Vecharynski
University of Colorado at Denver
Room 1603, 3:15 - 3:35

The work on this paper was caused, mainly, by the analysis of non-homogeneous problems of network optimization on large data files. Our main goal was to develop an effective (direct) method for solving large sparse systems of linear equations with embedded network structure, which appear naturally, e.g. as systems of restrictions, in a broad class of nonhomogeneous network flow programming problems. The "network nature" of the regarded system allows keeping data in the matrix-free form in the computer memory. The formulae, derived within the paper, are written in the component (network) form to provide clear approaches towards developing computational algorithms using efficient data structures for graph representation.

AN INTRODUCTION TO SPECTRAL

ments with many differences could cause a significant underestimation of the number of substitutions. Even in small strands if there a significant number of substitutions then it can be unreasonable to count them visually or if the strands are very long then counting the substitutions would be near impossible. Jukes-Cantor derived a method of estimating the number of substitutions when simple inspection of two sequences was not possible. As a result of their derivation analysis of mitochondria DNA between humans and even species has become easier.

ILLUMINATION FACE SPACES ARE IDIOSYNCRATIC

Jen-Mei Chang
Colorado State University
Room 1605, 1:50 - 2:10

Illumination spaces capture how the appearances of human faces vary under changing illumination. This work models illumination spaces as points on a Grassmann manifold and uses distance measures on this manifold to show that every person in the CMU-PIE and Yale data sets has a unique and identifying illumination space. This suggests that variations under changes in illumination can be exploited for their discriminatory information. As an example, when face recognition is cast as matching sets of face images to sets of face images, subjects in the CMU-PIE and Yale databases can be recognized with 100% accuracy.

MATHEMATICAL AND NUMERICAL MODELING OF WILDFIRES

Minjeong Kim
University of Colorado at Denver
Room 1605, 2:25 - 2:45

The goal in wildland fire modeling is to predict the behavior of a complex system involving many processes and uncertain data by a physical model that reproduces important dynamic behaviors. A wildfire is modeled by a system of nonlinear reaction-convection-diffusion equations. Solution of such equations exhibit travforecast distribution in a manner similar to a particle filter. These predictor-corrector filters are shown to combine the benefits of the EnKF and particle filters, while canceling out many of their problems. In the formulation, we have exploited the fact that model states tend to be solutions of differential equations and are elements of a space of smooth functions. This fact greatly reduces the effective dimensionality of the problem and allows the application of traditional particle filtering techniques. The morphing ensemble filters proposed attempt to remove the non-Gaussianity of the forecast distribution by transforming the ensemble state into something that is expected to be distributed more normally. For the purposes of transformation, each ensemble state variable is represented as a morphing function and a residual, which are computed using well known automated image registration techniques. The morphing function essentially describes the major features of the image in terms of their spatial location, while the residual describes any difference in the nature of the feature itself. Preliminary results for this method are given which show significant success in assimilating data with a poorly chosen initial ensemble, while eliminating filter divergence.

EVALUATION OF PARAMETER EFFECTS IN ESTIMATING NON-LINEAR UNCERTAINTY PROPAGATION

McKenna Roberts
University of Colorado at Colorado Springs
Room 1605, 3:40 - 4:00

The propagation of uncertainty in nonlinear cases can be handled accurately and easily with a piecewise linear approach to propagating the probability density function through the analysis equation. Previous work outlined this method but did not examine the effects of parameters on the accuracy of the results. Parameters to be chosen in this approach include the number of evaluation points and the distribution of those points over the range of interest. The effects of these parameters are explored for three elementary functions. It is found that for the functions examined, the piecewise linear approach always converged with increasing numbers of points. For the cases examined, 30-200 evaluation points were required for convergence. A uniform distribution of points was both the simplest to implement and converged the fastest.