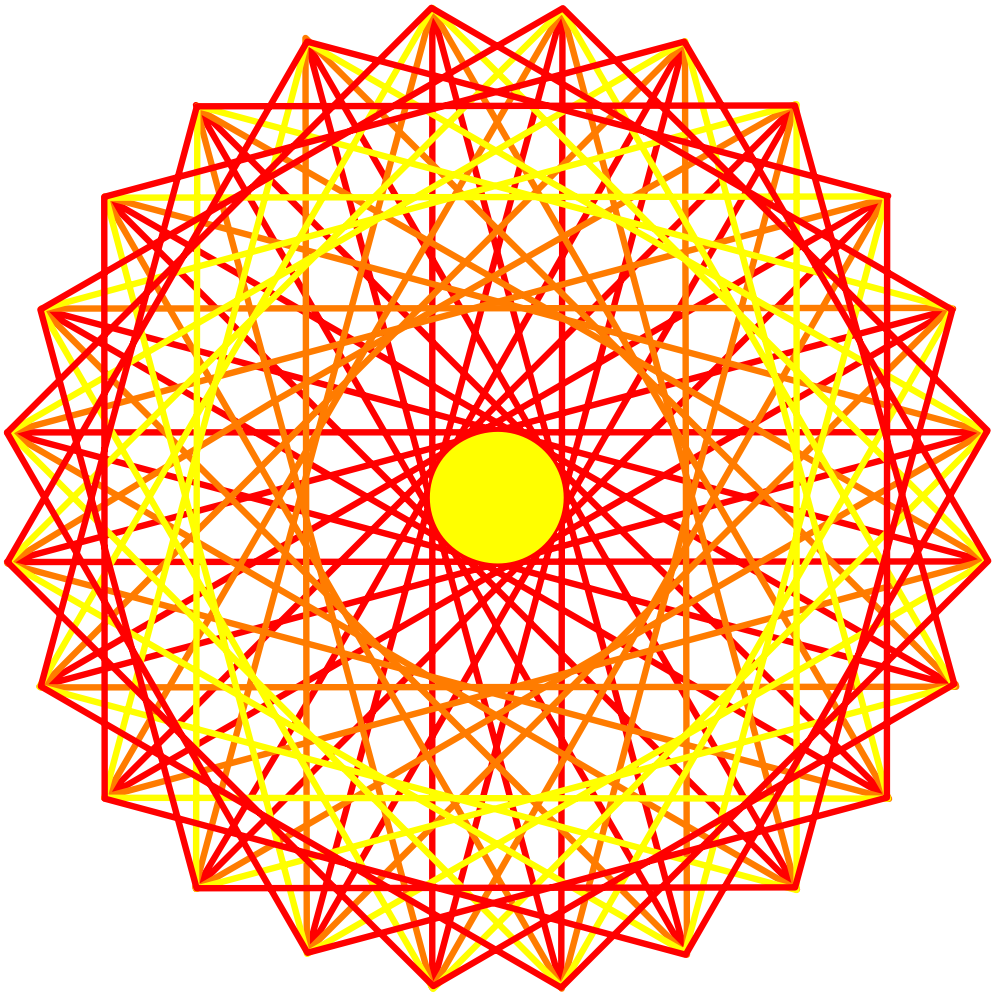
8th Conference for African−American Researchers in the Mathematical Sciences
Princeton University, June 18−21, 2002



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A TETRAHEDRAL EXTRUSION ALGORITHM USING A PRISMATIC APPROACH

Bobby Barnes
Department of Electrical Engineering
Stanford University
bbarnes@stanford.edu

Within the realm of surgical simulation, tissues and other surfaces are modeled with the creation of virtual meshes. These meshes on the simplest level are composed of very small triangles or "faces." Each vertex of a face is known as a node and the sides are known as edges. By varying the locations and sizes of the nodes and edges of a face while inter-connecting many faces, a virtual representation of any surface can be created. To give the virtual object realistic physical behavior, each edge on an entire mesh is modeled as a spring that can be either stretched or compressed.

When a virtual mesh is created to represent an object, usually only the outer surface of the object is virtually created for the simulation model. As mentioned above, the virtual mesh has the ability to exhibit physical behavior through calculations performed on the "spring-like" modeling of each of its edges. However, since only the outermost surface of a real object is virtually created, the physical behavior of the new virtual mesh does not always correspond to that of the object that it represents. To compensate for this problem, virtual meshes are extruded. Extruding a virtual mesh makes the mesh thicker by adding internal nodes and edges. In doing this, the physical behavior of a virtual mesh representing a real object becomes much more realistic.

At present, several extrusion algorithms exist that will add thickness to a virtual mesh. This paper focuses on a tetrahedral extrusion algorithm utilizing a prismatic approach to filling virtual meshes.

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MODELIZATION OF FRICTIONAL CONTACT IN REPRESENTING FLEXIBLE OBJECTS WITH CONSTRAINT OPTIMIZATION AND B-SPLINE SURFACES

Jules Degila
Départment de Génie Electrique
GERAD and Ecole Polytechnique de Montreal
jules.degila@gerad.ca

A great majority of the models simulating the behavior of flexible objects, are developed using the forces acting on the body and constructing the equation of motion. Dussault and Pfister proposed a different approach based on the minimization of a merit function representing the object's energy. However, one drawback of the model is the difficulty to integrate the effect of friction into the model. In this work, we study the frictional contact problem. Then we propose a way to improve the model taking into account the friction between objects. The result is illustrated through the simulations of different kinds of tissues.

This is joint work with Jean-Pierre Dussault, Université de Sherbrooke.

PATTERNEDGE: TOOL SUPPORT FOR WEB-COURSE DESIGN PATTERNS

Sherri S. Frizell
Department of Computer Science & Software Engineering
Auburn University
frizess@eng.auburn.edu

Design patterns for web-based instruction help to align educational and instructional theory with web-course design practice. However, novice designers' abilities to use design patterns effectively are unclear. We provide a design tool that supports novice course designers with pattern usage. *PatternEdge*, an interactive web-course tool, supports instructors in the application of design patterns to their course design problems. The system consists of a pattern language for web-based instruction and a design environment that scaffolds the pattern user's design tasks. We provide support for three main activities: finding and selecting the appropriate patterns, and the application of the selected patterns into the course's design. With PatternEdge, the instructor follows an effective design process that includes the use of patterns as a subtask. It is important that the novice designer learns to not only work with design patterns, but also gains a better understanding of web-based instructional design.

ROBUST EMPIRICAL LIKELIHOOD

Nancy Glenn
Rice University
Department of Statistics
nglenn@stat.rice.edu

This research introduces a new nonparametric technique: robust empirical likelihood. Robust empirical likelihood employs the empirical likelihood method to compute robust confidence intervals and multidimensional point estimates. The technique uses constrained optimization to solve a robust version of the empirical likelihood function. This technique allows data analysts to estimate parameters accurately despite any potential contamination.

Empirical likelihood combines the utility of a parametric likelihood with the flexibility of a nonparametric method. Parametric likelihoods are valuable because they have a wide variety of uses; in particular, they are used to construct confidence intervals. Nonparametric methods are flexible because they produce accurate results without requiring knowledge about the data's distribution. Robust empirical likelihood's applications include regression models, hypothesis testing, and all areas that use likelihood methods.

BANDWIDTH PROVISIONING FOR REAL-TIME SYSTEMS

Robert Cornelius Hampshire
Princeton University
Operations Research and Financial Engineering Department
rhampshi@princeton.edu

Customers of bandwidth services can be divided into two distinct groups: those customers requesting bandwidth for the future and those desiring bandwidth immediately. Forward contracts are created to satisfy the customers requesting bandwidth for the future.

We develop a dynamic network provisioning methodology that minimally satisfies the QoS (blocking probability) requirements for the 'on-demand' customers for real-time services. Our method is sufficiently general and captures time varying trends in the demand for services as well as different bandwidth requests for the multiple classes of customers. This allows a network provider to be efficient in reserving excess bandwidth for forward contracts. Asymptotic results and bounds for the Erlang loss system due to Jagerman are invoked to obtain simple approximate solutions to this bandwidth provisioning problem.

This research is based on joint work with W. A. Massey of Princeton University, as well as Debasis Mitra and Qiong Wang of Bell Labs, Lucent Technologies.


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APPLICATION OF GRÖBNER BASES TO LINEAR ALGEBRA

Ashton S. Harper
Department of Mathematics
Xavier University in Louisiana
Manifest86@aol.com

As part of our Science Engineering Mathematics (SEM) Fellowship at Xavier University we consider the following statement:

> Suppose that X is an $n \times n$ matrix over a field k. Let I be the ideal generated by the entries of X^n and let $T(X)$ be the trace of X. Then $d = n^2 - n + 1$ is the smallest positive integer such that T^d lies in I.

As part of our project, we will give a proof of this theorem in char $k = 0$. In this poster session, we give a proof of this result for $n = 2$ with char $k = 0$. We also give an example to show that this statement is not true for $n = 2$ with char $k = p > 0$.

This work was supervised by Russell Goward of Purdue University.

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INTERACTIVE AND INTELLIGENT CONSTRAINT RELAXATION

Mave T. Houston
Department of Computer Science and Software Engineering
Auburn University
maveh@eng.auburn.edu

Constraint Satisfaction can be defined as solving an equation of the form $f(x) = a_1x_1 + a_2x_2 + a_3x_3 + \ + a_nx_n$, where the a_i's are constants and the x_i's are variables representing resources or constraints that $f(x)$ must satisfy. There are a variety of methods used to solve this class of problems, also called linear programming problems. Some software tools that aim to solve this class of problems allow user intervention to assist the software program in resolving conflicts when the problem is overconstrained. When there is a conflict, the user can intervene and soften some of the constraints interactively. This process is called constraint relaxation. We present an interactive and intelligent constraint relaxation tool to provide the user with suggestions on how to soften these constraints until a solution to the problem is found.

SIMULATION AND ANALYSIS OF SPATIAL DATA

Monica Christine Jackson
Applied Mathematics and Scientific Computation Program
University of Maryland
mcj@math.umd.edu

In spatial data, we do not have the unidirectional flow of time that occurs with time series. Therefore, spatial models are built on nearest neighbors. The majority of applications are based on a continuous, Gaussian endpoint. For discrete data, there is an auto-Poisson model and an auto-binomial model. Each of the models has its drawbacks. Such as when analyzing rare diseases, such as lip cancer, the counts are low and contain several zeros. My research investigates which type of model is best for certain types of data in particularly rare diseases.

I will present models that already exist and characterize their use and weaknesses in terms of their ability to obtain accurate estimation of parameters and prediction. Several spatial models are presently available, but there do not appear to be good guidelines for how to choose among them. I develop a set of criteria for comparing models in general. For example, capturing key characteristics of the spatial data set, such as detection of trends in the data and ability to forecast. A set of real models will be defined and used to simulate data that mimic common problems in real data sets such as "too many" zeros and low counts. I will present the results of a simulation study and capture the results to draw conclusions. New models for spatial data will also be suggested and applied to a disease data set.

PERIOD DOUBLING AS A ROUTE TO CHAOS

Bruce A. Johnson
Department of Mathematics
Virginia Polytechnic Institute and State University
brjohns2@math.vt.edu

Period doubling is viewed as a common route to chaos. As discovered by Henri Poincaré around the year 1900, chaos refers to a special kind of behavior in time found in certain physical systems. It is known to occur in mechanical oscillators such as pendulums or vibrating objects, in rotating or heated fluids, in laser cavities, and in some chemical reactions.

For my research I examined a damped-driven pendulum, one of the simplest physical systems to exhibit chaotic behavior, using analysis and computation on a mathematical model, and also by observing a real system experimentally. By taking Poincaré sections (the stroboscopic snapshot of the motion in a phase space taken at regular time intervals), and with the use of Matlab, I was able to observe phenomena such as strange attractors and period doubling, as well as determine the threshold driving amplitudes for period doubling and certain chaotic regions.

THE BULLWHIP EFFECT: APPLICATIONS IN SUPPLY CHAIN MANAGEMENT

Stacey O. Nicholls
Applied Mathematics and Scientific Computation
University of Maryland at College Park
son@math.umd.edu

In recent times, supply chain management has been concerned with coordinating interactions between various members of a supply chain. These members include manufacturers, wholesalers, distributors, and retailers. This paper considers the case of an upstream interaction between retailer and manufacturer and their relationship to a phenomenon known as the "bullwhip effect". Also known as the "whiplash effect", it refers to cases where downstream members place demand-distorted orders to upstream members. In particular, we will review the factors that contribute to the bullwhip effect, discuss measures to quantify the bullwhip effect in a two-stage supply chain, and consider methods to minimize its effects.

EMBEDDINGS OF SOME CLASSICAL BANACH SPACES INTO MODULATION SPACES

Kasso A. Okoudjou
School of Mathematics
Georgia Institute of Technology
okoudjou@math.gatech.edu

We give sufficient conditions for a tempered distributions to belong to certain modulation spaces by showing embeddings of some non-homogeneous Besov-Triebel-Lizorkin spaces into modulation spaces. As a consequence we have a new proof that the Hölder-Lipschitz space $\mathcal{C}^s(\mathbb{R}^d)$ embeds into the modulation space $\mathcal{M}^{\infty,1}(\mathbb{R}^d)$ when $s > d$. This embedding plays an important role in interpreting recent modulation space approaches to pseudodifferential operators.

PERFORMANCE ANALYSIS OF A MULTI-CLASS, PREEMPTIVE PRIORITY CALL CENTER WITH TIME-VARYING ARRIVALS

Ahmad Ridley
Department of Mathematics
Applied Mathematics Program
University of Maryland - College Park
adr@math.umd.edu

Telecommunication call centers have become the primary channel of customer interaction service for many businesses. The level of professionalism and efficiency that call center agents deliver to customers provides a significant advantage over traditional customer service practices. The growth of call centers is driven by a company's desire to lower operating costs and to increase revenues.

Call centers are a collection of centralized communication resources that facilitate inbound and outbound calls between customers and agents. Typically, a large volume of calls are handled simultaneously during the day. These calls are screened, logged, and forwarded by the call center to a set of appropriately skilled agents.

Call center managers and planners have a difficult job of delivering quality service to customers with different needs and issues. Although today's call center technologies provide greater flexibility in routing and queuing calls, planning and analysis have become more challenging. Now, certain calls can be prioritized and call agents with different skill sets can be accessed automatically. However, this complexity in call traffic and agent skill sets is difficult to model analytically, especially in real-time. Thus, the performance analysis of call centers is a more important part of business than ever.

LEARNING AND REUSE IN VISUAL PROGRAMMING ENVIRONMENTS

Cheryl Denise Seals
Department of Computer Science
Virginia Tech
cseals@vt.edu

End User Programming has become a popular technique for supporting computer users in their day-to-day activities. I am investigating how to support teachers in the Creation and Reuse of Educational simulations. There is literature on kids learning to program, but no work in the area of supporting teachers as a novice programming community. I have identified strategies for reuse in this culture. We will build upon this and enhance their productivity, by analyzing their use of existing tools and developing a new set of tools that emphasize minimalism, active learning, and encourage component reuse.

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SOME RESULTS ON IDEALS OF MINORS IN FREE RESOLUTIONS

Regis A. Smith
Department of Mathematics
University of California, Los Angeles
rsmith@math.ucla.edu

Let M be a finitely generated module over a Noetherian ring, $0 \to F_\bullet \to M \to 0$ its free resolution with boundary maps $\phi_i : F_i \to F_{i-1}$, and J the annihilator of M. We describe relations between J and the ideals of minors of the maps ϕ_i.

MEAN REVERSION AND THE VOLATILITY OF INTEREST RATES: A MONTE CARLO STUDY BASED ON DIFFERENT SAMPLING FREQUENCIES

Tana Tanarugsachock
Hunter College and The Graduate Center, CUNY
Department of Economics

This paper emphasizes that it is important to use the proper likelihood specification, that incorporates information about the sampling interval, in studies based on different sampling frequencies. To demonstrate this point we examine an application based on term structure models. The analysis establishes several basic results. First, the absolute size of the mean reversion parameter does not vary with the level of aggregation. Second, the volatility parameter depends on the level of aggregation.

This is joint work with Terence D. Agbeyegbe of Hunter College and the Graduate Center, CUNY.

A REDUCED BASIS METHOD FOR MOLECULAR DYNAMICS SIMULATIONS

Rachel E. Vincent
Rice University
Department of Computational and Applied Mathematics (CAAM)
rvincen@caam.rice.edu

Molecular dynamics (MD) simulations allow scientists to computationally determine atomic positions in a molecule over a specified period of time. These simulations are computationally expensive and generally require a large amount of data storage. We expect to reduce computational costs and storage requirements using singular value decomposition (SVD) analysis. In any trajectory, whether generated by traditional dynamics methods, time-averaged refinements, or a reduced-basis set method, classical principal component analysis may be used to classify and represent the dominant characteristics of the MD trajectory. Here we augment the classical principal component analysis with an SVD updating scheme.

SVD analysis of the computed trajectories will be developed to augment abilities to locate active sites, to identify preferred molecular configurations, and to study periodic behavior. We present preliminary results obtained with respect to our test molecule, butane.

This work is supported by NSF Grant ACI-0082645 and the W. M. Keck Center for Computational Biology NLM 1T15LM07093.

AN ASYMPTOTIC OPTIMAL DESIGN OF THE M/M/C/K QUEUE FOR CALL CENTERS

Rodney B. Wallace
IBM / George Washington University
rbwallac@us.ibm.com

We are motivated by the performance analysis of call centers to analyze the queueing system $M/M/C/K$, where C equals the number of agents and $C + K$ equals the number of number of telephone or trunk lines. Our goal is to design this multi-server queueing system by holding both its steady state probabilities of blocking and delay time exceeding a specified threshold value below given tolerance values. We develop a framework for asymptotic optimization using heavy traffic analysis. The number of agents and the number of waiting spaces in the buffer are then uniquely determined by a fixed point iteration method that uses a generic special function which can be precomputed in a lookup table. We demonstrate that this approximation is effective by making comparisons with both the typical Erlang Loss/Delay approximation scheme and the exact solution for $M/M/C/K$ system.

This is joint work with William A. Massey of Princeton University.

ON THE FORMULATION OF A NEWTON METHOD FOR AMERICAN OPTION VALUATION UNDER STOCHASTIC VOLATILITY

Donald C. Williams
Rice University
Department of Computational and Applied Mathematics
donald@rice.edu

The numerical valuation of options and other derivative contracts are of extreme importance in corporate financial risk management. In recent years, substantial progress has been made in developing more realistic option valuation models that, in general, do not admit closed form solutions. One such model is the American option valuation model under stochastic volatility. In this work, we purpose a Newton based interior-point method for solving the variational inequality problem that arises in the valuation of American type options under stochastic volatility. The problem formulation consists of a 2-factor model of the underlying asset price process, stochastic volatility properties, and a generalized Black-Scholes differential equation. The economic significance of the underlying stochastic volatility model in relation to constant and deterministic volatility functions is assessed using S&P 500 Option prices.

AFRICAN AMERICAN DISTRIBUTED MULTIPLE LEARNING STYLES SYSTEM: A CULTURE-SPECIFIC APPROACH TO E-LEARNING

Dale-Marie Wilson
Auburn University
Department of Computer Science and Software Engineering
wilsodc@eng.auburn.edu

The African-American Distributed Multiple Learning Styles System (AADMLSS) is designed to provide culture-specific education. Theorists have suggested and current educational researchers confirm that knowledge is largely socially and personally constructed. It is well understood that people have differences in learning styles. The concept of culture-specific personalization is not novel: the television medium is an excellent example of a culture-specific medium. For example, there are culture-specific television channels for various ages, ethnicities, sexes, and other categories of interest. AADMLSS acknowledges that people are culturally entertained, as illustrated by television. It utilizes animated pedagogical agents in conjunction with web-deliverable content to create multiple teaching personas that differ with respect to culture, ethnicity, gender, etc. AADMLSS provides adaptive instruction using multiple representations of the same concept taught by an animated pedagogical agent selected by the learner.

This research is supported by:

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INSIGHTS IN PRICING PERCENTILE BASKET CREDIT DERIVATIVES

Eugene O. Yeboah
Britannia Capital Advisors, LLC.
eyeboah@hotmail.com

There are two types of basket credit derivatives. The payout of the first kind depends the ranking of credit events: first-to-default, second-to-default, etc. The second kind is characterized by a payout depending on the percentiles of the portfolios loss distribution induced by the credit events. In this paper we focus on the latter.

We introduce a basic framework in the pricing of these credit derivatives. We also try to find an analytical approximation to the exact pricing formula, if a closed form solution is not available.

The framework offered here, which is close to but not the latest state-of-the-art, simplifies some of the more mathematically sophisticated models.