CAARMS9
Graduate Student Poster Abstracts
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SUSTAINABLE GUESSING

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The 2002 Environmental Sustainability Index (2002ESI) is a linear aggregation of $k = 68$ environmental variables on $n = 142$ countries. The 2002 ESI, similarly with many environmental indexes, is set with a high level of missing data (missingness) across a moderate coverage. We consider Sequential Regression Multivariate Imputation (SRMI), a multiple imputation (MI) procedure for data with monotone or semi-monotone patterns of missingness - data where the joint distribution is conditionally factorable. Further, we investigate the principal assumptions of MI: 1) that the missingness is independent of the level of themissing observations, or, ignorable. 2) that the imputation modelis valid. We consider proxies, i.e. heuristically motivated tests, for the test of assumption 1), as there is no true statistical test of ignorable missingness. We suggest and apply refinements to the SRMI procedure. Lastly, we compare the SRMI procedure to a traditional Markovian (MCMC) approach.

This is joint work with Andrew Gelman and Marc Levy.
SHORTFALL RISK MINIMIZATION IN THE PRESENCE OF INSIDE INFORMATION

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The safest criterion for eliminating completely the risk associated with a risky position is the superhedging one but it may require too much initial capital. In a market with inside information, it makes sense to ask how much one can lower the initial cost and what risk it involves. I will discuss strategies for risk minimization in this context using a discrete model of stock fluctuations.
DYNAMICS OF THE FORCED VAN DER POL EQUATION: EXTENDING THE HALF-RETURN MAP

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The forced van der Pol equation has been a subject of study since the early 1900s, yet it’s still not well understood. During World War II, British mathematicians Cartwright and Littlewood studied the system as a model for radar and radio transmission. During this time, they discovered a phenomenon currently known in mathematics as chaotic dynamics. Mathematicians Guckenheimer, Hoffman, and Weckesser have also made developments in analyzing the equation via the investigation of a 3D system derived from the forced van der Pol using geometric singular perturbation theory. By studying bifurcations of this 3D system, they hope to gain insight into original system.

The overall aim is to develop a more in-depth understanding of bifurcations that occur within the forced van der Pol system. However, this project focuses specifically on the canards present in a 2-dimensional derivative of the aforementioned 3D system. Using the integrating capabilities of a newly developed math software package integro (via MATLAB), canards are accounted for within the 2D system, and are integrated into the analysis of bifurcations occurring within the 2D system. This project is one of many aspects of the 3D forced van der Pol system being investigated by students participating in Cornell University’s Summer 2002 Math REU program.
THE PROPAGATOR FORMULATION OF THE DEGENERATE PARAMETRIC OSCILLATOR

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After systematically deriving general expressions for a two-time correlation function and the photon number distribution in terms of the Q-function, we analyze the squeezing spectrum and the photon number distribution of the signal mode produced by a degenerate parametric oscillator operating below threshold. The time-dependent Q-function is obtained by solving the pertinent Fokker-Planck equation applying the method of evaluating the propagator discussed in Journal of Mathematical Physics 33 (1992) 2179.

Published: Optical Communications 151 (1998) 384-394.
FILLING IN THE GAPS: COMPUTATIONAL CONSTRUCTION OF A CONTINUOUS MAPPING FROM A ONE-TO-ONE FINITE MAPPING

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Given a one-to-one mapping \( f : X \rightarrow Y \) where \( X \) and \( Y \) are finite sets, \(|X| = |Y|\), and members of \( X \) and \( Y \) exist in potentially different multivariate spaces. I am interested in finding a mapping \( f^* : X^* \rightarrow Y^* \) such that \( f^* \) is continuous and differentiable with \( f^*(X) = Y \) as before (where \( X \subset X^* \) and \( Y \subset Y^* \)). However, for \( x' \in X^* \) approaching \( x \in X \), \( f^*(x') \in Y^* \) should likewise approach \( f(x) \in Y \). Furthermore, no \( x' \) approaching \( x \) should exist s.t. \( f^*(x') = f^*(x) \) where \( x' \in X^* \) and \( x \in X \). Lastly, the sought after algorithm should be as fast and efficient as possible. We will demonstrate algorithms designed to construct such mappings while attempting to remain as fast and efficient as possible.
OPTIMIZING PERFORMANCE FUNCTIONS ON ORBITS OF CHAOTIC SYSTEMS

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Chaotic dynamical systems can exhibit a wide variety of motions, including periodic orbits of arbitrarily large period. We consider the question of which motion is optimal, in the sense that it maximizes the average over time of some given scalar “performance function.” Past work has shown that optimal motions tend to be periodic orbits with low period but does not describe, beyond a brute force approach, how to determine which orbit is optimal in a particular scenario. We have found a constructive manner of actually calculating the optimal average and corresponding periodic orbit. Our numerical method appears to be quite adequate for finding the optimizing orbit if its period is less than 15.
ASYMPTOTIC ANALYSIS OF SOJOURN TIMES FOR THE TIME DEPENDENT, M/M/1 PROCESSING SHARING QUEUE

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We define the concept of a virtual customer to study the effects of the evolution of an M/M/1 processor sharing queue with time varying rates on the sojourn time of a virtual job of a given size. Applying the asymptotic analysis of uniform acceleration, we obtain strong law of large number and central limit theorems for these sojourn times. In turn this gives us fluid and diffusion approximations for the sojourn times of jobs during periods of overloading.
ROUTING AND WAVELENGTH ASSIGNMENT IN WDM NETWORKS WITH MINIMUM BLOCKING

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WDM networks are telecommunication networks of great capacity based on optical technologies. It is a very attractive medium for networks that carry high transmission rate, an enormous bandwidth is available on a fiber and the same fiber can be used for multiple data streams. One of the challenging optimization problem in WDM networks deals with the routing and wavelength assignment problem. Given a set of connection requests (static routing) and the number of available wavelengths the fiber supports on each link, we are to find through the network a route for each request and assign wavelength (or wavelengths depending on the hypothesis on the routers and switching nodes) to them. Several algorithms and approaches have already been proposed in the literature. We here propose a new two-phase algorithm that corresponds to an interlaced two-phase procedure and compare its results with previous computational results of the literature.
A COMPARISON OF ESTIMATION METHODS FOR SPATIAL DATA ANALYSIS WITH DISCRETE DATA ON A LATTICE

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We simulate data under two models for discrete data on a lattice. We develop a Gibbs sampling algorithm to generate conditionally specified Poisson and Binomial data. In addition, we generate data from a generalized linear mixed model with random effects having a spatial correlation structure.

We investigate the properties of proposed estimation methods for these kinds of data. The methods include two methods explicitly defined for discrete data on a lattice and a third method which involves transforming a discrete response variable and then analyzing the data as if it were normally distributed. We then investigated how well these estimation methods operated under various scenarios. We have shown that arbitrary elimination of edges (regions on the periphery) leads to a reduction of power. We have shown that elimination of outliers can yield an improvement in power. We also investigate the case of low counts.

We also present analyses of two real data sets, notably the well-studied data sets of SIDS incidence in North Carolina and the lip-cancer incidence in Scotland. We show that irrespective of which method of estimation is selected, similar conclusions are found with respect to impact of a covariate or the presence of spatial dependence. Finally, we suggest some limitations to our simulation study and suggest some future avenues of research.
APPLICATION OF DESIGNER POLYNOMIALS TO THE SOFT-COULOMB POTENTIAL IN ONE-DIMENSION

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In a recent article [C.A. Weatherford, E. Red, A. Wynn III, International Journal of Quantum Chemistry 90, 1289-1294 (2002)], an algorithm was described whereby a "synthetic" weighted polynomial basis may be constructed which is adapted (designed) to a particular potential. It was applied therein to the Schrödinger equation with a coulomb potential in one dimension (−1/|x|). A weighted polynomial basis with weight function \( w(x) = \exp(-\alpha|x|) \) was employed. It was observed that this potential had no even parity solutions-only odd parity solutions. The question arises as to the relationship of the solutions (eigenfunctions and eigenvalues) for this "hard" coulomb potential to the solutions for the "soft" coulomb potential (−1/√(x^2 + β^2)). In particular, since the soft coulomb potential is clearly expected to possess both even and odd parity solutions, how do these solutions behave as \( \beta \to 0 \) and thus what happens to the even solutions. This problem is deceptively difficult-none of the standard basis sets produce a variational minimum as a function of \( \alpha \) for nonzero \( \beta \). This is apparently why this problem has never been done before. A new orthonormal basis was designed with weight function \( \exp(-\alpha\sqrt{x^2 + \beta^2}) \) which did produce a variational minimum for variable \( \alpha \) and arbitrary fixed \( \beta \). The present paper describes these solutions and clearly indicates how they behave as \( \beta \to 0 \).

This work was directed by Professor C.A. Weatherford and was supported in part by the Army High Performance Computing Research Center under the auspices of the Department of the Army, Army Research Laboratory cooperative agreement number DAAD19-01-2-0014, the content of which does not necessarily reflect the position or the policy of the government, and no official endorsement should be inferred. It was also partially supported by NASA Grant NAG5-10148.
AN INTEGRATED APPROACH FOR DESIGNING RELIABLE GMPLS NETWORKS

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The increase of bandwidth demand for new Internet applications suggests mapping directly IP over the WDM layer. Since reliability is such a critical issue in these broadband networks, we propose an integrated design method which addresses the problem of survivability as viewed from the IP/MPLS layers but taking into account the failure mechanisms in the optical layer. This approach is becoming practical because of the emergence of GMPLS as a multi-layer control plane that can support the signaling required for coordinating the restoration mechanisms in multiple layers.

The model relies on network calculus to evaluate a QoS metric as actually perceived by end users and computes a preplanned restoration scheme to recover from failures. We discuss the numerical implementation, the convergence and the solutions produced by the algorithm and show that the resulting network can provide the prescribed QoS guarantees for all failure states.

Work supervised by Prof. B. Sansó and Prof A. Girard.
SPECIAL VALUES OF
DIRICHLET L-FUNCTIONS

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A recent result of Ball and Rivoal shows that the Riemann \( \zeta \)-function takes on irrational values at infinitely many odd integers. In this work in progress, we make use of a more general class of auxiliary functions and extend their techniques to achieve a similar result for Dirichlet L-functions.
A REAL OPTIONS APPROACH TO THE SYNTHESIS OF TRANSACTION COST ECONOMICS AND THE RESOURCE-BASED VIEW OF THE FIRM

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In response to the complementary, albeit occasionally contradictory, nature of the transaction cost economics and resource-based perspectives regarding the firm boundary decision, this research proposes a real options approach. Unlike previous research in the organizational literature, the real options model herein employed combines both a Wiener process and a Poisson process. The paper explores the correlation between these processes and aspects of both transaction cost economics and the resource-based view of the firm. Finally, the ensuing discussion uses the proposed model to unify the two extant theories and demonstrate how they collectively affect governance choice.
PERFORMANCE ANALYSIS OF A MULTI-CLASS, PREEMPTIVE PRIORITY CALL CENTER WITH TIME-VARYING ARRIVALS

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We model a call center as a preemptive-resume priority queue with time-varying arrival rates and two priority classes of customers. The low priority customers have a dynamic priority where they become high priority if their waiting-time exceeds a given service-level time. The performance of the call center is measured by the virtual waiting time and waiting-time distribution for the customers. Several methods, namely Laplace transform inversion, fluid and diffusion approximations, and stochastic simulation methods, are used to compute the distribution.

Laplace transform inversion is performed using a Fourier-series method and applied to each priority class of the waiting-time distribution for two types of queues. These queues are the $M/M/n$, non-preemptive priority queue and the $M/M/1$ preemptive-resume priority queue. The Fourier-series method was developed by Abate and Whitt.

Fluid and diffusion approximation limits are computed using an asymptotic scheme where the ratio of the offered load to the number of servers remains constant. The queue length and waiting time mean and variance of the fluid and diffusion approximations are solutions to a system of differential equations.

We investigate the effectiveness of the previous modelling approaches using a stochastic simulation model of the call center. The call center is modelled as an $M_t/M/n$, preemptive-resume priority queue with time-varying arrival rates and two (dynamic) priority classes of customers. We show that the fluid and diffusion approximations are relatively close to the simulation results in heavy traffic.
BIVARIATE MEAN RESIDUAL LIFETIME FUNCTION

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In survival analysis the additional lifetime that an object survives past a time $t$ is called the residual life function of the object. Mathematically speaking, if the lifetime of the object is described by a random variable $T$ then the random variable $T - t$, conditioned on the event $\{T > t\}$, is called the residual life random variable. The quantity $e(t) = E[T - t|T > t]$ is called the mean residual lifetime (MRL) function or the life expectancy at age $t$.

There are numerous situations where the bivariate MRL function is important. Times to death or times to initial contraction of a disease may be of interest for twin studies in humans. The time to a deterioration level or the time to reaction of a treatment may be of interest in pairs of lungs, kidneys, breasts, eyes or ears of humans. In reliability, the distribution of the life lengths of a particular pair of components in a system may be of interest. Because of the dependence among the event times, we can not use the univariate MRL function on each event times in order to assess the aging process. A bivariate MRL function is useful in analyzing the joint distribution of two event times where there is dependence between the event times.

In recent years, though a considerable attention has been paid to the univariate MRL function, relatively little research has been devoted to the analysis of bivariate MRL function. The purpose of my work is to extend and apply the concept of MRL functions to a problem that arise in a bivariate survival analysis.
AN INVESTIGATION OF SEQUENTIAL AUCTIONS IN THE BUSINESS-TO-BUSINESS CONTEXT

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Electronic auctions allow for economic discovery in business-to-business (B2B) transactions. Motivated by the pulp and paper industry, we aid procurement management in economic decisions while exploring the less-studied area of auction theory where individual buyers and suppliers initiate auctions sequentially and receive financial and informational benefits. We characterize the auction process to determine whether who initiates the auction affects the final sale price and if so what strategies might be beneficial to auction participants. This step leads to the overall goal of this analysis, which is to understand the economic value gained through B2B auctions in spot procurement relevant to this industry.
OPTIMIZATION FRAMEWORK FOR AMERICAN OPTION VALUATION WITH FINANCIAL CONSTRAINTS

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Over the past decade, financial derivatives have continued to evolve and play a more integral role in global financial markets. For example, the total estimated value of outstanding over-the-counter derivative contracts stood at almost $128 trillion in 2002, up from an estimated $3 trillion in 1990. The complexity of new derivative product innovations driving the unabated growth poses major challenges for conventional pricing algorithms and can lead to unrealistic models and valuation inaccuracies. The economic implications to financial risk management and corporate decision analytics are far reaching.

Fundamental to many complex derivative financial products is the valuation and optimal exercise of options with American-style exercise features. This American option valuation problem remains one of the most important and intellectually challenging problems in option pricing theory. This work proposes a direct computational algorithm for solving the American option valuation problem under stochastic volatility. The algorithm employs a Newton type constrained nonlinear interior-point optimization method for solving the discretized variational inequality problem that arises. Considerations are made in terms of numerically approximating, in a stable manner, the governing parabolic partial differential equation that can become convection dominated in certain areas of the solution domain. Also, considerations are made for incorporating additional financial constraints within the optimization framework. Some example computations are presented for special cases of American-style options with the aim of revealing the general applicability of the constrained optimization pricing methodology.