

**INDUSTRIAL & SYSTEMS
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WORKING PAPER SERIES

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IE Working Paper 04-001

Comparison of Partial Least Squares Model and Response Surface Model in Optimizing Batch Settings

Di Xu and Susan L. Albin

Abstract:

A batch process is not only controlled by the process settings, but also subject to the influence of uncontrollable variables such as material properties and environmental factors. The uncontrollable variables are usually random and their means and variances vary from batch to batch. The challenge in adjusting a batch process is that the process settings that work well for one batch may not work for another due to variation in uncontrollable variables. To efficiently identify optimal process settings is an important step to reduce production cycle and increase production throughput for the batch process.

Response surface method (RSM) is a usual approach to identify optimal settings. This paper presents an alternative method, built on the partial least squares (PLS) model, to solve for the optimal settings. PLS is a powerful multivariate statistical approach and it can be used to effectively model the relationship between output variables and process settings and uncontrollable variables in historical baseline data. Given the *PLS* model and the means and variances of the uncontrollable variables for a particular batch, we construct an optimization program to identify the optimal process settings for that batch.

The PLS method is gaining popularity in the monitoring and control of multivariate processes in the last decade. However, there is no significant research existing in the literature that compares the PLS method to the response model approach in solving multivariate process control problems. The aim of this paper is to compare the effectiveness of the two methods and we hope it'll lead to more comparative study.

IE Working Paper 04-002

Foundational Issues in Software Reuse and Reliability

William B. Frakes and Michael Tortorella

Abstract:

This paper examines the question of whether increased software reuse can improve software reliability. Once conclusion is that the assumed positive relationship between them depends on three different hypotheses, which this paper clarifies and makes testable. The intuitive concept of reusable and equivalent one-use components is clarified through the identification of attributes for comparing

them, and showing how these attributes affect reliability. By applying measurement theory and using simple programs, the paper shows how various reliability models can be applied to collect data for one-use and reusable programs.

IE Working Paper 04-003

Optimum Accelerated Life Testing Plans Based On Proportional Mean Residual Life

Wenbiao Zhao and Elsayed A. Elsayed

Abstract:

In This paper, we present efficient and practical approach for designing ALT plans based on a "distribution-free" regression model called the proportional mean residual life (PMRL) regression model. The plans determine the appropriate levels for each stress type and the number of test units allocated to each level in order to obtain accurate mean residual life estimates at normal operating conditions. Unlike previous ALT plans, the proposed plans need not assume the time to failure distribution and the life stress relationship. A numerical example that demonstrates the design of such accelerated plans is presented. The proposed plans can also be applied in situations with more than single accelerating stress without any difficulties.

IE Working Paper 04-004

Maintenance of Continuous Monitored Degrading Systems

Haitao Liao, Ling-Yau Chan and E. A. Elsayed

Abstract:

In this paper we consider a condition-based maintenance policy for continuously monitored degrading systems. We investigate a robust maintenance policy, *availability limit policy*, which ensures that a maximum availability level of the system is achieved. The optimum degradation threshold level that ensures the desired steady-state availability of the system is also determined. A numerical example that demonstrates this policy is presented.

IE Working Paper 04-005

Modeling Traffic Flow Interrupted by Incidents

M. Baykal-Gursoy, W. Xiao and K. Ozbay

Abstract:

A steady-state M/M/C queueing system under batch service interruptions is introduced to model the traffic flow on a roadway link subject to incidents. When a traffic incident happens, either all lanes or part of a lane is closed to the traffic. As such, we model these interruptions either as complete service disruptions where none of the servers work or partial failures where servers work at a reduced service rate. We analyze this system in steady state and present a scheme to obtain the generating function of stationary number of vehicles on a link. For those links with high C values, the closed-form solution of M/M/ ∞ queues under batch service interruptions can be used as an approximation. We present simulation results that show the validity of our approximate model.

IE Working Paper 04-006

Influence of Friction Models on Finite Element Simulations of Machining

Tugrul Ozel

Abstract:

In the analysis of orthogonal cutting process using FE simulations, predictions are greatly influenced by two major factors; a) flow stress characteristics of work material at cutting regimes and b) friction characteristics mainly at the chip-tool interface. The influence of work material flow stress upon FE simulations may be less or even none when there is a constitutive model for work material that is obtained empirically from high-strain rate and temperature deformation tests. However, the difficulty arises when one needs to implement accurate friction models for cutting simulations using a particular FE formulation. In this study, a thermo-mechanical updated Lagrangian finite element formulation is used to simulate continuous chip formation process in orthogonal cutting of low carbon free-cutting steel. The effects of using various chip-tool interface friction models on the simulations are investigated. Experimentally measured stress distributions on the tool rake face are utilized in conjunction with metal cutting theory to develop several friction models and the evaluation of the results for the friction models is carried out. The results depict that the use of various chip-tool interface friction models has at most influence in predicting chip geometry, forces, stresses on the tool and temperature at the chip-tool interface and the predicts are best when using variable shear friction model at the chip-tool interface. Predictions presented in this work also justify that the FE simulation technique used for orthogonal cutting process is an accurate and viable analysis as long as flow stress behavior of the work material obtained realistically and friction at the chip-tool interface is modeled correctly.

IE Working Paper 04-007

Estimation of Work Material Flow Stress and Tool-Chip Interfacial Friction by Inverse Computation of Modified Oxley's Model of Machining

Tugrul Ozel and Erol Zeren

Abstract:

Finite Element Analysis (FEA) based techniques have become increasingly available to simulate metal cutting process and offer several advantages including prediction of tool forces, distribution of stresses and temperatures, estimation of tool wear, optimization of cutting conditions, tool edge geometry and coatings, and determination of residual stresses on machined surfaces. However, accuracy and reliability of the predictions heavily depend on the work material flow stress at cutting regimes i.e. high deformation rates and temperatures, and variable friction characteristics at tool-chip interface, which are not completely understood and need to be determined. This paper utilizes an extended metal cutting analysis originally developed by Oxley and coworkers [6] and presents an improved methodology to expand applicability of Johnson-Cook material model to the cutting regimes and simultaneously determine friction characteristics at tool-chip interface from the results of orthogonal cutting tests. A number of cutting temperature models are also assessed in characterizing the accuracy of the average temperatures at primary and secondary deformation zones. Predictions using cutting models are compared with the results of testing data obtained for AISI 1045 through assessment of machining models (AMM) activity. The methodology requires experimental data for cutting and thrust forces, chip thickness and tool-chip contact length. The methodology is practical and estimates both the parameters of work material Johnson-Cook constitutive flow stress model and the interfacial friction characteristics along tool rake face. The friction model is based on estimation of normal stress distribution over the rake face. Predicted friction characteristics include parameters of the stress distribution on the rake face $\sigma_{m \max}$ and power exponent a , the average shear flow stress at tool-chip interface, k_{chip} , plastic contact length l_p , at sticking region of the tool-chip interface, an average coefficient of friction μ_e , in sliding region of the tool-chip interface. The extended Johnson-Cook work material flow stress parameters and tool-chip interfacial friction characteristics can directly be entered into most FEA software.

IE Working Paper 04-008

Design of Optimum Simple Step-Stress Accelerated Life Testing Plans

E. A. Elsayed and Hao Zhang

Abstract:

The mission time of today's products is extended so much that it is difficult to observe failures under normal operating conditions. Therefore, accelerated life testing (ALT) is widely conducted to obtain failure-time data in a much shorter time and to make inference about reliability at normal conditions. The accuracy of the reliability prediction is dependent on well-designed ALT plans. A step-stress ALT allows the test condition to change at a given time or upon the occurrence of a specified number of failures. Step-stress accelerated life testing, an important type of ALT, is more difficult to model compared with constant stress ALT, however it yields failures more quickly. A test unit starts at a specified low stress. If the unit does not fail in a specified time, the stress is increased and held constant for a specified time. Stress is repeatedly increased and held constant until the test unit fails. In this paper, we propose a procedure to determine the parameters of the optimum simple step-stress testing plan so that the reliability prediction at normal conditions is accurately determined. The parameters of the process are the lower stress level, the number of failures at the lower stress level, the duration of test at the lower stress level (change time to higher stress level), the higher stress level, and the number of failures at the higher stress level and the duration of test at the higher stress

level. In many cases, most of these parameters are predetermined based on experience and field failures. We intend to investigate efficient procedures to estimate most, if not all of these parameters under different operating conditions. The resultant optimum plan will be verified through simulation.

IE Working Paper 04-009

A Note on Maximum Likelihood Estimation for Sums of Binomial Random Variables

Michael Tortorella

Abstract:

In nonparametric estimation from pooled life tables [1], [2], the data from the pool cannot be identified as to which component of the pool they come from. Hence it is necessary to treat these data in their native form as sums. In some cases (such as [2]), the sum is of a number of binomially distributed random variables, which may have different numbers of trials and different success probabilities. While the number of trials in each component of the pool is typically known, the probabilities of success are not known and are to be estimated. The theorem presented in this note gives the maximum likelihood estimator (MLE) of these parameters.

IE Working Paper 04-010

Composite Importance Measures for Multi-state Systems with Multi-state Components

Jose E. Ramirez-Marquez and David W. Coit

Abstract:

This paper presents and evaluates composite importance measures (CIM) for multi-state systems with multi-state components (MSMC). Importance measures are important tools to evaluate and rank the impact of individual components within a system. For multi-state systems, previously developed measures do not meet all user needs. The major focus of the study is to distinguish between two types of importance measures that can be used for evaluating the criticality of components in MSMC with respect to multi-state system reliability. This paper presents Type 1 importance measures that are involved in measuring how a specific *component* affects multi-state system reliability. A Monte Carlo (MC) simulation methodology for estimating the reliability of a MSMC is used for computing the proposed CIM metrics. Previous approaches (Type 2) have focused on investigating how a particular component *state* or set of states affects multi-state system reliability. For some systems, it is not clear how to prioritize system component importance, collectively considering *all* of its states, using the previously developed importance measures. That detracts from those measures. Experimental results show that the proposed CIM can be used as an effective tool to assess component criticality for MSMC. Illustrative examples are used to illustrate and compare the proposed CIM with previous multi-state importance measures.

IE Working Paper 04-011

Modeling and Reliability of Threshold Weighted Voting Systems

Minge Xie and Hoang Pham

Abstract:

In many applications, ranging from target detection to safety monitoring systems, one needs to determine whether or not to accept a hypothesis based on a given set of available information. In this paper we model the reliability of threshold weighted voting systems (WVS) with multi-failure-modes, where a general recursive reliability function of the WVS is presented. We also develop approximation formulas for calculating the reliability of the systems with a large number of units. In addition, we develop reliability functions of time-dependent threshold weighted voting systems, where the system reliability depends on the time that each individual unit spends on decision-making. Finally, the optimal stopping time that minimizes the total cost of the systems subject to a reliability constraint is discussed.

IE Working Paper 04-012

A Method for Correlating Field Life Degradation with Reliability Prediction for Electronic Modules

David W. Coit, John L. Evans, Nathan Vogt and James R. Thompson

Abstract:

A methodology was developed to correlate field life with observed degradation for electronics modules. This procedure was developed by identifying common deterioration characteristics in field units, modeling observed trends, and then, developing a model to predict future deterioration trends. This particular method focused on the deterioration of solder joint strength due to solder fatigue and comparing these values to a threshold based on known electrical failures. A conditional probability density function was formulated and quantified for both random shear strength and the minimum shear strength within a module. The conditional probability density function characterized both the changing mean and variance for a normally distributed random shear strength. With this methodology, time or mileage (life) prediction is based on the probability that the minimum performance response is less than a defined failure threshold. The methodology described herein promises to be an effective product development tool as the effect of design changes on product life can be more quickly and easily evaluated. While the technique developed herein is applicable to all electronic designs, the method was developed with particular focus on understanding these relationships for automotive (harsh environment) applications.

IE Working Paper 04-013

A Hierarchical Probabilistic Approach for Risk Assessments of An Aviation Safety Product Portfolio (DRAFT)

Erim Kardes and James T. Luxhoj

Abstract:

Bayesian Networks (BNs) are widely used for knowledge representation and probabilistic inference in stochastic domains. An attempt is made in the risk modeling context to develop a general Aviation System Risk Model (ASRM) [16]. Following this initial ASRM, an operational/maintenance ASRM prototype is developed that is based on real case studies [17]. Past and current research efforts focus on multiple case designs in the context of an aviation accident category. Hierarchical Bayesian Networks (HBNs) are an extension to the conventional BN methodology, which provide an *expressive* power by allowing a node in the network to represent an individual BN. HBNs express the knowledge in a *structured* way, leading to more *realistic* probabilistic models. HBNs, like classical BNs, represent a stochastic modeling language, where the random variables symbolize the domain attributes. The probabilistic dependencies among the variables are modeled using directed acyclic graphs. A new case that combines different cases to obtain a single safety enhancement value can be designed using HBNs. The use of HBNs presents a novel application in the aviation safety domain and offers significant promise for risk assessments of an aviation safety product portfolio.

IE Working Paper 04-014

Probabilistic Programming Models for Response Vehicle Dispatching and Resource Allocation in Traffic Incident Management

Kaan Ozbay, Weihua Xiao, Cem Iyigun and Melike Baykal-Gursoy

Abstract:

This paper proposes mathematical programming models with probabilistic constraints in order to address incident response and resource allocation problems for traffic incident management. In incident response problems, we introduce the concept of quality of service during a potential incident to give the operator the flexibility to determine the optimal dispatching policy in response to various situations. A mixed-integer programming (MIP) model with probabilistic constraints is proposed to address the dispatching problem with consideration given to the stochastic resource requirements at the sites of the potential incidents. For the resource allocation problem, assuming that the stochastic distribution of incidents over a network is given, we introduce a mathematical model to determine the number of service vehicles allocated to each depot to meet the requirements of the potential incidents by taking into account the stochastic nature of the resource requirement and incident occurrence probabilities. For completeness, relevant concepts and solution algorithms in stochastic programming are also presented. Several examples are included to demonstrate the applications of these models to real-world problems. This paper concludes with a summary of results and recommendations for future research.

IE Working Paper 04-015

Merging and Splitting Autocorrelated Arrival Processes and Impact on Queueing Performance

Baris Balcioglu, David L. Jagerman and Tayfur Altioik

Abstract:

In this paper, we have developed a three-parameter renewal approximation to analyze the splitting and superposition of autocorrelated processes. When it comes to handling the superposition problem, traditionally component autocorrelated processes have been first approximated by a two-parameter renewal process, and then the superposition of the renewal processes has been carried out. With this approach, one incurs errors at each stage of approximation, which can degrade the overall performance markedly. Our methodology, on the other hand, makes a single-step approximation in case data from the superposed stream can be collected. If we only have data from the component processes, we can analyze the superposition of the approximating renewal processes, too. The accurate renewal approximation of a general process helps sustain accuracy if it is split, by-passing the need to sample from branched processes. We have tested the impact of our approximation on the accuracy of the mean waiting time, which compared favorably with simulation results of the original systems.

IE Working Paper 04-016

Cushioning Systems for Impact Energy Absorption

Laure LaRue, Basily B. Basily and Elsayed A. Elsayed

Abstract:

In this paper we investigate the use of an innovative sheet folding theory and technology in the design of new cushioning systems. Flat sheets of material are folded into three-dimensional patterns. The effectiveness of the folded pattern in absorbing impact energy without subjecting items being cushioned to high acceleration is dependent on the sheet material, the fold configuration (number of folds per unit length), dimensions of the fold, number of stacked layers, number of sheets folded together and other factors. Full design of experiments is conducted to obtain a relationship between the acceleration observed by the contents of the cushioning systems and the parameters of the cushion design. The relationship has been validated experimentally using different system parameters. The application of the work in providing cushioning systems for highly sensitive items such as electronic components or providing cushioning systems for high velocity airdrop items is extensive.

IE Working Paper 04-017

Service Reliability Theory and Engineering

Michael Tortorella

Abstract:

The concepts and methods of reliability theory and engineering are applied to services. This has not yet been done in a systematic fashion because services are intangible and the primitives and concepts necessary to making the connection of intangibles and the mathematical theory of reliability have not yet been documented. A good example of the confusion this causes comes from the telecommunications services industry, where professionals often confuse “network reliability” with what is really the reliability of the services provided over the network: a phrase that could make sense when correctly applied to tangible engineering systems is applied (without proper preparation) to reliability of an intangible, the services. The purpose of this paper is to clarify the notions of service reliability theory and to describe some mathematical models useful for service reliability engineering. The paper covers primitive terms in the theory, basic concepts, failure modes and failure mechanisms for services, service reliability figures of merit and metrics (including modeling and estimation), and describes some open problems. Many of the illustrative examples are drawn from the author’s experiences in the telecommunications industry. The paper offers a foundation for clear discussion and quantitative statements about the reliability of services, and brings clarity to service planning and development. The value for professionals in the quality sciences and quality engineering is in the systematic extension of reliability engineering concepts and techniques to intangibles, in the provision of a framework and language for quantitative study of service reliability, and in focusing quality attention on service industries, now the major part of the economies of many developed countries.

IE Working Paper 04-018**Repairable Systems Reliability Trend Tests and Evaluation**

Peng Wang and David W. Coit

Abstract:

Repairable systems reliability trend tests are reviewed, extensively tested and compared to evaluate their effectiveness over diverse data patterns. A repairable system is often modeled as a counting failure process. For a counting failure process, successive inter-arrival failure times will tend to become larger (smaller) for an improving (deteriorating) system. During testing and development of new systems, reliability trend analysis is needed to evaluate the progress of the design development and improvement process. Often a program of testing and modification, followed by more testing and modification, is required to achieve a desired system reliability goal. Reliability trend tests can be an important part of this program. The objective of system reliability trend tests is to determine whether and how the pattern of failures is significantly changing with time. This paper reviews the following four trend tests: (1) Crow/AMSAA Test, (2) PCNT (pair-wise comparison nonparametric test), (3) Laplace Test, and (4) Lewis-Robinson Test. These tests are extensively tested, evaluated and compared for diverse repairable system reliability trends. Particular emphasis focused on comparisons with low sample sizes. Simulation models for trend tests are presented and discussed; and simulation results are summarized and compared. Based on these comparisons, it is concluded that the Crow/AMSAA test is the most robust trend test.

IE Working Paper 04-019

Optimization of System Reliability Robustness Using Accelerated Degradation Testing

Haitao Liao and Elsayed A. Elsayed

Abstract:

In the system design stage, several component types (or modules) with competitive reliability are usually available for the design of each subsystem; however, their robustness against uncertain operating conditions might be significantly different. Designers attempt to address the design of a reliable and robust system by choosing the “best” components from those candidates. The problem is more difficult when constructing reliable systems with highly reliable components due to the difficulty of evaluating the reliability and robustness of such components under normal operating conditions. In this paper, we investigate a 3-step procedure for system optimization regarding the reliability robustness through Accelerated Degradation Testing (ADT) experiments. In the first step, baseline ADT experiments are conducted to obtain degradation data for each degradable component type of interest using a small number of test units. In this step, an ADT model along with the parameters of each component type is estimated based on the initial data (baseline data). The second step refines the estimation accuracy of those critical model parameters by designing an optimum ADT plan. The optimum testing plan belongs to a D-optimal plan, which minimizes the determinant of the variance-covariance matrix of the parameter estimates. Finally, in the third step the reliabilities of alternative component types are predicted under nominal operating conditions and their robustness is evaluated considering the uncertainty of the operating conditions. The design procedure is demonstrated using an example of a brake system design.

IE Working Paper 04-020

An Extended Linear Hazard Regression Model with Application to Time-dependent-dielectric-breakdown of Thermal Oxides

Elsayed A. Elsayed, Haitao Liao and Xindong Wang

Abstract:

We develop a generalized Extended Linear Hazard Regression (ELHR) model with linear time-varying coefficients to estimate reliability under normal operating conditions using failure time data obtained from accelerated conditions. The model considers the proportional hazards effect, time-varying coefficients effect as well as time-scale changing effect. Extensive simulation experiments demonstrate that the ELHR model provides more accurate reliability estimates than those obtained by the existing ALT models. We utilize this model to study the reliability of time-dependent-dielectric-breakdown of thermal oxides on n-type 6H-SiC using laboratory data. The results show that oxide reliability considerations effectively preclude SiC MOS devices from many high-temperature applications.

IE Working Paper 04-021

Distributed Sensing for Quality And Productivity Improvements

Yu Ding, Elsayed A. Elsayed, Soundar Kumara, Jye-Chyi Lu, Feng Niu and Jianjun (Jan) Shi

Abstract:

Distributed sensing, a system-wide deployment of sensing devices, has resulted in both temporally and spatially dense data-rich environments. This new technology provides unprecedented opportunities for quality and productivity improvement. This paper discusses the state-of-the-art practice, research challenges, and future directions related to distributed sensing. The discussion includes optimal design of distributed sensor systems, information criteria and processing for distributed sensing, and optimal decision making in distributed sensing. The discussion also provides applications based on the authors' research experiences.

IE Working Paper 04-022

Maintenance of Continuously Monitored Degrading Systems

Haitao Liao, Elsayed A. Elsayed and Ling-Yau Chan

Abstract:

This paper considered a condition-based maintenance model for continuously degrading systems under continuous monitoring. After maintenance, the states of the system are randomly distributed with residual damage. We investigate a realistic maintenance policy, referred to as *condition-based availability limit policy*, which achieves a maximum availability level of such systems. The optimum maintenance threshold is determined using a search algorithm. A numerical example for a degrading system modeled by a Gamma process is presented to demonstrate this policy in practical applications.

IE Working Paper 04-023

Repair-Limit Risk-Free Warranty Policies with Imperfect Repair

Jun Bai and Hoang Pham

Abstract:

Current competitive market environment requires manufacturers to continuously provide better service and support. As a result, warranty considerations emerge as a significant instrument for increasing product marketability. In this paper, we propose a new warranty policy, the repair-limit risk-free warranty with a threshold point on the number of repairs, where replacement is deemed to

be more cost effective thereafter. Consumers are better off than with a traditional free repair policy since they could be compensated with a new product in case of premature failures. As for the manufacturers, it not only offers extra marketing incentives, but also reduces the possibility of high cost lawsuits due to the products with 'proven' bad quality. Some useful results of the warranty cost of imperfectly repaired products are derived through a censored quasi-renewal process.

IE Working Paper 04-024

Quadratic Integer Programming: Complexity and Equivalent Forms

W. Chaovalitwongse, I.P. Androulakis and P.M. Pardalos

Abstract:

Quadratic integer programming (QIP) has been used to model a variety of important practical problems in operations research, engineering, and computer science. In this paper, we will discuss the complexity and various equivalent forms of the QIP. We will demonstrate the connection between integer programming and complementarity problems, which is the foundation of the equivalence of mixed-integer linear programming and quadratic integer programming problems. The complexity issues of the QIP will also be reviewed in this paper.

IE Working Paper 04-025

Multi-quadratic Zero-one Programming

W. Chaovalitwongse, O.A. Prokopyev and P.M. Pardalos

Abstract:

MQP plays an important role in modeling many diverse problems. The MQP encompasses many other optimization problems since it provides a much-improved model compared to the simpler linear relaxation of a problem. Indeed, linear mixed 0-1, fractional, bilinear, bilevel, generalized linear complementarity, and many more programming problems are or can easily be reformulated as special cases of MQP. The MQP constitutes an important part of mathematical programming problems, arising in various practical applications including facility location, production planning, VLSI chip design, optimal design of water distribution networks, and most problems in chemical engineering design. In this paper, we give a short review of the problem complexity, applications, and solution approaches of MQP.

IE Working Paper 04-026

Mathematical Programming for Data Mining

I.P. Androulakis and W. Chaovalitwongse

Abstract:

This short review is intended to serve as an introduction to an emerging research and applications area. We will provide a general overview of the importance of data mining and we will describe some pressing research challenges and opportunities for contributions from the field of optimization and mathematical programming.

IE Working Paper 04-027**EEG Classification in Epilepsy**

W. Chaovaitwongse, P.M. Pardalos and O. A. Prokopyev

Abstract:

Epilepsy is the second most common serious brain disorder after stroke. Worldwide, at least 40 million people or 1% of population currently suffer from epilepsy. Approximately 25-30% of epileptic patients remain unresponsive to anti-epileptic drug treatment, which is the standard therapy for epilepsy. There is a growing interest in predicting epileptic seizures using intracranial electroencephalogram (EEG), which is a tool for evaluating the physiological state of the brain. Although recent research in seizure prediction has demonstrated the seizure predictability, the question of whether the brain's normal and pre-seizure epileptic activities are distinctive or differentiable remains unanswered. In this study, we apply data mining techniques to EEG data in order to verify the classifiability of the brain's normal and pre-seizure epileptic activities through the measure of the brain dynamics, which were previously shown capable of contemplating dynamical mechanisms of the brain network. A statistical cross validation is implemented to estimate the accuracy of the brain state classification. In addition, support vector machines were also implemented to classify the brain's activities. The results of this study indicate that it may be possible to design and develop efficient seizure warning algorithms for diagnostic and therapeutic purposes. This framework is also an initial proof of concept investigations, which is a necessary first step in differentiating the brain's normal and pre-seizure epileptic activities.

IE Working Paper 04-028**Performance of a Seizure Warning Algorithm Based on the Dynamics of Intracranial EEG**

W. Chaovaitwongse, L. D. Iasemidis, P.M. Pardalos,
P. R. Carney, D.-S. Shiau and J. C. Sackellares

Abstract:

During the past decade, several studies have demonstrated experimental evidence that temporal lobe seizures are preceded by changes in dynamical properties (both spatial and temporal) of EEG signals. In this study, we evaluate a method, based on chaos theory and global optimization

techniques, for detecting pre-seizure states by monitoring the spatio-temporal changes in the dynamics of the EEG signal. The method employs the estimation of the short-term maximum Lyapunov exponent (STL_{max}), a measure of the order (chaoticity) of a dynamical system, to quantify the EEG dynamics per electrode site. A global optimization technique is also employed to identify critical electrode sites that are involved in the seizure development. An important practical result of this study was the development of an automated seizure warning system (ASWS).

The algorithm was tested in continuous, long-term EEG recordings, 3 to 14 days in duration, obtained from 10 patients with refractory temporal lobe epilepsy. In this analysis, for each patient, the EEG recordings were divided into training and testing data sets. We used the first portion of the data that contained half of the seizures to train the algorithm, where the algorithm achieved a sensitivity of 76.12% with an overall false prediction rate of 0.17 per hour. With the optimal parameter setting obtained from the training phase, the prediction performance of the algorithm during the testing phase achieved a sensitivity of 68.75% with an overall false prediction rate of 0.15 per hour. The results of this study confirm our previous observations from a smaller number of patients: the development of automated seizure warning devices for diagnostic and therapeutic purposes is feasible and practically useful.

IE Working Paper 04-029

Multiple Weighted Objectives Heuristic for the Redundancy Allocation Problem

David W. Coit and Abdullah Konak

Abstract:

A new heuristic is proposed and tested for system reliability optimization. The multiple weighted objective heuristic is based on a transformation of the problem into a multiple objective problem, and then ultimately, transformation into a different single objective problem. The multi objectives are to simultaneously maximize the reliability of each individual subsystem. This is a logical approach because system reliability is the product of the subsystem reliabilities so if they are maximized, the system reliability will also be high. This new formulation and associated heuristic are then based on solving a sequence of linear programming problems. It is one of the very few optimization approaches that allow for linear programming algorithms and software to be used for the redundancy allocation problem when mixing of functionally equivalent components is allowed. Thus, it represents an efficient solution method that relies on readily available optimization tools. The heuristic is tested on many example problems and compared to competing solution approaches. Overall, the heuristic performance is observed to be very good on the tested problem, and superior to the max-min heuristic regarding both efficiency and performance.

IE Working Paper 04-030

Parametric Confidence Intervals for the Renewal Function Via Coupled Integral Equations

Michael Tortorella and Steve G. From

Abstract:

In this paper parametric inference for the renewal function is considered. An algorithm is presented for computing parametric confidence intervals for the renewal function. The partial derivatives needed in this algorithm are obtained by solving a pair of coupled integral equations. The validity of asymptotic confidence intervals is checked via numerical experiments. Some extensions of this algorithm are discussed.

IE Working Paper 04-031

**Analysis of Process Completion Time with
Autocorrelated Times to Failures**

Baris Balcioglu, David L. Jagerman and Tayfur Altioek

Abstract:

Process completion time analysis has been extensively used to study systems, in which workstations fail from time to time. Process completion time expresses the characteristics of the service time in terms of those of inter-failure and repair times. This helps us conduct sensitivity analysis varying the inter-failure and repair time distributions to observe the system behavior. Yet, the majority of the works on process completion time assume Poisson interruption process, although this does not hold true in many real life scenarios. This is due to the fact that general times to failure lack the simplicity of the memoryless property. In this paper, we study process completion time and propose an accurate approximation for the mean waiting time in queues with servers experiencing autocorrelated failure times. To do this, we employ a three-parameter renewal approximation that represents the autocorrelated inter-failure time stream. The analysis is exact in the case of the phase-type interruption processes if the arrival process is Poisson.

IE Working Paper 04-032

**Drift Time Detection and Adjustment Procedures
for Processes Subject to Linear Trend**

Hesham Fahmy and Elsayed A. Elsayed

Abstract:

In this paper, we consider a linearly trended production process in the mean of a quality characteristic. First, we introduce a procedure to detect the drift time of the process mean as early as possible. Then, based on the estimate of the drift time, a new adjustment procedure based on the maximum likelihood estimate of the drift time is developed to keep the process on target. We analyze and compare the performance of the proposed estimator with cumulative sum (CUSUM) and exponentially moving average (EWMA) change point estimation procedures using Monte Carlo

simulation. It is observed that the procedure indeed estimates the drift time effectively for moderate and large trend rates. However, there is a noticeable decrease in its ability to detect drift time at small trend rates. Furthermore, the performance of the new adjustment procedure is compared with EWMA controllers. It is shown that the new procedure is more stable through a wide range of trend rates and its performance does not depend on any parameters of the process.

IE Working Paper 04-033

Hard Turning Optimization using Neural Network Modeling and Swarm Intelligence

Yigit Karpat and Tugrul Ozel

Abstract:

In this paper, multi-objective optimization of hard turning has been reported. A neural network model was developed in order to model the surface roughness and tool wear characteristics of hard turning when CBN tools are used. Objective is to obtain optimum process parameters, which satisfies given limit, tool wear and surface roughness values and maximizes the productivity at the same time. A recently developed optimization algorithm called particle swarm optimization is used to find optimum process parameters. Accordingly, the results indicate that a system where neural network is used to model and predict process outputs and particle swarm optimization is used to obtain optimum process parameters can be successfully applied to multi-objective optimization of hard turning.

IE Working Paper 04-034

Workpiece Material Model Based Predictions for Machining Processes

Yigit Karpat, Erol Zeren and Tugrul Ozel

Abstract:

In this paper, a methodology for work material constitutive model based calculations of forces, stress and temperature distributions in orthogonal machining are introduced. Oblique moving band heat source theory is utilized and combined with modified Oxley's parallel shear zone theory. Non-uniform heat intensity at the tool-chip interface is obtained from the predicted stress distributions utilizing slip line analysis of the modified secondary shear zone. Model validation is performed by comparing some experimental results with the predictions for machining of AISI 1045 steel and AL 6082-T6. Good agreements with the experiments are observed. A detailed stress and temperature distributions computed analytically is obtained.

IE Working Paper 04-035

Design of Optimum Reliability Test

Plans under Multiple Stresses

Elsayed A. Elsayed and Hao Zhang

Abstract:

Accelerated life testing (ALT) is used to obtain failure time data quickly under high stress levels in order to predict product life and performance under the design stress. Most of the previous work on designing ALT plans is focused on the application of a single stress. However, as components or products become more reliable due to technological advances, it becomes more difficult to obtain a significant amount of failure data within a reasonable amount of time using single stress only. Multiple-stresses ALTs have been employed as a means of overcoming such difficulties. In this paper, we design optimum multiple stresses ALT plans based on the proportional hazards model. We do not make assumptions about the failure distribution of the test units. We develop efficient multiple stress plans using the proportional hazards model and the proportional odds model. We then validate the reliability estimates predictions of the two approaches.

IE Working Paper 04-036

An Experimental Study on Forecasting Using TES Processes

Abdullah Karaman and Tayfur Altioek

Abstract:

Forecasting is of prime importance for accuracy in decision-making. For data sets containing high autocorrelations, failure to account for temporal dependence will result in poor forecasting. TES (Transform-Expand-Sample) is a class of stochastic processes to model empirical autocorrelated time series and is used in Monte Carlo simulation. Its merit is to simultaneously capture both the empirical distribution function and the autocorrelation function. The transition structure of TES processes can be utilized to calculate forecasts for future periods. In this paper, we utilize phase-type random variables as the innovation density in TES model fitting methodology, and we investigate the forecasting performance of TES processes compared to traditional auto regressive integrated moving-average models. We find that TES models yield forecasts as accurate as time series models.