Abstract Booklet

The 12th Seminar on

Reliability Theory and its Applications

Department of Statistics
Alzahra University
15 & 16 July 2026

In the Name of God

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Department of Statistics
Faculty of Mathematical Sciences
Alzahra University
Tehran, Iran

15-16 July 2026

Preface

It is a great honor to host the "12th Seminar on Reliability Theory and its Applications" in the Department of Statistics at Alzahra University on July 15-16, 2026. On behalf of the organizing committee, we extend a warm welcome to all participants. We trust this seminar will serve as a premier platform for engaging discussions and the exchange of innovative scientific ideas within our community. This event is made possible through the unwavering support of numerous institutions and the dedicated contributions of researchers and students whose work defines the quality of this seminar. We would like to express our profound gratitude to the Research Council of Alzahra University, the "Center of Excellence on Ordered Data, Reliability, and Dependency", the Islamic World Science Citation Center (ISC), the Iranian Statistical Society, the Insurance Research Center (IRC), and the Kahkeshan Group. Furthermore, we are deeply indebted to our scientific committee, peer reviewers, and the staff of the Faculty of Mathematical Sciences at Alzahra University for their invaluable cooperation in making this event a success.

Nasrin Soltankhah (Conference Chair)
Mahdi Alimohammadi (Scientific Chair)
Fariba Azizi (Organizing Chair)
July, 2026

Seminar Topics:

- Reliability of systems and networks
- Maintenance and repair models of systems
- Reliability analysis based on degradation data
- Accelerated lifetime tests
- Statistical inference and analysis of lifetime data
- Software reliability
- Warranty models and field data
- Ageing concepts
- Dependency concepts and copula functions
- Risk analysis in reliability
- Bayesian methods in reliability
- Stochastic orderings
- Data mining in reliability
- Shock models
- Survival analysis
- Statistical quality control
- Reliability in fuzzy environments
- Case studies in industry
- Big data in reliability
- Artificial intelligence in reliability

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Ms. Fatemeh Zamani (Bachelor's student and Secretary of the Statistics Student Association)

Contents

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A Quantum Operator Approach to Reliability and Stochastic Ordering

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Abstract

This paper presents a theoretical framework for generalizing the fundamental concepts of reliability analysis and stochastic order to the realm of quantum computing. The main innovation lies in mapping classical probability distributions to quantum states via amplitude encoding, which enables the representation of key reliability indices such as the failure rate, hazard rate, and mean residual life as quantum operators. We rigorously analyze the properties of these operators and demonstrate that, under appropriate conditions, the well-known hierarchical relationships among classical stochastic orders (including the usual stochastic order, hazard rate order, likelihood ratio order, and convex order) are preserved in the quantum formulation.

Keywords: Quantum reliability, Stochastic orders, Quantum information

[1]Speaker

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An Opportunistic Preventive Maintenance Policy for Coherent Systems Subject to Fatal Shocks

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Abstract

This paper examines a coherent system subject to fatal shocks modeled as a nonhomogeneous Poisson process, where each shock results in exactly one component failure. We propose a preventive maintenance (PM) policy that involves inspecting the system at a random time X before the scheduled PM time T_{PM}. During inspection, if the number of failed components exceeds a threshold m, a PM action is taken immediately unless it is postponed to T_{PM}. Additionally, in the event of system failure, corrective maintenance is conducted. The analysis includes deriving the mean cost per unit time for this PM model and determining the optimal values of T_{PM} and m to minimize this cost. To illustrate the effectiveness of the proposed maintenance approach, examples are examined numerically and graphically.

Keywords: Preventive Maintenance, Random Inspection, Mean cost function,Repairable Systems; Reliability

[1]Speaker

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A Survival modeling Framework For Mortality Decline in Cancer Populations

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Abstract

The phenomenon of mortality deceleration—the observed slowing or reversal of the mortality hazard at extreme ages—has been formalized by a non-homogeneous Poisson process (NHPP) of external shocks. While that additive hazard model captures population heterogeneity, it relies on fixed frailties and ignores time-varying covariate effects. We propose a unified extension that integrates some recent methodological developments in this survival analysis area: (i) a model that provides interpretable log-hazard functions under the proportional hazards assumption, (ii) a survival model that relaxes the proportionality constraint by treating time as a direct input, and (iii) a recurrent-event random survival forest that handles multiple event times and right censoring. Using simulated data calibrated to real-world cancer registries, we compare the three approaches that all of them substantially outperform the classical NHPP-based hazard model. The findings suggest that flexible survival frameworks provide a statistically robust approach for modeling heterogeneous mortality processes in cancer survival and aging research. The proposed

[1]Speaker

methodology offers an extension of stochastic mortality theory and may be applicable to broader biomedical settings involving long-term hazard stabilization and cure-like survival behavior.

Keywords: Mortality deceleration, Survival analysis, Hazard model, Cancer survival

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Optimal Maintenance Planning for Degradation Systems under Random Inspection

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Abstract

In this talk, we introduce a preventive maintenance (PM) strategy for systems that deteriorate over time, combining age-based replacements with random screening. System degradation is modeled through a gamma process, with failure occurring once degradation hits a set threshold D. A scheduled replacement occurs at age T, and a screening takes place at a randomly determined inspection time governed by a specified probability density function. Decisions to replace preventively are based on degradation observed during inspection and a risk threshold that assesses the probability of failure before the scheduled replacement. We provide analytical formulas for the expected cycle cost and duration, leading to the calculation of the long-term average cost rate of the proposed policy. A detailed numerical analysis examines how variables such as replacement age, inspection timing, screening threshold, and other cost and degradation factors influence the optimal maintenance approach. We show that the

[1]Keynote Speaker

proposed framework extends the existing fixed-screening model by modeling inspection time as a random variable, thereby offering a flexible and realistic method for maintenance planning under uncertain inspection schedules.

Keywords: Preventive maintenance, Gamma process, Degradation modeling, Random inspection, Condition-based maintenance, Reliability optimization

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Testing Goodness-of-Fit for Exponential Distribution Based on Exponential Exteropy and Weighted Exponential Extropy

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Abstract

In this paper, we first introduce two measures of extropy based on k-records and next introduce goodness-of-fit test for assessing exponentiality based on them. Monte Carlo simulation is used to compute the critical values of the two proposed tests for different sample sizes and significance level $\alpha = 0.05$. To demonstrate the advantage of the proposed test, two competing tests were considered and their adjusted powers were computed against various alternative distributions. The power results indicate that our two proposed tests exhibit high adjusted power when the alternatives have increasing failure rate or decreasing hazard rate and a unimodal hazard rate. Finally, three real-world examples are used to demonstrate the applicability and robustness of the proposed

[1]Speaker

tests.

Keywords: Testing exponentiality, Adjusted power, Record value

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Development of Repair Alert Model for Components Having Discrete Lifetimes in the Power Series Family

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Abstract

This paper introduces a novel repair alert model designed for systems exhibiting discrete lifetime patterns, a common feature in maintenance data such as operational cycles, weekly failure reports, or counts of units produced before failure. We develop a robust framework under the assumption that system lifetimes follow a discrete distribution from the powerful and versatile power series family. The study tackles the critical challenge of parameter estimation for three prominent members of this family. Subsequently, we employ the Akaike Information Criterion (AIC) to identify the most suitable model and construct precise approximate confidence intervals for its parameters. The practicality and effectiveness of the proposed model are conclusively demonstrated through a comprehensive analysis of a real-world dataset, showcasing its significant potential for optimizing maintenance

[1]Speaker

strategies.

Keywords: Maximum likelihood estimation, Power series family, Random sign censoring, Repair alert model

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Stochastic Comparisons of Sequential $(n-r+1)$-out-of-n Systems Based on Relative Ageing

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Abstract

The hazard and reversed hazard rates are two important measures to study the lifetime random variables in reliability theory, survival analysis and stochastic modeling. In this article, we study the stochastic comparisons of sequential $(n-r+1)$-out-of-n systems based on these measures via relative ageing which is rather younger than classic ageing in one sample, as well as two samples cases.

Keywords: Hazard rate function, Reversed hazard rate function, Order statistics, Record values

[2]Speaker

Stochastic Ordering and Reliability Properties of a Discrete Lévy-type Distribution

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Abstract

In this paper we study stochastic ordering and reliability properties of a discrete distribution generated by the Lévy density (discrete Lévy-type distribution). We show that the family is ordered with respect to its parameter in the likelihood ratio order, which implies both hazard rate ordering and the usual stochastic order. These ordering relations provide a natural interpretation of the parameter in terms of lifetime behavior: larger parameter values correspond to stochastically larger lifetimes and lower hazard rates. We also investigate the asymptotic behavior of the main reliability characteristics. In particular, the hazard rate decreases asymptotically to zero, while the mean residual life increases linearly for large ages. These results provide a unified understanding of how the parameter of the discrete Lévy-type distribution governs both stochastic ordering and long-term reliability behavior, offering insight into the dependence between lifetime characteristics, hazard rate decay, and mean residual life growth.

[1]Speaker

Keywords: discrete Lévy-type distribution, stochastic ordering, hazard rate, mean residual life

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The δ-Shock Model in Systems Reliability: A Review

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Abstract

The δ-shock model is a survival model for studying the life behavior of shock-exposed systems that are sensitive to the length of the time distance between consecutive shocks. This model has many applications in various sciences, including applied probability, reliability engineering, biology, and finance, to name a few. Depending on the different failure scenarios for systems suffering from short time intervals between consecutive shocks, the δ-shock model is considered in more advanced versions, some of which include generalized versions, mixed models, and run-based models. This review provides an introduction to the δ-shock model as well as related advanced versions.

Keywords: System reliability, δ-shock model, inter-arrival time

[2]Speaker

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Agent-Informed Discretization:A Knowledge-Informed Reinforcement Learning Framework for Smart Steel Production Maintenance

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Abstract

In a scrap-based steel production line, traditional maintenance policies fail due to complex interactions between hammer wear, buffer limits, demand, and RUL. Existing DRL approaches are reactive and rely on pre-defined degradation models. This paper proposes Agent-Informed Discretization: a DDQN agent is first trained in a continuous space with 21 actions (0-20 hammer replacements). Knowledge extraction via sensitivity and action-frequency analysis identifies strategic breakpoints and prunes actions to 5 effective ones (0,3,5,15,20), forming an interpretable 96-state discrete space. Zero-shot evaluation shows our model achieves higher mean reward (-1549.2 vs. -1534.6 and -1275.21) and lower standard deviation (22.96 vs. 16.11 and 12.67). Unlike

[1]Speaker

black-box DRL, the resulting policy is transparent, expressed as simple if-then rules from learned behavior. This work demonstrates that combining expressive DRL training with principled knowledge extraction yields high-performance, low-cost, deployable maintenance strategies for real industrial systems.

Keywords: Reinforcement learning , Maintenance optimization, Scrap-based steel production line, Remaining useful life, Multi-component system

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Multi-State Stress-Strength Reliability Models

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Abstract

A system comprising n independent components (or subsystems) is considered. The system reliability under stress-strength is analytically evaluated, and the states of the system are classified considering the number of components whose strengths above (below) the multiple stresses available in an environment. That is, consideration of m stresses create $m+1$ states for the system and its components. In this study, multi-state systems, in particular, multi-state k-out-of-n:G and multi-state consecutive k-out-of-n:G, are considered in a stress-strength setup. Results are illustrated for various stress-strength distributions. Maximum likelihood estimators of state probabilities are also presented. The study demonstrates that ignoring various states of components leads to significant bias in reliability estimation. Finally, key conclusions and generalizations are discussed.

Keywords: Exponential distribution, Maximum likelihood estimate, Multi-state k-out-of-n:G system, Order statistics, Pareto distribution, Stress-strength reliability

[1]Speaker

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A Statistical Model for Real Lifespan Under Environmental Conditions: A Gamma-Dirichlet Approach

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Abstract

This paper introduces a novel statistical framework for modeling the actual lifespan of components under real-world environmental conditions. Unlike traditional laboratory-based assessments, our model incorporates environmental variability by defining the actual lifespan as the product of a Gamma-distributed laboratory lifetime and a Dirichlet-distributed environmental impact vector. We derive the joint distribution of this product and explore its fundamental properties, including moments and covariance structure. The model is further extended to scenarios

[2]Poster

involving multiple independent positions, where the aggregate lifespan is expressed as a sum of such products. For cases where exact distributions are intractable, we propose an approximation method based on moment matching. Numerical simulations demonstrate the accuracy of a Beta approximation for a representative case, validated by Kolmogorov-Smirnov goodness-of-fit tests. The proposed framework offers a flexible tool for reliability analysis in fields such as civil engineering and manufacturing.

Keywords: Environmental lifetime, Gamma distribution, Dirichlet distribution, Product of random variables, Approximation

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Maximum Varma entropy distribution with conditional known Lorenz curve constraints

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Abstract

The maximum entropy principle provides a systematic approach for deriving probability distributions consistent with incomplete information. In this study, a maximum entropy framework based on Varma entropy is developed under constraints relevant to economic distribution analysis. Specifically, the probability distribution is derived under the conditions of known mean and a specified Lorenz curve, allowing inequality information to be incorporated directly into the entropy maximization process. The corresponding Lagrange multipliers are also obtained as part of the estimation procedure.

[1]Poster

In the empirical application, the resulting maximum Varma entropy distribution is fitted to income data for two countries. The performance of the proposed distribution is then compared with the exponential and Fréchet distributions. Model comparison is conducted using standard goodness-of-fit measures, including the mean squared error (MSE) and mean absolute error (MAE). The results demonstrate the effectiveness of the proposed entropy-based distribution for modeling income data characterized by inequality.

Keywords: Shannon Entropy, Varma Entropy, Maximum Entropy, Euler's equation, Lorenz curve

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Estimation of Multicomponent Stress–Strength Reliability Based on Lower Record Values from the Topp–Leone Distribution

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Abstract

This paper deals with the inference of the multicomponent stress–strength reliability (MSS) model under the assumption that the strength and stress variables follow independent Topp–Leone distributions with different shape parameters (α_1, α_2). Maximum likelihood estimators of $R_{s,k}$, Bayesian estimates, and asymptotic confidence intervals are derived based on lower record values. Various bootstrap confidence intervals are constructed, and Bayesian credible intervals are also obtained using MCMC methods. A simulation study is conducted to compare the performance of the various estimators of multicomponent stress–strength reliability. Finally, a real-life example is analyzed to

[1]Poster

illustrate the practical applications of the proposed methods.

Keywords: Bayesian estimation, Gibbs sampling, Lower record, ML estimation, Multicomponent stress–strength, Topp Leone distribution

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Reliability Status in Safeguarding Systems Against Sabotage

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Abstract

In this presentation, we begin by introducing the concept of asset protection against sabotage. Next, we examine the position of security and protection within the broader framework of dependability and explore their interactions. We then present the principle of defense-in-depth and its protective layers, clearly articulating the role of reliability in each layer of the defense-in-depth architecture. Finally, we discuss practical case studies that highlight the significance of reliability in countering sabotage. The presentation concludes with the unveiling of a roadmap for sabotage mitigation from a reliability perspective—presented for the first time in this session.

Keywords: Sabotage Mitigation, Defense-in-Depth, Dependability Framework, Asset Protection

[1]Keynote Speaker

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Design of an Modified Exponentially Weighted Moving Average Control Chart

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Abstract

The production of high quality products requires the use of statistical quality control tools, especially control charts. These tools allow for accurate monitoring of production processes and rapid identification of changes. In this study, assuming the normality of quality characteristics, we design hybrid control charts that are obtained by combining moving average, exponentially weighted moving average, and Modified exponentially weighted moving average control charts. The performance of these charts has been evaluated using a probabilistic method for different parameters. The results show that the proposed control chart performs better than the existing control charts in identifying small changes.

Keywords: Statistical quality control, Control chart, Exponentially weighted moving average, Average run length

[1]Speaker

Comparative Evaluation of Group Replacement and Run to Failure Policies in Heterogeneous Multi Component Systems

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Abstract

In multi component maintenance planning, economies of scale can typically achieve through group maintenance strategies. This study focuses on a heterogeneous multi unit system and formulates two cost minimizing maintenance policies. Using renewal theoretic reasoning, the expected number of failures over a finite interval is numerically estimated, forming a key element of the models. The analysis also shows how one policy collapses into alternative strategies under specific conditions. A numerical example is provided to demonstrate the models' performance and the resulting cost expressions.

Keywords: Maintenance, Renewal theory, Replacement, Group Replacement Policy, Run to Failure Policy

[1]Speaker

Optimal Weibull Reliability group test plans using truncated prior distribution

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Abstract

This paper focuses on designing reliability group sampling plans based on Weibull failure count data. A linear combination of expected producer and consumer risks is minimized and the optimal number of groups are also determined by solving integer nonlinear programming problems where the prior information on failure probability is described by a truncated beta model. Numerical and graphical analyses are provided for illustrative and comparative purposes.

Keywords: Reliability testing, Expected producer and consumer risks, Lot sampling inspection, Weibull model

[1]Speaker

Preservation of Aging Classes Under the Formation of Coherent Systems

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Abstract

We show that some distributions play a crucial role in the aging classes closure under the creation of semi-coherent (or mixed) systems with identically distributed component lifetimes. In this way, if the class is inherited for that key distributions, then so is for the remaining distributions included this class. In the most important aging classes, the key distribution is the exponential one, which plays a central role in this context since it represents units without aging (with the lack of memory property). In other classes the key distributions are the uniform and Pareto models. These distributions lead to mathematical properties that may be useful to decide if an aging class is inherited by a specific system. We consider both the cases of systems with independent and dependent components.

Keywords: Aging classes, Coherent systems, Closure properties, Distortion function, Dependent components

[1]Keynote Speaker

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Stress vs. Strength: A Log-Uniform Model for Quantifying Reliability in Cognitive Performance and Battery Degradation

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Abstract

This paper develops and compares estimators of the stress-strength parameter $R = P(X > Y)$ when both variables follow independent log-uniform distributions. We derive the maximum likelihood estimator (MLE), the uniformly minimum variance unbiased estimator (UMVUE), and a novel shrinkage estimator that optimally blends MLE and UMVUE. A simulation study confirms that the shrinkage estimator reduces bias and mean squared error compared to the MLE while approaching the UMVUE in large samples. The practical value of the methodology is then demonstrated through two real-world case studies. First, in an educational psychology context, we quantify the effect of coffee consumption on students' accuracy in a statistics exam, obtaining

[1]Speaker

a reliability estimate of approximately 0.35. Second, in an electrical engineering setting, we analyse lithium-ion battery degradation under thermal stress, yielding a reliability estimate of about 0.56. In both applications, the log-uniform model provides an adequate fit, and the estimators deliver interpretable, actionable insights that align with domain-specific literature. The paper includes compact derivations of the key analytical forms, making it self-contained for applied researchers.

Keywords: Stress-strength model, Log-uniform distribution, Shrinkage estimator, Coffee and academic performance, Battery thermal reliability

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Ordering Results of Series Systems Consisting of Dependent and Heterogeneous Exponential Components under Archimedean Copula

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Abstract

This paper investigates series systems comprising m dependent subsystems, each containing heterogeneous and dependent Exponential components. The dependence among components is modelled using Archimedean copulas. We establish sufficient conditions for the stochastic comparison of two such series systems when the vector of scale parameters of the first system majorizes that of the second, and when the vectors representing the number of components in each subsystem differ between the two systems. A numerical example is provided to illustrate the theoretical findings.

Keywords: Series system, Usual stochastic order, heterogeneous Exponential components, Archimedean Copula

[1]Speaker