Preface

In today's technological world nearly everyone depends upon the continued functioning of a wide array of complex machinery and equipment for our everyday safety, security, mobility and economic welfare. We expect our electric appliances, lights, hospital monitoring control, next-generation aircraft, nuclear power plants, data exchange systems, and aerospace applications, to function whenever we need them. When they fail, the results can be catastrophic, injury or even loss of life.

As our society grows in complexity, so do the critical reliability challenges and problems that must be solved. The area of reliability engineering currently received a tremendous attention from numerous researchers and practitioners as well.

This **Handbook of Reliability Engineering**, altogether 35 chapters, aims to provide a comprehensive state-of-the-art reference volume that covers both fundamental and theoretical work in the areas of reliability including optimization, multi-state system, life testing, burn-in, software reliability, system redundancy, component reliability, system reliability, combinatorial optimization, network reliability, consecutive-systems, stochastic dependence and aging, change-point modeling, characteristics of life distributions, warranty, maintenance, calibration modeling, step-stress life testing, human reliability, risk assessment, dependability and safety, fault tolerant systems, system performability, and engineering management.

The Handbook consists of five parts. Part I of the Handbook contains five papers, deals with different aspects of *System Reliability and Optimization*.

Chapter 1 by Zuo, Huang and Kuo studies new theoretical concepts and methods for performance evaluation of multi-state k-out-of-n systems. Chapter 2 by Pham describes in details the characteristics of system reliabilities with multiple failure modes. Chapter 3 by Chang and Hwang presents several generalizations of the reliability of consecutive-k-systems by exchanging the role of working and failed components in the consecutive-k-systems. Chapter 4 by Levitin and Lisnianski discusses various reliability optimization problems of multi-state systems with two failure modes using combination of universal generating function technique and genetic algorithm. Chapter 5 by Sung, Cho and Song discusses a variety of different solution and heuristic approaches, such as integer programming, dynamic programming, greedy-type heuristics, and simulated annealing, to solve various combinatorial reliability optimization problems of complex system structures subject to multiple resource and choice constraints.

Part II of the Handbook contains five papers, focuses on the *Statistical Reliability Theory*. Chapter 6 by Finkelstein presents stochastic models for the observed failure

rate of systems with periods of operation and repair that form an alternating process. Chapter 7 by Lai and Xie studies a general concept of stochastic dependence including positive dependence and dependence orderings. Chapter 8 by Zhao discusses some statistical reliability change-point models which can be used to model the reliability of both software and hardware systems. Chapter 9 by Lai and Xie discusses the basic concepts for the stochastic univariate and multivariate aging classes including bathtub shape failure rate. Chapter 10 by Park studies characteristics of a new class of NBU-t_0 life distribution and its preservation properties.

Part III of the Handbook contains six papers, focuses on *Software Reliability*. Chapter 11 by Dalal presents software reliability models to quantify the reliability of the software products for early stages as well as test and operational phases. Some further research and directions useful to practitioners and researchers are also discussed. Chapter 12 by Ledoux provides an overview of some aspects of software reliability modeling including black-box modeling, white-box modeling, and Bayesian-calibration modeling. Chapter 13 by Tokuno and Yamada presents software availability models and its availability measures such as interval software reliability and the conditional mean available time.

Chapter 14 by Dohi, Goševa-Popstojanova, Vaidyanathan, Trivedi and Osaki presents the analytical modeling and measurement based approach for evaluating the effectiveness of preventive maintenance in operational software systems and determining the optimal time to perform software rejuvenation. Chapter 15 by Kimura and Yamada discusses nonhomogeneous death process, hidden-Markov process, and continuous state-space models for evaluating and predicting the reliability of software products during the testing phase. Chapter 16 by Pham presents basic concepts and recent studies nonhomogeneous Poisson process software reliability and cost models considering random field environments. Some challenge issues in software reliability are also included.

Part IV contains nine chapters, focuses on *Maintenance Theory and Testing*. Chapter 17 by Murthy and Jack presents overviews of product warranty and maintenance, warranty policies and contracts. Further research topics that link maintenance and warranty are also discussed. Chapter 18 by Pulcini studies stochastic point processes maintenance models with imperfect preventive maintenance, sequence of imperfect and minimal repairs and imperfect repairs interspersed with imperfect preventive maintenance. Chapter 19 Dohi, Kaio and Osaki presents the basic preventive maintenance policies and their extensions in terms of both continuous and discrete-time modeling. Chapter 20 by Nakagawa presents the basic maintenance policies such as age replacement, block replacement, imperfect preventive maintenance, and periodic replacement with minimal repair for multi-component systems.

Chapter 21 by Wang and Pham studies various imperfect maintenance models that minimize the system maintenance cost rate. Chapter 22 by Elsayed presents basic concepts of accelerated life testing and a detailed test plan that can be designed

before conducting an accelerated life test. Chapter 23 by Owen and Padgett focuses on the Birnbaum-Saunders distribution and its application in reliability and life testing. Chapter 24 by Tang discusses the two related issues for a step-stress accelerated life testing (SSALT) such as how to design a multiple-steps accelerated life test and how to analyze the data obtained from a SSALT. Chapter 25 by Xiong deals with the statistical models and estimations based on the data from a SSALT to estimate the unknown parameters in the stress-response relationship and the reliability function at the design stress.

Part V contains nine chapters, primarily focuses on *Practices and Emerging Applications*. Chapter 26 by Phillips presents proportional and non-proportional hazard reliability models and its applications in reliability analysis using non-parametric approach. Chapter 27 by Yip, Wang and Chao discusses the capture-recapture methods and the Horvits Thompson estimator to estimate the number of faults in a computer system. Chapter 28 by Billinton and Allan provides overviews and deals with the reliability evaluation methods of electric power systems. Chapter 29 by Dhillon discusses various aspects of human and medical device reliability.

Chapter 30 by Bari presents the basic of probabilistic risk assessment methods that developed and matured within the commercial nuclear power reactor industry. Chapter 31 by Akersten and Klefsjö studies methodologies and tools in dependability and safety management. Chapter 32 by Albeanu and Vladicescu deals with the approaches in software quality assurance and engineering management. Chapter 33 by Teng and Pham presents a generalized software reliability growth model for N-version programming systems which considers the error-introduction rate, the error-removal efficiency, and multi-version coincident failures, based on the non-homogeneous Poisson process. Chapter 34 by Carrasco presents Markovian models for evaluating the dependability and performability of fault tolerant systems.

Chapter 35 by Lee discusses a new random-request availability measure and presents closed-form mathematical expressions for random-request availability which incorporate the random task arrivals, the system state, and the operational requirements of the system.

All the chapters are written by over 45 leading reliability experts in academia and industry. I am deeply indebted and wish to thank all of them for their contributions and cooperation. Thanks are also due to the Springer staff, especially Peter Mitchell, Roger Dobbing and Oliver Jackson, for their editorial work. I hope that practitioners will find this Handbook useful when looking for solutions to practical problems; researchers can use it for quick access to the background, recent research and trends, and most important references regarding certain topics, if not all, in the reliability.

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