An uncertain programming model for preventive maintenance scheduling

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Abstract

Purpose – The purpose of this paper is to illustrate an uncertain programming model for scheduling of preventive maintenance (PM) actions. The PM scheduling, in which PM actions are performed under fixed intervals, is solved by grey systems theory.

Design/methodology/approach – The paper applied the grey evaluation method based on triangular whitenization weight functions which includes two classes: endpoint evaluation method and center-point evaluation method.

Findings – Two methods give the same results based on endpoint and center-point triangular whitenization weight functions. For validation, the results were compared by Cassady's method.

Originality/value – The scheduling of PM is crucial in reliability and maintenance engineering. Hundreds of parts compose complex machines that require replacement and/or repairing. It is helpful to reduce the outage loss on frequent repair/replacement parts and avoid lack of maintenance of the equipment by controlling the equipment maintenance frequency.

Keywords Uncertainty, Failure, Grey systems theory, Preventive maintenance scheduling

Paper type Research paper

Nomenclature

β	Weibull shape parameter for probability distribution of T	$N(\tau)$	number of machine failures in τ time units of machine operation
η	Weibull scale parameter for probability distribution of T	$z(t)$	hazard function of T
τ	PM interval for the machine	t_r	time required to repair the machine
$A(\tau)$	steady-state machine availability	t_p	time required to perform PM on the machine
$m(\tau)$	$E[N(\tau)]$		

1. Introduction

Timely and cost-effective production is becoming increasingly important in today's global competitive markets. For the manufacturers, it is vital to optimize the machine resource utilization by ensuring an efficient and stabilized schedule at the operational level. Traditional literatures on scheduling assume that machines are available at all times. However, in many realistic situations, machines may be unavailable during the scheduling horizon for different reasons, such as breakdowns and scheduled maintenances in typical industrial settings. This availability consideration adds complexity to any scheduling problem, even in a single machine environment (Lu *et al.*, 2015).

In a long-term scheduling, production system is always subject to deterioration with usage, which will affect the availability of machines and the stability of the system.

Uncertain Programming

Clemens Wendtner

Uncertain Programming:

    Theory and Practice of Uncertain Programming Baoding Liu,2013-04-17 Real life decisions are usually made in the state of uncertainty randomness fuzziness roughness etc How do we model optimization problems in uncertain environments How do we solve these models In order to answer these questions this book provides a self contained comprehensive and up to date presentation of uncertain programming theory It includes numerous modeling ideas hybrid intelligent algorithms and various applications in transportation problem inventory system facility location allocation capital budgeting topological optimization vehicle routing problem redundancy optimization and scheduling Researchers practitioners and students in operations research management science information science system science and engineering will find this work a stimulating and useful reference   **Uncertain Programming** Baoding Liu,1999 An up to date authoritative comprehensive look at optimization theory in uncertain environments Real life management decisions such as buy sell decisions in the stock market are almost always made in uncertain environments Is it possible to make model decision problems to fit these circumstances Once constructed can these models be solved In Uncertain Programming Baoding Liu answers both of these questions in the affirmative and goes on to lay a solid foundation for optimization in generally uncertain environments Uncertain Programming describes the basic concepts of mathematical programming provides a genetic algorithm for optimization problems and introduces the techniques of stochastic and fuzzy simulation After examining some basic results of expected value models the book moves on to explore chance constrained programming with stochastic parameters and illustrate applications of chance constrained programming models Dr Liu discusses dependent chance programming in stochastic environments and extends both chance constrained and dependent chance programming from stochastic to fuzzy environments He then constructs a theoretical framework for fuzzy programming with fuzzy rather than crisp decisions This remarkable and revolutionary book Lays a foundation for optimization theory in uncertain environments Provides a unifying principle for dealing with stochastic and fuzzy programming Incorporates the most recent developments in the field Emphasizes modeling ideas evolutionary computation and applications of uncertain programming Uncertain Programming is a reliable authoritative and eye opening guide for researchers and engineers in operations research management science business management information and systems science and computer science   Uncertain Graph and Network Optimization Bo Zhang,Jin Peng,2022-05-03 This first book focuses on uncertain graph and network optimization It covers three different main contents uncertain graph uncertain programming and uncertain network optimization It also presents applications of uncertain network optimization in a lot of real problems such as transportation problems dispatching medical supplies problems and location problems The book is suitable for researchers engineers teachers and students in the field of mathematics information science computer science decision science management science and engineering artificial intelligence industrial engineering economics and operations research   *Uncertainty Theory* Baoding Liu,2014-11-03 When

no samples are available to estimate a probability distribution we have to invite some domain experts to evaluate the belief degree that each event will happen Perhaps some people think that the belief degree should be modeled by subjective probability or fuzzy set theory However it is usually inappropriate because both of them may lead to counterintuitive results in this case In order to rationally deal with belief degrees uncertainty theory was founded in 2007 and subsequently studied by many researchers Nowadays uncertainty theory has become a branch of axiomatic mathematics for modeling belief degrees This is an introductory textbook on uncertainty theory uncertain programming uncertain statistics uncertain risk analysis uncertain reliability analysis uncertain set uncertain logic uncertain inference uncertain process uncertain calculus and uncertain differential equation This textbook also shows applications of uncertainty theory to scheduling logistics networks data mining control and finance   Advanced technologies for planning and operation of prosumer energy systems Bin Zhou,Siqi Bu,Liansong Xiong,Hugo Morais, Junjie Hu,Jingyang Fang,Jian Zhao,Peng Hou,2023-04-28   **Proceedings of 2021 Chinese Intelligent Systems Conference** Yingmin Jia,Weicun Zhang,Yongling Fu,Zhiyuan Yu,Song Zheng,2021-10-06 This book presents the proceedings of the 17th Chinese Intelligent Systems Conference held in Fuzhou China on Oct 16 17 2021 It focuses on new theoretical results and techniques in the field of intelligent systems and control This is achieved by providing in depth study on a number of major topics such as Multi Agent Systems Complex Networks Intelligent Robots Complex System Theory and Swarm Behavior Event Triggered Control and Data Driven Control Robust and Adaptive Control Big Data and Brain Science Process Control Intelligent Sensor and Detection Technology Deep learning and Learning Control Guidance Navigation and Control of Flight Vehicles and so on The book is particularly suited for readers who are interested in learning intelligent system and control and artificial intelligence The book can benefit researchers engineers and graduate students   **Special Issue on Uncertain Programming Modeling, Algorithms and Applications** ,2013   Proceedings of International Conference on Systems Science and Engineering (ICSSE '88) : 25-28 July 1988, Beijing, China Weimin Cheng,1989 Some 170 papers of the July 1988 meeting survey advances in the main areas of systems science and engineering Areas covered include theoretical and methodical developments applications to population telecommunication transportation and water resource systems optimization multicriteria decision making game theory decision analysis management information and decision support systems Printed in China on acidic paper directly from authors typescripts many of which strain legibility Four papers are printed after the author index while not appearing in the table of contents Sloppy production for a 200 book No subject index Annotation copyrighted by Book News Inc Portland OR   **An Algorithmic Study on Basic Planning Problems in Operations Research** Kakuzo Iwamura,2003   **Advanced Materials and Computer Science** Garry Zhu,2011-04-19 Selected peer reviewed paper from 2011 International Conference on Advanced Materials and Computer Science ICAMCS 2011 May 1 2 2010 in Chengdu China   *Fuzzy Systems Conference (FUZZ), 2000* IEEE Neural Networks Council,2000-05   Mathematical Programming and

the Analysis of Capital Budgeting Problems H. Martin Weingartner,1967   CUSTOM (Center for Uncertain Systems: Tools for Optimization and Management Conference) Center for Uncertain Systems: Tools for Optimization and Management,2004

Modelling Uncertain Data Hans Bandemer,1992 Mathematics of Computing Miscellaneous   **Management Science** ,2004-11 Issues for Feb 1965 Aug 1967 include Bulletin of the Institute of Management Sciences   Electricity Supply Planning when Demand is Uncertain Robert Boyd,1978   **INFOR.** ,2005   *Tools for Making Acute Risk Decisions* ,1994-08-15 The complexity of today s risk decisions is well known Beyond cost and risk there are many other factors contributing to these decisions including type of risk such as human injury or fatality the economic impact on the local community profitability availability of capital alternatives for reducing or eliminating the risk costs of implementing alternatives codes standards regulation and good industry practice This book presents a large range of decision aids for risk analysts and decision makers in industry so that vital decisions can be made in a more consistent logical and rigorous manner Though primarily aimed at the process industry this book can be used by anyone who makes similar decisions in other industries including those in management science   Machine Learning and Uncertain Reasoning Brian R. Gaines,John H. Boose,1990   **Programming Under Uncertainty** Roger Jean-Baptiste Robert Wets,1965

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