

# 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 whitening 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 whitening 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

$\beta$	Weibull shape parameter for probability distribution of $T$	$N(r)$	number of machine failures in $r$ time units of machine operation
$\eta$	Weibull scale parameter for probability distribution of $T$	$x(t)$	hazard function of $T$
$r$	PM interval for the machine	$t_r$	time required to repair the machine
$A(r)$	steady-state machine availability	$t_p$	time required to perform PM on the machine
$w(r) = E\{N(r)\}$			

## 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

**L Darling-Hammond**



## **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

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**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

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