Preface

This book concerns the use of nonparametric statistical tools for the inferences of the performance characteristics of reliability dynamic systems operating in a certain physical environment that determines their behaviour through time.

Although many statistical methods rely on assumptions about the structure of the data to be analysed, there are many practical situations where these assumptions are not satisfied. In such cases, it may not be appropriate to use traditional parametric methods of analysis. In fact, very often a free-model method, and therefore, a data driven focus to the problem, is the only option.

The term nonparametric does not mean that there is a complete lack of parameters; rather it implies that the number and the nature of the parameters are not fixed in advance. In any case, nonparametric methods require a very limited number of assumptions to be made about the underlying distribution of the data, which undoubtedly confers an advantage over parametric methods. First of all, they have a wider applicability and are more robust. Moreover, nonparametric methods are intuitive, flexible and simple to carry out. Among the disadvantages, we should mention that appropriate computer software for nonparametric statistics may be limited; however, this is a continually improving situation.

Roughly speaking, we could summarize the main purpose of this book as understanding systems' performance. To undertake this task, there are many aspects that manufacturers, analysts and of course, users must take into account such as: the mode and the intensity of usage, the environmental conditions, the maintenance actions (when these are accomplished), the internal structure of the system, etc. To what extent all these features should be examined is mainly a question of the quality and quantity of the information the analyst is willing to get. Because of this, we may be confronted with many different practical situations that vary between two extremes.[1] On the one hand, the less informative procedure applies when the method used for system observation does not make use of any

[1] Nicolai, R.P., *Maintenance Models for Systems Subject to Measurable Deterioration*, Ph.D. Thesis, Erasmus University, Rotterdam (2008)

particular knowledge of the physical characteristics implicit in the system operation. In this case, the deterioration model consists merely of describing the relation between time and failure, and is therefore reduced to a lifetime distribution model. We refer to these models as black-box models and we devote the first part of this book to study these models by using nonparametric approaches.

In contrast, we may be facing situations in which a deeper (as far as possible) understanding of the different mechanisms of failures is required and therefore, we need models that are as close as possible to a full description of the real system, in other words, a physics-based model is required. Think for example of the case where the different components of the system, as well as the relationships between them, are relevant to get significant information for understanding the system behaviour and consequently for making certain decisions in the manufacture procedure. These models are called white-box models in the literature. Although the major advantage of these models is their enormous degree of flexibility, nevertheless, the extremely high complexity and computing burden involved in setting a pure white-box model as a copy of reality make their formulation not feasible at all in practice. The third part of the book discusses how to represent the evolution to failure of reliability systems under three approaches that could be considered, to some extent, into this group.

The intermediate formulation is what we denote as grey-box models. We understand that a grey-box model provides a mathematical representation, but some of the physics is approximated. For our purposes, the model is reduced to a deterioration model that indicates the time-dependent deterioration and failure. These models are studied in the second part of the book.

This book is primarily intended for practitioners and researchers in reliability engineering, who faced with reliability data would like to explore the possibility of nonparametric descriptions of underlying probability mechanisms. The book is hence an alternative to much of the current reliability literature which is based on parametric modelling. Given the extensive collection of models and methods considered, the book should also be of interest for a wider audience working in for example software engineering, biostatistics, operations research, economics and other fields where events occurring in time are studied.

Computations and graphs are done using R (http://www.r-project.org/) and MATLAB. Some of the program code and datasets can be obtained from the authors.

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