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**Stéphane Tufféry**

# **DATA MINING AND STATISTICS FOR DECISION MAKING**

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# Data Mining and Statistics for Decision Making

*Data Mining and Statistics for Decision Making*, First Edition. Stéphane Tufféry.

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# Data Mining and Statistics for Decision Making

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Translated by Rod Riesco



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*to Paul and Nicole Tufféry,  
with gratitude and affection*

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# Preface

All models are wrong but some are useful.  
George E. P. Box<sup>1</sup>

[Data analysis] is a tool for extracting the jewel of truth from the slurry of data.  
Jean-Paul Benzécri<sup>2</sup>

This book is concerned with data mining, which is the application of the methods of statistics, data analysis and machine learning to the exploration and analysis of large data sets, with the aim of extracting new and useful information for the benefit of the owner of these data.

An essential component of decision assistance systems in many economic, industrial, scientific and medical fields, data mining is being applied in an increasing variety of areas. The most familiar applications include market basket analysis in the retail and distribution industry (to find out which products are bought at the same time, enabling shelf arrangements and promotions to be planned accordingly), scoring in financial establishments (to predict the risk of default by an applicant for credit), consumer propensity studies (to target mailshots and telephone calls at customers most likely to respond favourably), prediction of attrition (loss of a customer to a competing supplier) in the mobile telephone industry, automatic fraud detection, the search for the causes of manufacturing defects, analysis of road accidents, assistance to medical prognosis, decoding of the genome, sensory analysis in the food industry, and others.

The present expansion of data mining in industry and also in the academic sphere, where research into this subject is rapidly developing, is ample justification for providing an accessible general introduction to this technology, which promises to be a rich source of future employment and which was presented by the Massachusetts Institute of Technology in 2001 as one of the ten emerging technologies expected to ‘change the world’ in the twenty-first century.<sup>3</sup>

This book aims to provide an introduction to data mining and its contribution to organizations and businesses, supplementing the description with a variety of examples. It details the methods and algorithms, together with the procedures and principles, for implementing data mining. I will demonstrate how the methods of data mining incorporate and extend the conventional methods of statistics and data analysis, which will be described reasonably thoroughly. I will therefore cover conventional methods (clustering, factor analysis, linear regression, ridge regression, partial least squares regression, discriminant

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<sup>1</sup> Box, G.E.P. (1979) Robustness in the strategy of scientific model building. In R.L. Launer and G.N. Wilkinson (eds), *Robustness in Statistics*. New York: Academic Press.

<sup>2</sup> Benzécri, J.-P. (1976) *Histoire et Préhistoire de l'Analyse des Données*. Paris: Dunod.

<sup>3</sup> In addition to data mining, the other nine major technologies of the twenty-first century according to MIT are: biometrics, voice recognition, brain interfaces, digital copyright management, aspect-oriented programming, microfluidics, optoelectronics, flexible electronics and robotics.



analysis, logistic regression, the generalized linear model) as well as the latest techniques (decision trees, neural networks, support vector machines and genetic algorithms). We will take a look at recent and increasingly sophisticated methods such as model aggregation by bagging and boosting, the lasso and the ‘elastic net’. The methods will be compared with each other, revealing their advantages, their drawbacks, the constraints on their use and the best areas for their application. Particular attention will be paid to scoring, which is still the most widespread application of predictive data mining methods in the service sector (banking, insurance, telecommunications), and fifty pages of the book are concerned with a comprehensive credit scoring case study. Of course, I also discuss other predictive techniques, as well as descriptive techniques, ranging from market basket analysis, in other words the detection of association rules, to the automatic clustering method known in marketing as ‘customer segmentation’. The theoretical descriptions will be illustrated by numerous examples using SAS, IBM SPSS and R software, while the statistical basics required are set out in an appendix at the end of the book.

The methodological part of the book sets out all the stages of a project, from target setting to the use of models and evaluation of the results. I will indicate the requirements for the success of a project, the expected return on investment in a business setting, and the errors to be avoided.

This survey of new data analysis methods is completed by an introduction to text mining and web mining.

The criteria for choosing a statistical or data mining program and the leading programs available will be mentioned, and I will then introduce and provide a detailed comparison of the three major products, namely the free R software and the two market leaders, SAS and SPSS.

Finally, the book is rounded off with suggestions for further reading and an index.

This is intended to be both a reference book and a practical manual, containing more technical explanations and a greater degree of theoretical underpinning than works oriented towards ‘business intelligence’ or ‘database marketing’, and including more examples and advice on implementation than a volume dealing purely with statistical methods.

The book has been written with the following facts in mind. Pure statisticians may be reluctant to use data mining techniques in a context extending beyond that of conventional statistics because of its methods and philosophy and the nature of its data, which are frequently voluminous and imperfect (see Section A.1.2 in Appendix A). For their part, database specialists and analysts do not always make the best use of the data mining tools available to them, because they are unaware of their principles and operation. This book is aimed at these two groups of readers, approaching technical matters in a sufficiently accessible way to be usable with a minimum of mathematical baggage, while being sufficiently precise and rigorous to enable the user of these methods to master them and exploit them fully, without disregarding the problems encountered in the daily use of statistics. Thus, being based on both theoretical and practical knowledge, this book is aimed at a wide range of readers, including:

- statisticians working in private and public businesses, who will use it as a reference work alongside their statistical or data mining software manuals;
- students and teachers of statistics, econometrics or engineering, who can use it as a source of real applications of their statistical learning;

- analysts and researchers in the relevant departments of companies, who will discover what data mining can do for them and what they can expect from data miners and other statisticians;
- chief executive and IT managers which may use it a source of ideas for productive investment in the analysis of their databases, together with the conditions for success in data mining projects;
- any interested reader, who will be able to look behind the scenes of the computerized world in which we live, and discover how our personal data are used.

It is the aim of this book to be useful to the expert and yet accessible to the newcomer.

My thanks are due, in the first place, to David Hand, who found the time to carefully read my manuscript, give me his precious advice on several points and write a very interesting and kind foreword for the English edition, and to Gilbert Saporta, who has done me the honour of writing the foreword of the original French edition, for his support and the enlightening discussions I have had with him. I sincerely thank Jean-Pierre Nakache for his many kind suggestions and constant encouragement. I also wish to thank Olivier Decourt for his useful comments on statistics in general and SAS in particular. I am grateful to Hervé Abdi for his advice on some points of the manuscript. I must thank Hervé Mignot and Grégoire de Lassence, who reviewed the manuscript and made many useful detailed comments. Thanks are due to Julien Fournel for his kind and always relevant contributions. I have not forgotten my friends in the field of statistics and my students, although there are too many of them to be listed in the space available. Finally, a special thought for my wife and children, for their invaluable patience and support during the writing of this book.

This book includes an accompanying website. Please visit [www.wiley.com/go/decision\\_making](http://www.wiley.com/go/decision_making) for more information.

# Foreword

It is a real pleasure to be invited to write the foreword to the English translation of Stéphane Tufféry's book *Data Mining and Statistics for Decision Making*.

Data mining represents the merger of a number of other disciplines, most notably statistics and machine learning, applied to the problem of squeezing illumination from large databases. Although also widely used in scientific applications – for example bioinformatics, astrophysics, and particle physics – perhaps the major driver behind its development has been the commercial potential. This is simply because commercial organisations have recognised the competitive edge that expertise in this area can give – that is, the business intelligence it provides - enabling such organisation to make better-informed and superior decisions.

Data mining, as a unique discipline, is relatively young, and as with other youngsters, it is developing rapidly. Although originally it was secondary analysis, focusing solely on large databases which had been collated for some other purpose, nowadays we find more such databases being collected with the specific aim of subjecting them to a data mining exercise. Moreover, we also see formal experimental design being used to decide what data to collect (for example, as with supermarket loyalty cards or bank credit card operations, where different customers receive different cards or coupons).

This book presents a comprehensive view of the modern discipline, and how it can be used by businesses and other organizations. It describes the special characteristics of commercial data from a range of application areas, serving to illustrate the extraordinary breadth of potential applications. Of course, different application domains are characterised by data with different properties, and the author's extensive practical experience is evident in his detailed and revealing discussion of a range of data, including transactional data, lifetime data, sociodemographic data, contract data, and other kinds.

As with any area of data analysis, the initial steps of cleaning, transforming, and generally preparing the data for analysis are vital to a successful outcome, and yet many books gloss over this fundamental step. I hate to think how many mistaken conclusions have been drawn simply because analysts ignored the fact that the data had missing values! This book gives details of these necessary first steps, examining incomplete data, aberrant values, extreme values, and other data distortion issues.

In terms of methodology, as well as the more standard and traditional tools, the book comes up to date with extensive discussions of neural networks, support vector machines, bagging and boosting, and other tools.

The discussion of eight common misconceptions in Chapter 13 will be particularly useful to newcomers to the area, especially business users who are uncertain about the legitimacy of their analyses. And I was struck by the observation, also in this chapter, that for a successful business data mining exercise, the whole company has to buy into the exercise. It is not something to be undertaken by geeks in a back room. Neither is it a one-off exercise, which can be undertaken and then forgotten about. Rather it is an ongoing process, requiring commitment from a wide range of people in an organisation. More generally, data mining is

not a magic wand, which can be waved over a miscellaneous and disorganised pile of data, to miraculously extract understanding and insight. It is an advanced technology of painstaking analysis and careful probing, using highly sophisticated software tools. As with any other advanced technology, it needs to be applied with care and skill if meaningful results are to be obtained. This book very nicely illustrates this in its mix of high level coverage of general issues, deep discussions of methodology, and detailed explorations of particular application areas.

An attractive feature of the book is its discussion of some of the most important data mining software tools and its illustrations of these tools in practice. Other data mining books tend to focus either on the technical methodological aspects, or on a more superficial presentation of the results, often in the form of screen shots, from a particular software package. This book nicely intertwines the two levels, in a way which I am sure will be attractive to readers and potential users of the technology.

The detailed case study of scoring methods in Chapter 12 is excellent, as are the other two application areas discussed in some depth – text mining and web mining. Both of these have become very important areas in their own right, and hold out great promise for knowledge discovery.

This book will be an eye-opener to anyone approaching data mining for the first time. It outlines the methods and tools, and also illustrates very nicely how they are applied, to very good effect, in a variety of areas. It shows how data mining is an essential tool for the data based businesses of today. More than that, however, it also shows how data mining is the equivalent of past centuries' voyages of discovery.

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