

Preface

Many approaches have already been proposed for classification and modeling in the literature. These approaches are usually based on mathematical models. Computer systems can easily handle mathematical models even when they are complicated and nonlinear (e.g., neural networks). On the other hand, it is not always easy for human users to intuitively understand mathematical models even when they are simple and linear. This is because human information processing is based mainly on linguistic knowledge while computer systems are designed to handle symbolic and numerical information. A large part of our daily communication is based on words. We learn from various media such as books, newspapers, magazines, TV, and the Internet through words. We also communicate with others through words. While words play a central role in human information processing, linguistic models are not often used in the fields of classification and modeling. If there is no goal other than the maximization of accuracy in classification and modeling, mathematical models may always be preferred to linguistic models. On the other hand, linguistic models may be chosen if emphasis is placed on interpretability.

The main purpose in writing this book is to clearly explain how classification and modeling can be handled in a human understandable manner. In this book, we only use simple linguistic rules such as “*If the 1st input is large and the 2nd input is small then the output is large*” and “*If the 1st attribute is small and the 2nd attribute is medium then the pattern is Class 2*”. These linguistic rules are extracted from numerical data. In this sense, our approaches to classification and modeling can be viewed as linguistic knowledge extraction from numerical data (i.e., linguistic data mining). There are many issues to be discussed in linguistic approaches to classification and modeling. The first issue is how to determine the linguistic terms used in linguistic rules. For example, we have some linguistic terms such as *young*, *middle-aged*, and *old* for describing our ages. In the case of weight, we might use *light*, *middle*, and *heavy*. Two problems are involved in the determination of linguistic terms. One is to choose linguistic terms for each variable, and the other is to define the meaning of each linguistic term. The choice of linguistic terms is related to linguistic discretization (i.e., granulation) of each variable. The definition of the meaning of each linguistic term is performed using fuzzy logic. That is, the meaning of each linguistic term is specified by its membership function. Linguistic rules can be viewed as combinations of linguistic terms for each

variable. The main focus of this book is to find good combinations of linguistic terms for generating linguistic rules. Interpretability as well as accuracy are taken into account when we extract linguistic rules from numerical data. Various aspects are related to the interpretability of linguistic models. In this book, the following aspects are discussed:

- Granulation of each variable (i.e., the number of linguistic terms).
- Overlap between adjacent linguistic terms.
- Length of each linguistic rule (i.e., the number of antecedent conditions).
- Number of linguistic rules.

The first two aspects are related to the determination of linguistic terms. We examine the effect of these aspects on the performance of linguistic models. The other two aspects are related to the complexity of linguistic models. We examine a tradeoff between the accuracy and the complexity of linguistic models. We mainly use genetic algorithms for designing linguistic models. Genetic algorithms are used as machine learning tools as well as optimization tools. We also describe the handling of linguistic rules in neural networks. Linguistic rules and numerical data are simultaneously used as training data in the learning of neural networks. Trained neural networks are used to extract linguistic rules.

While this book includes many state-of-the-art techniques in soft computing such as multi-objective genetic algorithms, genetics-based machine learning, and fuzzified neural networks, undergraduate students in computer science and related fields may be able to understand almost all parts of this book without any particular background knowledge. We make the book as simple as possible by using many examples and figures. We explain fuzzy logic, genetic algorithms, and neural networks in an easily understandable manner when they are used in the book. This book can be used as a textbook in a one-semester course. In this case, the last four chapters can be omitted because they include somewhat advanced topics on fuzzified neural networks. The first ten chapters clearly explain linguistic models for classification and modeling.

I would like to thank Prof. Lakhmi C. Jain for giving me the opportunity to write this book. We would also like to thank Prof. Witold Pedrycz and Prof. Francisco Herrera for their useful comments on the draft version of this book. Special thanks are extended to people who kindly assisted us in publishing this book. For example, Mr. Ronan Nugent worked hard for the copy-editing of this book. Ms. Ulrike Stricker gave us helpful comments on the layout and production. And general comments are given by Mr. Ralf Gerstner, who patiently and kindly contacted us. Some simulation results in this book were checked by my students. It is a pleasure to acknowledge the help of Takashi Yamamoto, Gaku Nakai, Teppei Seguchi, Yohei Shibata, Masayo Udo, Shiori Kaige, and Satoshi Namba.

Sakai, Osaka, March 2003

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Classification and Modeling with Linguistic Information
Granules

Advanced Approaches to Linguistic Data Mining

Ishibuchi, H.; Nakashima, T.; Nii, M.

2005, XII, 308 p., Hardcover

ISBN: 978-3-540-20767-2