Preface

Modern technologies have collected massive datasets from observations, experiments, and scientific simulation. Although progress has been made, it still remains a challenge to effectively and efficiently discover knowledge from such massive datasets. This is mainly because of the following two features. One is that the size and number of attributes (dimensions) of some datasets can be unmanageable. The other is that, due to the dynamic nature of the real world, changes and uncertainties are characteristics of datasets.

> A significant change in scientists' ability to analyze data to obtain a better understanding of natural phenomena will be enabled by (i) new ways to manage massive amounts of data from observations and scientific simulation, (ii) integration of powerful analysis tools directly into the database,
> ...
> Final report of the International Science 2020 Group, Microsoft, 2006

In contrast to classical point methods for arranging and processing data, in this book, we investigate strategies for knowledge processing with interval and soft computing.

Knowledge processing with interval methods has intrinsic merit. First, qualitative properties are often presented as ranges of data attributes rather than specific points. For example, one's blood pressure is normal if within the normal range (i. e. normal interval). By grouping attribute values into meaningful intervals, we can omit insignificant quantitative differences and focus more on qualitatively processing datasets. More importantly, interval-valued attributes contain more information than points and can represent variability and uncertainty. Finally, interval-valued computational results can be more meaningful and useful than point-valued output in a dynamic environment.

Statistical and probabilistic methods have been widely applied in knowledge discovery. However, despite the fact that confidence intervals and fuzzy intervals have been used to deal with uncertainties, they may not always work

well in practice. By integrating interval methods with stochastic models and fuzzy logic, this book provides at least additional, if not more powerful, tools for knowledge processing, especially for handling variability and uncertainty.

Successful applications have been putting interval computing into the mainstream of computing. In 2006, the C++ standard committee evaluated a detailed proposal to include interval computing as a part of the ANSI/ISO C++ standard library. Interval arithmetic has already been in the kernel computations of Intel's Itanium-based architecture. Aside from many other software tools, Sun Microsystems has already included interval arithmetic in its Sun Studio.

More importantly, applying unique properties of interval computing, new algorithms have been developed to solve some otherwise very difficult problems. For example, one can computationally find all roots for nonlinear systems of equations on a given domain with interval Newton/generalized bisection methods and reliably find nonlinear global optima with interval branch-and-bound algorithms computationally. Very recently, Ferguson and Hales proved the 400-year-old Kepler conjecture with interval methods. In 2007, they received the first Robbins Prize from American Mathematical Society for their work.

Knowledge processing with intervals is significantly different from that with points. In this book, we extend previous knowledge processing methods to interval-valued datasets. By embedding interval and soft computing methods into distributed homogeneous and/or heterogeneous database systems that collect and manage massive datasets, scientists may significantly enhance their ability to process massive datasets.

This book can be used as an introduction to interval methods and soft computing for knowledge processing for upper-level undergraduates or first-year graduate students. It can also be a reference for researchers and practitioners.

We intended to make this book self-contained. Chapters 1, 2, and 3 provide necessary background knowledge for readers who are unfamiliar with interval and soft computing. Specifically, Chapter 1 introduces fundamentals of interval computing. In using interval computing for knowledge processing, soft computing technologies are applied. Therefore, Chapter 2 reviews essentials of soft computing. Although interval arithmetic and soft computing were developed independently, both of them can deal with uncertainty. We devote Chapter 3 to presenting their relationships. Readers familiar with these topics may skip the first three chapters.

Innovative algorithms and applications of interval and soft computing in knowledge processing are reported in Chapters 4 to 9. Specifically, Chapter 4 discusses knowledge processing methods related to interval linear algebra. Chapter 5 investigates interval function approximation. Chapter 6 presents an interval decision-making system. Chapter 7 studies interval-valued matrix games. Chapter 8 extends graph algorithms for interval-weighted graphs. Chapter 9 uses intervals in probabilistic studies. In Chapter 10, we present a standards-based object-oriented interval computing environment in C++. The

entire software package is available at `http://www.cs.uca.edu/interval/`. Although these independent chapters cover different topics, there is some overlap. Each chapter is self-contained, but we reference other chapters as appropriate. By collecting our research results into a single volume, we unify and make accessible previously published work.

This book only introduces some initial applications of interval methods in knowledge processing. We sincerely hope to see more fruitful and significant results in both of theory and application in the future.

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