

PREFACE

There has been a spurt of activity during the last decade to integrate various computing paradigms, such as fuzzy set theory, neural networks, genetic algorithms, and rough set theory, for generating more efficient hybrid systems that can be classified as soft computing methodologies. Here the individual tool acts synergistically, not competitively, in enhancing the application domain of the other. The purpose is to develop flexible information-processing systems that can exploit the tolerance for imprecision, uncertainty, approximate reasoning, and partial truth in order to achieve tractability, robustness, low solution cost, and close resemblance to human decision making. The soft computing paradigm provides a foundation for the conception and design of high-MIQ (machine IQ) systems and forms a basis for future-generation computing technology. The computational theory of perceptions (CTP) described by Zadeh, with perceptions being characterized by fuzzy granularity, plays a key role in performing tasks in a soft computing framework. Tremendous efforts are being made along this line to develop theories and algorithms on the one hand, and to demonstrate various applications on the other, considering its constituting tools both individually and in different combinations.

Case-based reasoning (CBR) is one such application area where soft computing methodologies have had a significant impact during the past decade. CBR may be defined as a model of reasoning that incorporates problem solving, understanding, and learning, and integrates all of them with memory processes. These tasks are performed using typical situations, called *cases*, already experienced by a system. A case may be defined as a contextualized piece of knowledge representing an experience that teaches a lesson fundamental to achieving the goals of the system. The system learns as a by-product of its reasoning activity. It becomes more

efficient and more competent as a result of storing the past experience of the system and referring to earlier cases in later reasoning. Unlike a traditional knowledge-based system, a case-based system operates through a process of remembering one or a small set of concrete instances or cases and basing decisions on comparisons between the new and old situations. Systems based on this principle are finding widespread applications in such problems as medical diagnosis and legal interpretation where the knowledge available is incomplete and/or evidence is sparse.

Four prime components of a CBR system are retrieve, reuse, revise, and retain. These involve such basic tasks as clustering and classification of cases, case selection and generation, case indexing and learning, measuring case similarity, case retrieval and inference, reasoning, and rule adaptation and mining. The use of soft computing tools in general, and fuzzy logic and artificial neural networks in performing these tasks in particular, has been well established for more than a decade. The primary roles of these tools are in handling ambiguous, vague, or ill-defined information or concepts, learning and adaptation of intractable cases or classes, searching for optimal parameters, and computing with granules (clumps of similar objects or cases) for speedy computation. CBR systems that integrate these characteristics in various combinations for developing efficient methodologies, algorithms, and knowledge-based networks for various real-life decision-making applications have also been developed.

This book provides a treatise in a unified framework describing how soft computing techniques can be used in building and maintaining case-based systems. The book is structured according to the four major phases of the problem-solving life cycle of a CBR system—representation and indexing of cases, case selection and retrieval, case adaptation, and case-base maintenance—and provides a solid foundation with a balanced mixture of theory, algorithm, and application. Examples are provided wherever necessary to make the concepts more clear. Various real-life applications are presented in a comprehensive manner for the benefit of practitioners.

For the convenience of readers, the basic theories, principles, and definitions of fuzzy sets, artificial neural networks, genetic algorithms, and rough sets are provided in the appendixes. A comprehensive bibliography is provided for each chapter. A sizable portion of the text has been unified from previously published work of the authors.

The book, which is unique in character, will be useful to graduate students and researchers in computer science, electrical engineering, system science, and information technology as both a textbook and a reference book for some parts of the curriculum. Researchers and practitioners in industry and R&D laboratories working in such fields as system design, control, pattern recognition, data mining, vision, and machine intelligence will also be benefited.

The text is organized in six chapters. In Chapter 1 we provide an introduction to CBR system together with its various components and characteristic features and an example of building a CBR system. This is followed by a brief description of the soft computing paradigm, an introduction to soft case-based reasoning, and a list of typical CBR tasks for soft computing applications.

Chapter 2 highlights problems of case representation and indexing. Here we describe, first, traditional methods of case representation: relational, object-oriented, and predicate representation. This is followed by a method of case knowledge representation using fuzzy sets, examples of determining reducts from a decision table using rough sets, and a methodology of prototypical case generation in a rough-fuzzy framework. The significance of granular computing is demonstrated. Some experimental results on case generation are also provided for large data sets. Finally, some case indexing methods using a traditional approach, a Bayesian model, and neural networks are described.

Chapter 3 deals with the tasks of case selection and retrieval. We begin with problems in constructing similarity measures by defining a few well-known similarity measures in terms of distance, followed by the relevance of the concept of fuzzy similarity between cases and some methods of computation. Methods of computing feature weights using classical, neural, and genetic algorithm-based approaches are then discussed. Finally, various methodologies of case selection and retrieval in neural, neuro-fuzzy, and rough-neural frameworks are described. Here both layered network and self-organizing maps are considered for learning in supervised and unsupervised modes, and experimental results demonstrating the features are given.

Issues of case adaptation are handled in Chapter 4. After explaining some conventional strategies—reinstantiation, substitution and transformation—and a few methods based on them, various ways of using fuzzy decision trees, multilayer perceptrons, Bayesian models, and support vector machines for case adaptation are presented. We explain how discrepancy vectors can be used as training examples for determining the amount of adjustment needed to modify a solution. The use of genetic algorithms in this regard is also discussed.

Chapter 5 is concerned with problems of case-base maintenance. We first explain different characteristic properties that need to be assured through qualitative and quantitative maintenance. Then two methods of case-base maintenance using fuzzy-rough and fuzzy integral approaches are described. Tasks such as mining adaptation rules, adjustment through reasoning, selecting cases and updating the case base; and such concepts as case coverage and reachability, fuzzy integrals, and case-base competence are explained in detail through example computations. Some experimental results are also provided, as in earlier chapters.

Finally, some real-life applications of soft case-based reasoning systems are presented in a comprehensive manner in Chapter 6, together with their significance and merits. These include Web access path prediction, oceanographic forecasting, medical diagnosis, legal inference, property valuation, bond rating, color matching, and fashion shoe design.

We take this opportunity to thank John Wiley & Sons for its initiative and encouragement. We owe a vote of thanks to Ms. Yan Li and Mr. Ben Niu of the Department of Computing, Hong Kong Polytechnic University, for their tireless endeavors in providing remarkable assistance while preparing the manuscript, as well as to colleagues at the Machine Intelligence Unit, Indian Statistical Institute, Calcutta, and Professor Tharam S. Dillon, La Trobe University, Melbourne, for

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their cooperation at various stages. Financial support from Hong Kong Polytechnic University, grants HZJ90, GT377, and APD55, and RGC grant BQ496, is also gratefully acknowledged. The project was initiated when Professor Pal was a Visiting Professor at the Hong Kong Polytechnic University, Hong Kong, during 2000–2001. The names of the authors are arranged alphabetically, signifying their equal contribution.

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June 29, 2003