Yuri Avramenko and Andrzej Kraslawski

# Case Based Design

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## Applications in Process Engineering

With 61 Figures and 23 Tables

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# Foreword

The case-based reasoning (CBR) and case-based design (CBD) have been around for some time and established themselves as one of the commonly used mechanisms of approximate reasoning in intelligent systems and decision support systems, in particular. In a nutshell, the CBR mechanisms offer a powerful and general environment in which we generalize on a basis of already accumulated experience being represented in the form of a finite and relatively small collection of cases. Those cases constitute the essence of the existing domain knowledge. When encountering a new situation we invoke and eventually modify the already collected decision scenarios (cases) and arrive at the pertinent decision or a certain design alternative. Interestingly, uncertainty or granularity of resulting decision is inherently associated with the nature of the cases being used in the reasoning process and a way in which partial matching takes place between the historical findings (cases) and a current evidence.

The book by Professors Avramenko and Kraslawski is unique in several important ways. First, it is an impressive and in-depth treatment of the essence of the case-based reasoning strategy and case-based design dwelling upon the algorithmic facet of the paradigm. Second, the authors provided an excellent applied research framework by showing how this development can be effectively utilized in real word complicated environment of process engineering – a pursuit that is rarely reported in the literature in such a comprehensive manner as done in this book. In a highly authoritative and systematic manner, the authors guide the reader through the essential features of the CBR machinery. The book is structured into 10 chapters. The authors start with some useful generalities by setting up a stage and discussing the principles of the design process of products and stressing on the rapidly growing importance of decision support systems in design activities. Case-based reasoning forms the essence of the consecutive chapter which offers the reader an insight into the algorithms of the reasoning scheme. Chapter 4 is a useful compendium on the variety of concepts that are at the heart of the CBR activities, such as similarity measures and adaptation algorithms. The authors did an excellent job here by combining the badly needed formalism with highly motivating explanatory notes present behind the genuine diversity of the ideas being used there. Chapter 5 brings us closer to the specific applications as the authors navigate the readers through the main functionality of the software environment of the CBR. Finally, the last part of the book consisting of Chaps. 6–9 deals with real-world applications such as, e.g. synthesis of wastewater treatment sequence or design of distillation systems.

While the practicality of the investigations offered in the book is the remarkable strength of the volume, the formal aspects, notation and derivations are rigorous, yet clear.

The writing is lucid and explains the fundamental ideas in a direct manner. The suite of real-word examples is a genuine asset of the book. Through such examples, be they chemical or biological processes, we are provided with a comprehensive, well-structured and clear guidance to the overall design process of the CBR systems.

All in all, the book is an interesting and valuable addition to the body of knowledge on fundamentals and practice of automated reasoning – an important and vitally essential step towards building intelligent systems.

Witold Pedrycz
President, IFSA
May 15, 2007

# Preface

The growing amount of knowledge creates new opportunities as well as challenges. Unfortunately, the challenges often start to be the problems. In chemical and process engineering, the most common problems related to the huge amount of available data, information and knowledge are: difficulties with estimation of their quality, lack of efficient methods enabling the fast access to the relevant information or knowledge and "use once" model of knowledge application. The above-mentioned problems are common for all activities in chemical and process engineering: modelling, simulation, design and control. However, design phase is critical from the point of view of the satisfactory functioning of the process unit or the whole system. The wrong assumptions or errors made at this stage could be corrected only with the great amount of time and money but often it is too late for any essential change. The design is difficult as usually there is a lot of uncertainty involved. The good designers used to deal with the problem using their intuition supported by the past experience. The trouble is that industry and society are more and more innovation hungry. There is a growing demand for designs which are less and less similar to their predecessors.

There are two major approaches to deal with this situation, either to make new experiments, develop new models and on this basis build new designs or to use the existing information and knowledge. The second option is much more economically viable and less time demanding than the first one.

The use of the existing information and knowledge is performed in two ways. First method is aimed at getting new information by searching the exiting knowledge repositories. It is so-called knowledge discovery from literature. This approach usually leads to radical innovations. The second method is based on the assumption that the similar problems have the similar solutions. It is a basis of case-based reasoning. It usually leads to incremental innovations.

The objective of this book is to bridge a gap between the huge amount of available knowledge and its very small subset which is not only generated and stored but also actively used. The book is a sort of guide in a store where knowledge is stocked up and we are invited to look for the pieces which could be useful for us in solving new problems. The authors have penetrated only a very small fragment of this huge warehouse – a room in which some elements of knowledge related to chemical and process engineering have been left.

This book is about knowledge re-use by applying of case-based reasoning to the problems typical in chemical product and process design. It is composed of three parts: description of the product and process design and decision support methods related to it, presentation of case-based design principles, issues related to adaptation of the retrieved solutions and case-based reasoning environment and finally examples of application of case-based reasoning to product and process design. The application part covers the broad spectrum of examples dealing with products formulation, synthesis of the system of processing units and mathematical models re-use.

The authors would like to thank many people for the valuable discussions, comments and advice. We are not able to mention all of them but we are particularly grateful to Dr. Tivodar Farkas and Dr. Christan Botar-Jid. We highly appreciate Professor Janusz Kacprzyk for his encouragement and constant support during the preparation of this book.

We hope that this book will contribute to a broader use of case-based design in engineering practice.

Yuri Avramenko
Andrzej Kraslawski
Lappeenranta, May 2007

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