Intelligent Systems in Process Engineering: Paradigms from Design and Operations

Edited by George Stephanopoulos and Chonghun Han, Academic Press, New York, 1996, 625 pp., $69.95.

Are there "intelligent systems" or not? There are, if we understand them as software artifacts with an algorithm to "model and emulate," and thus automate, an engineering task that used to be carried out *informally* by a human.

Intelligent Systems in Process Engineering: Paradigms for Design and Operations uses this working definition and presents the results of ten years of research started at the Laboratory for Intelligent Systems in Process Engineering (LISPE) in the Chemical Engineering Department at MIT.

The book is divided into two sections with five chapters each. The first five chapters are related to process and product design, and the rest focus on process operations. Each chapter is centered around two themes: a process engineering problem and a set of techniques used to solve it. In each chapter one or more of these techniques are drawn from artificial intelligence, and the rest from more traditional areas such as systems and control theory, mathematical programming, and statistics. The following list summarizes techniques and applications covered in each chapter.

1. Modeling languages/descriptions of chemical reactions and processes
2. Automation in design/conceptual synthesis of chemical processes
3. Symbolic and qualitative reasoning/design of reaction pathways
4. Inductive and deductive reasoning/identification of potential hazards
5. Searching spaces of discrete solutions/design of molecules
6. Nonmonotonic reasoning/synthesis of operating procedures.
7. Inductive and analogical learning/improvement of process operations
8. Neural networks/functional estimation
9. Reasoning in time/modeling of temporal process trends
10. Explanation-based learning/improving batch scheduling algorithms.

It is not a textbook or a review but a showcase of several paradigms for some applications of artificial intelligence in process engineering. While it is not an introductory book, it provides the reader with a good overview of the area. It can also be read as an interesting and well written account of how some previously unsolved problems were tackled with the integrated approach, ingenuity and open mindedness of a new breed of chemical engineers and computer scientists. The contributors of the book should be commended for their efforts in demystifying artificial intelligence and intelligent systems and for their attempt to formalize and provide mathematical proof and analysis (in terms of complexity and combinatorics) wherever possible.

Although some of the original work described in the book was carried out at the end of the 80s, most chapters have an updated set of references to related work. Two exceptions are the chapters on Conceptual Synthesis of Chemical Processes and on Identification of Potential Hazards in Chemical Processes, which do not provide updated references to related research elsewhere in the U.S. and Europe.

In the integration of artificial intelligence and numerical techniques, their relative contribution is a continuum. This is clearly reflected in the book structure, which moves from the traditional artificial intelligence, i.e., "soft" (but not easy!) tasks of modeling and design, to the application of artificial intelligence techniques for improved understanding and manipulation of numerical results and procedures. In the former case numerical calculations are auxiliary, such as the one used in evaluating design decisions, while in the latter the numerical calculation is the core task.

Despite the variety of techniques and applications, each chapter exemplifies the following:

- Capture, articulation and utilization of various forms of knowledge (be it numerical or symbolic) within a framework that requires interaction and/or integration of complementary methodologies
- Hierarchical modeling (of molecules, reaction systems, processes and operations) to reduce the complexity of systems; this confirms the observation of H. A. Simon (*The Sciences of the Artificial*, MIT Press, Cambridge, MA, 1969) that hierarchical systems are easier to analyze, describe, understand, and develop than nonhierarchical systems.

As has been mentioned, however, there are many possible combinations of artificial intelligence and traditional techniques. A generic pattern emerges in their interaction, namely, that in most cases artificial intelligence techniques should be applied at the first stages where the problem is less formalized to prune the solution space. Numerical techniques can then be better exploited at the final stages for evaluation and optimization tasks.

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Polymer Science and Technology

By J. R. Fried, Prentice Hall PTR, Englewood Cliffs, NJ, 1995, 509 pp., $70.00.

During the past few years, a number of new textbooks have appeared for introductory courses in polymer science. Most of these are improvements over the first generation of polymer textbooks simply because more recent developments have been included. One of the latest additions to this area is *Polymer Science and Technology* by Joel R. Fried at the University of Cincinnati. Fried's reasons for writing this book are stated clearly in the Preface: "The decision was based on my belief that none of the available texts fully addressed the needs of students of chemical engineering. It is not that chemical engineers are a rare breed, but rather that they have special training in areas of thermodynamics and transport phenomena that is seldom challenged by texts designed primarily for students of chemistry or materials science." As a chemical engineer with research interests that overlap with polymer science, I reviewed this