Handbook of Expert Systems Applications in Manufacturing Structures and rules

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CHAPMAN & HALL

London · Glasgow · New York · Tokyo · Melbourne · Madras

Published by Chapman & Hall, 2–6 Boundary Row, London SE1 8HN

Chapman & Hall, 2–6 Boundary Row, London SE1 8HN, UK

Blackie Academic & Professional, Wester Cleddens Road, Bishopbriggs, Glasgow G64 2NZ, UK

Chapman & Hall Inc., One Penn Plaza, 41st Floor, New York NY 10119, USA

Chapman & Hall Japan, Thomson Publishing Japan, Hirakawacho Nemoto Building, 6F, 1-7-11 Hirakawa-cho, Chiyoda-ku, Tokyo 102, Japan

Chapman & Hall Australia, Thomas Nelson Australia, 102 Dodds Street, South Melbourne, Victoria 3205, Australia

Chapman & Hall India, R. Seshadri, 32 Second Main Road, CIT East, Madras 600 035, India

First edition 1994

Typeset in Times 10/12 by Interprint Limited, Malta
Printed in Great Britain by **Clays Ltd, St. Ives plc, Bungay, Suffolk**

ISBN 0 412 46670 8

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication data available

Handbook of Expert Systems Applications in Manufacturing

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Handbook of Expert Systems Applications in Manufacturing
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Edited by A. Mital and S. Anand

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Preface

Artificial intelligence (AI) is playing an increasingly larger role in production and manufacturing engineering. Much of this growth is the result of special-purpose computer controlled machines that are dominating modern manufacturing operations, such as computer numerically controlled machines and robots, and production activities, such as materials handling and process planning. Since a great deal of production and manufacturing engineering knowledge can be put in the form of rules, expert systems have emerged as a promising practical tool of AI in solving manufacturing and production engineering problems. The expert systems allow knowledge to be used for constructing human–machine systems that have specialized methods and techniques for solving problems in a particular application area.

Over the years, many expert systems have been developed for applications in manufacturing and production engineering. Most of these expert systems, however, have been of little use to practitioners at large. The primary reason for this limited utility is that in most cases the developers do not divulge the knowledge base and inference mechanism that form the backbone of an expert system. Without the knowledge base, users can only derive a very limited benefit from an expert system and, for all practical purposes, a technical publication describing the expert system for the reader merely becomes a publicity brochure. The reader must either develop his own knowledge base or purchase the system from the developer, often at a substantial cost.

Our and our colleagues' frustration with such publications provided us the impetus for undertaking the development of this book, which is aimed at both researchers and practitioners, and provides a collection of expert systems in manufacturing and production engineering along with their knowledge base and rules. We believe that inclusion of the knowledge base and associated rules is essential if practitioners are to derive full benefit from these expert systems. This unique book is the result of our belief and the efforts of our distinguished colleagues who subscribe to this philosophy. We are confident that the expert systems included in this volume will be well received and readers will appreciate the efforts of all those who so generously agreed to contribute to this effort.

A total of 15 different expert systems are included in this book. These expert systems are preceded by an introductory chapter written by Kuo,

Mital and Anand. The expert system rules are included on a floppy disk in ASCII and can be easily accessed. These rules and the description of the expert system's structure should assist the users in customizing these systems.

In the introductory chapter, Kuo *et al.* provide a brief overview of expert systems basics, outline the advantages and limitations of expert systems, describe the basic expert systems development process, and review the various expert systems in production and manufacturing engineering.

The first expert system included in the book, developed by van Vliet, presents optimization rules for two flexible manufacturing system design problems: the machine allocation problem and the traffic allocation problem. This system should be particularly useful to automobile and electronics manufacturers in designing logistically sound manufacturing systems. In the following expert system, Marefat and Banerjee provide a reusable framework to generate solutions to manufacturing problems such as those encountered in laying out a facility and integrating process planning in designing manufacturing systems. The framework consists of hierarchical knowledge representation, preliminary design, iterative modification, four distinct information flow and reasoning paths, and solution validation.

Ohsuga and Guan provide a general purpose knowledge-based system that can be applied to a variety of design problems including mechanical design, chemical compound design and feedback control system design. The authors first describe the outline of their knowledge-based system and then demonstrate its application by designing a feedback control system. Solution to multi-model line balancing is provided by Suer and Dagli through their knowledge-based expert system. This expert system assigns different models to a varying number of lines with a varying number of workstations over a period of time such that the total number of resources, manpower and robots are not exceeded.

The knowledge regarding the production supervisor's informational needs and decision-making processes is modeled in the expert system developed by Moynihan. The system utilizes data commonly found in external manufacturing systems and files. Wang, Rao and Zhou provide an expert system that assists in the development of conceptual product designs. It's focus is on minimizing energy consumption, increasing raw material utilization and profits, and reducing environmental effects of effluents. The expert system also ensures flexibility, operability, controllability and safety of the manufacturing process. The expert system developed by Syan, on the other hand, assists in the selection of surface treatments and coatings at the product design stage.

The knowledge-based system developed by You, Chu and Kashyap assists in evaluating three-dimensional casting designs for manufacturability by incorporating rules on tolerancing, rounding, shrinkage, junction rules, wall thickness, parting line and solidification. The next system, developed by Rubinovitz and Karni, provides a qualitative approach to selecting materials handling and transfer equipment. It also serves as a design tool.

The next two expert systems primarily deal with scheduling. The knowledge-based system developed by De and Lee generates detailed production schedules for a flexible manufacturing system, and considers both assembly and non-assembly jobs. Chen and Thesen's expert system, on the other hand, assists in determining when a specific scheduling rule should be used. The goal of this system is to increase the production capacity.

The expert system developed by Liu, Emerson and Srihari is a multi-attribute expert system which utilizes fuzzy reasoning in selecting a pick-and-place machine for a surface mount technology printed circuit board assembly line. The goal is to enhance productivity and profitability of the manufacturing facility. Bidanda, Cohen and Tunasar's expert system is also an equipment selection system. The application, however, is limited to workholding devices for rotational parts.

The expert system developed by Berry and Kumara is intended to assist users in developing improved techniques for robot task planning. It combines machine learning with robotic planning systems to improve decision and reactive processes. Finally, Smith and Dagli provide an expert system for selecting appropriate quality control charts for a variety of manufacturing processes. The system can also assist users in interpreting results (trends) and selecting acceptance sampling plans.

Overall, the expert systems included in this volume cover a fairly wide variety of manufacturing and production engineering topics. We realize that the coverage leaves out many important areas but we hope our readers will appreciate the difficulty in compiling such a volume. Perhaps this book will act as a catalyst, inspiring further volumes at some point in the future.

Any book of this magnitude requires input from a number of individuals. In this case, these are individuals who contributed to this volume and those who assisted us in the review process. To all these people, our sincere thanks. We would also like to thank Mark Hammond, our editor at Chapman & Hall, for his constant encouragement and assistance.

Anil Mital
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CHAPTER 1

An introduction to expert systems in production and manufacturing engineering: the structure, development process and applications

Tsuang Kuo, Anil Mital and Sam Anand

1.1 INTRODUCTION

Due to the global competition, manufacturing is facing several challenges: short product life cycle, frequent design changes and small in-process inventory. The performance of a manufacturing system is affected by numerous needs, such as material requirement planning (MRP), capacity planning, facility and material handling device planning, inventory control, tool management, scheduling, quality control, and manufacturing information system management (Chang *et al.*, 1991). These necessities have led to the implementation of computer technologies, such as automated test facilities; MRP; computer-aided design (CAD); computer-aided manufacturing (CAM); computer-aided process planning (CAPP); computer-aided quality control (CAQ); digital computers simulation; and data collection, storage and analysis. While these operations and primarily digital manipulations that take advantage of speedy data storage, retrieval and computational capabilities of computers, other kinds of expertise, such as knowledge that is based on past experience and cannot easily be cast into mathematical formulae for conventional algorithmic programs, have yet to be fully exploited (Grimson and Patil, 1987). Expert systems, a technology falling into this last category, improve the quality of information provided to the responsible experts and users for operating modern automated and integrated systems, and assist them in reliable operation of their systems (Christie, 1990; Braun, 1990).