Artificial Intelligence Expert Systems Computer Vision and Natural Language Processing

by

William B. Gevarter

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np NOYES PUBLICATIONS
Park Ridge, New Jersey, USA

Library of Congress Catalog Card Number: 84-6014
ISBN 0-8155-0994-4
Printed in the United States

Published in the United States of America by
Noyes Publications
Mill Road, Park Ridge, New Jersey 07656

10 9 8 7 6 5 4 3 2

Library of Congress Cataloging in Publication Data

Gevarter, William B.
Artificial intelligence, expert systems, computer vision, and natural language processing.

Includes bibliographies and index.
1. Artificial intelligence. I. Title.
Q335.G48 1984 001.53'5 84-6014
ISBN 0-8155-0994-4

Foreword

An overview of artificial intelligence (AI), its core ingredients, and its applications is presented in this volume. AI is a field with over a quarter century of history; however, it wasn't until the 1980s that AI received economic and popular acclaim and went through the transition from a primary research area to potential commercial applications. The full impact of AI's transition has yet to be felt. Recently, AI was made the basic thrust of Japan's Fifth Generation computer research effort. Success in this venture could project the Japanese into a dominant position in information sciences in the 1990s. Similar importance has been placed on AI by the U.S., Great Britain, and France.

The real payoff for AI will be in applications. Intelligent computer programs are now emerging from the laboratory into practical applications. This book presents overviews of key application areas—expert systems, computer vision, natural language processing, speech interfaces, and problem solving and planning. Basic approaches to these systems, the state of the art, existing systems, participants, and future trends are detailed. The book should be useful to engineering and research managers, potential users and others seeking a basic understanding of the rapidly evolving area of artificial intelligence and its applications.

The information in the book is from:

> *An Overview of Artificial Intelligence and Robotics. Volume I—Artificial Intelligence, Part A—The Core Ingredients,* by William B. Gevarter, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration, June 1983.
>
> *An Overview of Artificial Intelligence and Robotics. Volume I—Artificial Intelligence, Part B—Applications,* by William B. Gevarter, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration, October 1983.

An Overview of Artificial Intelligence and Robotics. Volume I–Artificial Intelligence, Part C–Basic AI Topics, by William B. Gevarter, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration, October 1983.

The table of contents is organized in such a way as to serve as a subject index and provides easy access to the information contained in the book.

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NOTICE

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PART A

ARTIFICIAL INTELLIGENCE— THE CORE INGREDIENTS

The information in Part A is from *An Overview of Artificial Intelligence and Robotics. Volume I—Artificial Intelligence, Part A—The Core Ingredients,* by William B. Gevarter, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration, June 1983.

ACKNOWLEDGMENTS

I wish to thank the many people and organizations who have contributed to this report, both in providing information, and in reviewing the report and suggesting corrections, modifications and additions. I particularly would like to thank Jerry Cronin of U.S. Army Signal Warfare Lab., Ted Hopp and Len Haynes of NBS, Bob Hong and his associates at Grumman Aerospace Corp., Karen Hagedorn of Symbolics, Mache Creeger of LISP Machine, Inc., Fred Blair of IBM T.J. Watson Research Center, Jude Franklin of the U.S. Navy Center for Applied Research in AI, and David H. Brown of SRI International for their review of this report and their many helpful suggestions. However, the responsibility of any remaining errors or inaccuracies must remain with the author.

I. ARTIFICIAL INTELLIGENCE—WHAT IT IS

Definition

Artificial Intelligence* (AI) is an emerging technology that has recently attracted considerable publicity. Many applications are now under development. One simple view of AI is that it is concerned with devising computer programs to make computers smarter. Thus, research in AI is focused on developing computational approaches to intelligent behavior. This research has two goals: 1) making machines more useful and 2) understanding intelligence. This report is primarily concerned with the first goal.

The computer programs with which AI is concerned are primarily symbolic processes involving complexity, uncertainty, and ambiguity. These processes are usually those for which algorithmic solutions do not exist and search is required. Thus, AI deals with the types of problem solving and decision making that humans continually face in dealing with the world.

This form of problem solving differs markedly from scientific and engineering calculations that are primarily numeric in nature and for which solutions are known that produce satisfactory answers. In contrast, AI programs deal with words and concepts and often do not guarantee a correct solution—some wrong answers being tolerable as in human problem solving.

Table I-1 provides a comparison between AI and conventional computer programs. A key characteristic of AI programs is "heuristic search." Baraiko (1982, p. 448) quotes Minsky as saying "If you can't tell a computer how best to do something, program it to try many approaches." However, in complex problems the number of possible solution paths can be enormous. Thus, AI problem solving is usually guided by empirical rules—rules of thumb—referred to as "heuristics"—which help constrain the search.

TABLE I-1. Comparison of AI with Conventional Programming.

Artificial Intelligence	Conventional Computer Programming
• Primarily symbolic processes	• Often primarily numeric
• Heuristic search (solution steps implicit)	• Algorithmic (solution steps explicit)
• Control structure usually separate from domain knowledge	• Information and control integrated together
• Usually easy to modify, update and enlarge	• Difficult to modify
• Some incorrect answers often tolerable	• Correct answers required
• Satisfactory answers usually acceptable	• Best possible solution usually sought

*Also sometimes referred to as machine intelligence or heuristic programming. The relationship of AI to automation is discussed in Chapter I of Part C of this report.

Another aspect of AI programs is the extensive use of "domain knowledge." Intelligence is heavily dependent on knowledge. This knowledge must be available for use when needed during the search. It is common in AI programs to separate this knowledge from the mechanism that controls the search. In this way, changes in knowledge only require changes in the knowledge base. In contrast, domain knowledge and control in conventional computer programs are integrated together. As a result, conventional computer programs are difficult to modify, as the implications of the changes made in one part of the program must be carefully examined for the impacts and the changes required in other parts of the program.

The Basic Elements of AI

Nilsson (1982, see also Brown, 1981), a pioneer in AI and currently head of the SRI AI Center, likes to characterize the components of AI in terms of what he calls the onion model (see Figure 1). The inner ring depicts the basic elements from which the applications shown in the next ring are composed. We will first consider the quadrant designated as heuristic search.

Heuristic Search

Much of the early work in AI was focused on deriving programs that would search for solutions to problems. Note that every time one makes a decision, the situation is changed opening up new opportunities for further decisions. Therefore there are always branch points. Thus, one of the usual ways of representing problem solving in AI is in terms of a tree (see, e.g., Figure 1, Chapter III), starting at the top with an initial condition and branching every time a decision is made. As one continues down the tree many different decision possibilities open up, so that the number of branches at the bottom can get to be enormous for problems requiring many solution steps. Therefore, some way is needed to efficiently search the trees.

Initially, there were "blind" methods for searching trees. These were orderly search approaches that assured that the same solution path would not be tried more than once. However for problems more complex than games and puzzles, these approaches were inadequate. Therefore, rules of thumb (empirical rules), referred to as "heuristics," were needed to aid in choosing the most likely branches, so as to narrow the search. As an example, a simple heuristic to help choose which roads to follow when driving in the evening on back roads from Washington, DC to San Francisco is: "head for the setting sun." This may not produce the most optimum path, but can serve to help advance one toward one's goal. Heuristic rules like this can help guide search—reducing search enormously.

Knowledge Representation

Early on, AI researchers discovered that intelligent behavior is not so much due to the methods of reasoning, as it is dependent on the knowledge one has to reason with. (As humans go through life they build up tremendous reservoirs of knowledge.) Thus, when substantial knowledge has to be brought to bear on a problem, methods are needed to efficiently model this knowledge so that it is readily accessible. The result of this emphasis on knowledge is that knowledge representation is one of the most active areas of research in AI today. The needed knowledge is not easy to represent, nor is the best representation obvious for a given task.