Algorithmic Methods for Artificial Intelligence

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Preface

This book introduces artificial intelligence to non-specialists. It is concerned with programming methods and algorithms. The aim is practical, even though abstraction is necessary. To avoid presenting the theory in depth, techniques are usually presented through examples.

The algorithmic part of the book is preceded by two independent chapters. The first, Chapter 1, recalls the origin and scope of artificial intelligence. The second, Chapter 2, resumes techniques in programming and data structures which, while presenting no particular difficulty, are often unknown to self-taught programmers.

Chapters 2 and 3 are comparatively simple. They will probably not be included in a book of this type in a few years' time, since it is reasonable to suppose that with the stabilization of curricula, this subject matter will be included in all standard university courses. The chapters which follow are more mathematical. The whole text can be considered as an apprenticeship which will allow the reader to study more advanced topics presented elsewhere.

This is the second version of the book, the limited original edition was published in French. During the process, we were helped by several colleagues, to whom thanks are due. Françoise Nayroles and Louis Bourelly helped at different points. Inspiration also came from working with a group led by Michel Maury at the University of Montpellier, and in particular from the theses of Anne-Marie Massotte and Henri Betaille.

The French magazine *Jeux et Stratégie* kindly allowed the use of published problems, for which the full references are given in the References.

A job such as this needs material support, given in the first place by our laboratory, the Groupe de Représentation et Traitement de Connaissances (GRTC) of the CNRS at Marseille. The text was prepared on computing equipment supplied by the Centre Mondial Informatique et Ressource Humaine and by the Institut International de Robotique et d'Intelligence Artificielle de Marseille (IIRIAM).

Michael Griffiths
November 1986

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CHAPTER 1

History and scope of artificial intelligence

Introduction

Artificial intelligence has been studied for over thirty years, first as intellectual speculation, then as an oversold set of over-ambitious projects, and finally as a respectable academic science. It has now become a subject with wide application in different fields, which is one reason for this book. We aim to make the techniques of a difficult subject available to computer users. As with all new developments which might have an impact on human life style, artificial intelligence has been the subject of controversy. It is not our aim to comment on different people's opinions, but rather to study the programming methods which are involved in its use. We believe firmly that it is up to the potential users of the technology to decide how they use it, the duty of the scientist being to explain the facts as he understands them best.

It is perhaps useful to look at the reasons behind this perturbed genesis of a discipline which is surely going to be useful in fields as far apart as computer aided design, medicine and law. The most important factor is the bringing together of the computer and the human brain. This has provoked tremendous reaction from psychologists, teachers and doctors, without mentioning the doubts of ordinary citizens. It was thought originally that computer scientists were trying to make a complete model (perhaps improved) of the human brain. This is far from true. The computer scientist tries, often with the help of an expert from a particular application field, to make a program which, given a certain number of problems, would take the same decisions as a competent human being. The decision algorithm depends on analysing the application, without necessarily following the decision process of the human brain.

In different directions, computer scientists have attacked very difficult problems, while suggesting that remarkable developments were imminent. Consider two examples from 1960. At that time, Botwinnik, the then world chess champion, who is also an electronic engineer working on computers, foresaw that a program could become the world champion ten years later. When we consider these untrue predictions made by an expert, it is easy to imagine those of less competent reviewers. In the same year were published reports on automatic translation which predicted the disappearance of human translators and interpreters in a short space of time. Such audacity raised a rapid reaction, since the aims announced not having been achieved, annual funding in the field was severely reduced. Note that, in both cases, feelings are now calm, programs exist, and they are interesting and useful, even if not perfect. The science can now proceed normally, and we may hope that the twenty-first century will see the results predicted for 1970.

To the sources of these problems should be added the corporate image of threats from the computer to reduce employment in different fields, together with the reactions of the general public, who fear a future of the type foreseen by George Orwell in *1984* (Orwell 1949).

Since feelings have calmed down, artificial intelligence can now be considered as a branch of computing like any other, which allows us to categorize some traditional application fields. Like many such classifications, the one that follows is incomplete, but will give some idea of the scope of the subject:

1) combinatorial problems, often through games, and in particular chess;
2) theorem proving and its applications;
3) automatic translation and the treatment of natural languages;
4) pattern recognition (image, speech or signals);
5) expert systems and knowledge representation, that is modelling the logic of different application fields;
6) learning and modelling cognitive processes, etc.

Note that, in each application field, computer scientists collaborate with specialists from other disciplines such as linguists, psychologists or experts in fields which are

modelled. We describe the history of each category before examining the underlying programming techniques. Using these new tools is not just an act of faith, but is based on real experience in laboratories and in certain industries.

Application fields

The idea of using a computer for applications which now bear the label of artificial intelligence dates from the first published articles on computing, at the end of the Second World War, by some of the first well known names (eg Turing 1950). Scientific thinking of this type completed the vision of science fiction writers who considered social problems (Orwell 1949, Huxley 1932, Asimov 1950).

CHESS AND OTHER GAMES

General game theory together with the computing techniques behind its implementation have received much attention from research workers. A particularly important effort has gone into the game of chess, for which there exists a large number of programs.

It was one of the biggest names of his generation who wrote the first article (Shannon 1950) in which can be found the basis of current theory. A running program based on his ideas was produced by Alex Bernstein on an IBM 704 in 1958. This work has been preceded by articles written in Germany, under difficult conditions, at the end of the war (Zuse 1945), but these were only discovered twenty years later. Since these pioneering articles, there have already appeared over 300 English language articles (Marsland 1979), without mention of those written in other languages (Meissenberg 1968).

During the 1950s and early 1960s, the first programs, experimental and general, imposed evaluation principles which worked on trees as their principal data structure. We see later some tree manipulation techniques, together with strategies such as the alpha-beta algorithm or minimax. The level of play of these programs was average, and it would not have been possible to enter them in competitions. Even those programs which played relatively well were easily beaten by a human player with good strategical judgement.

Once the general evaluation method is established, it becomes necessary to improve programs by including specific knowledge, just like a player who studies, for example, end

game strategy with king and pawns against king. End game analysis by computer has been used in international competitions by Russian grandmasters during adjournments, which reflects the quality of certain programs. At this level of chess, computers have not been shown to be useful in openings, nor in middle game play.

The progress of general programs is such that there came into being, in the 1970s, national chess tournaments for computers (Newborn 1972, Souls and Marsland 1975, Richter 1976), and even world championships (Mittman 1974), of which the first was won by Kaissa, a Russian program. The references are to the first championship in each case. Such championships are now producing interesting games, and programs are often accepted in tournaments together with, and under the same rules as, human competitors, with acceptable results.

The best illustration of the current quality of chess playing programs is perhaps the availability on the market, over the past few years, of programs running on microcomputers which are useful for chess players in providing them with a suitable opponent who is always available. A computer has not yet won the world championship, but programs already play better than most human players below national level. Starting from the current situation, game analysis and knowledge implementation are sufficiently difficult to make progress relatively slow, and estimations of the date at which a program will be world champion get further away every year. For state of the art programs read Clarke (1977, 1980).

While research into chess has dominated, other games should not be forgotten. Samuels (1959) is a fundamental article which considered checkers, the American form of draughts. Another important step was the resolution, by learning, of the game of GO-MOKU, a Japanese form of noughts and crosses (TIC-TAC-TOE) which needs five pieces in a row on a 19*19 board (Elcock and Murray 1967). As far as the author knows, this was the first program which played better than human beings in a serious game. Another achievement was the win by a program (The Moor), on June 19th, 1980, at REVERSI/OTHELLO, against the world champion Hiroshi Inoue. The same accident happened to the world backgammon champion at around the same time.

The state of the art programming of a set of games, with