Searching in a Maze, in Search of Knowledge: Issues in Early Artificial Intelligence

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“He possesses two of the three qualities for the ideal detective. He has the power of observation and that of deduction. He is wanting only in knowledge…”
Sherlock Holmes, in speaking of Franfois de Villard, the French detective

Abstract. Heuristic programming was the first area in which AI methods were tested. The favourite case-studies were fairly simple toy-problems, such as cryptarithmetic, games, such as checker or chess, and formal problems, such as logic or geometry theorem-proving. These problems are well-defined, roughly speaking, at least in comparison to real-life problems, and as such have played the role of Drosophila in early AI. In this chapter I will investigate the origins of heuristic programming and the shift to more knowledge-based and real-life problem solving.

1 Introduction

AI has been around for 50 years now: 1956 was the year when the Dartmouth meeting officially signalled the birth of AI. An anniversary like this is a fitting occasion to take stock of the events of a half-century worth of research. We can do so in at least two different ways: (i) we could map out possible future scenarios on how AI will evolve, by a look at today’s most promising research programs (and those less promising) – an evaluation that not all would agree with; or (ii) we could revisit certain topics and theoretical issues, certain experimental research and methodological controversies that were raised and developed in the era of the Dartmouth pioneers, to think about how the evolution of AI has led us to the point where it stands today.

In this chapter, I have chosen the second option. I aim to discuss some topics, results and controversies which have characterised AI research in the fifteen or so years following Dartmouth (1956-72 ca.). This was, indeed, a lively time in AI – it was then that a large part of its scientific vocabulary came into existence. As we shall see, some topics appear to have been given a systematic form during this time, while others were put aside, to be brought to the fore again later, in more mature contexts.

The topics I shall consider here include heuristic search and heuristic programming (sections 2 and 3), problem representation (section 4), and the early approaches to knowledge representation, regarding both the nature of the problems
faced and the different methods employed: toy problems and real-life problems (section 5), and well-structured and ill-structured problems, weak and strong methods (section 6). A conclusion follows in section 7, including a brief look at the most recent developments in some of these areas. My aim is to suggest, through these developments, how AI has not evolved along a linear path, nor can its evolution be described through a succession of “paradigms”. All this may prove to be instructive when considering the first alternative (i) mentioned above.

2 From a “Mythical Being” to the Actual Decision Maker

Claude Shannon had already started to think about a computer chess program around the mid-1940s. His sketch of the program was based on the idea that the best move could be evaluated using a look-ahead analysis of alternative moves based on the minimax procedure (see [50]). This procedure had been the basis of an earlier chess program hand-simulated by Alan Turing (Hodges [21] 213-214). The origins of the minimax procedure lie in the early formulations of mathematical game theory. The chess player was established as a common metaphor in the analysis of decision making, with its classic formulation in Theory of Games and Economic Behavior, published by von Neumann in 1944 together with the economist Oskar Morgenstern. In their terminology, chess is a zero-sum game. In theory, this means imagining a perfectly rational player who applies the minimax procedure to every possible move, assigning a value of +1 for a victory, 0 for a stalemate and −1 for a loss. In practice, this optimal strategy encounters an insurmountable difficulty owing to the combinatorial explosion of possible moves, which Shannon calculated to be to the order of $10^{120}$.

The best comment on this situation came from von Neumann and Morgenstern themselves:

This relative, human difficulty necessitates the use of those incomplete, heuristic methods of playing, which constitute “good” chess, and without this human difficulty there would be no element of “struggle” and “surprise” in this game (von Neumann and Morgenstern, [35] 125).

This is the difficulty that Norbert Wiener seems to have had in mind when in the first edition of Cybernetics in 1948, he suggested building a machine which, without playing “an optimum game in the sense of von Neumann”, would in any case be able “to [...] offer interesting opposition to a player at some of the many levels at which human chess players find themselves” (see [62] pp. 164-65).

Thus, when Shannon took on the problem of programming a procedure based on the minimax algorithm, he could not avoid the problem of how “to develop a tolerably good strategy for selecting the move to be made” (see [50], p. 260). He suggested the program should have in-built selectivity criteria taken from the Dutch psychologist Adrian de Groot’s investigations into the choice processes of chess masters who made their analyses by “thinking-aloud” during the game.

In those years it was the choice-making processes themselves which came under the scrutiny of one pioneer of organisation theory and Operations Research