XX. ARTIFICIAL INTELLIGENCE*

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RESEARCH OBJECTIVES

The purpose of our work is to find ways of making machines solve problems that are usually considered to require intelligence. Our procedure is usually to attack the problem by programming a computer to deal directly with the necessary abstraction, rather than by simulating hypothetical physiological structures. Nevertheless, it is our conviction that such investigations provide important insights into the kinds of mechanisms that are involved in complex perceptual cognitive activities.

When a method for solving a problem is not known, it is necessary to search over spaces of potential solutions of the problem, or of parts of the problem. Such spaces are usually too enormous for systematic, exhaustive exploration, and it is necessary to devise heuristic methods.

Current research in our group is aimed in several directions, each concerned with some aspects of the problem of organizing cognitive processes in computers.

(a) Pattern Recognition: Study of processes to recognize visual objects by hypothesis generation and subsequent selective attention to relevant parts of the visual field. Study of systems using stereopsis and pattern recognition, to construct symbolic three-dimensional representations of the visual environment within computer memory. We are constructing an apparatus for real-time computer tracking of human-eye movements. The present technique is basically similar to the apparatus of Mackworth; the important difference is that the visual stimulus will be generated and controlled by a computer display system, which will give us close control of the visual environment.

(b) Visual-Motor Coordination: We are constructing a system combining a computer-controlled arm and hand with a real-time television input to the computer, and plan to work out systems that coordinate visual-motor activity, e.g., pursuit or collection of objects of specified type. This will involve constructing an appropriate "body-image" computer model.

(c) Heuristic Problem-Solving Strategies: Study of tree search and goal-priority assignment strategies in game situations and in symbolic mathematical proof situations. In particular, theses in progress include geometry, chess, and group theory.

(d) Design of Computer Languages to Facilitate Heuristic Program: Our group has completed the development of the powerful symbol-manipulation language, LISP, and has adapted it to work within the M. I. T. time-sharing system. A new language, LISP 2, is now being developed jointly with several other groups.

(e) Semantic Analysis: Study of programs to manipulate the meanings of statements written in natural language. Question-answering programs using linguistic analysis combined with logical deduction methods are to be developed in this area.

The major accomplishments of our group can be summarized by referring to several publications.

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1. Pattern-Recognition

We proposed the use of structural analysis for visual picture-processing.[1] Canaday describes a system to analyze overlapping geometric figures.[2] Evans presents a very advanced system that recognizes abstract structural analogies between drawn figures.[3] Teitelman's thesis[4] is a system for learning to recognize hand-drawn characters, using the association-tree concept of Feigenbaum.[5]

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2. R. Canaday, Recognition of Overlapping Line Drawings, S. M. and E. E. Thesis, Department of Electrical Engineering, M. I. T., 1962.

3. T. Evans, A Heuristic Program for Solving Geometric Analogy Problems, Ph. D. Thesis, Department of Electrical Engineering, M. I. T., 1963.

4. W. Teitelman, Real-Time Recognition of Hand-Drawn Characters, S. M. Thesis, Department of Mathematics, M. I. T., 1963.

5. E. Feigenbaum, The Simulation of Verbal Learning Behavior, Proc. Western Joint Computer Conference, (WJCC), 1961.

2. Visual-Motor Coordination

Work was done in this area several years ago,[1] and we are just now resuming the project. Ernst's mechanical hand was able to find objects and boxes, and then to put the objects in the boxes, or assemble them into a tower, and so forth. It used only tactile and proximity detectors associated with the hand. We plan now to extend this to the use of real stereoscopic visual pattern recognition.

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3. Heuristic Problem Solving

Several papers discuss a number of aspects of this area.[1-6] The doctoral theses of Slagle and Abrahams are computer systems concerned with heuristic theorem-proving methods.[7,8] The doctoral thesis of Blum[9] is not properly in this area, but is a relevant theoretical study of the notion and relative complexity of computational algorithms.

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4. M. Minsky, Problems of Formulation for Artificial Intelligence, Proc. Symposia in Applied Mathematics (American Mathematical Society Symposia, Vol. 14, 1962), pp. 35-46.

5. M. Minsky, Progress in Artificial Intelligence, Discovery, pp. 33-37, October 1962.

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7. J. Slagle, A Computer Program for Solving Problems in Freshman Calculus (SAINT), Ph. D. Thesis, Department of Mathematics, M. I. T., 1961.

8. P. Abrahams, A Computer Program for Checking Mathematical Proofs, Ph. D. Thesis, Department of Mathematics, M. I. T., 1963.

9. M. Blum, Machine-Independent Theory of Difficulty of Computation, Ph. D. Thesis, Department of Mathematics, M. I. T., 1964.

4. Computer Languages

The LISP symbolic programming language system was designed by J. McCarthy, and some of its theoretical background is discussed in two papers.[1,2] A manual for the completed LISP 1.5 system has been published.[3] Work on a more comprehensive language, combining the advantages of ALGOL, LISP and COMIT, is proceeding now under support of M. I. T.'s Project MAC.

References

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2. J. McCarthy, A Basis for a Mathematical Theory of Computation, Proc. Western Joint Computer Conference, 1960.

3. LISP 1.5 Programmer's Manual, Computation Center and Research Laboratory of Electronics, M. I. T., August 17, 1962 (reprinted by The M. I. T. Press, Cambridge, Mass., 1963).

5. Semantic Analysis

The artificial intelligence group has concentrated on developing systems that do reasoning on the basis of factual statements. The problem is partly one of finding appropriate logical systems, and partly one of building a "model" of the situation under discussion. Three recent Ph. D. theses cover a spectrum: Bobrow[1] deals with natural language in regard to somewhat restricted (algebraic and numerical) context; Raphael[2] deals with more restricted language but with a semantic context in which several kinds of relations are mixed; and Black's[3] is a highly formal, but rather general, deductive system realizing many of the goals set by McCarthy.[4]

References

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4. J. McCarthy, Programs with Common Sense, Proc. Symposium on Mechanization of Thought Processes, National Physical Laboratory, Teddington, England, November 24-27, 1958 (published by H. M. Stationery Office, London, 1959).

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