RECOGNIZING THE INTELLIGENT COMPUTER

by
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One of the aspects of computer science which is of greatest interest to the philosopher is the field of artifical intelligence. Although a considerable amount of work has been done on the problem of producing an intelligent computer, there has been only one notable attempt at providing a criterion by which this work could be measured. With the exception of Turing's Test, the computer scientist busily pursues the goal of computer intelligence without considering how he would recognize an intelligent computer once it was constructed. Likewise, he fails to clearly define 'intelligence.' The rectifying of these oversights would seem a valid activity for the philosophy of science.

Of course, when the computer scientist attempts to build an intelligent computer, he is implicitly dividing what the philosopher calls mind into two functions. The computer scientist is not attempting to build a conscious or sentient machine. There is after all, as Gunderson[1] points out, no definition for a task called 'consciousness.' Rather the computer scientist is interested in building a computer which could perform those processes which involve some activity or task generally considered to be within the mind but which are still subject to objective criteria. Thus, with reference to the machine, the computer scientist is implicitly a logical behaviorist, and for the purposes of this paper, we will follow his/her lead.

It is clear that in attempting to develop computer intelligence, the computer scientist has inadvertently wandered into difficulties arising from the other mind problem. Thus, it is hardly suprising that the various approaches to computer intelligence parallel some of the proposed solutions to the problem of other minds. There is one notable exception. For obvious reasons, all those solutions to the other mind problem which depend on structural similarity between the subject and the observer are excluded. Although there have been a few special applications of physical analogies between the human nervous system and computer design, such as uses in computer vision, as an approach to an intelligent computer the building of "brains" has proved impractical.[2]

Thus, the approaches to computer intelligence which have been most successful are those based on analogies between the behavior of subject and observer. For convenience, we will divide these behavioral approaches into three catagories, from the type of behavior being imitated.

The first we will call the Descartes Criterion, after the philosopher most often associated with this definition of intelligence. As H. H. Price[3] points out, one of the strongest reasons we have for assuming that other entities have minds is their capacity for usable speech. In his opinion this trait can even outweigh a difference in physical structure. Thus a computer capable of speech would seem a likely candidate for intelligence.

This criterion is the one implicitly contained in the Turing Test.[4] In this test, a computer is considered to be intelligent if an observer is unable to predict at a better than chance level whether he is communicating with a human being or a computer without actually seeing either. This is, of course, simply an operational definition of the "usable speech" which Descartes considers to be an essential mark of intelligence in his *Discourse on Method.*[5] Of course, Descartes, in proposing this criterion, certainly never considered that a machine might be able to meet it.

Present work on the computer use of language has advanced to the point where this criterion may be considered, at least in principle, to be capable of solution. Although the most advanced program in this field, the 'Hearsay' program, has a vocabulary of only 676 word phrasings, the limit lies not in the principles of the machine's programing, but in the size of the computer available for this project.[6] The development of programing techniques, such as recursive languages, make a solution for the Turing Test theoretically possible.[7]

However, despite this success, there has been no tendency by either theoreticians in the field or the workers actually in contact with this computer to consider it intelligent. It is clear that some additional characteristic is contained in the concept 'intelligent.'

A second criterion which has played a major role in artifical intelligence development is what we shall call Leibniz's Criterion. This criterion is a composite of many activities and has not been seen as a unified whole by the computer scientists. Nevertheless, a number of small goals in artifical intelligence can be placed into a single category. Basically, all the activities in this category consist in attempts to enable the computer to successfully engage in some difficult mental activity, usually one that heretofore only humans could perform. Leibniz has been choosen as the father of this group because of his interest in chess playing automata and his successful solution for the problem of building a mechanical adding machine.

This criterion has, with one exception, been the easiest to achieve. The chess 4.5 program for the cyber 176 now holds a rating considerably above that of most human players.[8] Other game playing and computing problems have likewise been solved with considerable success. However, there exists a class of problems within this category which continues to present considerable difficulties, that is, those involving pattern recognition. In human terms, pattern recognition is the activity of making a gestalt perception, of correctly identifying a pattern among a group of entities, of forming an intuition, etc. In computer science, the classic example of a pattern recognition problem is the developing of a program whereby a computer is enabled to recognized the letters of the alphabet inspite of all the individual variations in handwriting. Only moderate success has been achieved in designing such systems. The most successful attempts have been made by using mathematical theories structured in non-linear patterns, such as topology or automata theory.[9]

The last criterion is one which, for lack of a better name, we will call the psychological. Although it has not been of major importance in artifical intelligence, we include it because it demonstrates a common view and represents a trait which most people expect in an intelligent entity. This criterion asserts that intelligence is indicated by some form of irrational or emotional behavior. It is this trait which, it is often believed, crucially differentiates man and machine. In actual fact, simulations of mental aberrations such as paranoia, have proved to be easily developed and in general, a computer can be as irrational, absurd, or inconsistent as a human being if it is so programed.[10] Therefore, this criterion may be considered achieved.

These three criteria successfully categorize all present work in artifical intelligence. It would therefore seem that when a computer scientist talks about an intelligence computer, he means a computer which can talk, recognize patterns, can learn any game played by humans, and which is capable of an occasional irrationality or inconsistency.

The major part of this criteria which has not yet been successfully achieved is the recognition of patterns. From the examples we have given, it would appear that pattern recognition is properly an inductive, rather than deductive procedure.

For example, let us consider the process in which a number of slightly different shapes are all recognized as being letter 'E's by humans. The possible variations in the shapes that a human being will recognize as 'E' form a continuum and thus, at least in principle, are infinite in number. For example, the long stroke of the 'E' may be rotated from its normal upright position, thereby producing a tilted letter. In so doing it may move through all possible points of the compass within a given segment. The count of these points is, of course, infinite in number. Therefore, the explanation of the procedure often given that the shape in question is matched to some ideal mental image can not be supported. It is impossible

to store an infinite number of images. A second explanation which suggests a "partial matching" has no clear meaning and is really only a restatement of the problem. Rather it is clear that the mind, by some inductive process, constructs some criterion which defines limits and degree of acceptable variation.[11] The performance of such an activity by currently existing computers poses a theoretical problem.

Virtually all multi-use, programable computers, are digital. That is, all computers which can be programed to perform a variety of tasks are built using the principles of Boolean Algebra, which is, of course, two-valued.

If pattern recognition is indeed an intrinsically inductive procedure, then the question is raised concerning how successfully a deductive system can simulate an inductive one. This is, of course, hardly a new question to philosophy. However, pragmatic attempts at logical simulation of three and four stated systems by digital computers suggest an additional fact, to wit that for any adequate approximation to be undertaken, the machine in question must be much greater in size than it would have to be in order to solve a deductive problem of a similar kind. This follows from the method by which such simulations are made.[12]

In addition to considerations of size, it will be clear to the logician that this procedure only partially simulates an inductive, multi-valued system. Most of the actual computing procedure at the machine level remains two-valued. Thus it may be that some of the inductive character of the process is being lost.

It is thus interesting to speculate on the question of whether a computer whose basic logical elements were multi-valued would not have a greater likelihood of performing the sorts of tasks in artifical intelligence research which have proved most difficult. In addition to an overwhelming improvement in the size and speed of the machine, it is possible that certain types of inductive tasks simply can not be simulated by an inherently deductive system.

At the engineering level, an inductive machine is quite possible. A MOSLSI transistor can be used as a 5-stated element, although at present it is not generally applied in this fashion. The resolution of information in this element is such that a group of such transistors can be formed into a module which can express 1240 characters.[13]

Therefore, the limitation on building such a computer does not lie in the realm of engineering or programing, but rather in that of formal logical. At present no formal multi-valued system proposed is completely consistent and without difficulties. Before an inductive computer could be built, a logical structure for a multi-valued system would have to be developed which had the consistency and efficiency of Boolean Algebra.

It thus seems probable that an intelligent computer could be built, not by increasing computer size, nor by improved programing, but by the development of a formal multi-valued logic. This is an undertaking which clearly lies within the realm of philosophy and whose pragmatic value is indubitable.

NOTES

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4. A. M. Turing, "Computing Machinery and Intelligence," *Mind*, (October, 1950) Vol. LIX, No. 236, pp. 433-460.
5. Rene Descartes, *Discours de Methode* (Paris: Libraire Larousse, n.d.), pp. 55-59.
6. Lee D. Erman, "Overview of the 'Hearsay' Speech Understanding Research," *SIGART News Letter*, (February, 1976), N. 56, pp. 9-16.
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8. Hans Berliner, "Outstanding Performance by Chess 4.5 Against Human Competition," *SIGART News Letter*, (November, 1976), No. 60, pp. 12-14.
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12. Glenn R. Case and Jerry D. Stauffer, "SALSIM—a Language for Control of Digital Logic Simulation," *Proceedings of the Asilomra Conference on Circuitry, Systems and Computers*, Fall, 1977; and Ronald C. De Vries and Lee S. Height, *Multilevel Logic Circuits Using Limited Input NAND or NOR gates*, (No. EE-162-69) S-094 (Albuquerque, New Mexico: University of New Mexico Bureau of Engineering Research, July, 1969).
13. Glenn R. Case, Personal communication, Sandia Laboratories, Albuquerque, New Mexico, October, 1977.

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