Programming Computers to Play Games, by Arthur L. Samuel. Reviewed by Paul C. Gilmore, of the Research Center, I.B.M., in Yorktown, N. Y.

Roughly half of this article is devoted to a summary of several serious attempts to program a computer to play chess. Discussed in various detail is the work of Shannon, Turing, a Los Alamos group (Ulam), Bernstein and Newell, Shaw and Simon.

But for one section on Strachey's program for checkers and one section on programs for games other than chess and checkers, the remainder of the article describes Samuel's program for checkers and experiments essentially as it is described in the author's article "Some Studies in Machine Learning, Using the Game of Checkers," *IBM J. Research Develop.* 3, 210–229, (1959).

Binary Arithmetic, by George W. Reitwiesner. Reviewed by Bruce Gilchrist, of the Research Center, I.B.M., in Yorktown, N. Y.

In the preface to the whole volume it is stated that each article is intended to be a piece of technical writing intelligible and interesting to specialists in fields other than the writer's own. The sixth article in the volume completely fails to come even close to this intention. This is especially disappointing as the first five articles are well pitched.

The author himself states that "the text suffers from an exhaustive attention to details." This reviewer agrees entirely with this comment. A consideration of binary arithmetic is certainly of importance to computer people, but this article considers only a part of the problem, admittedly in detail, and in fact completely ignores the extremely important question of floating point arithmetic. A newcomer to logical design may well find the text useful, but the experienced designer will certainly not find a large "part of a set of specifications for the design of an optimally performing binary arithmetical organ of a digital computer, with only the particular values of certain parameters left to be specified."

Unfortunately the reviewer can only sum up his feelings as "a disappointing end to an otherwise interesting and informative volume."

Machine Recognition of Spoken Words, by Richard Fatehchand. Reviewed by Morris Halle, Department of Modern Languages, Massachusetts Institute of Technology (currently at the Center for Advanced Study in the Behavioral Sciences, Stanford).

This survey of machine recognition of the spoken word gives a good picture of developments in this as yet almost virgin field. It correctly ascribes the very modest progress that has been made in utilizing computers in speech recognition to the great difficulty of the task, which requires machines to "perform some or all of the processes normally the province of the human listener" (p. 194). In agreement with the overwhelming majority of workers in the field Fatehchand sees these processes as consisting of procedures for determining "the features in the acoustic waves which the listener has learned to associate with particular speech sounds, by which he differentiates one sound from another, and by which he groups the sounds into words" (p. 194). The model of perception which is

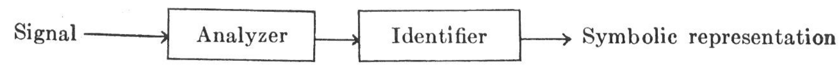

Fig. 1. "Passive" model of speech perception

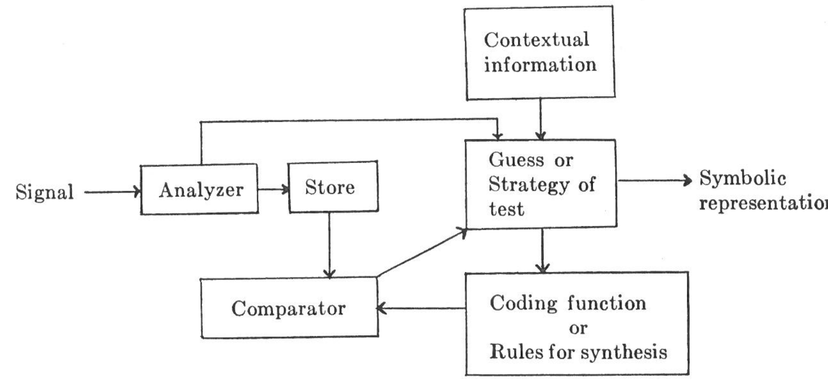

Fig. 2. "Active" model of speech perception

implicit in this remark may be represented schematically as in Fig. 1. The perceiver is assumed, thus, to track certain significant properties in the acoustic signal and to make his identification on the basis of the configurations of tracked properties that he discovers in the signal. This essentially passive model underlies almost every speech recognition scheme as well as the great majority of pattern recognizers that have been proposed.

In spite of its great popularity, however, the model can hardly be regarded as an adequate analog of the human process of speech perception. To mention just one of its shortcomings, it treats the process of perception in complete isolation from its inverse, that of synthesizing utterances, and fails therefore to account for the fact that in normal human beings the ability to speak a language implies always the ability to understand it. A model in which production and perception of speech are more closely linked would certainly have to be regarded as superior. Moreover, the practical results that have been obtained with the above model in the automatic recognition of speech are by no means so striking as to make search for a different model economically unwise.

Such a model of perception has been discussed at various times in the past, but its relevance to the automatic recognition of patterns, in general, and to that of speech, in particular, has unfortunately been overlooked for the most part. Although more than ten years have elapsed since the operation of this model (which *in nuce* can be found already in Bishop Berkeley's writings on vision) was described by D. M. MacKay as a process that could be simulated in an electronic computer,[1] the idea has provoked so little response from workers in the field that

[1] D. M. MacKay, Mindlike behaviour in artefacts, *British J. Phil. Sci.* No. 6, 105–121 (1951).

Fahtechand has not included any reference to the model in his survey. A brief description of the model is given below since such descriptions are much less accessible than they should be in view of the very great potential importance of the model.

The heart of the model (see Fig. 2) is the component labeled "Coding function or rules for synthesis," which is the machine analog of what speaker and listener have in common: the knowledge of the language. This function, which represents the link between production and perception, implies (in a mathematical sense) the (infinite) set of properly constructed utterances. The role of this function in the synthesis of utterances is self-evident; I shall comment, therefore, only on its role in the analysis process.

In analyzing an input signal the device first makes a "guess" as to its identity—on the basis of information from a direct analysis of the signal as well as such contextual cues as the identity of the preceding signals—and replicates internally the "guessed" signal. It then compares the latter with the signal under analysis which has been previously stored in its memory for just this purpose. This procedure is repeated until the match between input signal and the internally generated signal can no longer be improved. The "guess" that produced this best match is the desired identification. Speech perception is, therefore, regarded as an active process that might perhaps be pictured (in almost Watsonian terms) as an attempt at silent repetition of what is heard, though as MacKay stresses "it should be clear that the input dealt with by the replicatory mechanism is generally in quite a different physical form from the original input to the sensory receptors. An olfactory stimulus for example might be mapped electrically, and would not have to be replicated by generating odours." (See p. 114 of footnote 1, p. 89.)

Since a practical device will have to complete its analysis as nearly in real time as possible, it is necessary that the number of guesses that are actually compared with the input signal should be kept at a minimum. This presupposes not only that the initial guess be fairly accurate, but also that there be a procedure for running through alternatives in such a way as to maximize the probability of correct identification while minimizing the number of possible alternatives that have to be tested. The development of such rational strategies of "guessing" now becomes as important a problem for the automatic recognition of speech as the complete understanding of the rules by which the utterance is synthesized. The study of these strategies may conceivably provide us with important new insights not only about speech perception but also about perception, in general.

For further discussion of the "active" model and its practical utilization in schemes for the automatic recognition of speech as well as of other types of patterns see the following recent publications:

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4. Eden, M. and Halle, M. (1961). The characterization of cursive writing. *In* E. C. Cherry, ed., *Symposium on Information Theory,* London, 1960. In press.
5. Halle, M. (1960). Review of "Materialy po mašinnomu perevodu," *Language* **36,** 112–117.

Grundlagen und Anwendungen der Informationtheorie. By W. Meyer-Eppler. Springer-Verlag, Berlin-Gottingen-Heidelberg, 1959. xvii + 446 pp. D.M. 98.00.

The foreword to this monograph indicates that it was the intention of the publishers to present a series of works covering Communications and Cybernetics, the present volume being the first in this series. The author of "Foundations and Application Theory" and the editor for this series was Dr. W. Meyer-Eppler, Professor and Director of the Institute for Phonetics and Communications at the University of Bonn. Unfortunately Dr. Meyer-Eppler died a short while after the appearance of his book.

Presumably it was his intention to present an overview of the field of "information theory," reserving more detailed presentations for the later volumes. It should be pointed out that Information Theory has been interpreted much more broadly in Europe than in the United States. In the preface Dr. Meyer-Eppler states: "There is a clear tendency nowadays to employ the word "information" in various ways, on the one hand with approximately the content that it assumes in colloquial speech and which finds use in the handling of linguistic problems, and on the other hand, with a purely abstract mathematical meaning particularly useful in dealing with questions of probability theory. Essentially, I have attempted in this book, to take account of the colloquial meaning of the word "information" at the same time being concerned to give an exact definition to compound words containing "information" (information content, information density, information volume, etc.), so that the mathematical treatment may be firmly grounded." (My translation, M. E.)

Thus it is not the communication link, the channel, or for that matter, the physical signal which is central to the book, but rather the human observer. The distribution and relative emphasis accorded to the various topics reflect this difference in viewpoint. Chapter I, *Communications Links*, defines several kinds of link, the observation link, the diagnostic link, the linguistic link, external feedback circuit, etc. Chapter II, *Structural Theory of Signals*, introduces the subject of continuous signals and considers methods for the treatment of continuous wave-forms. Chapter III, *Properties of Linear Transmission Systems*, introduces various notions relative to capacity. Chapter IV, *Symbol Statistics*, treats information theory as applied to discrete symbol spaces and reviews the present knowledge of statistical linguistics. Chapters V and VI deal with noisy systems and error correction. In these chapters which may be considered to be