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MACHINES FOR THE TRANSLATION OF LANGUAGES

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The purpose of this article is to give a report of certain progress being made in our technology which promises to be of importance to the field of international communication. This technological advance which is looming on the near horizon is the possibility of translating languages automatically by means of machines. Perhaps we should not call it just a possibility, for this development seems inevitable. For the first time in history, extensive communication will be possible between people who do not understand each other's languages. At present, such communication

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some proficiency in both languages. Frequently the solution of a problem merely exposes other problems to view. When the technical problems connected with this development have been solved, we will be faced with other, more difficult problems. They will not be how can we do such a thing, but what should we do with such a thing, and what will result from such a thing.

It is difficult to explain a technological development without some technical background for perspective. For this purpose, just a little will be given here. Every advance in the methods of human communication has rested upon prior technological advances. The development of writing was based on an understanding of the use of charcoal, clay tablets, papyrus, ink, and so on. The development of printing was based on advances in metal technology and on an understanding of certain mechanical principles. The perfection of the telegraph and telephone depended upon the scientific knowledge of electricity which came almost entirely after the American revolution. Radio and television depend on the vacuum tube which was invented only fifty years ago. These developments may be thought of as machines for the transmitting of information. Today there exists a new technology that will make possible the development of machines for translating as well as transmitting language. This technology is associated with the printing telegraph, with the dial telephone exchange, the automatic punched-card business machine, and most important, with the electronic digital computer, better known to readers of science fiction as giant brains, in spite of the fact that they can't think.

A translating machine may be something like this. There will be a keyboard. Material in one language will be typed on this keyboard. It will be converted into electrical impulses in much the same way as the modern telegraph operator's keyboard converts the typed telegrams into electrical impulses for transmittal over the telegraph wire. These impulses will enter a machine, about which more will be said later. Also connected to this machine will be another electric typewriter which will automatically type out a translation in the other language.

For the present we will be dealing only with the written language. Now, of course there is a great need for translation and interpretation of spoken language. It seems, however, that it probably will not be technically feasible to translate spoken language by

machine in the near future. It is a development that will eventually come, to be sure. There is a great effort being made at several universities and research establishments which will result in electronic techniques for the recognition of speech sounds, thus enabling the automatic transcription of the highly complex sounds of the spoken language directly into a phonetic or phonemic alphabet suitable for introduction into a translating machine. Similarly, work is progressing on speech synthesizers which could be used as an output, producing speech-like sounds from the coded output of the machine. But for the present, we are dealing only with the written language. Most important communications are reduced to the written form first, anyway, even though intended for oral presentation. So the limitation may not be as serious as one might suppose at first. Probably the first use of our machines will be in translating periodical literature, perhaps first in the fields of science and technology. The M.I.T. library, for example, carries over 200 scientific and technical periodicals in the German language alone. Much of the information they contain is useful and should be translated.

What is there in these latest technological developments which ensures the possibility of designing a machine to translate languages? First, many ways of storing information mechanically have been developed. For example, in the automatic business machine, information is stored on punched cards. These punched cards are familiar to everyone, in connection with income tax returns, if for no other reason. Alphabetical or numerical characters may be represented on these cards by means of the presence or absence of punched holes in various locations. Information may be presented in machines in other ways too: in the position of wheels or gears, even in vacuum-tube circuits. In the dial telephone exchange, information is stored in electromagnetic relays which close electric contacts. The most efficient devices for the mechanical storage of information are to be found in the electronic digital computer. Here, all of the previously mentioned methods of storage may be used, as well as several new methods which allow for very quick storage and recall of the desired information. All of the most widely used methods of storage of information in machines represent letters or numbers by patterns of the presence or absence of something. In the case of the punched cards, it is the pattern of the holes. So we know how to store information in a machine. We can make a dictionary.

The other ability which these machines have is to compare two pieces of information and make a decision on the basis of this comparison as to what to do next. An everyday example of this ability to make a decision is found when you pick up the telephone and dial a number. If the line is not busy, the result of the comparison in the apparatus is the decision to ring your party. If, on the other hand, the line is busy, the result of the comparison is different and the equipment gives you a busy signal. Although it is not immediately obvious, these two abilities of existing mechanisms, the ability to store or remember information, and the ability to make decisions are logically sufficient for translating one language into another.

What is meant by translation? Of course, there is no such thing as a perfect translation. Two highly qualified translators may translate the same text, both doing an excellent job, and then, finding that their two versions do not agree, enter into a heated argument as to which is correct. It is not expected, of course, that machines will produce a perfect translation either. But it is realistic to suppose that a machine can produce some sort of an approximate translation, adequate for most purposes. Only time and the result of many years of hard work will tell us how good a translation we can expect a machine to make. It is estimated on the basis of work which has been done thus far, that a machine can make a translation which will be adequate for communicating straightforward ideas such as this: "The model 2B sewing machine makes button holes without special attachments." By translation, is meant, therefore, the production in one language of a good approximation to a message in another language. In other words, we can translate the sense of the message. We will not be able to translate fine prose by machine and expect fine prose to come out. We will not be able to translate poetry. It is not foreseen that machines will be able to handle the more subtle aspects of a piece of writing, particularly those aspects which involve the sound of words or the rhythm of the line. But it is expected that it will be possible to translate the approximate meaning of the text.

Now the big question is: how can we design a machine to do this? It was hinted earlier that a machine could act as a dictionary. The first possibility then is to have a machine provide a word-for-word or dictionary translation. This has been seriously proposed by some workers in the field but there are two difficulties. The first difficulty with a word-for-word translation is that we usually do not

have a 1:1 correspondence in the meanings of words. A word in one language may have several meanings. According to Webster's Collegiate Dictionary "to" has 20 meanings; "have" has 14 meanings; "go" has 28 meanings; "when" has 5 meanings; "the" has 8 meanings; "that" has 5 meanings; "on" has 20 meanings; "run" has 54 meanings. These various meanings may correspond to several different words in another language. A dictionary or word-for-word translation would have to itemize the several possible translations of each word, and the reader would be left to find his way through this multiple choice guessing game somehow or other. The second difficulty with a word-for-word translation is concerned with word order. Those of you who know German are well aware that the placement of certain parts of the verb is quite different from English. Those of you who know French are well aware of the different placement of the adjective. In less closely related languages the differences may be much greater. If a sentence is to be translated properly, we must not only choose the correct words to express the meaning, but we must also place them in the correct order for the output language. This is because the order of the words is important for carrying the meaning in all languages. Without word order, a sentence would degenerate into a series of items like a shopping list. The major problems in developing machines to translate languages are linguistic problems such as these. Fortunately, linguistics, particularly in America, has made great strides recently in methodology. Although the linguistic problems raised by mechanical translation are challenging, modern linguistics can meet the challenge. Work is going on at several places in this country and abroad, and progress is being made. Many of the answers that we seek are to be found in a careful re-examination of grammar and syntax. A majority of the multiple meaning and word order problems in a given text to be translated involve those little or grammatical words such as the articles, prepositions, conjunctions, adverbs and pronouns. This is because they are so frequent in the text and also because they usually have more multiple meanings than the nouns, verbs, and adjectives. Most of the problems are therefore associated with the grammatical and syntactic structure of the sentence. If we can recognize and describe properly the linguistic features which signal the grammatical structure of the sentence, we think that we can design a mechanical routine by which these features or clues can be used by a machine to make a grammatical analysis of each sentence.

If this can be done many of the problems of multiple meaning and word order will be solved.

It seems inevitable that we will have machines for translating languages, maybe not next year, but certainly before very many years. These machines will not cause technological unemployment among human translators. In the first place the machines will require many language specialists to keep them working. In the second place, the ready availability of machine-made approximate translations, adequate for most purposes, will increase the public awareness of the extensive foreign language literature, and thus will stimulate an increased demand for careful, extremely accurate man-made translations of the most important writings which ought to be translated carefully and which today remain untranslated. Neither will these machines compete with international languages as a solution to our problems. They may even hasten the acceptance of an international language by making available translations of all important material in one international language. This will certainly be much more economical than making available translations of all important material in all languages.

The eventual solution to the problem of translating languages by machine will create many new problems for us. What will the world be like when machine-made translations are available on a large scale? How should these machines be used? Will we in fact experience a lessening of the difficulties caused by language barriers? These are problems for the future, but they are certainly problems about which we should be thinking today.

REFERENCES

For those who wish to read in greater detail about work in the field of mechanical translations, an annotated bibliography was published last year in Vol. I, no. I of *Mechanical Translation* (Room 14N-307, Massachusetts Institute of Technology, Cambridge 39, Massachusetts). This bibliography is being kept up to date in succeeding issues which also carry news and articles by the various workers in the field. In addition, a book will soon be available: *Machine Translation of Languages*, edited by W. N. Locke and A. D. Booth, to be published in the spring jointly by the Technology Press of M. I. T. and John Wiley, Inc. It is to contain 14 essays representing the latest thinking of 17 workers in the field.