

XV. MECHANICAL TRANSLATION\*

Prof. V. H. Yngve  
Prof. A. N. Chomsky

Prof. J. R. Applegate  
Dr. G. H. Matthews

R. B. Lees  
Ursula C. Dickman

A. PRESENT STATUS OF THE RESEARCH

The framework within which we are working is presented in schematic form in Fig. XV-1. This framework has evolved after careful consideration of a number of factors. In order to solve difficult word-order and multiple-meaning problems in translation, it seems necessary to adopt techniques that are more refined and powerful than ad hoc or empirical rules. Such techniques are being sought in sentence-for-sentence translation, which relies upon an adequate linguistic description of the sentence. These descriptions are emerging as a result of recent advances in the understanding of syntactic structure. Further information on the reasoning behind the adoption of this framework will be found in references 1, 2, and 3.

Figure XV-1 represents a hypothetical translating machine. German sentences are fed in at the left. The recognition routine, R.R., by referring to the grammar of German,  $G_1$ , analyzes the German sentence and determines its structural description,  $S_1$ , which contains all of the information that is in the input sentence. The part of the information that is implicit in the sentence (tense, voice, and so forth) is made explicit in  $S_1$ . Since a German sentence and its English translation generally do not have identical structural descriptions, we need a statement of the equivalences,  $E$ , between English and German structures, and a structural transfer routine, T.R., which consults  $E$  and transfers  $S_1$  into  $S_2$ . The construction routine, C.R., is the routine that takes the structural description of the English sentence and constructs the appropriate English sentence in conformity with the grammar of English,  $G_2$ .

The general form that the grammars  $G$  should take (4, 5) is now fairly clear: A grammar is a set of rules which allows the grammatical sequences or sentences of a language to be separated from ungrammatical sequences that are not sentences. Considerations of simplicity lead to grammars that are divided into three parts: phrase structure, transformational structure, morphology and orthography. These grammars will relate the structural descriptions of the sentences of a language to the actual sentences, and are therefore appropriate for our translation procedure.

There is no known straightforward procedure for obtaining a grammar from a corpus, or sample of language. A grammar is of the nature of a scientific theory and must be discovered. Detailed attention has been given to the development of methodology for discovering grammars. Some theoretical work has been done on the general problem of discovery procedures, and some statistical techniques have been

---

\* This work was supported in part by the National Science Foundation.

(XV. MECHANICAL TRANSLATION)

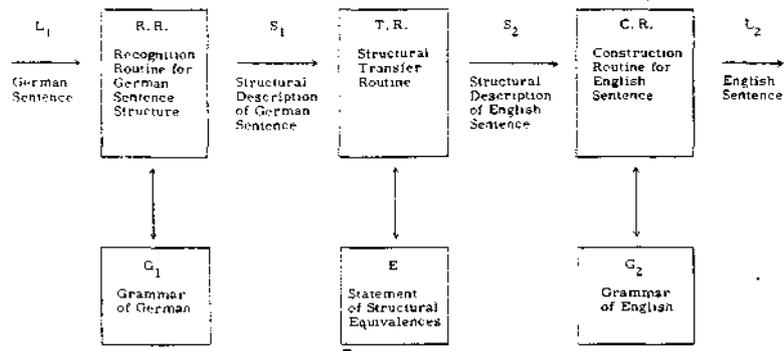


Fig. XV-1. Scheme for translating machine.

investigated which may pave the way for effective use of a digital computer for examining a very large corpus as an aid in discovering pertinent facts about a language.

A preliminary English grammar is almost finished; a German grammar is well under way. These preliminary grammars will, of course, be far from complete, but they are already complex enough to make it difficult to determine the significance, for the grammar as a whole, of changes made in some part of it. The grammars are so detailed that the use of a computer for checking them is advantageous.

Work has progressed on writing a construction routine, C.R., for the IBM 704 computer. The availability of sentence-construction routines programmed on this machine, and the ultimate availability of recognition and transfer routines, will provide an important research tool that will aid in the production of more complete and therefore more detailed grammars. One hundred thousand words of German and one hundred thousand words of English on punched tape are being made ready for research with the 704 computer.

When preliminary grammars are available, work can proceed on the important recognition routine, R.R. A straightforward approach may provide these routines. Routines using heuristic procedures, which have been investigated by those interested in theorem-proving and learning machines, also look promising. Work on grammars and recognition routines may have added significance in the field of literature search and retrieval machines.

Work on the transfer routine, T.R., awaits a preliminary statement of structural equivalences which must be based on the grammars.

V. H. Yngve

References

1. V. H. Yngve, Syntax and the problem of multiple meaning. Chapter 14, Machine Translation of Languages, edited by W. N. Locke and A. D. Booth (The Technology Press, Cambridge, Mass., and John Wiley & Sons, Inc., New York, 1955).
2. V. H. Yngve, Sentence-for-sentence translation. MT. Vol. 2, No. 2, pp. 29-36 (Nov. 1955).
3. V. H. Yngve, The technical feasibility of translating languages by machine, Communications and Electronics, No. 28, pp. 792-797 (Jan. 1957); Elec. Engrg. 75, 994-999 (Nov. 1956).
4. N. Chomsky, Three models for the description of language, Trans. IRE, vol. 1T-2, no. 3, pp. 113-124 (Sept. 1956).
5. N. Chomsky, Syntactic Structures (Mouton and Co., 'S-Gravenhage, 1957).