[*Mechanical Translation and Computational Linguistics*, vol.11, nos.1 and 2, March and June 1968]

Is the Generally Accepted Strategy of Machine-Translation Research Optimal?*

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This paper first presents a theoretical interpretation of the translation process. It then analyzes existing machine-translation research strategies and points out that some of the generally accepted principles of these strategies are not optimal. Finally, an alternative strategy is proposed, based on the author's theoretical position and research results.

The possibility of achieving independent high-quality machine translation (be it only the translation of scientific and technical literature, to say nothing of fiction and poetry) has always been the object of animated discussions. Even today, after fifteen years of hard work in both the Old and New World, this possibility is called in question by some authors who feel it impossible to realize this goal either in general or at least in the foreseeable future.

These authors, in upholding the impossibility of achieving high-quality MT, have used different arguments: the limited possibilities of the electronic computer; the impossibility of formalizing this type of mental activity of man [1]; the general idea of untranslatability; the impossibility of describing precisely and therefore of algorithmizing the language processes, which, in their opinion, are purely human processes reflecting the subtleties of the human mind [2]. Other reasons given are economic impracticability and, finally, a number of emotional arguments in favor of the greatness and primacy of man [3] and the like. The development of contemporary scientific thought, as well as the conclusions which follow from the theoretical studies in MT and from the analysis of experimental algorithms, show (setting aside the economic problems) that most of these arguments, usually products of preconceived ideas or inadequate information [4], are not convincing and do not deserve further treatment.

One indisputable fact remains, however: apart from the Centre d'étude pour la traduction automatique (CETA) in Grenoble, which has set itself the task of producing a program for production translation of Russian scientific texts into French [5] by the end of 1968, no group has worked out, or adopted as its objective to develop, an algorithm capable of giving independent high-quality translation of a sufficiently wide class of texts in the near future.

Here I do not have in mind the numerous successful experimental MTs of separate texts or the considerable practical successes achieved in the automation of the translation of special types of texts, such as bank texts, bookkeeping, patent texts, etc., as well as the successes achieved in the creation of translators in algorithmic languages.

Why is there so far no widely applicable algorithm for MT?

This problem has interested specialists in this field not only immediately after the frustration of the illusory hopes which rose after the initial successes, but today as well. The essence of Bar-Hillel's opinion [6, 7] is that high-quality independent MT is impossible because, as a result of the specific characteristics of natural languages, a number of cases of polysemy and homonymy cannot be solved in the long run without taking their semantic value into consideration and without taking the real world into account. (In this connection, see the interesting and justified criticism of Bar-Hillel's view by Rosenzweig and Revzin [8].

After enumerating the difficulties which researchers in this field had to face up to 1963, and after stating that we want to algorithmize a process which we do not know, Ceccato comes to the conclusion that before algorithmizing the process of translation we have to study and describe in operational terms the process of human thinking (the studies of the Milan operational school are developing in this direction [9]).

It is one of the basic conclusions of the well-known ALPAC report [10] that independent high-quality MT will not be possible until we have acquired a thorough and formalized knowledge of human languages. The possibility for MT was discussed from this standpoint in some statements at the International Conference on MT in Erevan, Soviet Armenia (April 1967), and at the Second International Conference on Computational Linguistics in Grenoble, France (August 1967). Special attention to this problem, as well as to the problem of the strategy of MT (the latter for the first time), was given at the symposium on MT of the member countries of the Council of Economic Assistance "Mashperevod 67" [11].

Thus, in his introductory report, Ju. A. Šrejder (USSR) points out that after the two early illusions which are quite commonly held even today (namely, that it is possible to achieve high-quality MT by means of the use of limited patterns of natural languages, and that the problem of MT has already been solved in principle and demands only a major organizational and technological effort for its practical achievement) have been

* I wish to acknowledge with thanks the efforts of Paul L. Garvin in revising and editing the English wording of this paper.

shown to be fallacious, the problem of MT remains unsolved. This problem is far more complicated than was originally thought; it turned out to be radically different from the original conception that all that had to be done was to determine the functioning of a complicated biological system that contains a number of insufficiently determined mechanisms, such as natural languages. And hence my basic conclusion is that the problem of MT will not be solved until we have adequate mathematical models of natural languages at our disposal.

Similar thoughts were expressed in some other reports read at this symposium; the reports of Szépe (Hungarian People's Republic [12]) and Sgall (Czechoslovakia [13]) contain quite interesting and motivated views which actually question the veracity of some of the earlier statements.

All these and similar statements actually equate the extent, character, and content of linguistic knowledge necessary from the point of view of theoretical linguistics with the knowledge necessary for the achievement of MT. They in fact transform the question, Is MT possible? into the question, Is mathematical modeling of natural languages possible? The latter is of course a basic problem, but I shall not deal with it here.

Perhaps the reason for the present state of the work on MT is the incorrect approach on which it is based. This well-grounded thought was first expressed by Garvin [14, 15]. He thinks that the reason the problems of MT have not been solved is the nonrealizability in practice, at least for the present time, of what he calls the "perfectionist" approach and the "tripartite" form of algorithms. Instead of the latter he suggests his well-known "fulcrum" approach [16]. But if this view is correct, then why not look for the reasons still deeper—in the overall strategy of the MT?

With this in mind, my aim in this article is to take one more step forward in this direction and, on the basis of an analysis of the existing strategies of MT on the one hand (Part I), and of the functioning of the process of human translation on the other (Part II), first, to show that some basic principles of these strategies generally accepted today are not optimal (Part III) and, second, to propose in their place the foundations of another "selective" strategy, based on some of my theoretical investigations and on the practical work of the machine translation and mathematical linguistics group at the Mathematical Institute of the Computation Center of the Bulgarian Academy of Sciences (Part IV).

I

When talking about the strategy of MT one usually has in mind (without any clear differentiation) at least the following three types of considerations:

1. The totality of views about human translation (HT) and MT, which include: the basic linguistic conceptions and traditions in a given country and group; the general direction of the work (both theoretical and practical); economic considerations, etc., on the basis of which essential problems of MT are solved in a preliminary way [17]; independent or dependent analysis, with or without pre- or postediting; the degree of adequacy; the fields of application (i.e., the class or classes of texts); whether the translation is bilingual or multilingual, etc.

2. For each given way of solving the linguistic problems connected with the recovery of the information carried by the input data and with the generation of the output text (i.e., of organizing the analysis and synthesis for MT), the following matters have to be taken into account: dependent or independent analysis, MT with or without an intermediate language, operation only on the level of *parole* or including the deep levels of *langue,* "grammatical" or "semantic" MT, type of recognition and generative grammars, the manner of organizing the lexicon, standardized or multiple synthesis, etc.

3. Methods must be found for formalizing and organizing algorithms, as determined by the aim and general direction of the work as established under (1) and by the types of solutions chosen for linguistic problems of the MT process as discussed under (2): type, power, and logic of mathematical models; ways of combining them; "bipartite" or "tripartite" algorithms; algorithms and formalisms, etc.

Without trying to give a proper definition, let us make clear that by "strategy" in MT we understand, above all, the problem areas under (2).

Since the strategies adopted by the different MT groups depend primarily on the factors set forth under (1), the definition of their basic characteristics requires, in the first place, a generalization and analysis of these factors and, in the second place, a comparative analysis of the specific algorithms developed on the basis of these strategies. But, since space limitations do not allow me to give such analyses, I shall state only some of the results of the analysis of these matters which I have undertaken.

In the course of this analysis the basic theoretical publications and experimental algorithms of the following leading groups working in the field of MT in Europe have been considered: First Laboratory of MT in Moscow (1st Lab); Department of Structural Linguistics of the Institute of Linguistics (I Ja) of the Soviet Academy of Sciences; a group working on mathematical linguistics and MT an Leningrad University (LG); a group working in the field of MT at the Computation Center of the Academy of Sciences of the Armenian Soviet Socialist Republic (AG); the Department of Mathematical and Applied Linguistics and Machine Translation at the Academy of Sciences of the Georgian Soviet Socialist Republic (GAN); a group working on MT and mathematical linguistics at Charles University in Prague (PG); a group working on MT at the Computation Center of the Hungarian Academy of Sciences (UAN); the Centre d'étude pour la traduction automatique in Grenoble, France (CETA). In addition, the strategies

of two MT groups in the United States has been analyzed: that of the Bunker-Ramo Corporation (RAMO) and that of the RAND Corporation (RAND). I have noted the following trends:

1. The so-called 100 percent approach (e.g. [17]), based on the organic connection between MT research and contemporary linguistics, especially mathematical linguistics, on whose models the process of MT should be based (e.g. [18]).

2. Transition from the so-called local method to an integral method with multiple synthesis (I Ja).

3. Recognition of the circumstance that adequate MT cannot be achieved without transition to the semantic level (e.g., I Ja, 1st Lab, PG, CETA) and in some cases without analysis within the framework of a whole paragraph. In contrast to this, representatives of other groups (e.g., LG, GAN, RAMO) hold that high-quality "grammatical" MT is possible.

4. Conception of the intermediate language in MT as an instrument for recording the invariant, that is, of the semantic value of the translation and its development as a separate language, with linguistic units and a syntax of its own (e.g., PG) or without its own linguistic units and syntax (CETA).

5. Acceptance of the necessity, on the one hand, of semanticizing the structures of the input phrase produced by the syntactic analysis (e.g., CETA, PG) and, on the other, of inventorying the cases of structural ambiguity which cannot be resolved without recourse to semantic criteria (e.g., GAN, LG).

6. A tendency to work out a so-called "inner," that is, independent, strictly intermediate, language-oriented analysis (e.g., LG, CETA).

7. Conception of the process of analysis (and in the opposite direction, of the process of synthesis) as a combination of consecutive interlevel transitions from the level of *parole* to the deepest possible level of the language—the semantic level—and conception of this process as the transformation of all the units of the surface level into units of the semantic level.

8. A tendency to model the process of analysis (and in the opposite direction, the process of synthesis) as a series of linked, relatively independent (cybernetic) systems, consisting of separate models describing the corresponding consecutive levels of the language (e.g., LG, PG, CETA). The complexity of these models (and, consequently, of the corresponding types of analysis) increases with the progression to deeper levels.

9. The need for all possible segmentations, structures, and interpretations to be ascribed to the units of all levels (e.g., CETA). The opposite tendency has also been noted: organization of the analytic process in such a way that only one structure at a time is ascribed to each current sentence (e.g., GAN).

10. The transfer of unresolved ambiguities of a given level to deeper levels (LG, CETA).

11. The conduct of the analysis at every level either only within the framework of the corresponding units (CETA) or with attention given to contextual factors of this level, that is, the conduct of the analysis not only in depth but also in "width" (LG).

From my point of view, the most characteristic aspects of the strategies used in MT (except for the so-called "fulcrum" approach of RAMO) are set forth under (1), (7), and (11) above. Because of the tendency of these strategies to make direct use of the models of mathematical linguistics and to transform *all* the elements of the input information into elements of the semantic level, I shall call them global.

In addition to pointing out these basic assumptions, let me say a few words about the criteria for evaluating the "optimality" of these strategies. This problem has not been worked out in the theoretical literature of today, but it can be taken for granted that, at least tacitly, the research workers dealing with this matter base their assumptions on the following two criteria for optimality: adequacy of the translation resulting from the application of a given algorithm based on a given strategy, and the simplicity of this algorithm (the content of the latter concept is not further specified).

II

The particular features, the methods, and the ways of algorithmizing a given process, as well as the types of the necessary mathematical models, are determined by the specific character of the type of process that is to be algorithmized. In this connection, it is hardly necessary to prove that the strategy which will be adopted when algorithmizing HT—that is, the human translation from one natural language (L_i^N) into any other natural language (L_j^N) (this type of translation will be symbolized as $L_i^N \rightarrow L_j^N$, where the sign $\rightarrow$ does not indicate implication)—should first of all be determined precisely, on the basis of the particular features of the process $L_i^N \rightarrow L_j^N$.

In spite of the obviousness of this principle, and in spite of the most instructive examples provided for us by pioneers in the field of MT, such as W. Weaver, V. Yngve, Y. Bar-Hillel, A. Oettinger, A. Lyapunov, and others, this principle has almost completely escaped the attention of research workers in our field of study. In view of this, we should begin with an analysis of the linguistic nature of the process of HT. Since it is obvious that a complete analysis is not feasible within the limits of a single article, I shall confine myself to stating the two basic principles of my semiotic conception of translation [17, 19, 20, 21, 22].

It is generally accepted that the processes of both monolingual communication (strictly speaking, monolingual communication based on natural languages does not exist [19]) and translation presuppose, apart from the understanding of other things, an understanding of the input information. But is the *understanding necessary for monolingual communication* identical with the *understanding required for the achievement of the process*

of translation, as almost all authors seem to think? I shall show that these two types of understanding are not identical. I shall call the understanding necessary for "ordinary" language communication, which is realized logically or referentially, *objective* understanding. With this type of understanding, roughly speaking, the subject who is receiving some language communication aims at establishing only that information about the real world which is encoded in the communication. This type of understanding presupposes reference to data about the real world previously stored in the memory of the subject receiving a given communication. Thus if I am to understand the Russian sentence Кривизна трехмерного пространства /К/ означает поэтому на- личие "дефекта" или "избытка" о треугольников ("the curvature of three-dimensional space therefore indicates the existence of a 'defect' or 'residue' in triangles"), I must first of all know what is understood by the phrase.

In other words, I have some information about the real world stored in my memory (or else I should acquire it from somewhere)—such information, for instance, as is signaled by a statement of the following type: "The rotating solid disk does not follow the rules of Euclidean geometry. The higher the angular speed, the greater the deviation from Euclidean geometry. This means that the higher the angular speed, the smaller the area of a single triangle. But there is something else in addition to this. If the angular speed is given, then the deviations grow increasingly greater with the increase of the linear speed $V = rw$. This means that the farther away a given disk region is from the rotating axis, the greater are the deviations from Euclidean geometry (the angular speed of the rotating disk being *w).* This in turn means that the area of a single triangle is determined by the distance between the triangle and the axis. While in non-Euclidean geometry a single triangle has the same dimensions in any region of the plane, in our case the size of the triangle is different in different regions of the plane. The deviation from Euclidean geometry is measured by the deviation of the sum of the angles of a triangle from the sum of two right angles. If these angles are marked *a, b,* and *c,* then the so-called defect is represented by the formula $180 — (a + b + c)$. Since the defect depends on the area of the triangle, it is advisable to introduce the quantity Δ/A, where A stands for the area of the triangle, and Δ represents the defect. The quantity expressed by the formula $K = \Delta/A$ is in Russian called кривизна пространства ('space curvature')."

The understanding necessary for the achievement of the translation process, which, like objective understanding, may take place referentially and linguistically, will conditionally be called *selective* understanding. Roughly speaking, with this type of understanding the subject who translates a given language message is interested in establishing not the information about the real world carried by this message but the information about the language components of this message which will enable him to select such corresponding units from the target language as, taken together, will produce a text that will carry information about the real world which is invariant with respect to the information carried by the input message. In other words, understanding in translation presupposes unequivocal determination (selection—hence the term "selective understanding") of the meanings (i.e., of the translation equivalents, for it is accepted that the meaning of a language sign consists of its translation by another sign—e.g. [23]) of the language components of the input message.

The same Russian sentence will illustrate the above. If I am an interpreter and have to translate this sentence into English, it is not at all necessary for me to have an objective understanding of the Russian expression кривизна пространства, which presupposes information in my memory of the type given above, but it is enough for me to know (or to establish in some way or other)—that is, to collect information about this expression which will tell me—that in this context the Russian expression means "space curvature."

Many such examples could be cited, but what has been said so far is sufficient to make a statement closely connected to the two universally accepted definitions of the meaning of language units given by modern linguistics, logic and semiotics.

The first of these states that meaning is the totality of situations in terms of which a given language expression is generated, and the second, already mentioned, states that the meaning of a given expression is its translation by another language expression.

My statement is the following: the understanding necessary for translation, that is, for the generation of a text that could provide the possibility for the same objective understanding as the input text, does not necessarily presuppose objective understanding and is different from it.

At first sight the setting apart of these two types of understanding (objective and selective) could remind one of the subdivision of the translation process by Rosencvejg and Revzin into interpretation and translation. The similarity is, however, only superficial (the subject is treated in more detail in [20] and [17]).

Of course, if the addressee of a monolingual communication, that is, the subject of objective understanding, is also familiar with the language into which the translation is made and makes it his aim to translate the given communication, he could just as well perform the translation on the basis of objective understanding, but this would still imply selective understanding as well. It does not follow, however, that the opposite is also true, that is, that selective understanding is impossible without objective understanding. This is confirmed beyond dispute by the practice of professional translators all over the world.

One could raise an objection here that is not unfounded, namely, that in certain cases the translator is

also forced to compare what he is translating with the real world (or with whatever information about it he has stored in his memory), that is, that he must first achieve objective understanding. Such cases do occur because of the particular characteristics of natural language. If we look at them more closely, however, it becomes clear that even in these cases the referential approach is aimed not at establishing information about the real world for its own sake but at using the real world to establish information about the corresponding devices of the language.

Thus, monolingual communication presupposes objective understanding and is impossible without it, whereas the translation process presupposes both objective and selective understanding. From this it follows unequivocally that in at least one of the two possible cases these two processes based on natural language are different. Of course, from a historical point of view one should not forget that selective understanding is based on objective understandings achieved in the past. Furthermore, we have every reason to suppose that in the minds both of the translator and of the addressee of a monolingual communication there is no ideal differentiation between the translation process based on objective understanding and that based on selective understanding; rather, there is present a complex combination of both with the various devices of the language, a combination which is probably especially noticeable in the translation of fiction.

Let us note that in line with the semiotic conception of translation there is no essential difference between artistic and nonartistic translation. The fact that in artistic translation the translator has to resort more often to objective understanding is due above all to our inadequate knowledge of the mechanism of language and to the insufficient degree of its exact description. What we call translator's license is due to the same inadequacy. With the improvement of the exact language description, this license will increasingly turn into a conscious discipline [19].

All this complicates the differentiation and separate treatment of the two processes but does not obliterate the difference between them. And since this difference has objective existence, science should not overlook it.

Let us now turn our attention to another fundamental fact. As has been pointed out, the selective understanding necessary for the translation process presupposes the gathering of information about the language devices used in the input messages. As this information must allow the translator to establish unambiguously the meanings of the language components of the input message, and since it has already been agreed that these meanings are in fact translation equivalents, I shall call this information the *necessary translation information—* $I(T_n)$. The essence of this construct, introduced in [17], is the following: in line with the well-known characteristic properties of natural language, a set of elements in a given natural language (with another language the composition and the size of this set of elements would be different), belonging to different levels of this language, does not of itself allow one to extract the $I(T_n)$. The translator therefore has to derive some additional information from the context, in the broadest sense of the word. It is this additional information, together with the basic information supplied by the text under translation, that constitutes $I(T_n)$. This $I(T_n)$ is collected in the course of analysis. On this basis we can formulate the following conception: the main problems of human translation are linguistic problems which in turn are connected with the extraction of $I(T_n)$, whereas the main problem of machine translation is the algorithmization of this process of extraction.

The introduction into the theory of translation of this logical construct—the notion $I(T_n)$ and the treatment of the process of analysis as a process of collecting $I(T_n)$ — makes it possible to establish the following factors characteristic of the language mechanism of HT. The composition and size of $I(T_n)$ is an objective and previously established quantity which varies not only with different language pairs but also with the various subcodes and levels of a given natural language; the previous establishment of the composition and size of $I(T_n)$ for a given language pair turns the inductive problem of translation into a deductive problem. With different language pairs the classes of objects for whose translation additional information is necessary are different; with different classes of objects belonging either to the same level or to different levels of a given natural language, the ways of collecting $I(T_n)$ are different—in some cases referential (i.e., by means of referring them to a deeper level than that to which the unit under consideration belongs), in others nonreferential (i.e., without such reference). The $I(T_n)$ about the same classes of objects on the same level of a given language can, in the process of translation into another language, be collected at different levels as a result of different types of analysis. From all this one can arrive at the following basic conclusion: the process of human translation (and therefore of analysis in the course of translation from one natural language into another, for such translation could be treated as a combination of successive translations from one level to another) does not have *global* character because additional information has to be collected *not* about *all* components of the input message but rather only about some of them; this being so, *not all* components are recoded to deeper levels going as far as the semantic level, so that the process of human translation has a selective character, whose features are above all the following: (1) With different language pairs the same classes of objects from the same levels are treated in different ways; (2) with a given language pair different classes of objects from different levels are treated in different ways; and (3) in the process of collecting $I(T_n)$ not all objects arc transferred to deeper levels, while the depth of the levels to which the separate classes of objects are carried varies as well. In the light of the above, let us

now consider briefly the previously mentioned three basic positions taken by present-day research groups with regard to the strategy of MT.

III

1. The widespread so-called 100 percent approach, along with the belief that MT presupposes the presence of a complete mathematical model of language in general and of the specific languages in particular, in practice amounts to equating the nature and extent of the knowledge of language in general which is necessary from the point of view of theoretical linguistics with the extent of knowledge of language necessary for the achievement of translation from one language into another. This approach also amounts to equating the description of communication in general with that of the translation process; it ignores the specific characteristics of the process as mentioned above and the linguistic problems of the theory of translation (both HT and MT) into the general problem area of mathematical linguistics.

Since the realization of the process of MT, as well as of that of HT, depends on the collecting of $I(T_n)$, which presupposes the carrying out of some operations (different depending on the particular characteristics of the relationship between a pair of languages and of certain given levels of language) over some linguistic objects (different again in terms of the same particular characteristics), the extent of knowledge about language necessary for the achievement of MT with a given language pair must be determined in terms not of the aims of theoretical linguistics but of the particular characteristics of the pertinent methods and objects. From this follows that the mathematical models describing these two types of processes, as well as the branches of science that treat these problems, must also be different. Mathematical linguistics must establish as its purpose not only the creation of models corresponding to the conditions familiar to us from the first works of Chomsky (to generate [= account for] all labeled phrases of a given L^N and only them, and to assign to them structural characteristics that are not in contradiction with our intuition) but also, as is agreed upon by most specialists in the field today, the description of the mechanism linking sound and meaning in the act of speech (i.e., the process of objective understanding).

On the other hand, the theory of MT (which is a branch of the semiotic theory of translation, not of computational linguistics) must construct models describing the process of selective understanding, that is, in the first place, of the collection of $I(T_n)$, making use of the achievements of mathematical linguistics in doing this.

Let us note that all our reasoning is based on an examination of the process of understanding and, consequently, on an examination of the process of generation in language communication (e.g., multiple synthesis) and of translation, that is, of synthesis.

It follows from the above that those who want researchers in the field of MT to construct general linguistic models rather than models of the translation process are setting them a task different from the one that has to be fulfilled for the achievement of MT.

Of course, a solution of the problems of mathematical linguistics would also bring with it a solution of the problems of MT. But it does not follow (and this could be confirmed by many examples from the development of the so-called exact sciences) that the latter must be absorbed into the former. There are processes of translation taking place in the mind of the translator that are different from the process of monolingual communication. One of the tasks of modern science, inspired by the great aims of cybernetics, is the modeling of all the processes that take place in the creative human mind. This modeling must, in observance of the rules set forth by Descartes, move from the simpler to the more complex. An absorption of the problems of translation into the general problems of mathematical linguistics not only violates these principles but, as is shown by current practice, leads to undesirable results. It should not be forgotten, either, that the modeling of the specific process of translation between two natural languages has not only utilitarian but also deep theoretical significance that could be useful for the fulfillment of the objective of mathematical linguistics as well.

2. The tendency, characteristic of the global strategy, to transfer and recode *all* units of the input communication to the deepest level, passing successively from one level to the next (a tendency which may be said to contribute to a certain extent to the solution of the basic problem of mathematical linguistics—the modeling of the mechanism linking meaning to sound), does not correspond exactly to the mechanism of the translation process, which, as was pointed out earlier, does not conform to this linear scheme. In the translation process only *some* components are transferred, in the course of which the depth of the level to which they are transferred also varies with the different language pairs. All this shows that the modeling of analysis in MT as a strict sequence of the recoding and transfer of the meanings of *all* elements of the input communication to the deepest level is not based on the specific characteristics of the translation process itself. Rather, this type of modeling ignores its selective character and is brought in from outside for the very reason that the models required for MT are equated with the models of mathematical linguistics.

This mechanical transfer can be illustrated by the following example, among others. It is almost universally accepted that in word-for-word MT, based on contextual analysis at a lexicomorphological level, the deep syntactic and semantic connections are not taken into consideration. But I cannot agree to this because the analysis of the context, even on the level of elementary syntagms (classes of words), is a syntactic analysis par excellence, which also takes into consideration their

valence as determined by semantics. The difference lies in the fact that in this case these deep connections are established and described on a more superficial level and not in the terms of the syntactic models of mathematical linguistics that we are familiar with. It goes without saying that the way of establishing and describing a given connection or relation does not have any effect on its nature.

3. The conduct of the analysis only within the frameworks of the units of each level, without a contextual analysis of the level, likewise is in contradiction with the "selective" character of the analysis in human translation. It is not difficult to show that the process of analysis represents the totality of the processes of translation. If this is so, then these processes likewise have a "selective" character. Thus, it follows that the analysis of each unit on a given level within the framework of only this unit without contextual analysis, as well as the transfer of all other unsolved difficulties to deeper levels, does not correspond to the reality of the translation process. On the basis of the above and adding to the two previously mentioned criteria of optimality (the adequacy and simplicity of translation) an additional one (the degree to which the human translation process has been modeled), we come to the conclusion that neither the three basic principles of the global strategies nor these strategies themselves are optimal.

IV

This closing part will be devoted to the basic principles of the *selective* strategy of MT which I propose on the basis of the selective character of human translation.

1. The linguistic mechanism by means of which the process of translation from one language into another is carried out does not correspond exactly to the linguistic mechanism of monolingual communication.

2. The work connected with the algorithmization of the translation process must be carried out deductively; it must be based on the previous determination of the composition and volume of $I(T_n)$ about a given language pair. The MT work carried out on other language pairs will lead to the gradual increase and further specification of $I(T_n)$, and hence of the categories of the corresponding intermediate language as well.

3. In algorithmizing the translation process at all levels, one should keep in mind its linguistically "selective" character.

4. In the solution of MT problems on the basis of the achievements of modern linguistics (both conventional and mathematical), we should not take as our point of departure the extent of knowledge of language in general which is necessary from the point of view of theoretical linguistics, nor should we equate the generative and recognition models of mathematical linguistics with the analysis and synthesis models of MT. Rather, we should base our work on the knowledge of the two specific languages in question and the particular character of their relationship, as required for the organization of the process of collecting the $I(T_n)$ for a given language pair and for the classes of input texts to which the research is limited, on the basis of which special models are created.

5. The basic type, the logic, and the power of the models describing the different levels of language (as well as the power and the categories of the intermediate language) should be defined deductively. One should follow as a guiding principle the specific character of the translation process and the requirement of the collection of $I(T_n)$: these features should not be adopted as they stand from mathematical linguistics. The approach proposed here would gradually create the prerequisites for the development of a "grammar for the translator." (From a logical point of view this possibility is confirmed by the experiments devoted to the creation of a "grammar of the hearer." The exploration of this idea must, however, be left for the future.)

6. Analysis (as well as synthesis) should be modeled as a system of interlevel translations and should be carried out not only in "depth" and "breadth" but also "upward," and each of the stages should be subjected to the principle of selectivity. In the process *(a)* the difficulties of the *deeper* levels should be transformed, as far as this proves possible, into difficulties closer to the surface, in order to be solved by means of simpler types of analysis, and *(b)* not all elements of the input information should be transferred to all deeper levels, but only those creating difficulties in the collection of $I(T_n)$ with a given language pair on a given level, and only in those cases where these difficulties cannot be solved on the given level. Nor should they be transferred as a result of analysis within the framework of only the units of this level, or by means of a contextual analysis on this level, or by means of being transformed into difficulties of the levels closer to the surface.

One of the typical features of this strategy, whose fruitfulness is confirmed by the practical work in machine translation carried out by the Sofia group [22], consists in the transformation of difficulties of the deeper levels into difficulties of the levels closer to the surface and in their solution by means of a simpler type of analysis characteristic of the level. It is here that the similarities between this strategy and Garvin's "fulcrum" approach become apparent.

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Summing up my argument so far, it can be asserted that the current critical state of MT research throughout the world, although much has happened that legitimately causes well-grounded anxieties and doubts as to its possibilities, is due to a certain degree to the maximalistic tendencies, however laudable they may be in themselves, of the global strategy. By giving due consideration to the particular characteristics of the translation process and of its study, as well as to the differentiation of the aims of mathematical linguistics from the theory of MT and of the fields of competence and performance

from each other, research in this field would be channeled in a direction both more realistic for our time and more closely in accord with the facts.

Received September 14, 1968
Revised January 30, 1969

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