

The Fulcrum Approach — Twelve Years Later

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The Fulcrum method developed by the author 12 years ago is reviewed in retrospective. The main concept is fulcrums — sentence elements which serve as basic points for analysis, the main procedure is the pass method. The first, simplified version was computerized, the second, having an heuristic component, was ready for realisation. Arguments are given for the theoretical and practical value of the approach. The importance of practically oriented approaches to MT is emphasized.

When machine translation research began in the United States in the middle 50's, it was considered — at least by some linguists — an extraordinary opportunity for linguistics to show its mettle. About a decade later, the late Uriel Weinreich, in the first of his lectures in the trends in linguistics lecture series at the Indiana University Linguistic Institute on July 13, 1964, referred to machine translation as 'linguistics' most conspicuous and expensive failure*', a statement which I interpret to mean that he thought what the late Yehoshua Bar-Hillel called 'fully automatic high quality machine translation' was in principle unachievable. Not long after that, an official evaluation committee of the United States Government, more specifically, the Automatic Language Processing Advisory Committee of the National Academy of Sciences — National Research Council, gave its formal seal of approval to the Weinreich statement. In its report [2] it stated that 'no one can guarantee, of course, that we will not suddenly or at least quickly attain machine translation, but we feel that this is very unlikely'. This marks the beginning of the end of scholarly machine translation research in the United States. My own machine translation project at The Bunker-Ramo Corporation was terminated in 1967 for lack of funds; ironically, this was soon after the exhilarating experience of participating in the 3rd All-Union Conference on Machine Translation in Yerevan, USSR. Gradually, the linguistic profession lost all interest in machine translation. Today most linguists in the United States regard machine translation as unattainable, or even worse, uninteresting. For one who never made extravagant claims in the beginning of machine translation research, and who—on the other hand — never doubted the ultimate rationality of it as both a research objective and a practical task, this is perhaps now a good time for looking back.

Let me first make clear that, although I am — through no fault of my own — no longer actively engaged in machine translation research, I have not lost my interest in the question as an intellectual challenge, nor have I found reason to change my basic point of view with

regard to the research direction in which I was engaged in my active days as a machine translator. In the following, I shall first present a brief recapitulation of the principles of the Fulcrum Approach which I have advocated and which I still endorse. I shall then conclude by stating some of the reasons why I haven't changed my mind about it..

PRINCIPLES OF THE FULCRUM APPROACH*

1. The Fulcrum Approach is problem-solving rather than theory-oriented. This means that it aims directly for a solution of translation problems by computational means through utilisation of linguistic and systems know-how, rather than first trying to develop a theoretical 'understanding' of the translation process and then applying this understanding through some form of computer implementation. As a result, the Fulcrum Approach has from the beginning been concerned with developing specific translation programs going from one particular language to another, rather than attempting to come up with some theoretical schema for a universal translation system applicable to any pair of languages whatsoever in any direction. Given the circumstances under which this development was initiated, the research was concerned with translating Russian into English. Furthermore, it was clear from the beginning that only translation of stylistically neutral texts such as technical writing, could be seriously contemplated for the time being—although, of course, the possibility of ultimately dealing with less straight-forward texts was never theoretically excluded.

2. In developing the design principles for a machine translation system, the primacy of recognition over generation was accepted from the very outset. Clearly, without first recognising the structure and content of the source language text, the data upon which to base the generation of the target language text would not be available. Thus, the main portion of a system based

* This statement was not included in the published version of his lecture [1].

* For a more detailed discussion of these principles see [3]

on the Fulcrum Approach would consist of an automated linguistic pattern recognition program which operated on the basis of graduated context searching. That is, the information necessary for recognising linguistic patterns was first searched for in the immediate context, and only if this first search could not provide the required information would increasingly more remote contextual searches be undertaken. These searches were implemented by incorporating appropriate search instructions into the program rather than trying to operate with a generalised algorithm and language specific grammar tables as was done in other efforts of the period. The search instructions were of course based on a particular understanding of the grammar of the source language (which, as already noted, in our case was Russian); these instructions operated upon coded linguistic information which — as is common in most language data processing operations, not just machine translation — were stored in a machine dictionary together with the verbal dictionary entries that they accompany. The coded linguistic information was intended to provide all of the translationally relevant grammatical and semantic possibilities associated with each dictionary entry. Once again, this was based on a particular understanding of the linguistic structure of the source language and, particularly in the case of possible translation equivalence, the relation between the source language and the target language.

3. The principle of graduated context searching was implemented through two basic design features: the notion of the Fulcrum, and the pass method. The notion of the Fulcrum is based on the insight that not all of the elements of a text carry the same amount of translationally relevant information — thus, the predicate of a sentence by virtue of its agreement and government characteristics will tell you more about possible accompanying nominal structures than conversely: it is therefore desirable for the recognition program to address first those elements of the text that convey the maximum of information (the Fulcra), and then branch out from these to retrieve the remaining necessary information (in the example cited above, the predicate of a sentence would be its Fulcrum and hence addressed first, and then the program would direct its searches at the accompanying nominal structures such as possible subjects, objects or complements).

The pass method is the design feature most directly concerned with graduated context searching. It is based on the recognition that the information elements of interest to the translation process cannot be accessed at once but must be accessed in some reasonable order of both availability and importance. Thus, the information available in the immediate context and processable without the acquisition of previous information should be accessed first, and information in a more remote context and requiring possession of previous information should be accessed later. This gradual acquisition of information can best be achieved by implementing a series of passes at the sentence; each of these will be concerned with increasingly more remote and more complex kinds of information in the order considered most conducive to a successful search. Thus, before the predicate and accompanying nominal structures of a clause can be recognised, it is necessary to have prior recognition of the individual phrases that compose these clause constituents —

hence, before a clause recognition pass can be implemented, previous passes have to achieve recognition of the individual constituent phrases. Since there is much more sentences in natural text than just phrases entering into clauses, a good number of passes are required in order to collect all the information that is necessary for the recognition of each sentence.

4. To allow identification of linguistically significant textual elements, the program must be able to operate with appropriate linguistic recognition signals; in the case of a source language like Russian, the most important recognition signals are the inflectional affixes which, together with relevant word class information, allow useful inferences as to the possible syntactic function of each word in the sentence. The retrieval of this recognition information must be organised in terms of an effective order of search rather than in terms of some theoretically based principle of hierarchisation of language, although, of course, a theoretical conception of the nature of language underlies the Fulcrum Approach, together with the empirically oriented linguistic research needed to provide the information on which to base development of the recognition program.

5. Given that there is no guarantee that the recognition program will correctly recognise all the linguistic patterns contained in a given source language text, a special heuristic component was developed for the latest version of the Fulcrum Approach which was designed to ascertain whether all the necessary analytic decisions were made, and whether they were made correctly. The basis for this heuristic component was the understanding that certain linguistic relations are mandatory and that, therefore, if the recognition program has not correctly identified such structures, it has produced a mistaken analysis which is in need of correction. Thus, for instance, if a verb in a predicate is mandatorily transitive, and if the recognition program has not identified the appropriate object that fits the government properties of this word, then an analytic mistake has occurred which must be corrected. This requires, first of all, that such mandatory relations be included in the coded linguistic information that is carried in the machine dictionary; the correction of a mistaken analysis is based on the assumption that the kind of ambiguity resolution which might have occurred on the basis of the immediate context (and which ordinarily would be given priority in terms of graduated context searching), would have to be revised on the basis of the mandatory relations that the mistaken analysis has failed to identify. An example are the many cases in which a Russian nominal affix can function as either a genitive or an accusative; very often this ambiguity will be resolved as genitive on the basis of the immediate context (for instance, if a noun with such an ambiguous affix follows another noun); however, if for instance a mandatorily transitive verb governing the accusative is present in the sentence and the recognition program has not identified an object governed by it, then the ambiguous case suffix of the earlier recognized noun would have to be re-labelled in light of this new information so that an accusative noun can now be assigned as object to the mandatorily transitive verb.

6. Two consecutive versions of the Fulcrum Approach were developed. The earlier one, Fulcrum I, had a somewhat simplified pass method and lacked a heuristic

component. It was, however, implemented computationally through an experimental program which produced some sample translations that were judged of almost acceptable quality. The later version, Fulcrum II, included all the features noted in the preceding section, as well as some rather sophisticated principles for the generation of the English target text. Thus, it contained a greatly more sophisticated pass method and better defined fulcrum. It also included a heuristic component. It was developed conceptually to the point where computer implementation could be seriously considered; at that point, funding was discontinued and the research team concerned with developing the Fulcrum Approach had to turn to other tasks.

7. The principles discussed so far are adequate to produce translation based on the information contained in individual sentences. Some thought was also given to the additional principles required for dealing with ambiguities the resolution of which requires information beyond the bounds of the individual sentence, and for ensuring textual continuity. Thus, textual content information of the sort required for information retrieval could be kept in an ongoing antecedent storage and utilised for resolution of complex ambiguities and maintenance of contextual continuities. However, these principles were not developed to the same extent as the ones discussed in the earlier paragraphs.

8. Questions of computational efficiency, such as the development of modularised subroutines for the performance of certain standardised search tasks, were also addressed in the course of the work on Fulcrum II. Thus, the stage was in fact set for implementation.

TWELVE YEARS LATER

In retrospect, the basic question is how the Fulcrum Approach can be evaluated. Clearly, since its latest version was never implemented computationally, one cannot take its translation output and judge the quality of the program by it. The only possible assessment is in purely intellectual terms: the question that can be asked is whether the Fulcrum Approach is still conceptually valid and whether — given favorable circumstances — it is worth implementing.

The difficulty with such a purely intellectual assessment is that it depends largely on the epistemological stance of the assessor. Even if I had given a significantly more detailed description of the Fulcrum Approach than the brief outline which I have presented, I am certain that many of my colleagues would remain highly skeptical because of their commitment to a different theoretical and epistemological stance from mine. Thus, all I can do in this regard is repeat my initial statement, namely, that I have not changed by mind about the Fulcrum Approach. Other than that, I can only adduce a few arguments which have confirmed me in my convictions, but may very well be as unconvincing to others as my original arguments were at the time when

I was actively developing the Fulcrum Approach. There are as it stands now only three major points worth making: one negative one and two positive ones.

The negative point is that, at least to my knowledge, no other approach has so far produced any machine translation output worth bragging about. While this does not say anything about the Fulcrum Approach, it certainly does say that other approaches have not done sufficiently better for me to change my mind about the Fulcrum.

The two positive points have to do with features of the Fulcrum Approach that have since been independently 'reinvented' and incorporated in other approaches, one computational and one purely conceptual.

1. The principle of including the grammatical information in the algorithm itself rather than separating algorithm from a grammar table has since been applied in some recent approaches to automatic parsing in artificial intelligence research.

2. The notion of the Fulcrum has since found its analog in some theoretical interpretations of human sentence recognition in psycholinguistics. The earlier notion of sentence recognition through 'analysis by synthesis' has here given way to the notion of 'recognition strategies' that operate around pivotal points within the sentence serving as anchors for the processing of the linguistic information — the parallel to the Fulcrum is unmistakable.

All of this is, of course, quite inconclusive. While it is flattering to have some form of corroboration — no matter how indirect — of the validity of one's approach, it is clearly far from definitive.

Nevertheless, the basic question — at least my opinion — has not changed. It is not whether machine translation is possible or not, but rather what is the best way of accomplishing it. And here again, I can only repeat the opinion I voiced at the beginning of this paper as well as on many previous occasions: machine translation is a problem to be solved and not a theory to be constructed; consequently, only a problem-solving approach such as the one I have been advocating can be expected to yield worthwhile results in the long term.

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