A Future for Machine Translation

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Abstract

It was realized, in the 1960's, that the production of fully automatic, high quality translations by computer was a problem of immense difficulty, if not impossible. The use of computers as an aid to the human translator was recognized to be technically feasible but, in practice, was not economically viable, largely because of the cost of key punching and the slowness of the response.

Recent developments have changed this picture significantly. Social, political and economic changes have resulted in an increased demand for translations and the cost of providing translation services has increased dramatically. The widespread and increasing use of word processors means that many of the documents which have to be translated are already available in machine readable form. Research work in machine translation and other aspects of natural language processing has shown that, provided the subject matter of the documents is suitably circumscribed, it is possible to produce translations which require comparatively little editing.

All these facts suggest that it should now be technically feasible to produce machine translation systems working in tandem with word processing systems, which would produce economically attractive gains in the productivity of human transators. Such systems would only be capable of operating over a limited range of subject matter, but expert system technology offers attractive possibilities for tailoring translation systems to new areas of discourse.

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1. INTRODUCTION

As is well known, research in machine translation was triggered by a memorandum written by Warren Weaver in 1949. Early demonstrations of simple systems were sufficiently convincing to encourage various agencies of the United States government to make large sums of money available to research teams. Some of this money was channelled to research teams in Europe and some money was also made available by European governments; nevertheless, the vast bulk of the research effort was located in the United States.

Despite the large amount of effort expended, no completely satisfactory results were forthcoming and, in 1964, the funding agencies caused the National Science Foundation to set up a committee to survey the field of machine translation research. The committee was known as ALPAC (Automatic Language Processing Advisory Committee) and it reported in 1966.

The ALPAC report [1] criticized existing machine translation systems for being slower, more expensive and less accurate than manual translation and could see little prospect of useful machine translation systems being produced. It advised against any further investment in machine translation systems in the United States but recommended the development of machine aids for translators and continued support for general research in the area of computational linguistics.

The publication of the ALPAC reported had a devastating effect on machine translation research in the United States. It also, unfortunately, had a severe effect on such research in other countries. The perceived need for machine translation in the United States was largely limited to translation of scientific material for a comparatively small number of users. The economic and social conditions surrounding the translation activity are completely different in Canada and in the European Community and the need for machine translation is correspondingly greater.

Much the most successful of the early machine translation systems was the Georgetown Russian to English system [2], [3], installed

in 1964 at the Oak Ridge National Laboratory and at Euratom in Ispra, Italy. SYSTRAN [4], a much improved version of the original Georgetown system is in use at a number of sites and was used by NASA for the Apollo-Soyuz project. An English to French version of SYSTRAN has been evaluated for the Commission of the European Communities (see section 3.1 below).

With the benefit of hindsight, one can pinpoint the following major reasons for the failure of early machine translation systems:

- the systems were too ambitious both in the choice of difficult source languages (e.g. Russian) and attempting to cover too wide a range of source material (e.g. all scientific and technical writings);
- the systems were written as huge, monolithic programs with grammatical rules embedded in the code;
- the systems were linguistically naive both in failing to take into account appropriate linguistic theory and in failing to appreciate the subtlety of the translation process;
- the appropriate technological environment was not available at the time that the systems were developed;
- the systems were not designed to operate in an appropriate economic environment.

In this paper we shall attempt to show that none of these problems necessarily apply to modern machine assisted translation systems.

RECENT DEVELOPMENTS

1 Developments in Computer Technology

The development of VLSI technology, of Winchester disc technology and of cheap terminals and cheap, high quality printers have together led to the widespread use of word processing systems. This single factor contributes a great deal to the economic viability of machine assisted translation systems since many of the documents to be translated will already be in machine readable form. These same advances in technology also mean that a word

processor system can be enhanced to provide the computational power and storage capacity necessary for a machine assisted translation system at comparatively little cost.

On the software side, there have been important developments in software tools (including programming languages) which have made it much easier to build large software systems. In particular, the importance of modularity in ensuring the robustness and maintainability of such systems is now almost universally acknowledged. Machine translation systems are large and complicated and, at least in the early part of their life cycle, need extensive maintenance. The lessons of software engineering have been taken to heart and modern machine translation systems are much more robust and much more easily maintainable than their predecessors.

2.2 Developments in Computational Linguistics

From the point of view of practical machine translation systems, the most important developments have been in morphological analysis and syntactic analysis. A number of tried and proven techniques are available and this area should no longer present any difficulty, although, of course, the preparation of the grammars used to drive the analysers remains both difficult and time consuming.

Typical of these techniques is the parser developed by Wood [5], [6], based on the use of augmented transition networks (ATN) to represent both the morphological and syntactic components of the grammar. The ATN representation is described in [7], [8], [9] and [10]. Apart from its use in machine translation systems, this technique has also been extensively used in artificial intelligence work based on the understanding of natural language.

Wood's parser is well documented and the ATN representation of a grammar seems very easy to work with. In particular, ATN's provide a type of 'subroutining' feature which leads to a well modularized grammar.

2.3 TAUM (Traduction Automatique de l'Université de Montréal)

The TAUM project has a long history; it has been supported by the Canadian government since 1962. The outstanding achievement of

this group is the system Météo [11], [12], which has been in daily operational use since 1977 for translating Canadian meteorological bulletins from English into French. It is reported in [12] that the time required for a translator to produce the translation of a bulletin has been reduced from between 30 and 40 minutes using purely manual methods to an average of 3.8 minutes using the interactive Meteo system. Again according to [12], the prototype system was developed by the TAUM team in the University of Montreal but the operational system was developed from this by a commercial organization. At present the system runs on a large mainframe but plans are under consideration to transfer the system to a dedicated micro-processor.

The TAUM team are at present engaged in the development of a system for translating aircraft hydraulic circuit maintenance manuals from English to French; this project is known as Projet Aviation [13], [14].

2.4 The PAHO (Pan American Health Organization) System

This system, described in [15], was developed for the Pan American Health Organization by a team from Georgetown University and the Tabar Corporation. It translates documents in the public health and medical fields from English into Spanish and vice versa; its approach is based on the Xonics system [16] for translation between Russian and English. The system runs on IBM 370 series computers and is not interactive; it is programmed in PL/I.

So far as can be ascertained from the limited documentation available, the system presents little in the way of technical novelty. Its interest in the present context lies first in the quality of the translation produced and secondly in the way in which it has been engineered.

From the sample given in [15], it appears that the quality of the translation is good. In 222 words of English translation produced by the system, 15 changes are necessary. About half of these involve merely inserting or deleting the definite article in cases

where Spanish idiomatic usage differs from English. (Spanish, like Italian, requires the definite article before the name of a company or organization, for example, and this is incorrect in English; thus 'la Fiat' must be translated as 'Fiat'.)

A second source of error arises from the Spanish relative clause construction which permits the following word order:

'la colaboracion que presta el Incap a los gobiernos'.

The word order must be reversed in English:

'the assistance which Incap provides to the governments';

the order

'the assistance which provides Incap to the governments'

is completely incorrect.

A third source of error in the sample is the need to insert subject pronouns, which are usually suppressed in Spanish, as they are in Italian.

The remainder of the errors in the sample are mistranslations. In no case is the translation misleading; the words chosen are merely unidiomatic in the context.

On the basis of this sample, there can be little doubt that the PAHO system would provide a very substantial increase in the productivity of a human translator. It is also clear that the quality of the translation is due in large measure to the limited range of documents which it is intended to handle.

While the PAHO system suffers ergonomically (and economically) from being a batch system run on a mainframe, a serious attempt has been made to produce a satisfactorily usable system. This is especially apparent in the facilities provided for dictionary maintenance. Of particular interest is the feature which allows a preliminary scan to be made over a text in order to identify words not in the dictionary. Such words can then be inserted into the dictionary before the translation run is carried out.

Also of some interest are the figures given for speed and memory occupancy for the PAHO system. The figures quoted in [15] show an average of 4.8 cpu seconds per 100 words on a 370/148; 176Kb of memory are required to run the Spanish to English translation programs, all dictionaries being held on disc.

2.5 Commercially Available Systems

Several systems are reported to be available commercially but the only one about which we have any details is the system developed by Weidner and marketed in the U.K. by Hamilton Rentals. This system runs on PDP11 computers and is claimed to translate in both directions between English and any of French, German and Spanish as well as translating from English into Portuguese and Arabic. Other languages are being developed and so is a VAX implementation.

The most interesting aspect of this system is its environment. Input to the system can come from a word processing system and its output can be directed to a type setting system. The translation system itself can be used interactively and incorporates a sophisticated editing capability, including such features as highlighting words for which alternative translations are available. It seems clear that such a machine environment is likely to maximize the economic benefits which can be derived from a machine-assisted translation system.

So far as can be gathered from a few samples of translations from English into French carried out by the system, the quality of the translation is a little disappointing. On average, about one word in twenty needs to be changed. These errors are due to failure of the grammatical analysis rather than to incorrect translation of individual words. Thus

'one of the president's tasks will be ...'

is translated into

'un des presidents que les taches seront ...'

Despite these faults, the system is impressive.

3. FUTURE SYSTEMS

Within the next few years we shall certainly see existing machine assisted translation systems coming into wider use and further systems being developed. Such systems are likely to be interactive and linked to word processing and computer typesetting systems, along the lines of the Weidner system. The feasibility, both economic and technical, of such systems will depend on the characteristics of the environment for which they are designed; in any event, their performance will be restricted by certain important limitations. Broadly speaking, the characteristics of the environment in which the systems are used can be divided into linguistic ones, which serve to determine technical feasibility, and non-linguistic ones, which affect the economic feasibility.

3.1 Non-linguistic Characteristics

The ideal environment for a machine assisted translation system would have the following characteristics:

(i) the input is already available in machine readable form and the output is needed in this form.

(ii) a substantial body of material has to be translated on a regular basis so that present manual methods are extremely costly and, further, the amount of material to be translated is expected to increase.

(iii) the translators involved are already accustomed to the use of word processors and are therefore likely to be able and willing to adapt to the new system with little difficulty.

The effect of (i) is to eliminate the potentially high cost of keyboarding the source material; the effect of (ii) is to ensure that an increase in the productivity of the human translators will result in significant financial savings while (iii) ensures human factors will not prevent the potential productivity gains from being fully realized. In this context it is instructive to look at the results of a study carried out on behalf of the Commission of the European Communities, reported in [17]. This study examined the cost and quality of machine translations from English into French, using

the SYSTRAN system and compared these with manually produced translations; the documents used for the tests were concerned with food science and technology.

In this study, texts were key punched, translated by SYSTRAN, revised manually and retyped. Manual translation was carried out in two stages, the original translation being revised and retyped by a second translator. So far as can be ascertained from the report, the machine translation was not of very good quality but the final product, after manual revision, was of about the same quality as the product of the completely manual translation. In the manual revision of the machine translation, it was necessary to change some 25% of the words in the translation.

The raw figures presented in the report suggest that, if we remove the costs of data preparation (some 30% of the total cost of the revised machine translations), the cost of the manually revised machine translation was between 20 and 40% of the cost of the completely manual translations and slightly less than the cost of producing unrevised translations using freelance translators. However the report suggests that the manual revision of the machine translations was carried out 'abnormally quickly' and that the costs for this should therefore be revised upwards.

The results of this study should clearly be treated with great caution. On the one hand, SYSTRAN is a rather old-fashioned, general purpose translation system and English is a difficult language from which to translate automatically; we therefore expect to be able to produce very substantially better translations than SYSTRAN, with less than 5% of words needing changing. On the other hand, the costings in the study seem to be based purely on the operational costs of SYSTRAN with development costs completely ignored (although this is not stated explicitly).

3.2 Linguistic Characteristics

It is important that the documents to be translated are linguistically fairly homogeneous; such homogeneity would be found, for example, in motor car maintenance manuals or bureaucratic directives in agriculture. This has many significant consequences:

- the number of items in the dictionary is limited;
- the morphological variety is reduced (the French past definite is unlikely to be found in a maintenance manual, for example);
- the range of possible syntactic structures is limited, thus reducing the size and complexity of the grammar;
- much ambiguity is removed because many source language terms which have several possible target language equivalents in general, will have only one equivalent in this context;
- comparatively few idioms are used.

None of the above serve to reduce the theoretical difficulty of machine translation, but the total practical effect is very considerable in that the much reduced complexity of the system renders it so much more manageable.

It is important also that the source language and the target language are reasonably closely related. In practice this means that many concepts, such as active and passive, are applicable to both languages. The closer the relationship, the easier it is to translate between the languages, whether manually or by machine: to translate from Spanish to Italian is very easy, to translate from Navajo to Chinese is rather difficult.

Machine translation is facilitated if the source language possesses a well developed system of inflections and grammatical agreement since this serves to eliminate many potential ambiguities. It is the lack of this which makes English a rather awkward source language to handle.

3.3 Limitations

While every system will have its own set of limitations, we can point out some of the limitations which are likely to be common to all systems for some time to come.

In Italian and Spanish, the subject pronoun is normally suppressed except where required for emphasis. In English it is always required. A problem arises when the verb is in the third person

singular, because the suppressed subject pronoun could correspond to any of the English pronouns 'he', 'she', 'it' or 'you'. It is not sufficient to refer back to the subject of the previous main verb as the following example shows:

> 'La FC viene assegnata dall' utente; deve assicurarsi che non e gia in uso.'

Clearly the pronoun subject of 'deve' refers to 'utente' not to 'FC'.

The reflexive is a widely used and very powerful construction in the Romance languages which has no single equivalent in English. Consider the following pairs of Italian sentences and their idiomatic English translations:

'La macchina si è spenta'	'The machine has switched itself off'
'La macchina si spegne tramite l'interruttore A'	'The machine is switched off by means of the switch A'
'La macchina si è fermata'	'The machine has stopped'

These examples show the three different ways in which the Italian reflexive may be translated: English reflexive, English passive and English active. Furthermore, the first two examples show that the same Italian reflexive verb may need translating by different English constructions in different contexts.

The correct idiomatic translation of prepositions is always a source of difficulty, since no two languages exhibit the same patterns of usage. Similar difficulties occur with the use of articles.

As a target language, English presents difficulties because of its aspectual system. Of the Western European languages, only Welsh has a system which is in any way comparable. In consequence, misuse of English aspects has become a characteristic of the non-native speaker. Machine translation systems suffer the same difficulties.

In the long term, it may well be that inferential techniques from other areas of artificial intelligence can be used to alleviate these problems. It may be possible to identify contextual markers whose presence or absence affects the probability of a given translation being appropriate. (The presence of the French adverb 'hier', for

example, increases the probability that the appropriate translation of the French perfect tense will be the English simple past.)
The technology used for constructing knowledge bases may also prove useful in tailoring machine assisted translation systems to specific areas.

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