# MACHINE TRANSLATION IN EUROPE

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## INTRODUCTION

Whereas in the United States work in machine translation (MT) has only recently been reinstated as a 'respectable' natural language processing (NLP) application, it has long been considered a worthwhile and interesting topic for research and development in both Europe and Japan. In terms of number of projects in one sub-field of computational linguistics, MT is currently perhaps the most important application.[1] One obvious reason for this is simply the daily awareness that people communicate in languages other than English, a situation that naturally encourages an interest in translation. On a practical level, for example, every television cable system in Europe broadcasts stations from numerous countries, and on the political level, the European Community (EC) is committed to protecting the language of each of the Member States, which implies providing numerous translation services. From an economic viewpoint, every company knows that in order to market its products, the documentation must be in the language of the target country. And a last motivation for interest in MT, which was also the origin of MT activities in the US and an important concern for Japan, is the desire for better access to information—important documents often exist in some foreign language.

Yet MT in Europe is not viewed as just a matter of developing working MT systems for commercial and practical needs—it is also accepted as a legitimate topic of research. The view of MT as a test bed for NLP work has long been defended in the United States (Kay,1980). Reasons why this position has only recently gained favor can be attributed to Bar-Hillel's strong view on the impossibility of high-quality MT coupled with the far-reaching effects the ALPAC report (1966) had on funding in the US. All direct funding for translation was withdrawn and redirected to more basic research and thus linguistics and AI work prospered. Though practical work continued, as well as a real need for translation,[2] MT fell into disrepute as an academically respectable enterprise. While there is consensus that fully automatic high quality MT of unrestricted text is impossible, it is nevertheless an attractive long-term goal, similar to pursuits in artificial intelligence. In Europe, a growing number of researchers in computational linguistics regard translation as a challenging field of application. Based on developments in the field such as a more rigorous formalization of semantics (e.g., Montague grammar), the attention paid to formal and computational properties of linguistic theories (e.g., LFG and GPSG) and the definition and implementation of linguistically problem-oriented computational methods (e.g., unification), it is quite natural that attempts are being made to test their adequacy with regard to problems of translation.

The multilingual setting of Europe, where translation is a fact of life, along with its varied and decentralized funding agencies (including EC, national and regional programs), as opposed to the more centralized nature of US federal agencies, helps explain why the ALPAC report had less of an impact overseas. Machine translation has a long and relatively stable tradition in Europe. Similar to the early work with computers and language in the United States where CL and MT were synonymous, MT projects in Europe have served as a vehicle for developing expertise in computational linguistics in centers which had little experience in the field. This latter point is particularly true in the Eurotra project; Greece, for example, had no tradition in computational linguistics.

The historical and socio-political references have been introduced as background material, given the rather strong positions taken up by members in and out of the community over the last decades. The distinction between research and development or theoretical vs. practical, though somewhat artificial (and definitely a touchy issue in the community), serves as a means of clarifying and motivating what people are working on and why. The extreme view repeatedly put forward by M. Kay that "all machine translation of natural languages is experimental ..." (Kay, 1984:75) is, in my view, correct. There are nevertheless things that we can accomplish, albeit imperfectly, and from which we can learn both about language and about translation—a situation similar to all NLP work. My purpose here is to distinguish major topics currently popular in MT work and to identify the projects and centers active in the field.

## WHAT IS SPECIFIC TO MACHINE TRANSLATION

Bar-Hillel (1964:212), in one of his numerous papers on translation, identified the following five prerequisites for high quality human translation:

(1) competent mastery of the source language,
(2) competent mastery of the target language,
(3) good general background knowledge,
(4) expertness in the field,
(5) intelligence (know-how).

1 At the two most recent Coling conferences, for example, the number of papers devoted to issues in MT constituted the largest single topic; and this figure does not take into account all the general NLP papers presented by the MT projects.

2 Ironically, the Georgetown system, on which the ALPAC report was based, continued to be used in Europe, until well into the 70s and Systran, a direct descendant, is still the most widely used commercial MT system.

For MT, the first four are obviously necessary and moreover, remain research topics for NLP in general. The last point could simply be replaced by 'the ability to establish a correspondence between the source and target language.' For humans, it is well-known that bilinguals are not necessarily good translators, and discussing intelligence in the context of MT (given the lack of any theory of translation and the current relatively undeveloped state of the art) would only lead to philosophical speculation. Perspectives on combining Artificial Intelligence (AI) and MT can be found in the numerous discussions by Wilks (e.g., Wilks, 1973), mentioned here in view of his long history in working on this topic both in the US and in Europe.

The major portion of work in any MT project is concentrated on points (1) and (2) and hence does not differ from any other NLP project except in so far as it involves descriptions of two languages. Limiting the application to a well defined semantic domain or specific corpus reflects the concern for points (3) and (4). One proposal addressing (4) explicitly is to include expert system modules in addition to linguistic rules (Boitet & Gerber, 1984) or to divide the system into expert tasks (Johnson & Whitelock, 1985). In this perspective, MT can thus be viewed as a sub-field of NLP which in some cases, also means incorporating general AI techniques.

A number of topics specific to MT can be identified, though some of them may be shared by a portion of the CL community, albeit for different reasons. For example, the adequate level(s) of representation, will be determined in MT by the ability to express the relevant facts about two natural languages and to state the translation relation between them; similarly, in a database query system, the concern is to map between two representations where one is an abstraction of the natural language expression but the other is an expression in a formal query language (which has already been defined).

Current issues which often figure in the literature and which we will look at in somewhat more detail are:

- bilingual lexicography (describing words and their translations)
- bilingual concordancing (using texts and their translations)
- level(s) of representation (the types of information and their notation)
- transfer mechanisms (mapping between representations)
- reversibility (of grammars and of the translation relation)
- compositionality (decomposing the problem, giving a declarative definition)
- interlingual representation (abstracting away from natural language phenomena)

This list is by no means exhaustive, but every MT researcher will have at least one view on most of these topics.

Whereas in monolingual lexicography for computational applications, progress has been made on at least a subset of the basic information necessary, this is not the case in the field of bilingual lexicography (Warwick, 1987). In dictionary publishing houses (of interest as a starting point for building machine tractable dictionaries) bilingual lexicographers are seen as the poor cousins, and across any two dictionaries there is essentially no consensus on which translations should be included nor on how to code them. Each project or product has a notation so specific to the system in which it is used, that it is of little use to others. It is notable that almost all work on using machine readable dictionaries has concentrated on monolingual dictionaries, and for the most part only on English; the two European languages which have received some attention are Italian (by the center in Pisa) and German (by the Institute for the German language, IDS, Mannheim, and the IKP at the University of Bonn).

In light of this situation and given the crucial role that the lexicon plays in any system, this topic has been identified as a field in its own right. Two European initiatives, EUROTRA-7 and MULTILEX, are currently underway under the title of 'reusability of lexical resources' (McNaught, 1990). The EUROTRA-7 project (ET-7, 1990) is currently conducting a broad survey on what resources are available with a view to developing standards for mono-, bi-, and multi-lingual lexical descriptions.[3]

Another project arising from work in EUROTRA, is the EUROTRA-Lexic project whose aim is to build one bilingual dictionary adequate for human and machine needs, involving partners from the publishing, private and academic sector (Eurotra-Lexic, 1989). MULTILEX is an ESPRIT project whose aims are to develop a European multilingual and multifunctional lexicon which will be tested in prototypical applications. The Acquilex project, also funded under ESPRIT, is another project working on standards and a prototype implementation for acquiring and coding mono- and bilingual lexical information.

Bilingual concordancing is a relatively new topic which will most likely grow in importance, in parallel with the current trend to make use of large corpora. Instead of building an MT system based solely on a corpus and its translation, as reported on in Brown, et al. (1988),[4] emphasis in Europe has been on developing tools to navigate through texts as an aid for the linguist or lexicographer working on the problem of characterizing the context for the translation of words (cf. Picchi & Calzolari, 1986 and Warwick, et al., 1990). In Czechoslovakia, at the Charles University, Prague, a project has just begun to build a bilingual concordance environment for Czech and English as a first step in work on a new machine translation project (personal communication). A somewhat related project, which plans to make use of structured texts and their translations is the BSO Bilingual Knowledge Bank system (Sadler & Vendelmans, 1990). Projects in MT using statistical methods are just beginning in a number of centers, but information about these activities has not yet reached the public domain.[5]

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3 The result of this survey will be made available to the general public. Contact: Mr. R. Cenconi, CEC, B4/00s, Jean Monnet Bldg., 2920 Luxembourg.

4 Other European IBM centers may also begin projects with similar methods and goals (personal communication).

5 Two centers which have reported on such plans are the University of Stuttgart where work on alignment of texts, in view of linking not only words but also phrases, is planned, and the Rosetta project at Philips, which is considering collecting knowledge of the world for a separate semantic component by statistical methods (personal communication).

Representation issues have been at the core of machine translation since its very beginning. One of the current trends is to use existing linguistic theories as the basis for translation. One project in Stuttgart has been exploring the use of an extended LFG representation as the basis for translation (cf. Kaplan et al. (1989), also Sadler et al., 1990) whereas a project in Berlin, has taken GPSG syntactic representations as the starting point for adding additional levels (Busemann & Hauenschild, 1988).[6]

Other examples of basing MT on state of the art CL methods and theories include the use of situation schemata as the basis for translation Rupp (1989), defining transfer over 'quasi logical forms' developed at SRI, Cambridge (Alshawi et al., 1991) and derivation trees of a Montague style (Landsbergen, 1987 & Appelo, et al., 1989). The Eurotra MT project bases its work on a number of levels essentially corresponding to traditional linguistic categories, i.e., morphology, syntax, and semantic relations plus a special level for transfer known as the interface structure (Arnold, et al., 1985). These are explicit levels and a transfer mechanism allows a mapping between them (Arnold, 1987, Bech & Nygaard, 1988).[7]

The search for the ideal level of representation for expressing a translation relation raises the well known issue of transfer vs. interlingua. Almost all projects currently underway in Europe essentially rely on two independent levels, one per language, with an explicit mapping between the two. One exception is the DLT project which uses Esperanto as a pseudo interlingua (Witkam, 1988); a choice of representation which has "aroused a lot of skepticism" in the community (op cit., p.756). The one project theoretically committed to an interlingua is the Rosetta system, a project noteworthy for its theoretical commitment and steady development over the past ten years (Landsbergen, 1989). The work on multilingual generation based on conceptual hierarchies in the project Polygloss (Emele et al., 1990) may also be considered a type of interlingua system.

A very practical reason for the popularity of the transfer model, especially for systems to treat more than one language pair, stems from the inherent difficulty of defining a representation adequate for more than one natural language, especially when the competent people who might work on such an interlingua cannot work together in one place (as in the Eurotra project which is spread all over Europe). To define an interlingua for translation requires expertise in linguistics (applied to the languages in question), plus a large range of issues often labelled 'extra-linguistic,' knowledge of translation (to ensure that a mapping is possible) as well as familiarity with formalisms for representing the information (as found in much of the work in AI).

6 The German government has demonstrated an important commitment to the field of MT as well as NLP in the numerous projects and positions it has financed. The two projects are supported by the government under a program known as Eurotra related research projects (Eurotra Begleitforschung).

7 The original motivation for separate levels in the monolingual portion came in part from practical concerns that for each language some progress could be measured (e.g., each language had accounted for morphology, syntax, etc.). For the bilingual portion, this choice had a theoretical motivation, i.e., transfer as the model for translation, and the mechanism for mapping between levels was extended to distinct monolingual levels.

Two topics which have gained importance as a result of adopting a transfer model are the formalization of the transfer component and the issue of reversibility of grammars (cf. Isabelle, 1988). Reversibility of a grammatical description ensures that all necessary information has been accounted for in the representation for both parsing and generation and also defines what the output of transfer from one language to another must be. If the representation from analysis is underspecified, in a reversible description this will become apparent as overgeneration. For translation, the notion of reversibility helps to test whether the relation is symmetric, an attractive working hypothesis for a theory of translation.

The transfer mechanism in earlier work, as in older systems such as the different versions of ARIANE (Boitet, 1988), a system developed in Grenoble at one of the oldest European centers for machine translation; METAL (White, 1985), the Siemens German-English system initially developed in the States;[8] and the SUSY system (Maas, 1988), a system developed in the 1970s in Saarbruecken, was an arbitrary tree-to-tree transformation. Compositionality and declarativity have since become basic tenets as a means of overcoming the ad hoc and procedural mechanisms those systems employed (cf. Landsbergen, et al., 1989 on compositionality in the Rosetta system and des Tombe, et al., 1985 for a discussion of "relaxed compositionality" in the Eurotra framework). Current work concentrates on constraining the transfer mechanism within a well defined computational model, e.g., transfer rules are defined between feature structures and the mechanism is based on unification (cf. van Noord, et al., 1990, Russell et al., 1991 and Wedekind, 1988). Unification as the basis for MT systems serves as a basis for quite a number of MT projects in Europe (in addition to the above mentioned cf. also Carlson & Vilkuna, 1990 and Zajac, 1989); its advantages are the well understood formal aspects and the declarative nature of the rule schema for a given implementation.

As a conclusion to this section, let me mention a few outstanding topics that are under investigation in the CL literature but are noticeably absent in the MT literature in Europe. The approach to translation as more of an AI problem (cf. numerous papers by Nirenburg and Wilks) has not received much attention in Europe. This is perhaps due to the fact that MT projects are more often found in (computational) linguistic departments than computer science and AI labs. The generation work in MT has mainly concerned itself with reversibility issues and has hardly taken into account any of the work on planning, discourse, etc. I attribute this fact to the as yet ill-understood process of translation and, thus, the difficulty in defining a basis from which to generate. MT is still struggling with word, phrase and sentence translation (at best) and has therefore perhaps considered it premature to look at discourse problems. The one well-defined problem, and in many ways the most concrete, is the lexicon. Although lexical descriptions imply everything else, there is a feeling that word descriptions and their mapping to other languages can be improved gradually.

8 The system is now essentially worked on in Europe and is being extended to other European languages including French, Spanish and Dutch.

## PARTIALLY AUTOMATING THE TRANSLATION PROCESS

As automation increases and, with it, access to more and more information, the demand for translation increases. Since high-quality machine translation of unrestricted text is no solution to this problem in any foreseeable future, there is a growing trend to look for partial solutions. One option is to build yet another complete MT system such as SYSTRAN, LOGOS, or METAL (the only three viable commercial systems) with full knowledge that the output will be comprehensible, at best. These systems are useful once the lexicon has been developed and tuned for a given corpus; however, given the long development time for building such a system, they will, by definition, be based on out-dated technology. The other solution is to concentrate on those parts of the translation process that can be automated.

The topic of automating only some parts in view of using a machine to aid in the translation process has been around for a long time (Kay, 1973), often under the name machine or human assisted translation; however, concrete projects addressing a specific aspect are, for the most part, relatively recent. The major aspects currently identified within the space of what can be usefully automated are when and where to use human interaction, identifying classes of restrictions on the input language (lexical, syntactic and semantic), separating the task into sub-tasks (monolingual vs. bilingual and further breaking these down along traditional linguistic lines and according to document preparation criteria).[9]

Identifying those aspects which can be automated and working towards a solution has found interest not only from a practical point of view, but also as a theoretical exercise. Ambiguity, for example, is an important problem for any language description task. For translation work this problem is compounded in that it may arise not only during parsing,[10] but also during translation and in generation. In generation, the problem is well-known in the CL literature as the problem of natural language paraphrases arising from a given 'meaning' representation; in the context of translation, a system that produces paraphrases is not very useful without some refinement on how the paraphrases differ. Though no formalization of this exists, there is general agreement that paraphrases in a target language often represent different translations w.r.t. a given source text. Another problem for generation in MT and shared with the CL community is that of lexical choice if the representation abstracts away from words, representing them as concepts or a set of features. This problem will be apparent in the bilingual component in a transfer system and in generation in an interlingua system.

One method of controlling the analysis is by limiting the input; one very simple and successful example is the Titus system which has basically a fixed number of templates which define the syntax of the input (Ducrot, 1982). This system, which is actually a database for the textile industry that permits natural language input and provides multilingual output, is also representative of another restriction common in most NLP applications, namely, limiting the application domain. Limiting the semantic domain is common practice in the MT community. Eurotra, for example, works on a limited corpus in the domain of telecommunications and the project reported on in Alshawi, et al., 1991, is developing a lexicon for the car industry. At ISSCO, work is underway on a sublanguage consisting of avalanche bulletins, somewhat similar to the exemplary TAUM-METEO system for weather reports.

Another means of automating the translation stages, while still controlling the process, is by allowing for interaction during the various phases (Johnson & Whitelock, 1985). Interaction may be limited to the monolingual component where questions are only asked about the source text (Whitelock et al., 1986). The interest in developing authoring systems (i.e., systems where an individual writes a text in the source language with a 'guarantee' that the translation will be correct) is an attempt to assure that the analysis of the text is not ambiguous and does have a translation (McGee Wood & Chandler, 1988). Or the interaction may be included in the bilingual component, where the user is asked to choose the correct translation.

The simplest example of the latter can be found in the bilingual dictionaries offered with some word processors, often referred to as translator's workstations. Such simple tools as on-line access to both monolingual and bilingual dictionaries, editors that support multiple scrolling screens, or hyphenation and spelling checkers for more than one language are by no means a standard in normal office settings. Development of very simple tools and a basic environment may provide a basis for adding more sophisticated components incrementally. Work in MT proper vs. work on environments for translators are essentially carried out in two different communities. Only the commercial systems have up to present taken the latter topic seriously; this situation is changing as more of the funding for research moves to the private sector.

## CONCLUSION

In presenting major themes in current MT work, a number of programs and activities have not received adequate attention. In particular the European activities planned as a follow-up to the Eurotra project, especially since the major portion of EC funding for MT has gone to this project which will end in 1992. For this phase, a number of sub-projects are currently under way, including the definition of a new formalism (that will be closer to standard unification systems) and tools for a better computational linguistic research environment. Plans or follow-up work have recognized the need for more basic research in all topics known to the CL community, but with emphasis on considering solutions in terms of multilingual needs. The problems specific to translation have essentially been mentioned above. Aside from the numerous lexical

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9 Seen from a practical viewpoint, the question of automating the process of translation must also take into account the actual working conditions. For example, many translation services work from printed sources rather than the electronic version. And in the larger centers, such as the EC translation services, much of the translation is done via dictaphone and typed by secretaries. In both of these cases, there is no place for interaction unless the entire working pattern is first changed.

10 In a recent demonstration I attended of a commercial MT system, it became clear to me that one of the reasons why the output of current systems is so bad, is not that the correct parse couldn't be found among the numerous possible ones, nor that it couldn't be translated, but rather that the system could only choose one parse, and often this was the wrong one.

projects (for which there will certainly be European and national initiatives), we can add a number of corpus initiatives (two of which are already under way in England). Education is also mentioned as a topic in its own right.

Some of the activities in purely academic centers have been overlooked, either because I didn't know about them or because they have not had any impact on the community. As to activities in the private sector, it is simply more difficult to obtain information. Many of the larger companies, such as Philips, Siemens or IBM, have shown a long-standing commitment to both research and development of MT. IBM, for example, has sponsored a number of workshops in the past years, inviting representatives from all of the well known centers in the world (cf. Lippman, 1986). Smaller workshops on topics such as unification and translation (ISSCO, 1989) have taken place all over Europe on an ad hoc basis.

One last outstanding topic to be mentioned in the context of MT is that of evaluation. Its absence in this review is due to its general absence as a recognized theme and its lack of direction in the field (Falkedal, 1990). Though numerous individual efforts have been undertaken (King & Falkedal, 1990), the results of this work often remain private.[11]

Simlar to developments in NLP, the topic has gained importance in the last few years and recently, a working group was formed headed by M. King and G. Magnusdottir. One other center active in this area is the University of Stuttgart (U. Heid). A first forum on Evaluation and MT will be held in Switzerland in April, including participants from the academic and private sectors.

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11 One exception to this is a report that may be obtained from the Canadian Government on evaluation, Bourbeau (1990).

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