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MACHINE TRANSLATION: THEORETICAL AND METHODOLOGICAL ISSUES (STUDIES IN NATURAL LANGUAGE PROCESSING)

Nirenburg, Sergei (editor)

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This title in the ACL-sponsored "Studies in Natural Language Processing" series is a collection of seventeen papers on Machine Translation (MT). Twelve of the papers are revised versions of presentations at the 1985 Colgate conference, and four of the papers are completely original. The appearance of this book is further evidence of the massive renaissance of MT, along with which comes the serious risk of surfeit of books and articles covering the same material. It is important, therefore, that publications in this field have something new to offer the experienced reader. Happily, this is the case with Nirenburg's collection, since most of the papers either focus on theoretical and experimental approaches to the problem, or else address some of the less commonly considered aspects of MT. Notable in this respect are Weischedel and Ramshaw's discussion of ill-formed input, McDonald on generation, and Walker's description of tools for extracting information from large databases.

Like the book itself, the remainder of this review is divided into six parts, as reflected in the section titles.

1. The state of the art

The editor's introduction is a rather heterogeneous collection of introductory thoughts. First, some of the flavor of MT is presented through the discussion of the types of knowledge involved in an MT system and the ways in which problems can be addressed, notably by restricting the input, or by involving the human in the translation process. The final section of this chapter gives a useful overview and summary of the remainder of the book. Tucker's contribution is a revised version of his 1984 *ARIST* article, and concerns strategies for MT together with brief sections on sublanguage and evaluation. Various MT systems are reviewed: these are divided into the "operational" systems SYSTRAN, SPANAM, TAUM-METEO, and METAL, and experimental projects EUROTRA, Mu, SUSY, DLT, and

TRANSLATOR. Most of these will be familiar names, except perhaps the last two: TRANSLATOR is Tucker and Nirenburg's own system, while DLT is a project under way in Utrecht, which envisages the use of Esperanto as an interlingua. Tucker is justly critical of this project, and one wonders why it merits two pages of discussion when other more worthy systems are not mentioned.

2. MT and linguistic theory

Raskin discusses the relationship between linguistics and NLP. He begins with a catalog of the various elements of linguistics and gives examples of problems in each domain which are relevant to NLP. He says that linguistic treatments are never complete; furthermore, they are rarely available in a coherent form acceptable for immediate implementation. Therefore, NLP projects must have linguists on their staff who know about, and can gain access to, linguistic materials. But theoretical linguistic work is not always useful for NLP, as we are shown (pp. 52-3) in an interesting point-by-point analysis of the different needs of theoretical linguistics and NLP.

Kittredge's excellent contribution is on the significance of sublanguage for MT. "Sublanguage" is defined informally as a linguistic system used in a particular domain of discourse, and is characterized by specific recurring structures and vocabulary. Although a sublanguage is a proper subset of some natural language, it will not necessarily be a subset of the general variety of that language. For example, the English of weather bulletins (as in METEO) has sentence patterns which are not generally found in standard English (e.g., omitted articles and lack of tensed verbs):

> In a sublanguage, the rules for constructing sentences may be quite different from (and even contrary to) the rules for sentences in the 'standard' language. (p. 63)

The main attraction of a given sublanguage for the purposes of MT is the extent to which it can be described by a significantly smaller grammar than that required for the full general language, and the extent to which lexical ambiguities are reduced by the exclusion of non-domain-relevant alternatives. Some sublanguages are not so "well-behaved" in this respect, permitting "seepage" from general language (p. 63).

Kittredge next considers the choice of sublanguages as suitable candidates for MT, noting that not all sublanguages are necessarily good in this respect. This was the experience of the TAUM-AVIATION project, where some of the characteristics of the aircraft hydraulics manual sublanguage were particularly unsuitable for MT (e.g., complex NPs). Finally, he offers some guides to estimating the suitability of candidate sublanguages for MT. These include comparing vocabulary size in texts of different lengths: a vocabulary growth curve which tends to flatten is a good indicator of a constrained vocabulary. Estimating the computational tractability of the grammar is more difficult. Kittredge gives

some informal rules of thumb, based on experience at TAUM, listing some of the more difficult English syntactic analysis problems, and grammatical and semantic phenomena which caused problems in English-French translation.

3. Methodologies

The first of five contributions in this section concentrating on specific approaches to MT is from Carbonell and Tomita. This paper, titled "Knowledge-based machine translation, the CMU approach", is in two distinct halves, the first (and longer) of which is essentially an overview of existing approaches to MT (interactive, pre-editing and post-editing). Considering the extent to which it covers somewhat basic material, it is rather too long, though the accompanying pictures might usefully be transferred to overhead projector slides for use in introductory lectures that many of us have to give from time to time. Nevertheless, in the midst of this is a section on "the knowledge-based approach" (KBMT) (p. 75) which invites a number of comments. In this approach, translation is achieved via a "language-free meaning representation"; it is a pity that the authors do not address some of the more obvious drawbacks to the "interlingua" approach, to counterbalance some of the perhaps controversial remarks made about the transfer approach. For example, citing two papers from Coling 1976, they state that

> A transfer grammar . . . is a large, amorphous, ad hoc set of rules, referencing specific lexical entries, that map phrases in one language into corresponding phrases in another language. Thus, a complete transfer grammar needs to be created for each pair of languages—over 5,000 gargantuan grammars to translate between the 72 most active languages. (p. 75)

To be sure, a transfer grammar "may" be large, amorphous, and ad hoc, but must it necessarily be so? That the grammar should reference "specific lexical entries" cannot be held against it (cf. LFG, which is later cited approvingly). And one wonders where the figure of 72 for the "most active languages" comes from. The authors may also be being a little naive (or controversial) in claiming generation to be "the simpler, less computationally demanding process", and in claiming that the interlingual approach

> . . . reduc[es] significantly the amount of development work required to reach eventual closure in the number of grammars needed to translate among all commonly spoken languages. (p. 75)

Returning to slightly less controversial terrain, the first half of this paper continues with a discussion of interactive systems. The authors do make the important point that in interactive MT systems, the nature and frequency of interactions must be carefully controlled, and the mechanism of interaction must be at least a little bit "intelligent" (p. 78). The first half of the paper ends with a proposal for an interactive system which bypasses source text via a system of "automated text

composition" for highly stereotyped text types. To this reviewer's knowledge, in fact, this type of template-based production of "translations" is indeed used in translation agencies where there is a frequent need to translate similar texts (e.g., birth certificates, driver's licenses).[1]

The translated pro-forma is stored on a disk, and the individual details entered in response to prompts which the translator can preset. The "translations" can thereafter be produced by clerical staff. Although of commercial interest, this approach probably does not represent an important theoretical or methodological issue.

The second half of the paper concentrates on KBMT system design at Carnegie Mellon. A frame-like "entity-oriented grammar formalism" is used to express domain-specific syntactic and semantic information, while domain-independent syntactic information is expressed in functional grammar formalism, the main advantages of which are its reversibility (i.e., the same grammar can be used for parsing and generation) and its familiarity for computational linguists. A problem with these formalisms, say the authors, is implementation inefficiency. They hope to combat this by grammar precompilation and efficient on-line parsing, using Tomita's very fast parsing algorithm (Tomita 1986).

The next paper in this section is Nirenburg, Raskin, and Tucker's description of their interlingual TRANSLATOR system. Whatever one's views on the plausibility on interlingua-based MT, one should admire this chapter at least for its attempt at some rigor in defining an interlingua (IL), and also its bold answers, in its concluding section, to some often recurring questions. The TRANSLATOR system is composed of three modules: source language analysis into IL, IL "augmentation", and synthesis of the target text. This augmentation consists of expansion of the essentially text-based IL taking into account possible inferences, anaphora, and discourse structure, using knowledge found in the IL dictionary and grammar. The main body of this paper is concerned with explaining and defining the IL dictionary and grammar. The "IL dictionary" contains descriptions of the types of entities that are used, which are of two kinds: concepts and properties. Among the types of possible properties are links to other IL dictionary entries, which give the dictionary its hierarchical organization. The most important of these links is via the "isa" property, with associated inheritance mechanisms, and generalization possibilities in inferencing. As the authors freely admit, this is all very familiar. The next few pages give some examples of dictionary entries.

The IL grammar is a definition of the syntax of an IL "text". An IL text is a network of frames, interconnected by discourse markers. The slots of the frames may themselves contain frames, as well as speech-act

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[1] N.P. Somers (Übersetzungsbüro Boxhall, Retzback, West Germany), personal communication.

and focus information. Some examples are given, among them some interesting alternative input texts which represent the same proposition but with differing focus (p. 103).

The next section briefly discusses the relationship between source texts and IL representations. Here there are some rather worrying statements which seem to imply close correspondence between source language syntactic categories and IL elements; e.g., a noun corresponds to an object frame, a verb to an action or state frame, and so on (p. 104). It is this reviewer's belief (Somers 1987) that a major factor in favor of an interlingual approach is precisely the extent to which it permits syntactic category differences to be neutralized: the noun *victory* no more represents an object than does the verb *win*, for example.

The paper ends with an interesting set of typical questions and the authors' responses. Most readers will find the viewpoints expressed here interesting and pro-vocative, and may care to think what their own answers would have been. The next paper, by Arnold and des Tombe, concerns the European Commission's MT proj-ect EUROTRA, and, in particular, its basic linguistic methodology. The paper gives a good overview of the underlying ideas, but the uninitiated may find the ter-minology confusing, and the rather simplistic exempli-fication misleading. It is unfortunate the terminology adopted by EUROTRA can only serve to confuse the reader: both "translation" and "language" are given special meanings, though they also appear sometimes in their everyday usages—on one occasion within the space of two lines! Some other criticisms should be made: at one point, some terminology is introduced without explanation or justification ("A-type rules"), and one of the examples has a perhaps important misprint (missing atom for "the-council" in (18) on p. 128). Also, the discussion of important questions like the treatment of ambiguity in this framework is re-stricted to the most simple of examples. On the positive side, however, careful reading of this article will pro-vide some real insight into at least the basic theoretical methodology of the project (which is, after all, the theme of the whole collection), and readers who find the linguistic approaches exemplified rather naive should understand that these are all subject to ongoing research which, the authors claim, is facilitated by the "very orderly environment" and the "high degree of modu-larity" that the approach provides (p. 134).

The next two papers both concern the basic design of interactive MT systems. The contribution of Johnson and Whitelock centers around the idea that current MT systems do not distribute the task of translation be-tween human and computer in an appropriate manner. They propose a translation expert system where the user's and system's skills complement rather than over-lap each other. In particular, the system should be more like a human translator in that it be permitted, if not expected, to compensate for gaps in its knowledge

concerning source language and subject area (real world) by consulting other experts, but not in its target-language and contrastive knowledge. The contribution is a well-argued "position paper", but readers may be disappointed in not finding more tangible details of the experimental English-Japanese system based on these principles, as compared to the previous articles.

Alan Melby's contribution is on much the same theme. He describes a three-level "translator's work-station", where different degrees of human or machine involvement are concerned. Melby defines four types of human interaction in the MT process: the usual pre- and post-editing, the former of which may be computer-assisted in the manner of spelling and grammar checkers now quite widely available. To these he adds "intra-processing", which is the familiar interaction during translation—e.g., for the choice of target lexical item— and "para-processing", by which is meant tasks such as the production of text-oriented glossaries, concor-dances, and other such items which are sometimes useful especially for large-scale translations. Para-proc-essing also includes consultation of term banks.

Melby's translator's workstation design has three levels. The first of these is chiefly a level of para-processing, with word-processing, on-demand dictio-nary look-up, telecommunications facilities (for consult-ing with clients, colleagues, etc.), and so on. The second level involves automatic dictionary look-up, plus morphological analysis. The third level is "full" MT, with the possibility of pre- and post-editing and intra-processing, all packaged together in a flexible and efficient way. Melby concludes by reminding the reader that there are different types of MT for different user needs, ranging from "indicative translation", for which the output from a fully automatic system may be suitable, down to legal and literary translation, for which perhaps the only suitable level of operation is the first.

4. MT and AI

This section contains three papers on topics not often addressed with MT in mind. They are, however, impor-tant and relevant areas, which, as the editor points out in his introduction (p. 18), even if not now being faced must be tackled before long.

The first is the question of ill-formed input, discussed by Weischedel and Ramshaw. To be fair, it must be said that although this paper is very interesting, the rele-vance to MT is not brought out as it might have been: indeed, MT is only mentioned once; a significant part of the chapter is given over to an example of the need to infer speakers' goals when interpreting interaction with a database (it is not obvious that there is a major need for such processing in MT); and there is no discussion of the varying needs for robustness in different types of MT system (cf. Arnold and Johnson 1984). On the other hand, much of the paper concerns different sources of ill-formedness, and notes that for each type different

solutions may be appropriate. The relevance here for MT does not need stating.

The authors first make a distinction between "absolute" ill-formedness, such as misspellings, homonym confusion, omission, ungrammaticality, selection restriction violation and presupposition violation, and what they call "relative" ill-formedness, i.e., input which a human would judge well-formed, but which is ill-formed with respect to the system's capabilities. Unknown words and constructions which we might call "extra-grammatical" rather than "ungrammatical" would be examples of relatively ill-formed input.

Ill-formed input and its corresponding treatment can be further subclassified according to the traditional linguistic divisions of "phonetics", morphology, syntax, semantics, and pragmatics. Phonetic (or in texts, orthographic) errors are misspellings and other typographical errors. According to the authors, these are often corrected in practise by random permutation of the letters, though as they point out, such errors are rarely in themselves random. Certain misspellings are common, but it might have been pointed out that many errors are due to hitting adjacent keys, and so could be interpreted given knowledge of the layout of the keyboard. Morphological and syntactic ill-formedness can sometimes be identified, though this is particularly difficult in English, with its impoverished morphology and very flexible system of word classes. The semantic interpretation of an unknown word—a frequent source of relative ill-formedness—can sometimes be inferred by a system, on the basis of its domain knowledge. Finally, the use of pragmatic knowledge to interpret ill-formed input is exemplified. As mentioned above, this takes the form of goal and plan prediction, the usefulness of which for MT must be questioned. However, all in all the article holds some useful new ideas that MT researchers would do well to keep in mind.

The next paper, Pustejovsky on discourse analysis, suffers even more than the preceding one from a lack of overt reference to MT. To be sure, it is an interesting overview of work on discourse analysis, plus a description of the author's own approach, but MT as such is not mentioned even once! Most MT researchers recognize that eventually MT systems will have to take "discourse" into account, but in MT circles this is usually understood as the need to resolve problems of pronoun and other anaphoric references, disambiguation, and (thinking about generation) pronoun insertion. Pustejovsky does not mention these elements, however: his article is essentially about the need to maintain a model of discourse in order to make correct choices of focus in generation. Irrespective of the quality of the content of this chapter, it must be said that its inclusion in a collection of papers on MT is of dubious benefit both to MT researchers, and to colleagues in discourse analysis, who will probably not read it.

McDonald's chapter on generation at least makes more explicit reference to MT. He notes that generation

programs used in state-of-the-art MT systems are very old-fashioned, and result in texts having an "awkward, mechanical style" (p. 192). The author gives a good overview of past, present, and future techniques in generation, including his own, in some detail, and this chapter will give MT researchers a good reminder that the effort put into developing the generation part of an MT system should at least approach the corresponding effort on the analysis side.

Generation in the context of MT is significantly different from generation in its more usual setting of NL interfaces, but, in either case, it requires an element of "planning", viz. the realization of goals in the presence of certain constraints. So a generation module should (a) identify the goals the utterance (read "target text") is to achieve, (b) plan the achievement of these goals, and (c) realize the plans. The old-fashioned method of generation, employed in MT and elsewhere, is called "direct replacement", and involves synthesizing text more or less directly from some representation (in the case of MT, the output of analysis/transfer). However "deep" or sophisticated this representation may be, deficiencies include the lack of an "internal" (generation-oriented) grammar, as well as the fact—not stressed by McDonald—that in the case of MT, the representation generally reflects the structure (whether syntactic, logico-semantic, or topic-comment) of the source text.

Turning to some current alternatives, McDonald briefly describes approaches to generation using ATNs, systemic grammar, or functional unification grammars, and then discusses his own "multi-level description-directed" approach. Here there is a three-level approach to generation: the message to be generated is converted to a syntactic representation prior to word-stream realization. Although this does not sound particularly innovative, the important point is that various decisions regarding generation can be made at different levels, and each might influence or determine some other choice. For example, choice of focus might be made at the deepest level, and this in turn may condition a grammatical choice at the syntactic level and a lexical choice at the realization level. Ordering choices (at the "message" level) may help determine pronominalization and other anaphoric devices at the syntactic level, and so on. As a final comment, McDonald stresses again the MT angle: noting that modern approaches to generation require information about rhetorical and conceptual perspectives, he suggests that output quality may be improved if the parsers are made sensitive to these concerns, i.e., whether information is new, salient, conventional, etc.

> "When parsers can notice these perspectives in source texts and associate them with the generation decisions that could have led to them, then we can expect that MT output should be able to be every bit as good as any text produced from an interface." (p. 224)

5. Research tools for MT

In the first of two papers in this section, John White describes the research environment of the METAL project. Although White gives details at rather too low a level, the careful reader can nevertheless pick out several points of interest. White makes the traditional point about the segregation of grammar formalisms and parser software, though the use in METAL of a "higher-level Lisp dialect" (p. 226) for the former somewhat compromises this distinction. The author underlines the advantages of developing tools within an established framework—in this case that of a Lisp machine (cf. McNaught (1986) on the use of Unix), the need to use real texts for testing, and the need for a variety of tools, especially for lexicon development, to reflect different types of users (cf. Boitet 1986).

Don Walker's contribution describes two knowledge resource tools based on a massive collection of machine readable databases including both linguistic and encyclopedic data. The first tool, called FORCE4, is used to identify text subject matter. Walker describes clearly how it works, and discusses honestly its limitations. Its application to MT is obvious, though one of its weaknesses is the absence of proper names in the lexical database which it uses. This problem may be attacked by the second tool, called THOTH, which displays on-screen information coded from various encyclopedic resources. Of the two tools discussed, the first seems to be of more practical interest to MT researchers, but in both cases it is interesting to see the first steps being taken towards implementing some sort of repository of that elusive "real-world knowledge" we read so much about.

6. Case studies of MT projects

The first of three descriptions of experimental MT systems is by Makoto Nagao. His main point is that the structure-preserving approach seen in systems translating between European languages is inappropriate for a language pair like Japanese-English. I would disagree with Nagao only insofar as he hints that this approach is reasonable for closely related languages; in my view, Nagao's approach, in which significant structural transformations must take place at the transfer stage, is more widely applicable. Unfortunately, the paper mostly consists simply of examples of these transformations, and although they will be of interest to readers familiar with Japanese, especially the suggestions (p. 273ff) for treating structures with missing arguments, they look more like ad hoc solutions to particular problem cases, rather than examples of some underlying general motivation.

The second contribution, by Cullingford and Onyshkevych, is a detailed description of an experimental "lexicon-driven" system. The main characteristic of this is that the analysis is directed by a kind of production system which builds a Conceptual-Dependency-like representation using rules associated with the words of the source text. The system translates—or rather, as the authors make clear, "retell[s] or para-phrase[s]"—simple Ukrainian sentences into English. The level of detail given is sufficient to get a good feel for the system, but some interesting questions remain unanswered. For example, in the face of well-documented practical experience over the last 20 years, it is necessary to justify the assumptions that the authors make regarding the feasibility of designing and using for translation an interlingua "encoded in terms of a relatively small number of *primitive* meaning units" (p. 279, emphasis original). A good example is given a few pages later, where the Ukrainian verb *zmyty* is shown as having the two different readings "wash away" and "wash off"; surely the "ambiguity" is translational rather than conceptual? (Ask a Ukrainian if the verb is ambiguous.) Another point of interest would be to see how the large amount of information given by the "conceptual representation" for the example sentence (p. 300) is pruned so as to produce the appropriate translation, for this is perhaps the main argument against the use of such representations for MT.

The final article, by Lytinen, describes an analyzer in which syntax and semantics are integrated. The proposal is quite an interesting one, in that it suggests a way in which the combinatorial explosion of syntactic ambiguities can be controlled, and although its relevance to MT is obvious, the article is really about parsing rather than MT.

In conclusion, it should be noted that the collection as a whole is not appropriate as an introductory textbook, in that it contains mostly somewhat controversial or ambitious ideas. I found it a little biased towards interlingua-style MT, perhaps reflecting the editor's view of what is the most pressing theoretical issue in MT at the moment. I was a little sorry to see nothing about the problems of implementing a large-scale MT system, where some of the suggestions made in these papers are really quite difficult to put into practice, but all in all I found the book certainly interesting and stimulating, and a worthy addition to the MT researcher's bookshelf.

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†Allen, James Frederick
[University of Rochester]
Natural language understanding
Menlo Park, CA: Benjamin/Cummings, 1987, xvi+574 pp
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†Allen, Jonathan; Hunnicutt, M. Sharon; and Klatt, Dennis; with Armstrong, Robert C. and Pisoni, David
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(Cambridge studies in speech science and communication)
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For truth in semantics
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†Alshawi, Hiyan
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Cambridge, England: Cambridge University Press, 1987, ix+188 pp
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†Altenberg, Bengt
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Prosodic patterns in spoken English: Studies in the correlation between prosody and grammar for text-to-speech conversion
(Lund studies in English 76)
Lund: Lund University Press, 1987, 225 pp
Paperback, ISBN 0-86238-125-8 and 91-7966-002-9, Skr 178.-

Baecker, Ronald M. and Buxton, William A. S. (writers and editors)
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Readings in human-computer interaction: A multidisciplinary approach
Los Altos, CA: Morgan Kaufmann Publishers, 1987, xiii+738 pp
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The onset of literacy: Cognitive processes in reading acquisition
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Cambridge, MA: The MIT Press/Bradford Books, 1987, 174 pp
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Burton, Mike and Shadbolt, Nigel
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Wokingham, England: Addison-Wesley, 1987, xi+207 pp
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Cercone, Nick and McCalla, Gordon (editors)
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Hardbound, ISBN 0-387-96557-2, $40.00

Charniak, Eugene; Riesbeck, Christopher Kevin; McDermott, Drew Vincent; Meehan, James R.
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Artificial intelligence programming (second edition)
Hillsdale, NJ: Lawrence Erlbaum Associates, 1987, xvi+533 pp
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†Church, Kenneth W.
[AT&T Bell Laboratories]
Phonological parsing in speech recognition