

# Interactive multilingual text generation for a monolingual user

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## Abstract

In this paper we describe an approach to machine translation which involves multilingual text generation via interaction with the user, who is monolingual: the system will work in a specific and fairly restricted domain. Key techniques used include the use of examples rather than linguistic rules to give the equivalents between the languages, and the encoding of contextual knowledge in the form of a model of possible texts.

## 1 Introduction

This paper describes the design principles of a system which embodies several new approaches to machine translation (MT)\*: the system is a multilingual text generation system for use by monolingual user, and operates in a restricted domain, permitting the user to compose, via a dialogue with the system, texts of the appropriate style and layout in several languages, including the user's own. The domain specificity of the system permits it to interpret the user's input, and even make predictions about the content of the text, both of which will contribute to high quality of translation. The domain that we are working in at present is the generation of multilingual job advertisements in semi-technical fields such as computer design, management or graphic arts. The domain has the advantage of moderately fixed text formats with some degree of flexibility in content, a combination which suits the particular approach we are taking. There are several other domains with similar properties, where the approach described here would also be suitable.

The mode of operation is as an interactive system with a flexible human-machine interface (system- and/or user-driven) where the system cooperates with the user in order to produce a guaranteed quality translation. The system's linguistic and domain-specific knowledge bases are closely related, in that translation equivalents are tied to situational contexts. Furthermore, its domain knowledge serves to guide the user towards acceptable and standardized text structures. The system is nevertheless flexible enough to permit more than a rigid 'phrase-book' type of message generation. The system is to accept input in English and generate texts in English, Spanish and Greek.

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## 2 Background

The design of the system is in response to perceived weaknesses in the classical approach to MT, as still found in so-called state-of-the-art developments (cf. [42]): notably these include reliance on structure-preserving translation as a first choice, a stratificational approach to both linguistic and computing aspects, leading to a predominantly bottom-up compositional system design, and the reliance on the intuitions and introspection of linguists rather than 'real' data. The system design is influenced by a number of recent research directions including Dialogue-Based MT with a monolingual user, Example-Based MT, corpus-based MT, and the use of sublanguage.

### 2.1 Dialogue-Based MT (DBMT) with a monolingual user

Until recently, the interactive approach to MT almost inevitably came in the form of the widely promoted Translator's Workbench' idea [21,29], the main aims of which are to help *translators* to translate texts. Now it has been acknowledged that there is a drawback in this approach, which is that it is sometimes difficult to see where the most appropriate division of labour between the computer and the human should occur, and there is sometimes even a conflict between what the system offers the translator-user, and what the user already knows, or between the extent to which the system or the user should take the initiative, which might differ from occasion to occasion.

Although first suggested by Kay [20], the alternative idea of an MT system for a monolingual user seems only to have really been followed up about five years ago, when several proposals for interactive MT for monolingual users were apparently initiated [7,14,17,38,48,49].

The idea to develop this sort of interaction in the direction of a more sophisticated clarification dialogue is now gaining currency with the emergence of DBMT [3,4,47] and the notion of 'MT without a source text' [43], where the dialogue aims not merely at disambiguating a given text, but in helping the user to compose it in the first place.

### 2.2 MT as multilingual text generation

If there is no source text, the focus obviously falls upon the generation of the target text(s), a problem in MT which was for a long time seriously underestimated (cf. [27]). Our present approach has been influenced by the 'phrasebook' approach to speech translation [44], in which set phrases are stored, as in a holidaymaker's phrasebook, and retrieved by the fairly crude, though effective, technique of recognising keywords in a particular order in the input speech signal. It also builds on research on interactive generation of stereotypical texts ([1,19,35]), where texts in certain restricted domains are stored and retrieved as appropriate through interaction with users, and are reformulated to fulfill the specific requirements expressed by them.

### 2.3 Example-Based MT (EBMT) and corpus-based MT

Perhaps the most important feature of the system is that it follows very closely some of the ideas of EBMT, which originated with Nagao [30], but have only recently been taken up [18,23,32,33,34,36,37,45,46]. In EBMT, a corpus of texts with their translations (which have been done by humans, and so are of guaranteed quality) serves as a knowledge base for MT: previously translated text fragments are seen as examples on which to base the translation of a given text. EBMT can be regarded as a special case of corpus-based MT (cf. [5,10,39]).

EBMT proceeds by finding suitable examples in the database and then 'recombining' them appropriately. Key factors are therefore the efficient retrieval of texts from the database which are sufficiently similar to the given text ([8,22,40]), and the alignment of translation pairs, given a bilingual corpus ([6,9,10,12,23]).

The advantages of EBMT are that translation quality is assured, because the example translations are real. The system knows its limitations: if a suitable example cannot be found, the system will not translate on a word-for-word basis as in rule-based MT. This approach does not depend on structure preservation as a first choice (cf. [41], p.84), and perhaps most interesting of all, it is easy to extend an EBMT system: we simply add more examples to the database. Unlike in rule-based MT, there is not the overhead of 'entropy' of performance, where the addition of a new rule has unforeseen repercussions on the rest of the system, which sometimes do not surface until many months after the change was made, and therefore are extremely difficult to trace.

## **2.4 Sublanguage MT**

It is again relatively recent that the notion of MT with restricted input has come to be associated with 'sublanguage' ([16,24,25,26]), as opposed to the case previously, when it was typically the MT system which dictated the restrictions rather than vice versa (e.g. [11,31]). In the system described here, the sublanguage approach gives us not only vocabulary and syntax, but also the contextual and domain knowledge employed by the system. And, in keeping with the strong corpus-based approach, these knowledge sources are derived directly from an analysis of corpora ([2]), not from some linguist's introspection, as is the case in conventional rule-based MT systems. An additional point of interest in this research is the contrastive aspect, since our approach requires us to make an explicitly comparative analysis of three corpora which, it should be stressed, are not in fact parallel corpora, but simply collections of pragmatically similar material.

## **3 The proposed system**

### **3.1 How do these approaches fit together?**

First we assume a system which is to be used by monolinguals, not translators. This leads us immediately to the realisation that we cannot at any time query the user as to the correctness of a translation. How then can we failsafe the translation process? This question leads naturally to the utilization of the examples, system-user dialogue, and contextual and domain knowledge sources.

The use — in EBMT systems generally — of example translations has the advantage of maximally exploiting surface regularities in the given sublanguage. Such examples not only encode the correct grammatical target language constructs but also capture stylistic factors appropriate for the text-type. However, although there are major advantages in using examples there are generally two problems: first, the flexible matching of input with examples, and second, the coverage of examples.

In our system, there is a third problem not found in other EBMT systems: because it is not based on a bilingual corpus as such, the examples are not automatically paired, and so we have the problem of matching source language examples to their corresponding target language examples.

The first problem can be paraphrased as "Which examples in the database best match this input?", and can be addressed initially by the method of representation of the examples. Examples are represented at various syntactic levels differing in their degree of abstraction, e.g. as a literal string, a syntactic pattern with slots for restricted phrasal alternatives, or as a functional formula where actual and preferred surface realisations of the example semantic frame can be represented (with the associated target language equivalences). With these types of surface level representation, matching will be possible in most cases although the number of candidates will increase as the level of abstraction increases.

In order to reduce the search space, contextual knowledge is employed. As well as a syntactic description, each example is associated with a contextual representation derived from the relations that hold between the example and the rest of the text from which it originated. In order to utilise this information, an 'intentional model' is required to allow the system to understand the nature of the text it is trying to compose (and consequently translate). For instance, certain contextual relations will occur together in certain circumstances (within the sublanguage). If an example with a specific contextual marker is matched, the intentional model will lead the system to expect some contextual relations but not others, thereby reducing the search space in which new input is processed. Also in cases where an input matches several candidate examples, this contextual knowledge determines the correct choice.

The intentional model will also help us overcome the third problem mentioned above, caused by our corpus not being one of parallel example translation pairs: we shall see how below.

The second problem of coverage can be paraphrased as "Are there any examples in the database which match this input at all?", and is the basic problem with EBMT in that, in the extreme, EBMT ignores the relevance of linguistic generalities. It can be overcome by making the source text and target text composition process 'recombinant' ([18,37]). This recombination of partially matching examples is significantly different from the corresponding technique of target text generation in standard MT systems, which is essentially rule-driven 'direct replacement' (cf. [27], pp. 200f) of an abstract representation with the corresponding text, based on pre-determined choices (cf. [15], pp.137f). In recombination of examples, it is necessary to locate the partially matched examples in a broader rhetorical structure: in order to accomplish this the representations and the contextual relation definitions of the examples, and the global intentional model all play their part. It is important to ascertain the grammatical, pragmatic and stylistic legality of recombining examples and to maintain textual cohesion. In some (extreme) cases, the system may require the user to rephrase the input so as to match more closely the expected input.

If recombination or rephrasing is required during the composition process, this implies consultation with the user. Therefore, the system must be able to interact in an intelligent manner with the user and, consequently, an additional module in the form of a human-machine interaction dialogue model is required. In order for the system to interact 'intelligently', it must understand the communicative intent of the user and therefore must have knowledge of the domain. We will not address here this aspect of the proposed system, which is essentially a typical problem of task-oriented dialogue ([13]).

A consistent thread throughout this discussion has been the requirements of the sublanguage approach. This is by now the least controversial of features of MT research, though it is important that a commitment to sublanguage is not merely an excuse to limit the vocabulary and syntax that

the system can translate. Rather, we see sublanguage as an essential factor binding and defining the contextual knowledge expressed in the intentional model, the linguistic knowledge in the representations, as well as pertaining to the domain knowledge for the system overall. The system becomes portable only inasmuch as the sublanguage and its ramifications are parameterizable. The overall design of the system is shown in Figure 1.

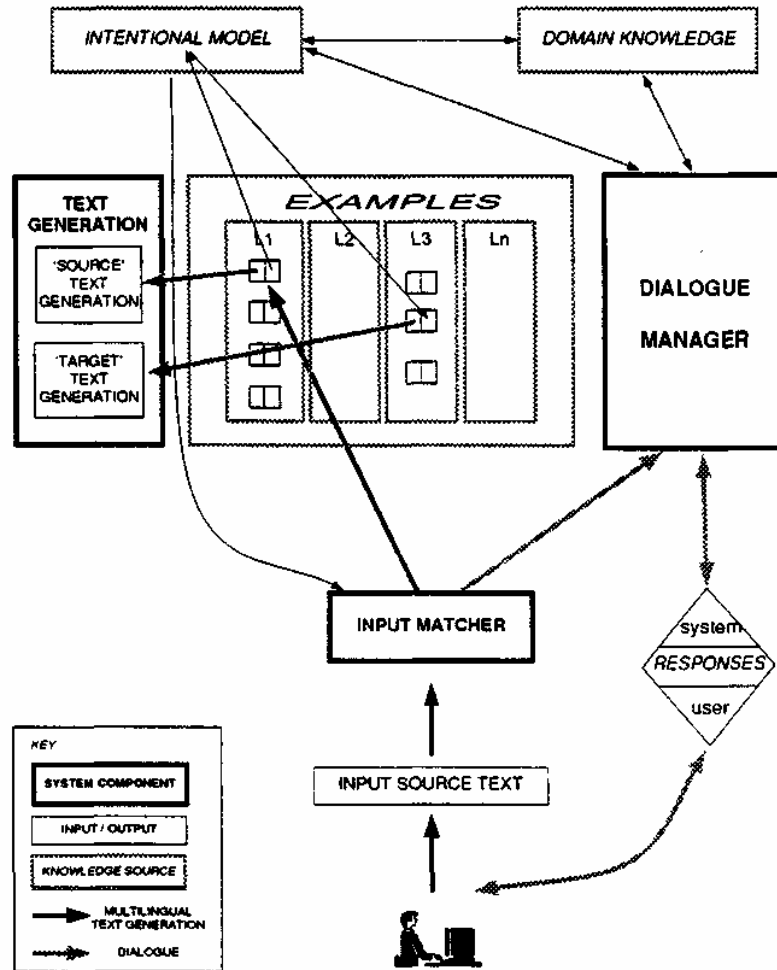


Figure 1 Overall design of the system

### 3.2 Details of the overall design

The main components of the system — the input matcher, the example-based multilingual text generator, and the dialogue manager — interact continuously, and share several knowledge sources. The operation of the system depends somewhat on the expertise of the user, but we can distinguish two extreme scenarios, with variations in between the two.

In the first scenario, appropriate with an experienced user, the user inputs a draft text. This text is input to a matching algorithm, which will attempt to find in the corpus of example texts in the

user's own language a set of examples closely matching the user's proposed input. Examples are stored as pairs of syntactic and pragmatic descriptions of text: the 'syntactic descriptions' range from whole text fragments, through partial text templates to more abstract linguistic representations. The 'pragmatic descriptions' capture the pragmatic or contextual information associated with the linguistic descriptions, which serve to locate the text fragments in a more abstract 'intentional model' which defines the possible structures of the texts in general. The form of the representation will probably be a lattice of frame-like feature-structures, where the slots of the frames indicate rhetorical functions, while the fillers identify, by reference to the database of examples, typical phrases which fulfill these functions. The intentional model thus serves to restrict the search space of examples which the input matcher addresses. Since the corpora are not parallel texts as such, but merely collections of pragmatically similar texts, the intentional model also serves to give the bi- and multi-lingual links between the languages, although of course there will also be some paired examples — e.g. of fixed phrases and single lexical items — which provide, where necessary, 'translations' in the conventional sense. The results of the matching phase are passed to the dialogue manager, which takes into consideration how closely the user's input matches the allowable inputs given the current textual situation: the dialogue manager's knowledge about this comes from two sources, namely, the intentional model, which contains knowledge pertaining to text structure, and a domain knowledge source which contains factual information about the general domain. The dialogue manager is able to interact with the user in order to confirm the acceptability of the input, or to negotiate ways in which it can be changed to conform more closely to the expected range of inputs. Once the 'source' text has been successfully negotiated, there remains the task of generating corresponding target texts. This task involves locating corresponding example fragments in the target language corpora, and — again because the corpora are not parallel — recombining them to form appropriate target texts.

In the second scenario, the user is less experienced, and it is the system which takes the initiative. In this case, the intentional model and domain knowledge together form a database which enables the system to have a predictive model of the text, which it can then use to prompt the user more or less explicitly for appropriate input. In the extreme case, the system could almost derive for itself a series of menus or hypertexts which it would present to the user. In a less extreme case, the system can prompt the user with more general suggestions outlining the functionality of each portion of text, while permitting the user to propose a first draft for each segment. The role of the dialogue manager, and the task of generating target texts, are as in the first scenario.

#### **4 Discussion**

The system will use a wide variety of techniques, many of which are at the forefront of research. For the task of matching of user's input with the stored examples, parsing of a traditional nature may be employed, but the primary technique will involve stochastic or other pattern matching techniques. Because the aim is to match inputs with similar, but usually not identical examples in the database, the matching techniques must be flexible enough to locate a range of candidate matches against a given input. For this reason, pattern matching incorporating a similarity measure is indicated, such as the techniques proposed in [8,22,23,40], though we are also experimenting with a connectionist approach to this problem ([28]).

The data forming the multilingual corpus of examples are derived empirically from real-life examples of job adverts. For practical reasons, we cannot expect to have available a truly parallel corpus of texts in this domain. The contrastive linguistic knowledge of the system cannot therefore be captured by paired examples of translational equivalents as in the IBM statistical approach for example ([5,6]), so the more abstract intentional model is relied on as a kind of mediator, where it is the functional rather than formal property of the text fragment that gives its target language counterpart. The analysis of the multilingual corpora ([2]) provides us with data influencing the design of the linguistic representations to be used in the example database, as well as determining the content and form of both the intentional model — where the functional and pragmatic aspects of the job adverts are defined — and providing information to enable the domain knowledge of the system to be defined. This last is based on the prepositional content of the corpus, which determines not only what are the commonalities of the language of the domain, but also enabling illegal phrases to be identified, as well as revealing problems of non-equivalences, especially of job titles and qualifications, etc. An additional point of interest arising especially from the text-type and domain chosen is the likelihood of cultural differences being reflected in differences in the examples and hence in the intentional models. These may be superficial, such as the typical order of presenting the information, or may pose more serious problems (see below).

Concerning the use of examples for generation by 'recombination', since the system is example-based, the issue here is not so much generation from representations — which are largely given *a priori* by the corpus of examples — but the capability of such a mechanism to generate texts which are not directly represented in the database of examples. The general advantages of example-based natural language processing have already been discussed. However, it is very much appreciated that in order for example-based systems to have any real degree of flexibility they must be afforded some degree of generative capacity above and beyond that supported by 'static' individual examples. This increased flexibility is gained by matching against subcomponents of more than one example across the example database. This may occur when an input text does not match against one complete example but several examples match against parts of the input. Obviously it is important not to reject the input text outright as 'ill-formed' in some way, but attempt to generate a corresponding 'clone' ([18]) of the input based on the highest scoring matches returned by the matching process. There is a need for information to guide this process, and this information comes from the intentional model and domain knowledge.

The domain knowledge itself includes pragmatic/linguistic knowledge captured by the intentional models, but also more general knowledge about the task of writing a job advert, which the dialogue manager will need to access in interpreting the user's input and responses to its questions, and in forming a model of the user's beliefs about the task in hand, since this is a typical example of a task-oriented dialogue. Additionally — and this is of particular interest — the domain knowledge must include the contrastive cultural knowledge about differences in job advert writing conventions, and associated problems such as the non-equivalence of qualifications in the different languages, or cultural differences relating to the actual content of the text. These very practical problems have to be captured in the domain knowledge, and used by the dialogue manager where appropriate, to ask the user to rephrase. In the design of the system, the knowledge needs a structure, which identifies what are the components of a typical advert.

Earlier, it was stated that the design of the system was in response to perceived weaknesses

in the classical approaches to MT. It should now be clear that the approach will avoid structure-preserving translation as a first choice, since the translation process involves no analysis of syntactic structure as such; the stratificational approach to linguistic description is likewise absent, and the predominantly bottom-up compositional theory-driven translation algorithm is replaced by a more global data-driven process; finally, the use of examples rather than rules and lexicons derived from linguists' introspection mean that the system will produce more natural output (especially where source and target are structurally dissimilar: so-called metaphors and idioms), will be more robust, easier to extend and to debug ([37]).

There are several other interesting aspects to this research project of which we cannot go into detail here: notably, these revolve around the dialogue part of the system. The project is interesting both because it gives us a chance to explore some new avenues of basic research, and also because the ultimate aim of the project is to implement a small demonstrator system which, in its functionality, will represent a novel approach to MT seen as multilingual text generation.

## References

- [1] Ahmad Zaki A.B. and Noor H.M. 1991. Malay official letters translation. Proceedings of the International Conference on Current Issues in Computational Linguistics (Penang, Malaysia), 413-420.
- [2] Alexa, M. and E. Barcena. 1992. Sublanguage and multilingual corpus analysis for example-based machine translation. Report No. 92/3, Centre for Computational Linguistics, UMIST, Manchester. (Submitted to Fourth International Conference on Theoretical and Methodological Issues in Machine Translation of Natural Languages, Montreal)
- [3] Blanc, E. and C. Boitet (eds) 1990. DBMT-90: Post-COLING seminar on dialogue-based MT (machine translation of/with dialogues) (Le Sappey, France), Proceedings.
- [4] Boitet, C. 1990. Towards personal MT: general design; dialogue structure, potential role of speech. COLING-90 (Helsinki), Vol.2, 30-35.
- [5] Brown, P.F., J. Cocke, S.A. Della Pietra, V.J. Della Pietra, F. Jelinek, J.D. Lafferty, R.L. Mercer and P.S. Roossin. 1990. A statistical approach to machine translation. *Computational Linguistics* **16**, 79-85.
- [6] Brown, P.F., J.C. Lai and R.L. Mercer. 1991. Aligning sentences in parallel corpora. Proceedings of the 29th Annual Meeting of the Association for Computational Linguistics (Berkeley), 169-176.
- [7] Carbonell, J.G. and M. Tomita. 1987. Knowledge-based machine translation, the CMU approach. In S. Nirenburg (ed.) *Machine Translation: theoretical and methodological issues*, Cambridge: Cambridge University Press. 68-89.
- [8] Carroll, J.J. 1990. Repetitions processing using a metric space and the angle of similarity. Report No. 90/3, Centre for Computational Linguistics, UMIST, Manchester.
- [9] Catizone, R., G. Russell and S. Warwick. 1989. Deriving translation data from bilingual texts. Proceedings of the First International Acquisition Workshop (Detroit).



- [10] Chen, S-C., J-S. Chang, J-N. Wang and K-Y. Su. 1991. ArchTran: a corpus-based statistics-oriented English-Chinese machine translation system. Proceedings of Machine Translation Summit III (Washington DC), 33-40.
- [11] Elliston, J.S.G. 1979. Computer-aided translation: a business viewpoint. In B.M. Snell (ed.) *Translating and the Computer*, Amsterdam: North-Holland. 149-158.
- [12] Gale, W.A. and K.W. Church. 1991. A program for aligning sentences in bilingual corpora. Proceedings of the 29th Annual Meeting of the Association for Computational Linguistics (Berkeley), 177-184.
- [13] Grosz, B. 1974. The structure of task oriented dialogs. IEEE Symposium on Speech Recognition (Carnegie Mellon University), Contributed Papers, 250-253; repr. in L. Polanyi (ed.) *The Structure of Discourse*, Norwood, NJ: Ablex.
- [14] Huang, X. 1990. Machine translation in a monolingual environment. Third International Conference on Theoretical and Methodological Issues in Machine Translation of Natural Languages (Austin, Texas), 33-42.
- [15] Hutchins, W.J. and H.L. Somers. 1992. *An Introduction to Machine Translation*, London: Academic Press.
- [16] Isabelle, P., M. Dymetman and E. Macklovitch. 1988. CRITTER: a translation system for agricultural market reports. Coling Budapest, 261-266.
- [17] Johnson, R.L. and P. Whitelock. 1987. Machine translation as an expert task. In S. Nirenburg (ed.) *Machine Translation: theoretical and methodological issues*, Cambridge: Cambridge University Press. 136-144.
- [18] Jones, D. 1991. The processing of natural language by analogy with specific reference to Machine Translation. PhD thesis, UMIST, Manchester.
- [19] Jones, D. and J. Tsujii. 1990. Interactive high quality translation for monolinguals. Third International Conference on Theoretical and Methodological Issues in Machine Translation of Natural Languages (Austin, Texas), 43-46.
- [20] Kay, M. 1973. The MIND system. In R. Rustin (ed.) *Natural Language Processing*, New York: Algorithmic Press. 155-188.
- [21] Kay, M. 1980. The proper place of men and machines in language translation. Research Report CSL-80-11. Xerox Palo Alto Research Center, Palo Alto, California.
- [22] Kay, M. and M. Röscheisen. 1988. Text-translation alignment. Research Memo, Xerox Palo Alto Research Center, Palo Alto, California.
- [23] Kitano, H. and T. Higuchi. 1991. Massively parallel memory-based parsing. Proceedings of IJCAI-91 (Sydney).
- [24] Kittredge, R.I. 1987. The significance of sublanguage for automatic translation. In S. Nirenburg (ed.) *Machine Translation: theoretical and methodological issues*, Cambridge: Cambridge University Press. 59-67.
- [25] Kosaka, M., V. Teller and R. Grishman. 1988. A sublanguage approach to Japanese-English machine translation. In D. Maxwell, K. Schubert and T. Witkam (eds) *New Directions in Machine Translation*, Dordrecht: Foris. 109-120.

- [26] Luckhardt, H.-D. 1991. Sublanguages in machine translation. Proceedings of the Fifth Conference of the European Chapter of the Association for Computational Linguistics (Berlin), 306-308.
- [27] McDonald, D.D. 1987. Natural language generation: complexities and techniques. In S. Nirenburg (ed.) *Machine Translation: theoretical and methodological issues*, Cambridge: Cambridge University Press, 192-224.
- [28] McLean, I.J. 1992. Example-based machine translation using connectionist matching. Report No. 92/2, Centre for Computational Linguistics, UMIST, Manchester. (Submitted to Fourth International Conference on Theoretical and Methodological Issues in Machine Translation of Natural Languages, Montreal)
- [29] Melby, A.K. 1982. Multi-level translation aids in a distributed system. Proceedings of Coling '82 (Prague), 215-220.
- [30] Nagao, M. 1984. A framework of a mechanical translation between Japanese and English by analogy principle. In A. Elithorn and R. Banerji (eds) *Artificial and Human Intelligence*, Amsterdam: North-Holland. 173-180.
- [31] Pym, P.J. 1990. Pre-editing and the use of simplified writing for MT: an engineer's experience of operating an MT system. In P. Mayorcas (ed.) *Translating and the Computer 10: the translation environment 10 years on*, London: Aslib. 80-96.
- [32] Sadler, V. 1989. *Working with Analogical Semantics: disambiguation techniques in DLT*. Dordrecht: Foris.
- [33] Sadler, V. 1991. The textual knowledge bank: design, construction, applications. Proceedings of International Workshop on Fundamental Research for the Future Generation of Natural Language Processing (Kyoto), 17-32.
- [34] Sadler, V. and R. Vendelmans. 1990. Pilot implementation of a bilingual knowledge bank. COLING-90 (Helsinki), Vol.3, 449-451.
- [35] Saito, H. and M. Tomita. 1986. On automatic composition of stereotypic documents in foreign languages. 1st International Conference on Applications of Artificial Intelligence to Engineering Problems, (Southampton). Research Report CMU-CS-86-107, Department of Computer Science, Carnegie-Mellon University.
- [36] Sato, S. 1991. Example-based translation approach. Proceedings of International Workshop on Fundamental Research for the Future Generation of Natural Language Processing (Kyoto), 1-16.
- [37] Sato, S. and M. Nagao. 1990. Toward memory-based translation. COLING-90 (Helsinki), Vol.3, 247-252.
- [38] Schubert, K. 1986. Linguistic and extra-linguistic knowledge. *Computers and Translation* 1, 125-152.
- [39] Sebba, M. 1991. The adequacy of corpora in machine translation. *Applied Computer Translation* 1, 15-27.
- [40] Skousen, R. 1989. *Analogical Modeling of Language*. Dordrecht: Kluwer.
- [41] Somers, H. 1987. Some thoughts on interface structure(s). In W. Wilss and K.-D. Schmitz (Hgg.) *Maschinelle Übersetzung — Methoden und Werkzeuge*, Tübingen: Niemeyer. 81-99.

- [42] Somers, H.L. 1990. Current research in machine translation. Third International Conference on Theoretical and Methodological Issues in Machine Translation of Natural Languages (Austin, Texas). 1-12.
- [43] Somers, H.L., J. Tsujii and D. Jones. 1990. Machine translation without a source text, COLING-90 (Helsinki), 271-276.
- [44] Steer, M.G. and F.W.M. Stentiford. 1989. Speech language translation. In J. Peckham (ed.) *Recent Developments and Applications of Natural Language Processing*, London: Kogan Page. 129-140.
- [45] Sumita, E. and H. Iida. 1991. Experiments and prospects of example-based machine translation. Proceedings of the 29th Annual Meeting of the Association for Computational Linguistics (Berkeley), 185-192.
- [46] Sumita, E., H. Iida and H. Kohyama. 1990. Translating with examples: a new approach to machine translation. Third International Conference on Theoretical and Methodological Issues in Machine Translation of Natural Languages (Austin, Texas). 203-212.
- [47] Tsujii, J. and M. Nagao. 1988. Dialogue translation vs. text translation — interpretation based approach. Coling Budapest, 688-693.
- [48] Whitelock, P.J., M.M. Wood, B.J. Chandler, N. Holden and H.J. Horsfall. 1986. Strategies for interactive machine translation: the experience and implications of the UMIST Japanese project. Proceedings of Coling '86 (Bonn), 329-334.
- [49] Zajac, R. 1988. Interactive translation: a new approach. Coling Budapest, 785-790.