Machine Translation in Practice

—

Is it applicable already?

Tino Schwarze

February 9, 2001

This paper is also available online:

<http://www.tu-chemnitz.de/~tisc/LaCo/hausarbeit/html/>

Contents

1 Introduction

1.1 A Quick Glance at History

In France and Russia, the first machine supported translation systems were built in the early 30ies of the 20th century. The first real computer was built in 1942 and created the condition for the development of Machine Translation (MT). In those years, the attitude to MT was very optimistic and the expectations were very high.

The famous Weaver memorandum in 1949 can be seen as a starting point for research in MT. The memorandum focused on general strategies and long-term objectives of MT and not on technical problems.

> Weaver raised four points:
>
> - the problem of multiple meaning and the resolution of ambiguity,
> - the logical basis of language
> - the application of communication theory and cryptographic techniques,
> - and the possibilites of language universals.
>
> He thus identified many of the fundamental problems of MT which remain a challenge today.
>
> [Newton 1992b]

In 1952 the first MT conference was held at the Massachusetts Institute of Technology (MIT). Two years later, the Georgetown Experiment, a public performance of MT, was an enormous success. Looking back at the experiment nowadays makes it look like a fake — the vocabulary was very limited and the sentences had to have a very simple structure. Anyway, research on MT was intensified by financial backing of several gouvernments.

The real world problems of MT became apperent in the 60ies. There was also increasing evidence that some of them could not be solved easily. The high expectations uttered ago had not yet been fulfilled. In 1964 a committee was formed to examine the current state of MT and future possibilities, the Automatic Language Processing Advisory Committee (ALPAC). Two years later, the ALPAC published the ALPAC Report which recommened the cessation of all MT funding. Although the report was primarily aimed at MT research and development in the US, it had a very negative impact on MT research in Great Britain, France and the Federal Republic of Germany too.

In 1967 the Commission of European Communities (CEC) started the first research on MT at the EURATOM establishment in Italy. Up to the late 70ies, considerable progress was made. This period can "in retrospect be seen as a period of reflection, learning and of gathering strength." [Pugh 1992]

The ambitious EUROTRA initiative was launched in 1978 by the Commission of European Communities after initial attempts to adopt the imported American SYSTRAN system to multilingual needs. EUROTRA contributed to the establishment of a European MT community with an established communication infrastructure.

1.2 Terminology

Several terms and acronyms are used within the MT context. I list them here, so I will not have to explain them later.

Source Text Text in source language.

Target Text Translated text in target language.

MT Machine Translation

HT Human Translation

FAHQT Fully Automatic High Quality Translation

The ultimate goal of machine translation. During the evolution of machine translation, it became more and more apparent that this goal will be difficult to reach if not impossible:

> By that time [the early 1980s], however, the elusiveness of this objective had become all too apparent, and today FAHQT is more of a dream than an ambition.
>
> [Pugh 1992, p. 18]

MAHT Machine Aided Human Translation

The machine supports the human during translation. The human translator uses the machine as a tool, e. g. for fast access to dictionaries, thesauri and corpora.

CAT Computer Aided Translation (see MAHT)

HAMT Human Aided Machine Translation

The human supports the machine during translation. The machine does most of the work and "asks" the human in unclear situations, e. g. ambiguities or unknown words.

FALQT Fully Automatic Low-Quality Translation

An (probably) imperfect MT system is used to get a quick and rough overview of the information contained in the source text.

x % **accurate** Specifiying percentages for translation correctness is completely useless in general since there are no standardized measurement methods.

There is no such thing as an 100 % correct translation since "correct" depends on the purpose of the translation.

2 Common Misunderstandings about Language

2.1 Bloomfield's Secondary and Tertiary Responses to Language

I'd like to start with a quotation of Bloomfield.

> Utterances about language may be called SECONDARY RESPONSES to language. [...] our culture maintains a loosely organized but fairly uniform system of pronouncements about language. Deviant speech forms in dialects other then the standard dialect are described as corruptions of the standard forms ('mistakes', 'bad grammar') or branded as entirely out of bounds, on a par with the solecisms of a foreign speaker ('not English'). The forms of the standard dialect are justified on grounds of 'logic'. [...]
>
> [Bloomfield 1944]

Bloomfield mentions several wide-spread misconceptions about language. The problem with understanding language is that everybody believes to understand it. But using something all-day does not imply to really understand it. There is a gap between theory and application and it is very difficult to deduce from application to theory, which, in my opinion, is the only way to approach language[1]. The following statements are almost always plain wrong upon closer knowledge of language and linguistics.

> Language A is more ...... than language B ('logical', 'profound', 'poetic', 'efficient', etc. *fill in the blank yourself*).

[1]Aproaching language from theory to practice seems to work for languages in general but not for natural languages in special.

> The structure of language C proves that it is an universal language, and everyone should learn it as a basis for studying other languages.
>
> Language D and language E are so closely related that all their speakers can always easily understand each other.
>
> Language F is extremely primitive and can only have a few hundred words in it.
>
> Language G is demonstrably 'better' than languages H, J and L.
>
> The word for '......' (*choose almost any word*) in language M proves scientifically that it is a worse — better, more 'primitive' or 'evolved', etc. — language than language N.
>
> Any language is easy to master, once you learn the basic structure all languages are built on.
>
> [Gross 1992, p. 106-7]

It looks like languages cannot be categorized easily. It takes years to study one language and build a theory about it. Not to talk about theories about several or even all languages.

2.2 The Chomskiyan Approach

Less than ten years after Bloomfield's death, new observations were made which "shared a certain philosophical groundwork with computational linguistics, constitute the credo of the Chomskiyan approach." [Gross 1992, p. 107] Some of them would probably have been regarded as secondary responses by Bloomfield as they do not emphasize studying languages but aim for generalizations.

> 1 All languages are related by a 'universal grammar'.
>
> 2 It is possible to delineate the meaing of any sentence in any language through knowledge of its deep structure and thereby replicate it in another language.
>
> 3 A diagram of any sentence will reveal this deep structure.

4 Any surface-level sentence in any language can easily be related to its deep structure, and this in turn can be related to universal grammar in a relatively straightforward manner through a set of rules.

5 These and related statements are sufficient to describe not only the structure of language but the entire linguistic process of development and acculturation of infants and young children everywhere and can thus serve as a guide to all aspects of human language, including speech, foreign-language training and translation.

6 The similarity of these deep- and surface-level diagrams to the structure of computer languages, along with the purported similarity of the human mind to a computer, may be profoundly significant.

[Gross 1992, p. 108]

The Chomskiyan approach to language seems overly optimistic. At least points 4-6 are highly questionable. The first point can be assumed to be true since the "universal grammar" only needs to be huge enough but this is of no practical significance since the resulting grammar would probably be useless for computers[2].

To point 6 it is to say that the human mind is not similar to a computer. They are fundamentally different: A computer usually takes one instruction after another, computes the result and stores it somewhere. It works with discrete values, mathematically correct. On the contrary, the human brain works massively parallel — millions of neurons simultaneously take incoming signals, process them, possibly outputting signals themselves. The signals are analog, each neuron is connected to various others, sometimes crossing half of

[2] Chomsky did theoretical research on grammars and languages which is important for Computer Science. His classification of languages — Chomsky's hierarchy — is part of theoretical computer science. It has been proven that there are semi-decidable grammars producing semi-decidable languages. For these grammars, a computer will only be able to figure out that a sentence is valid for the given grammar but it will never be able to tell that it is not (the program runs infinitely long in this case).

the brain. This "chaotic" shape should not be called similar to the orderly architecture of a computer[3].

3 Machine Translation Roentgenized

3.1 Strengths and Weaknesses of Computers in General

To get a first idea of possible applications of computers in translation, one should take a look at the strenghts and weaknesses of computers in general. We might be able to conclude what will be easy and what will be difficult to achieve using computers.

Computers are usually a synonym for very fast calculations. Today's computers easily handle several hundreds of millions operations per second (like adding two numbers). Further, computers have a very high bandwidth, that is they are able to handle huge amounts of incoming and outgoing data in short times (e.g. around 70 Megabytes per second – around 18,000 sheets of typed paper)[4].

Although these numbers might look impressive, computers have their shortcomings too. At first, computers lack creativity. There are examples for "com-

[3]Research in Artificial Intelligence (AI) led to so-called Neural Networks. They imitate the way the human brain works but they have a capacity orders of magnitude lower than the brain. It has been found that a human does not seem to be able to understand a neural network although the basic principles are not too complex. Neural networks "memorize" information the same way the human brain does — distributed over the whole network whereas computers store information at discrete locations. It looks like the human brain might never be able to completely understand itself as it has problems with processing distributed external(!) information.

[4]Again, research in AI and Robotics has shown that the human brain handles large amounts of "data" in passing — think of all visual, audible, tactile, smellable and tasteable impressions gathered and processed every second. A lot of different fields are being researched, each of them a basic ability of the brain: face, character and voice recognition, planning, navigation, knowledge representation, learning, etc. No spectacular breakthroughs are expected soon.

puter art" but these are usually based on mathematics and could be reproduced by humans as well (though probably requiring an immense amount of time). Secondly, up to now computers never understand the data they are processing. There has always been a human programming the computer and the machine is always limited to what it has been programmed to. Computers sometimes look intelligent but in fact they absolutely dumb. There are huge problems to make computers perform tasks which are considered very simple by humans.

From those properties we can conclude that computers are good at tasks that

1. are highly repetitive
2. are "stupid"
3. do not need any creativity
4. involve huge amounts of calculations (also repetitive).

3.2 Well-known Problems of MT

There are several well-known problems of machine translation which should not be kept secret here. They are very fundamental and pose difficulties for human translators as well (see also [Riedel, Schwarze 2000]).

Syntactical ambiguities: The structure of a sentence often depends on semantics, not only on the type of words.

Example: *Flying planes can be dangerous.* ⇒Is the correct grouping *(Flying planes)* or *(Flying) (planes)*?

Polysemy: Polysems are words which have several similar meanings. They are difficult to translate since an appropiate word in the target language has to be found.

Homonymy: Homonyms are several independent words which ”share” the same linguistic corpus. They are difficult to translate since their meaning often depends on the context.

Referential Ambiguity: Pronouns refer to certain words but it is often not clear to which. References might cross sentence boundaries and heavily depend on context and semantics. As a consequence, gender might change from language to language and has to be adjusted accordingly.

Metaphors and symbols: Both metaphors and symbols depend on the underlying culture and sometimes cannot be translated. There might exist equivalent expressions in the target language which can be located using idiomatic dictionaries.

Synonyms: There are often several words with almost the same meaning which makes it very difficult to choose the right translation since it depends on context, style and semantics. Differences are often very subtle.

Fuzzy Hedges: Vague words, terms and expressions like *in a sense* and *irgendwie* are called Fuzzy Hedges. Such expressions are language dependent and difficult to translate.

New developments: As society and technology progress, new words, terms and expressions are introduced. Words might be used in new contexts, new slangs might appear or marketing equips simple phrases with complete new meanings.

Example: The phrase *Ich bin drin* got associated with being online since AOL run advertisements with Boris Becker in Germany.

3.3 What Computers Probably Will Never Be Able to Translate

Communication of meaning is only one among many functions of language. Language is a social phenomenon. Computers rarely "know" about society and they will therefore have problems with translating utterances for:

- demonstrating one's class to the person one is speaking or writing to;
- simply venting one's emotions, with no real communication intended;
- establishing non-hostile intent with strangers, or simply passing time with them;
- telling jokes;
- engaging in non-communication by intentional or accidental ambiguity, sometimes also called 'telling lies';
- two or more of the above (including communication) at once.

[Gross 1992, p. 110]

3.4 More Linguistic Problems

There are even more problems which sometimes sound simple but are extremely complicated to solve in MT. They are all connected to context: It "is virtually impossible to separate the formulation of even the simplest sentence in any language from the audience to whom it is addressed" [Gross 1992, p. 110]. At the first glance, this is surprising, at the second it becomes obvious.

Further, there are translation tasks which are very complicated for human translators, e.g. stage plays, lyrics, advertising, titles of books, newspaper headlines, poetry etc. "A joke in language A must also become a joke in language B, even if it isn't" [Gross 1992, p. 111].

Translation is almost always associated with understanding the text to translate. Computers do not understand. They simply process.

Apart from MT problems there are real-world problems not yet solved. There are some cross-cultural issues which can not or only hardly be translated. Chinese medicine for example has several branches completely unknown to Western people. The branches themselfes are perfectly logical and consistent in their own terms and have their own explanations and methods for observations, measurements and diagnosis. But the specialized vocabulary is very hard to explain to non-specialists, not to talk about translating it into a foreign language. (Imagine a fully automatic MT system. It would need to know for whom the text to translate is intended. If the text was intended for normal people, the system had to add an explanation about Chinese medicine in general. The other way around, if there was special English vocabulary for that particular branch of Chinese medicine, the MT system would have to figure out what the English text was about and then use the specialized Chinese vocabulary.)

4 Applications of Machine Translation

4.1 Translating Large Volumes

"The real test of machine translation is whether or not it is effective in large-scale operations." [Vasconcellos, Bostad 1992] Therefore the evaluation of how MT worked at the Pan American Health Organization (PAHO) will provide evidence of whether MT can be used efficiently already.

4.1.1 Preconditions

Development of MT at PAHO was undertaken with two main purposes. First, to meet international translation demands more efficiently and second to propagate health information in the Latin American and Caribbean countries. Only a few of the translations are for information only. The majority of translations must be of a high quality and stand close inspection.

4.1.2 Overview

The first language combination introduced at PAHO was Spanish–English with the SPANAM system. In 1985, a more sophisticated system was used for translations from English to Spanish (ENGSPAN). Both systems are written in the programming language PL/1 and run on mainframe computers. Later, the SPANAM system was rebuilt using the more advanced architecture of ENGSPAN.

SPANAM and ENGSPAN have deeply coded dictionaries with 63,000 and 55,000 terms respectively. They are capable of handling a wide range of subjects: Medicine, agriculture, public health, management, law and computer science. They also have to cope with a variety of styles:

> Journal articles and abstracts, textbooks, manuals (both for human health and for software), proposals for funding, reports of missions, contracts and agreements, minutes of meetings, business letters, diplomatic exchange, certificates, product specifications, supply lists, captions for displays and even promotional materials and film scripts.
>
> [Vasconcellos, Bostad 1992, p. 59]

Texts are fed into the system without pre-editing. The translated texts are then post-edited by professional translators on-screen.

The PAHO environment is very special as the system is developed in-production. Suggestions for changes are best brought up by the people actually working with the system. They are able to tag the machine output for later review by a terminologist. They can also suggest general system improvements.

> The computational linguists, for their part, conduct their research on production text and are constantly monitoring the output to ensure that the two systems are performing up to standard.
>
> [Vasconcellos, Bostad 1992, p. 64]

This assures that the system is constantly updated and the editors also see their suggestions being implemented and that they have an influence on the quality of the output.

In 1989, MT was the primary mode of translation at PAHO as it supported at least 60 % of all regular production for the two languages involved. Around 1990, the machine output averagead around 6,000 pages (1,5 million words) a year.

4.1.3 Introduction of MT at PAHO

Machine translation was not introducted overnight. At first, a seperate unit was created at PAHO in direct competition to the existing human translation service. A certified translator was hired to work full-time on post-editing the translated texts. He/she also updated the dictionaries based on experience.

For the first five years, post-editing was done with no additional cost for the requesting office. The end consumer had the choice to use MT or not to use it. The new service was well accepted and the good word spread. MT had the advantage that the output was already machine readable which was not true for the results of human translation at this time. MT could also be used for informational purposes by limiting post-editing.

In succession to structural changes, an eleven-month experiment was undertaken in October 1987 to figure out whether MT at PAHO was cost-effective, fast in turnaround and could produce more than human translation within a year. MT ceased to be optional, all texts had to be submitted on diskette. The incoming work was checked to determine whether it was suitable for the computer.

The following characteristics were checked to determine whether to use MT or HT:

> 1. machine readability (or optical 'scan-ability')
> 2. complexity of format; and
> 3. linguistic characteristics (e.g. grammar, discourse, genre, need for between-the-lines interpretation etc.)
>
> [Vasconcellos, Bostad 1992, p. 68]

Time-frame considerations, availability of post-editors and individual abilities of the translators also influence the decision.

It turned out that post-editing seems to be a special skill. It is difficult not to rewrite the complete machine output on the one hand but to meet the high standards of a translation on the other hand.

> In order to come up to this standard, the post-editor must be certain of all technical terminology, capture every nuance, provide accurate interpretations for coherence [...], ensure idiomatic equivalence, maintain a uniformly appropriate register, build in cohesiveness where it is lacking, provide adequate 'staging' [...], and preserve the information structure [...]
>
> [Vasconcellos, Bostad 1992, p. 69]

All this post-processing requires a lot of contextual and semantic knowledge which was not available to the machine for the translation. This is an example of clear limitations of MT.

4.1.4 Results

The experiment was a great success for machine translation. A survey was made to get feedback on the service. The clients asked did not know wether their text had been translated by human or by a machine with human post-processing. The quality of machine translated and post-edited texts was sometimes rated higher than the quality of human translated texts. The goal of 30 per cent savings over in-house human translation was surpassed.

Finally, the MT effort at PAHO can be regarded as an successful application of machine translation. It reduced costs and raised productivity without sacrifcing quality. But this is also the result of a well-planned process and a lot of work.

> MT is now the principal mode of translation for these two language combinations [English ↔Spanish] and is an integral part of the organization's translation and terminology service.
>
> [Vasconcellos, Bostad 1992, p. 49]

4.2 Limited Context / Highly Standardized Language

The second application of MT I want to discuss here is possibly the most successful use of MT. It is the introduction of MT at Perkins Engines, Peterborough, England.

> It is an example of what can be achieved when a system is introduced in a thoroughly planned and methodical way into a restricted domain environment to process controlled-language source texts.

[Newton 1992c, p. 46]

Perkins is a manufacturer of Diesel engines and well established in worldwide export markets. There is a need for "rapid production of high-quality user documentation in five languages — English, French, German, Spanish and Italian." [Newton 1992c, p. 46] Until 1985, all translation was made manually.

It was found that existing translations had minor semantic and stylistic differences and also omissions and introduced elements. Therefore, more control from Peterborough was desirable while maintaining the quality of the translations.

4.2.1 Preconditions

The Technical Publications Manager, Peter Pym, decided to take a look at using MT. Fortunately, he had a foundation to build on — his department was already using controlled English known as Perkins Approved Clear English (PACE) for all documents.

A lot of problems of MT can be circumvente by restricting the source texts to a certain vocabulary (around 2,500 words for PACE), fixing the meaning of allowed words (one word = one meaning), avoiding ambiguities at word as well as at sentence level[5], avoiding synonyms and emphasizing clarity of expression.

The PACE dictionary lists all allowed words (nouns, verbs, adjectives and even articles, conjunctions, pronouns and prepositinos) with their definition and examples. Homographs for instance are only listed with their "allowed" meaning(s)[6]. There is also a set of rules for syntax and sentence patterns.

> This approach to writing grew out of a desire to convey technical information and instructions in as precise, clear and unambiguous a form as

[5] for instance, *right* is the opposite of *left*, it's use in the sense of *correct* is deprecated

[6] *seal* is listed as both verb and noun while *stroke* is only listed as a noun

> possible in the interests of safety and efficiency.
>
> [Newton 1992c, p. 47]

The texts produced by applying PACE are stylistically very homogenous, terminologically consistent and neutral in style and therefore well suited for automatic translation. Pym was aware that this could faciliate the introduction of MT and started to establish criteria for an ideal system in March 1984.

4.2.2 The Experiment

Pym and his team examined the few available systems and decided to give MicroCat a try. They had to build an English/French version of the PACE dictionary for the test. The core dictionary could not be modified so they had to copy entries for non-technical terms from the core dictionary and modify them accordingly, e.g. limiting the parts of speech in homographic entries. This optimization also increased the system's performance as the number of alternatives was reduced.

A problem with the input of the dictionary was that the system automatically generated inflected forms of target-language verbs, nouns and adjectives which could collide with the translation of identical forms functioning as other parts of speech. Therefore, all source-language words are entered uninflected[7].

The correct dictionary updating plays a key role in the quality of MicroCat's output. Multiple-word-entries were neccessary to compensate weaknesses of the system. Standard phrases and idioms were among them. MicroCat's feature of variable idioms was very useful here. Variable idioms are idioms with "holes" in them, e.g. *be % % away* where the "%" marks a hole to be filled in with a

[7] for example, *lubricating oil* had to be entered as *lubricate oil* to avoid interference with other *-ing* forms

word. These words can be further specified by selecting word type and allowed gender, number, person etc. There was also the possibility to specify "holes" which can be filled in or left empty. With these features, it is possible to enter generic "idioms" which handle a theoretically infinite number of permutations.

A trial and error process with iterative refinements of the dictionary led to a significantly improved quality of the raw output. It is difficult to get the right balance between useful additions and cluttering the dictionary with less frequent occurences since this increases processing time and may confuse the system.

After the impression was gained that little further improvement could be made by manipulating the dictionary, the English source texts underwent closer inspection to figure out whether changes could be made to improve the quality of translation. Critical sentences found during the repetitive updating of the dictionary were rewritten without sacrificing their naturalness. During this process, the number of verbs in the PACE dictionary was risen from 80 to around 250. Pre-editing is aimed at improving the system's output for an individual source text. The original, unedited version remains the official source language document.

Pre-editing led to a significantly improved quality of the output requiring only very little post-editing, although some problems could not be solved. The MicroCat system used for the tests is limited to the analysis of sentences. It cannot trace inter-sentence references. The translated texts therefore often lack coherence which needs to be added during post-editing.

4.2.3 Implementation

The translation experiment showed great promise. Peter Pym decided to order the software to translate the four language pairs his department had to handle.

The English/French language pair was almost complete but it was put through a broader test with previously human translated texts. A series of dictionary updating followed until it seemed to match Perkin's environment. The updates only afftected structures, not vocabulary which was already complete.

In 1986 the first text written under the modified PACE rules was translated by MicroCat. The result was better than expected. The raw translation was sent to Perkins in France for editing and proofreading.

> After final proofreading by Perkins France, the text was approved for publication. Painstaking preparation had created conditions in which very short turnaround times were achievable with minimal post-editing.
>
> [Newton 1992c, p. 54]

Since then, every new publication produced by Perkins has been translated by MicroCat. Other language pairs have been implemented and raw translations are polished by UK-based post-editors.

As a nice side-effect, the English source texts are very comprehensible which not only eases understanding by non-native readers forced to use the English version since their mother tongue is not available, but also for native speakers. Writing in controlled language leads to texts which are easier to understand and translate and also increases homogeneity between translated version of different target languages.

Conformance to PACE should not lead to untranslated words. If there are any words left untranslated by the system, they can be checked for potential addition to the PACE dictionary. Then, appropiate target-language translations can be determined and added to the MicroCat system. Additionally, post-editors are encouraged to report recurring structural problems.

4.2.4 Results

MT at Perkins is a another nice example of a successful application. This was not achieved by introducing MT but during the process of introducing MT. By "looking even more closely at what was being written and how it was being written" [Newton 1992c, p. 55], the field was leveled for successful machine translation.

The same procedures would also have eased human translation since a lot of general translation problems were simply avoided instead of trying to solve them.

Categorizing MT at Perkins as FAHQMT, HAMT or MAHT is not easy. The core of the translation is fully automatic. The translation result is also of a high quality and requires little post-processin; it would qualify as FAHQT. On the other hand, there is a lot of human preparation neccessary — the documents need to adhere to PACE writing rules and sometimes have to be restructured before translation. The mode of translation is therefore a mixture of HAMT and FAHQMT, it could be called Human Aided Automatic High Quality Translation.

5 Conclusion

5.1 Current Situation

Today, Machine Translation is a useful tool if one does not simply try to replace human translators by computers. There exist useable commercial systems and there has already been large-scale success. But all these successes in MT were based on thorough analysis, practical evaluation of demands and thoughtful application of available means, not marketing descriptions of inferior products.

Yet, there is no system keeping the promise of instant, accurate translation from language X to language Y. Pre- and/or postprocessing is always neccessary and, depending on the purpose of the translation, should be done by an able translator.

To get a rough overview of the contents of a document in a foreign language, some products might suffice. But usually it makes more sense to follow the machine aided human translation approach, that is the human translates and uses the computer's facilities to look up words, idioms, synonyms etc.

For special tasks, human aided machine translation can be used to reduce costs. Again, sound analysis is neccessary as the texts to be translated must be suitable for MT — just installing "some" software will not do it.

I agree with Jeanette Pugh:

> From the human translator's perspective, MT has gradually become more of an ally than a threat.
>
> [Pugh 1992, p. 18]

5.2 Perspectives

I only covered text-based MT here while translation covers more than that. There are promising projects, for example speech-to-speech translation in realtime like Verbmobil[8], needing completely new techniques and provoking new approaches which might lead to improvements in text-based MT as well.

> Another feature [of Verbmobil] is the presence of a special dialogue management module keeping track of the course of the dialogue. In several places, considerations about human interpreting strategies have found their way into the system modules. This tendency increases in the second project phase [...]
>
> These characteristics make the Verbmobil a typical representative of the new tendencies in MT. It is, however, only one of several interesting examples. The efforts of many other researchers are going into the same direction [...]
>
> [Hauenschild, Heizmann 1997, p. vii]

Research in MT continues. A lot of big problems are to be solved. I assume that for perfect MT we need to fully understand the human brain because language is the result of a very complex mental process. Linguistics hits several borders of human knowledge. Very fundamental questions are risen.

- How do we construct sentences?
- What is the link between language and thinking?
- How does the human brain resolve ambiguities?
- What is knowledge? Can it be appropiately represented by machines?
- What is meaning?
- Where does meaning come from?
- How do we think?

[8] Verbmobil's first project phase was finished in 1996 with the presentation of a research prototype

(Computer) Linguistics has already allied with Artificial Intelligence, Psychology and probably Neurobiologics as well. There have been experiments with neural networks which imitate the way the human brain works although they are very limited in capacity. There will probably be more attempts in that direction; we may end up simulating a whole human brain just to translate *Ich bin drin* into proper English.

References

[Bloomfield 1944] Bloomfield, Leonard (1944). "Secondary and tertiary responses to language". In: Hockett, Charles F., ed. (1987: 284-296).

[Gross 1992] Gross, Alex (1992). "Limitations of computers as translation tools". In: Newton, John, ed. (1992: 96-130)

[Hauenschild, Heizmann 1997] Hauenschild, Christa / Heizmann, Susanne, eds. (1997). *Machine translation and translation theory.* Berlin; New York: Mouton de Gruyter.

[Hockett 1987] Hockett, Charles F., ed. (1987). *A Leonard Bloomfield Anthology.* Chicago and London: The University of Chicago Press.

[Newton 1992a] Newton, John, ed. (1992). *Computers in translation: a practical appraisal.* London: Routledge.

[Newton 1992b] Newton, John (1992). "Introduction and Overview". In: Newton, John, ed. (1992: 1-13)

[Newton 1992c] Newton, John (1992). "The Perkins experience". In: Newton, John, ed. (1992: 46-57)

[Riedel, Schwarze 2000] Riedel, Marion and Schwarze, Tino, eds. *Machine Translation (MT): History, Theory, Problems and Usage.* Dec 2000. Chemnitz University of Technology. 03 Feb. 2001. <http://www.tu-chemnitz.de/˜tisc/LaCo/html/>

[Pugh 1992] Pugh, Jeanette (1992). "The story so far: an evaluation of machine translation in the world today". In: Newton, John, ed. (1992: 14-32)

[Vasconcellos, Bostad 1992] Vasconcellos, Muriel / Bostad, Dale A. (1992). "Machine translation in a high-volume translation environment". In: Newton, John, ed. (1992: 58-77)