Machine Translation and Machine-Aided Translation - what's going on

Jun-ichi Tsujii

Centre for computational linguistics, University of Manchester Institute of Science and Technology

1. INTRODUCTION

MT has always attracted a good deal of public attention, particularly that of people involved in translation. It has provoked controversies, sometimes very fierce, and unfounded worries among translators and their administrators. This happened partly because people put too much expectation on the possibility of MT. People talked about MT systems or the possibility of MT systems without using them.

This situation, however, has been changing rapidly. Quite a few commercial MT systems have been brought on to the market in the last two or three years and the number of translators using MT systems or at least having seen them, has significantly increased. People now can form their own judgements on MT systems by actually seeing or using them.

On the other hand, though old myths of MT have been debunked as people have seen and used actual MT systems, their experiences, especially of short encounters with MT, have sometimes led to new myths which are equally unfounded and wrong.

In this paper, we first make a short survey of the current state of MT systems and then discuss the capabilities and defects of current MT systems. We also suggest possible directions of future MT systems, where we emphasise new modes of man-machine co-operation in translation.

2. MACHINE TRANSLATION — PAST VS. PRESENT

MT has been conceived as one of the hardest "dreams" of information science to realize. The "difficulty" or "impossibility" of MT has been repeatedly stated by researchers and funding agencies which had been deeply disappointed by the performances of their MT systems after they had invested enormous amounts of resources for five or even ten years. They have expressed not only the difficulty of MT but the difficulty of translation as well. Translation requires not only knowledge about language but also the highest sort of human "general" intelligence. Translation is not easy even for human professional translators with a good knowledge of the languages but not enough knowledge of the subject matter of the texts.

As the current state of artificial intelligence research shows, computer systems, as they are now, are far from having "intelligence" comparable to human intelligence. Therefore, it is claimed, we cannot expect computers to translate properly.

The following statement was made by Bar-Hillel in 1951, forty years ago.

"Since the problems of semantic ambiguities could not be resolved, high-accuracy, fully-automatic MT is not achievable in the foreseeable future."

Another type of pessimism or criticism about MT comes from comparison of the cost-effectiveness between human translators and MT systems. This type of pessimistic view was expressed in the report issued by ALPAC in 1966 [ALPAC 1966]. They stated:

Although poorly paid, "the supply of translators greatly exceeds the demand" and "all the Soviet literature for which there is any obvious demand is being translated"

"the emphasis should be on speed, quality and economy in such translations as are required"

"MT was most definitely not a solution" (in comparison with human translation assisted by computer systems).

These two criticisms, one concerned with "the essential difficulty of translation" and the other with "cost-effectiveness of MT in comparison with human translators", were the roots of scepticism about MT, and still prevail even in these days.

However, though the essential difficulty of translation remains, the environments, technological or sociological, which once supported the second claim, have been rapidly changing and the number of people who believe in the "economic feasibility of MT" has been increasing.

The demand for translation has been growing rapidly, and in contrast to the U.S. in 1960's, societies such as Europe, Japan and other Asian countries suffer from a continuous shortage of human translators and the

cost of human translators is soaring up. What the ALPAC report said about human translators and the demand for translation may have been true in the U.S. at the particular period (1960's) and about the particular language pair of Russian and English, but is it not true in these countries (or societies) at present.

Apart from such sociological changes or differences, we have also observed in these two decades significant development in computer technology which affects the cost-effectiveness of MT systems.

First of all, the rapid development of hardware technology has largely removed difficulties caused by limitations of the ancient hardware such as memory capacity for storing large dictionaries, processing speed, etc., which were the major causes of technical difficulties in the earlier stage of MT research. The prices of computer systems have dropped with an unbelievable speed. Due to such rapid progress in hardware, small lap-top computers can provide a processing power sufficient for MT and the price of these machines is near to nothing compared with the price of the large-scale computer systems which researchers in earlier times assumed their MT systems would require. Note that the price of DUET by Sharp, a MT system from English to Japanese, is around £20,000, which includes the price of a standard Unix workstation with an OCR for alpha-numeric characters, ethernet interface, etc [See Table 1].

Secondly, in the last decade or two there has been remarkable progress in software systems which are not directly related to MT but have significant consequences for MT systems. In particular, progress in fields such as

[1] computer networks
[2] word-processing technologies including DTP (desk top publishing)
[3] data base and text base systems

allows us to conceive of highly automatised office environments or environments for groups of translators, terminologists and lexicographers where an MT system is integrated as one of the components, together with spell checkers, style/grammar checkers, intelligent access programs for text data bases, etc.

Not only in these related areas but also in the field of MT itself, we have observed remarkable progress. Though all researchers admit that FAMT (Full Automatic MT) is impossible, quite a few MT systems which assume human interventions in some form or other (e.g. HAMT – Human-Assisted MT, MAHT – Machine-Assisted Human Translation) have been brought onto the market and been successfully used in actual translation environments.

Experience of using these MT systems shows that MT systems could really reduce the cost of translation if they were used for types of translation suitable for them. There have been reports of successful installations of

[EX-1]   Sharp DUET
          English   —> Japanese

          OCR :   Multi-Fonts (117 different fonts)
                   recognition rate : 99.8%

          Translation Speed : 12,000 words/hour
          Price : £20,000

[Ex-2]   Toshiba Transac/1990
          English   —> Japanese
          Japanese   —> English

          CPU Speed: 13.2 mips
          Main-Memory : 8MB, Max 40MB
          Internal disc : 180MB
          Extension : 669 MB
          Ethernet Interface

          Translation Speed : 10000 - 12000 words/hour
          Dictionary : 50,000 words
          Technical Term Dictionary : around 50,000 words
                                      for each field
                                      (£4,000)
          Price : Hardware   : £8,000
                  Software   : £6,000 (both directions)

Table 1. MT on Small Computers

currently-available MT systems, although the actual figures for improvement quoted vary from one report to another. The following are some such examples.

[ex.1] PAHO (by Pan American Health Organization) : PAHO has developed two MT systems from English to Spanish (ENGSPAN) and from Spanish to English (SPANAM), for their own internal use. It took them three or four years to develop a prototype of SPANAM (1976-1979) and, after augmentation of the dictionaries (60,120 entries by 1984), they started to use SPANAM for actual translation and reported that they had succeeded in saving 61% of monetary costs and 45% of staff-days. [Vasconcellos 1985].

[ex.2] METAL (by Siemens) : They reported their experiences of in-house installations at a MT Summit [1987] saying "based on extensive pilot applications the hope for an increase in productivity by a factor of three does seem realistic".

[ex.3] DUET E/J (by Sharp) : The MT System DUET E/J developed

by Sharp (English to Japanese MT) has been used by a translation company where they use it to translate computer manuals from English to Japanese. After 1.5 years' preparation of domain-oriented glossaries, the system was reported to have increased productivity in translation by 30%. That is, while the average number of pages per month to be translated by human translators without MT was 120-130 pages, the MT system has increased this figure to 160-170 pages. Because eight translators in the company share a single DUET system through a computer network and the system is not expensive (around £20,000 – far less than the annual salary of a translator while they would get virtually 2.4 extra translators if the performances of eight translators were improved 30%), the translation company was reported to be well satisfied with the result.

These reports, together with other reports on the usage of commercial MT systems, show satisfactory performances of current MT systems. In short, though they are not at all perfect and cannot be used without human interventions, they can improve the cost-effectiveness of translation if used properly, which falsifies the scepticism expressed by the ALPAC report.

We can conclude this section by saying that the old criticism of MT based on the comparison with human translators has been losing ground.

3. LIMITATION OF CURRENT MT SYSTEMS

Though, as we see in Section 2, quite a few examples of using MT systems successfully in actual translation have been reported, there also have been many failures. There are many companies and organizations which once introduced MT systems with high expectations and gave up using them after several months' efforts.

We have to admit that the ability of current MT systems is severely limited so that they can be cost-effective ONLY if used properly in proper environments.

The limitations of current MT systems can be summarized under the following two headings.

[1] Restrictions on text types, subject matter, etc. : We cannot expect a single MT system to translate texts on any subject matter, any text types, etc. Some systems are good for translating computer manuals but not good for translating financial reports, which other systems may treat. For the time being, there will not be a universal MT system which can translate all documents. This means that, after purchasing an MT system, users of the system have to adapt it to their needs.

As extreme cases, some MT systems were developed only for single applications. TAUM-METEO is a typical example, where the system was designed in order to translate English meteorological reports into French. The linguistic knowledge (grammar rules, dictionaries, etc.) given to the

system was highly geared towards sentences appearing in meteorological reports [Thouin 1982]. ENGSPAN and SPANAM at PAHO, and the MU systems [Nagao 1985] [Nagao 1986] in Japan were also developed with very specific types of texts in mind. In the case of the MU systems, grammar rules and dictionaries were highly tuned towards translation of abstracts of scientific and technological papers. These systems are not intended to be used for translating different types of texts.

Though the MT systems currently on the market are intended to be more general than these systems specially designed for specific purposes, they have to be adapted towards specific applications, usually by users after having purchased them. The translation company mentioned in Section 2 which uses DUET E/J (Sharp) spent a year and a half preparing domain-specific glossaries, changing and adding grammar rules in order to cope with domain-specific (or text-type specific) linguistic phenomena (they use the system for translating computer manuals).

[2] Intervention by human translators: Current MT systems are not FAMT but either HAMT or MAHT. Though some application environments, like Systran at Xerox, assume human intervention before translation by MT systems [pre-editing], most current MT applications assume intervention after translation (post-editing) (See Fig. 1). That is, they usually assume that MT systems are to be used by people who have bi-lingual knowledge sufficient for verifying and changing translations produced by the systems, i.e. professional translators.
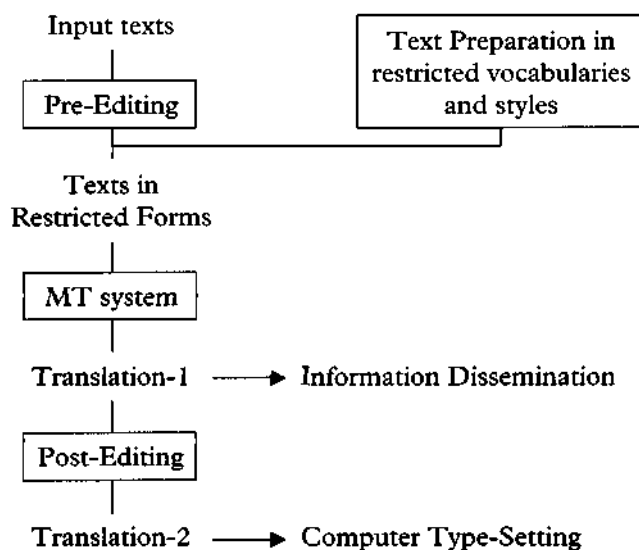

Fig. 1 Typical Flow Translation in HAMT

Though the underlying demand for MT systems is very high, these two limitations exclude large potential markets for MT systems. The current form of MT systems can be used successfully by a group of professional translators who are hired by large organisations to translate large amounts of uniform texts, but are not effective for

[a] ORDINARY people (not translators) who actually produce texts to be translated or want to get information from translated texts, because they lack sufficient bi-lingual knowledge

[b] single free-lance translators, because they have to treat much more diverse types of texts than those current MT systems assume and/ or because they, as independent single translators, cannot invest the time and money to adapt systems for their own purposes.

To investigate the reasons why current MT has the two limitations mentioned above, and what the consequences of these two limitations are, will reveal basic assumptions dominant in current MT research and development and will contribute to the discussion of future directions of this field.

4. BASIC ASSUMPTION OF CURRENT MT SYSTEMS — TRANSLATION AS A LINGUISTIC PROBLEM

It is obviously the case that GOOD translation requires deep understanding of texts. Even human translators sometimes produce wrong translations, when they do not understand texts. However, it is also the case that translators can produce reasonably good translations even though they don't understand texts FULLY.

Though we often talk about UNDERSTANDING of texts in Artificial Intelligence or Natural Language Understanding literature, there seems not to exist a single, absolute interpretation which can be called THE result of understanding a given text. "Understanding" is always relative to the goals or intentions of readers. Readers with different goals may understand the same text differently. People who want to use a computer system, for example, have to understand the manuals in a different way from translators who are asked to translate them.

The question of what sorts of "understanding" are required for translation is not trivial to answer. The only possible answer is that: an MT system should be able to understand texts in every possible aspect if a system is required ALWAYS to produce correct and natural translations. We will always be able to think of arbitrarily complex or tricky examples which require very DEEP understanding and for which even human translators might produce wrong translations if they did not understand.

However, from a practical point of view, the question to be asked is how

MT systems have to understand texts in order to produce reasonable translations for average, not so complicated or tricky, sentences.

The answer, or the position which current commercial MT system or MT research (with the notable exception of knowledge-based MT by CMU [Nirenburg 1987], etc.) have adopted, is one of the extremes. That is, they have assumed, implicitly or explicitly, that a certain quality of translation can be obtained without "understanding". They assume that a reasonable quality of translation can be obtained through manipulation of linguistic FORMS.

They have seen MT as a matter of manipulating linguistic forms i.e. transforming one form into another. Or more precisely, they have tried to define a translation relationship between two languages by referring only to forms of expressions of the two languages.

To illustrate this, consider the following example of a simple translation.

English   : Mr. Smith wrote a long letter.

Japanese   : Smith-san   ga nagai   tegami-wo   kai-ta.
              [Mr. Smith]   [long] [letter]   [to write: PAST]

These two sentences are considered to be translationally equivalent. What we want to do here is develop a theory by which we can explain why these two sentences are translationally equivalent, or more precisely, a theory by which we can distinguish pairs of sentences which are translationally equivalent from pairs which are not.

Since, as generative grammarians claim, we have an infinite number of sentences in any language, we cannot define such an equivalence relationship just by enumerating all pairs of equivalent sentences. That would require an infinite number of such pairs. What we have to do is exactly the same as generative grammarians do for defining grammatical sentences. That is, we decompose these equivalent sentence pairs into more basic, smaller units of equivalence and introduce a set of generative rules by which we can combine smaller units of translation equivalence to form larger equivalent units.

The obvious candidates for the smallest or basic units of equivalence are words in each language. There are, for example, the following pairs in translationally-equivalent words of English and Japanese.

letter <-> tegami
long   <-> nagai
write   <-> kaku
wrote   <-> kai-ta
etc.

Instead of enumerating all pairs of inflectional variants such as "write <-> kaku", "wrote <-> kai-ta", etc., we can define these equivalences by

dividing them into

[1]   mono-lingual knowledge such as
[1-a]   English : the past form of "to write" :=: wrote
[1-b]   Japanese : the past form of "kaku"   :=: kai-ta

and

[2]   bi-lingual knowledge (knowledge of correspondences of the
        two languages)
[2-a]   "to write" is translationally equivalent to "kaku"
[2-b]   the PAST-form in English plays a role translationally equivalent
        to the PAST-form in Japanese.

This clear division of linguistic knowledge into monolingual knowledge and bi-lingual knowledge leads to the conventional architecture of MT systems called the Transfer-based Approach (Fig. 2).
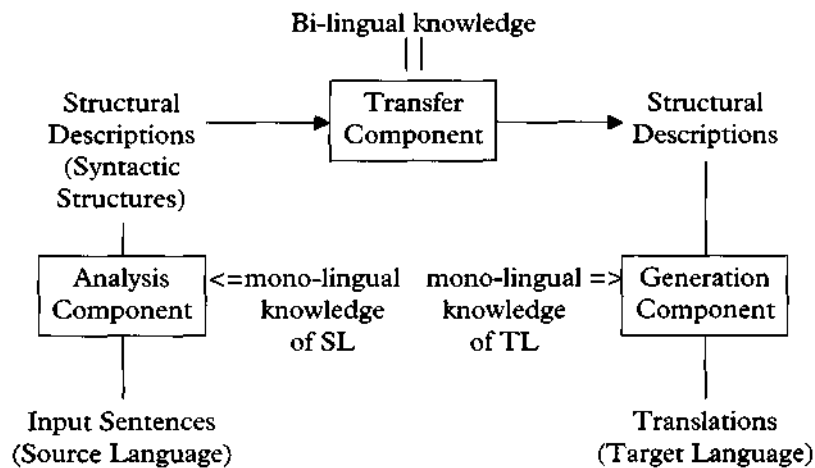

Fig. 2. Transfer Based MT

In this architecture, the forms of input sentences are described in the analysis phase by using mono-lingual knowledge of the source language. The surface form of English "wrote" is described in the result of the analysis phase as

{(to write), PAST},

and then, the second phase (the transfer phase) maps this description into the description of the target form like

{(kaku), PAST}.

The transfer phase uses the bi-lingual knowledge (knowledge about the correspondences between the two languages) such as "to write" corresponds to "kaku", "PAST in English corresponds to PAST in Japanese", etc.

The transfer phase has not only to replace source lexical items with corresponding target ones, but to change the order of phrases or structures as well, because individual languages have their own rules on word order. The direct object ("a long letter"), for example, follows the main verb (wrote) in English, while it has to precede the main verb in Japanese.

Such structural changes are also treated in the three separate phases in the transfer approach. That is, the analysis phase describes the input, for example, in the form of syntactic tree such as Fig. 3-(a), according to the rules of English grammar. Then, the transfer phase produces the corresponding target description such as Fig.3-(b).

[a]   English Structure
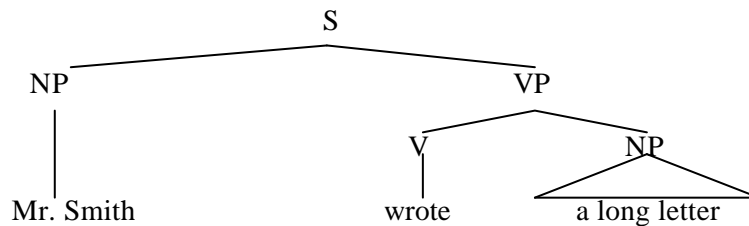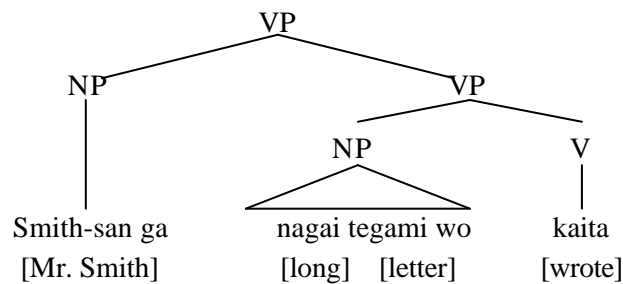
[b]   Japanese Structure

Fig.3   Structural Transfer

The analysis phase produces the description of the input sentence (Fig.3-[a]), by referring only to English grammar (mono-lingual knowledge), and the third phase (the generation phase) can produce a Japanese sentence from Fig.3-[b], by referring only to Japanese grammar.

Only the transfer phase refers to the bi-lingual knowledge which defines translation relationships between English and Japanese, in order to map the tree structure [a] in Fig. 3 into [b].
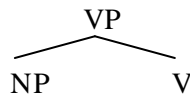
The structural changes in the above example is rather simple. That is, because Japanese is a typical of head-final languages, the English structure such as

{VP{V NP}},
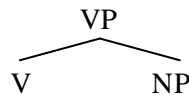
in which a verb, the head of a verb phrase, is located in the front of the whole VP, should be changed into

{VP{NP V}},

The same is the case for the English relative clause construction such as {NP-1 {NP-2 REL-CLAUSE}}, where the head of a noun phrase is located in front of a relative clause.

So we may have the following set of translation equivalent pairs of LOCAL structures of two languages.

English	Japanese
{VP {V NP}}	{VP {NP V}}
{NP {NP REL-CLAUSE}}	{NP {REL-CLAUSE NP}}
etc	

By combining these translation equivalent pairs of local structures and lexical correspondences, we can define translation relationships which cover all possible translation equivalent pairs of the two languages.

Of course, the definition of translation relationships between two languages is not so simple as above. A single word in one language, for example, may correspond to a phrase in another language. Or there is no guarantee that a word in one language corresponds to a word with the same part-of-speech in another language. A well-known example is the correspondence between English "like" and Dutch "graag", where a verb (like) in English corresponds to an adverb (graag) in Dutch (For more examples of complex cases, see [Lindop 1991]).

Such idiosyncratic correspondences may make the above simple story of defining translation equivalent relationships more complicated.

However, though we may have simplified too much and ignored complications involved, research and development of MT systems based on the transfer approach, which has been the dominant paradigm of MT in recent decades, have been carried out by following the line we described above.

In short, they assume that translation relationships can be defined based on linguistic forms and that there is an appropriate level of description where such translation relationships can be defined in a simple manner (a small number of rules).

5. TRANSLATION AS A PROBLEM OF COMPREHENSION : SEMANTIC BARRIERS

As we see in Section 4, the dominant paradigm of current MT has formulated MT problems basically as manipulation of linguistic forms. However, there are many problems which seem beyond mere manipulation of forms but require "understanding of texts".

The same example can be used for showing the necessity of "understanding" in translation. Though, for the sake of simplicity, we say the two sentences

English :   Mr. Smith wrote a long letter.
Japanese: Smith-san   ga   nagai tegami-wo   kaita.
             [Mr. Smith]   [long] [letter]   [write-Past]

are translationally equivalent, the same English sentence should be translated into Japanese differently, depending on the context in which this sentence appears. The above translation sentence is the correct translation only in a restricted context, for example, where the writer of this sentence is a neutral observer of the event.

On the other hand, if the writer of this sentence and Mr. Smith stand in a certain social relation where the writer should express his respect to Mr. Smith, an appropriate honorific expression should be used in the Japanese translation such as

            Smith-san   ga   nagai tegami-wo   kaka-re-ta.
            [Mr. Smith]   [long] [letter]   [write-Honorific,
                                                           PAST]

Or, if the writer gets a benefit from Mr. Smith's writing the letter and Mr. Smith is high up in the social hierarchy, the fact that the writer gets a benefit from the described action of Mr. Smith should be expressed explicitly in Japanese by using a specific auxiliary verb, such as follows.

      Smith-san   ga   nagai tegami-wo   kai-te kudasa-ta.
      [Mr. Smith]   [long] [letter]   [write] [Special Aux,
                                                Past]

If Mr. Smith is not so high up in the social hierarchy but a colleague of the writer, we have to use another auxiliary verb (morau) instead of ("kudasaru" in the above), in order to express that the writer gets a benefit from the action.

      Smith-san   ni   nagai tegami-wo   kaite   mara-ta.
      [Mr. Smith]   [long] [letter]   [write] [Special Aux,
                                                Past]

There are at least four different Japanese translations, only one of which is correct in a given situation.

Though these examples may appear idiosyncratic to English to Japanese translation, it is generally the case that, in order to translate texts properly, we have to know the background or context where the texts were written. It is often the case that factors which have a significant influences in selecting forms in one language have no influence at all in another language and so are not explicitly expressed in surface texts of the language. In translation, translators or MT systems have to recover from contexts these implicit factors which have influences in selecting target linguistic forms.

Because social relationships between the writers of texts and persons mentioned in texts have less influence in selection of English surface forms (and so are mostly implicit in English texts), we have to infer these factors from linguistic or extra-linguistic contexts. This process of inferring information not explicitly mentioned in texts is far beyond the current MT systems. Furthermore, because the current transfer-based MT paradigm sticks only to the linguistic forms and provides no framework for referring to contexts where the linguistic forms appear, it is theoretically impossible to treat such context dependent translations.

The fact that professional translators often claim that they spend more time doing research on the background of texts than actually translating shows that problems caused by implicit information prevail in actual translation.

Another type of problem, which is one of the major difficulties of current MT systems, is the selection of appropriate target words. We assume in Section 4 rather straightforward correspondences between words of two languages, i.e., we assume one-to-one correspondences like

"tegami   <->   letter",
"write   <-> kaku",
etc.

However, this assumption is, of course, unrealistic. The word

correspondence is also very much dependent on contexts. The same words should be translated differently depending on what they actually denote and, the denotations of the same word highly depend on contexts.
The following shows one oft-quoted example of word selection problems.

[English]   —>   [Japanese]

to wear	kiru	[suits]
	haku	[shoes]
	tsukeru	[watches]
	kakeru	[spectacles]
	kaburu	[hats]

This example shows that we have to choose one of five (actually more) Japanese verbs as the correct translation of the single English verb "to wear". The selection is also one of what [Allegranza 1991] calls "context dependent mappings", in the sense that appropriate selection requires checking what sorts of objects are actually worn. In order to facilitate such selection, we have to classify nouns such as hat, watch, suit, shoes, etc. into different classes of objects.

This classification is beyond semantic classifications in the sense of traditional linguistics but resembles classifications of objects or concepts in knowledge representation in research into artificial intelligence. That is, the introduction of such classification schemes for nouns is the first step to introducing real world knowledge in MT and, though the current MT paradigm emphasizes the linguistic aspect and de-emphasizes the understanding aspect, most current MT systems provide frameworks in which such world knowledge of domain-specific classification schemes can be represented.

However, this simple classification scheme fails in treating some cases, where not only static knowledge of the world but also understanding of dynamic contexts are required.

The same example of "to wear" can also be used to illustrate the point.

The correct selection of Japanese verbs actually depends on the place where things are worn, though we said that it depends on what are worn. The fact is that individual objects such as watch, hat, shoes, etc. have their own default places where these objects are normally worn so that we can choose correct Japanese verbs in most cases only by checking the objects to be worn. In some exceptional cases, however, the default assumptions on places are violated. In a robbery situation, for example, stockings will be worn on the face rather than on the legs so that we have to use "kaburu" (the verb for hat) instead of "haku2 (the verb for shoes or boots) which is a correct verb for "stockings" in most cases. To judge whether texts describe a situation similar to a robbery situation or not is extremely difficult for the current computer systems and so, there are cases where

even MT systems equipped with world knowledge (static knowledge such as classification schemes for objects) fail in producing correct translations. The Japanese verb "asobu" is another example. This single Japanese verb has to be translated into several English verbs, depending on contexts (or even which are described by the verb). The core meaning of this verb is something like "to spend time without doing "useful" things". It can be used to describe

"small kids are PLAYING in a park",
"a person STAYs in Paris just for sightseeing"
"a person SPENDs one year in Australia without any purpose",
etc.

The events which are captured and expressed by completely different English verbs are described by the same verb in Japanese, simply because those events share the same property of "spending time without doing useful things" and the Japanese capture this property as a single gestalt to be expressed by a single verb.

In order for MT systems to translate the verb correctly, they have to be able to reconstruct the scenes described by the Japanese verb and recapture the same scenes with the eyes of an English speaker to choose appropriate English verbs. This sort of reconstruction/recapture process seems totally different from what we call deductive inferences in AI and may be similar to the process which Schank tried to simulate with his Scripts, or episodic memory-based understanding.

However, how to represent such reconstructed scenes or human episodic memory in the form of computer programs or computable data is not at all clear and is far beyond the scope of practical MT systems. What Bar-Hillel called "semantic barriers" or "semantic gaps" still remain largely untouched.

These examples may look, again, too idiosyncratic. However, we have to note

[1] multiple correspondences between words of two languages are very common in translation even among European languages (We just need to see ordinary dictionaries where most verbs have several translations in other languages),

[2] conditions on lexical selection are usually highly idiosyncratic to individual words, as idiosyncratic as "haku", "kaburu", etc. in Japanese. To conquer a huge collection of such idiosyncrasies is THE major issue in practical MT systems.

The important point is that these examples show that correct or good translation cannot always be obtained through mere manipulation of linguistic forms but requires "understanding" of texts, which in turn requires both a huge amount of real world knowledge and inference

capabilities (or general intelligence). Considering the current state of the art in AI and knowledge engineering, we cannot expect MT systems to understand fully texts to be translated so that what Bar-Hillel called "semantic gaps" between human and computer still remain. As research, we have proposed a framework in which the process of "understanding" texts is integrated with the translation process (Fig.4) where translation relationships are defined basically in terms of linguistic forms but have contextual conditions which refer to "understanding" aspects [Tsujii 1989] [Phillips 1990].
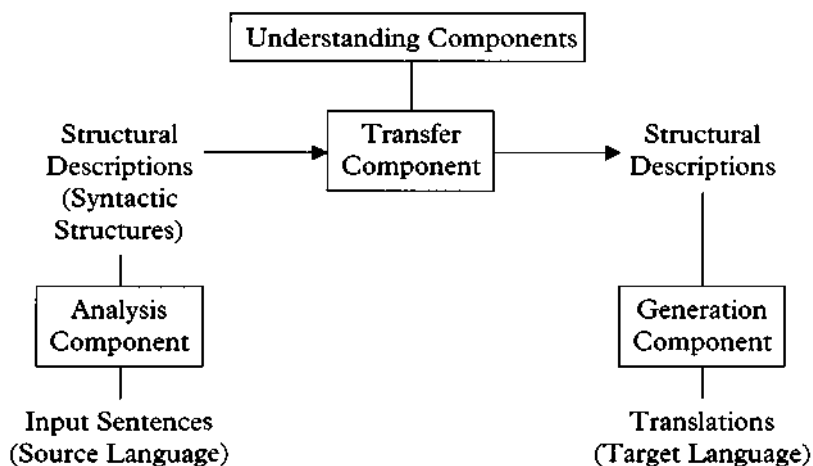

Fig. 4 Translation and Understanding

On the other hand, from a practical point of view, we have to admit the existence of large semantic gaps between man and machine, and devise practical ways of compensating for them, which we discuss in the following section.

6. FUTURE DIRECTIONS OF PRACTICAL MT SYSTEMS

In the previous sections, we have shown that

[1] the current MT systems basically perform translation through manipulation of linguistic forms

[2] the semantic gaps between man and machine still remain very large, though current MT systems introduce some frameworks where real world knowledge or domain-specific knowledge can be coded (for example, classification of nouns).

These observations explain what we called the limitations of the current MT systems in Section 3, namely

[a] restrictions on text types, subject domains, etc.
[b] human intervention

The need for human intervention is quite obvious: because of the semantic gaps between man and computer, current MT systems based on linguistic forms cannot translate texts 100% correctly and thus human intervention is inevitable unless we tolerate a certain percentage of errors and awkward translations.

The discussion in Section 5 also shows that difficulties caused by the semantic gaps between man and computer appear as difficulties of MT systems in treating "context dependency of translation". Restricting subject matters and text types means to restrict the contexts or background where texts to be translated are produced, and thus, contributes to reducing, at least superficially, the context dependency of translation.

In order to overcome the essential difficulties caused by semantic gaps, we may have to develop proper theories of human memory, theories for the process of transforming non-verbal understanding into verbal expressions (see the discussion of reconstruction/recapture process) etc., which Bar-Hillel indicated at the very beginning of the history of MT. However, though these are interesting as research topics in the long term, we will focus in the following on the topics which are interesting from practical points of view.

[A]   Man-Machine Interaction in MT

Current MT systems assume that the users are translators with bi-lingual knowledge. We expect translators to correct translation errors produced by the systems. However, this division of labour, i.e. machine produces erroneous translations and human revises them, is not so satisfactory, especially for translators. They tend to be bored with correcting trivial errors and also frustrated, because they feel they can translate by themselves much faster than correcting errors (which is often the case).

As we have already seen, translation requires two different sorts of knowledge, i.e. linguistic knowledge of two languages and extra-linguistic knowledge about contexts or background. The basic problem in the above conventional setting of HAMT is that, though both participants engaged in interaction have linguistic knowledge, they both lack the second type of knowledge i.e. extra-linguistic, background knowledge.

While human translators confess that they spend large proportions of their time in interviewing writers or reading relevant background literature in order to understand texts or sometimes to correct badly written source texts, the current MT systems do not provide any help. MT systems as they are now are just cheap, somewhat stupid, slaves which perform work which translators can do much better. Translators simply do not want to interact with such systems.

More meaningful interactions will be attained when one partner provides knowledge which the other lacks. The following two scenarios seem to us much more fruitful than the current HAMT situation.

[1] Human with extra-linguistic knowledge and MT system with linguistic knowledge: In this scenario, the human users are not translators but domain specialists or the writers of texts. Though they lack bi-lingual knowledge to correct errors in translation, they can provide extra-linguistic knowledge which MT systems do not have. On the hand, though systems have less amount of knowledge about the domains or the topics of texts, they can provide bi-lingual, linguistic knowledge which domain specialists or writers of source texts lack.

Unlike the current setting, translation produced by such systems should be correct and natural as target texts, because they are not to be revised by humans. Though this requirement sounds too demanding on MT systems, users of this type of systems will be more patient than professional translators because, unlike translators, they cannot translate texts by themselves and the system provides them with complementary skills. MT systems can ask every possible question relevant for formulating correct and natural target texts, including information absolutely implicit in source texts.

Systems of this type already exist, though they can only translate texts of highly restricted subject domains, eg. weather bulletins in [Kittredge 1991] and business correspondence in [Jones 1990].

[2] Human with linguistic knowledge and MT system with extra-linguistic knowledge : in this scenario, users are translators as is the case with current MT systems. However, in order to make the interaction fruitful, the systems will provide skills or knowledge which human translators lack. Terminology data bases of specific domains, for example, may be indispensable components of such a system. Terminology data bases, although rudimentary, are the first approximation of domain knowledge which human translators normally lack.

Because of the rapid development of global computer networks and cheap workstations, it is quite plausible for individual translators to share terminology data bases through networks. MT systems may be integrated as one of the components of such integrated environments for translators, together with other software such as translation oriented editors, style

checkers, etc.

As we discussed in Section 3, the conventional setting for HAMT seems effective only for translation of massive, uniform texts, where translations are produced in the same way as industrial products are produced in production lines. The above scenarios of different types of interaction in translation may cope with demands for translation which cannot be covered by current MT systems.

[B]   Domain Specific, Text-Type Specific MT Systems

As we discussed, "Context Dependency of Human Language" causes the major troubles in MT. Context dependency is closely related to creativity of language usages which distinguish human language from other artificially designed "languages". The same words or expressions have different "meanings", depending on the context where they are used. Or writers/ speakers use the same language creatively to express different things (different from "conventional meanings") and human readers/hearers can understand the newly-created meanings by considering contexts, basically because writers hearers share the same human cognitive devices and have similar experiences.

However, such unbounded creativity of human language, or unbounded context dependency can be largely constrained if we confine our interest to limited subject domains or text types [Kittredge 1987] [Ananiadou 1990]. Unbounded creativity or context dependency is partly due to the fact that we have to use the same language to describe arbitrary semantic domains. If we restricted the semantic domain to be described by language, the context dependency of translation would largely disappear.

The word "program", for example, may almost always denote "computer program" in the field of computer engineering, but it can also denote diverse concepts like concert "programs" "urban renewal programs", etc. Though these denoted objects or concepts share certain core properties in common (so that the same word is used in English to denote them), they may be expressed by several different words in other languages (Japanese, for example) because other languages may focus on different properties of objects as conditions of using their words.

In other words, while MT systems to treat texts in wider fields have to select appropriate target words for "program", a MT system which only translates texts in computer engineering fields could translate the word "program" into "sanpu" in Japanese, which would be correct in most cases.

As we discussed in Section 3, MT systems have been used successfully only when they are applied to the translation of texts in restricted domains and text types. In other words, the current MT systems can only be used to translate "language" in restricted domains, thus losing its "creativity"

as compared with human language. The word "program" may only denote "computer program" in the field of computer engineering, though the word can be used in general to denote things which have properties qualifying them to be called "program".

Straightforward correspondences between words and the things denoted by them also imply the straightforwardness of the correspondence of words of different languages and thus, we can expect far less context dependency of translation in such restricted domains. Furthermore, restricted subject domains allow us to encode extra-linguistic knowledge about the domain explicitly in the system and use them in order to resolve some types of semantic ambiguities. Knowledge-based MT proposed by several research groups including CMU in the U.S., ATR in Japan, etc., may not be practicable as MT systems which have to cover a large subject domain, but will be quite feasible as a framework for MT handling reasonably restricted subject domains.

However, as we noted in Sections 2 and 3, users of current MT systems have to adapt or tune their MT systems to their own applications after having purchased them, and this tuning process is usually very time-consuming and expensive.

That is, even though subject domains we select are restricted enough, it is generally not so easy to discover exactly what sorts of closure properties, or boundaries, the language in the domain has.

While it may be not so difficult to imagine that the word "program" in the field of computer engineering almost always denotes "computer program", it is not so easy to imagine what closure property the word "to match" has in the same field. Actually, though "to match" is given 11 different Japanese translations in a small English-Japanese dictionary, only one of them is used by a human translator to translate 212 occurrences of the word in the Unix manual. That is, the usage of "to match" in the Unix manual is fairly restricted and obviously reveals a closure property. However, it might be not so easy for MT system developers to know such closure properties in advance and reflect them in their translation dictionaries.

What we need here is a systematic methodology or a set of tools by which we can discover effective closure properties which the language in given subject domains shows. We need a good framework for man-machine cooperation here, too, where man, in this case, is a designer of an MT system who would like to tune an existing MT system towards his applications and machine here means a set of software tools and translation programs which facilitate this process of tuning [Tsujii 1990].

To conclude this section, though there might be many more to be discussed in the area of future directions of practical MT systems, we would like to emphasise that translation, which is one of the hardest intellectual activities of human beings and requires the highest sort of

human intelligence, cannot be performed by computer programs alone and, at the same time, that the ever-increasing demands for translation cannot be met by human translators alone. Good cooperation between man and machine, we believe, is the only solution to overcome translation problems in future.

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AUTHOR

Jun-ichi Tsujii, Centre for Computational Linguistics, UMIST,
PO Box 88, Manchester, M60 1QD.