Machine Translation in Natural Language Understanding

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Abstract

Introduction of understanding capabilities is inevitable for future advanced MT systems to produce much higher quality translations. However, the integration of understanding and translation processes is not so straightfoward. The paper discusses possible architectures of MT systems in which the two sorts of processes can be integrated in natural manner. Multilingual text preparation systems and dialogue translation systems are proposed as possible framework for future research.

1. Introduction

There have been great gaps between MT research and NLU (Natural Language Understanding) research in AI. MT researchers with few exceptions (Tomita, 1986) have generally claimed against exploitation of extra-linguistic knowledge and discourse information in MT, while exploitation of extra-linguistic knowledge and discourse information have been main research objectives in NLU. MT research so far has concentrated on formulating problems in MT as linguistic probems not as 'understanding' problems. Though I admit that a lot of things will have to be done in this framework, it is my contention in this paper that translation requires some extra factors, which we may call 'understanding'. We cannot avoid discussion about possible relationships between 'understanding' and translation, if we take 'high quality MT' seriously.

A research group of ATRL (Advanced Telecommunication Research Laboratory) in Japan, which is a research consortium established at 1986, aims to develop a machine translation system for telephone dialogues (Tsujii and Nagao, 1988; Kume and Sato, 1989), and is now gathering dialogue translation data in various hypothetical situations. Examining the accumulated data, we found a lot of examples of translation which are far beyond the ability of current, rather conventional MT systems which are mainly confined to 'linguistic' processings in translation. We would like to discuss in this paper the difficulties which we have found through the analysis of the sample data and propose a future research direction which will amend common defects of current conventional MT systems.

2. MT as an under-constrained problem

Most of the MT research so far seem to share the same common assumption that all information necessary for translation was conveyed by source sentences.

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Based on this assumption, the researchers who are interested in theoretical aspects of MT have tried to formulate linguistically 'translation relationships' between two languages, and those who are engaged in actual development of MT systems have tried to develop systems which analyse source sentences to get their structural descriptions and transform them to corresponding structural descriptions of target language, from which surface target sentences are generated.

The assumption that all information necessary for translation is contained in source sentences, however, is simply untrue in many cases. Human translators spend most of their time in interviewing 'writers' of texts to clarify their intentions or reading relevant documents to acquire background knowledge necessary for 'understanding' source texts, at least when they are required to produce 'good translations'.

The simultaneous (human) interpreters of KDD (the Japanese counterpart of ITT—International Telephone and Telegram or BTI—British Telecom International) who provide Japanese to/from English simultaneous translation services for international telephone calls usually start their services by making rather comprehensive conversation to their clients to acquire background knowledge about topics of dialogues and clients' intentions of making dialogues, i.e. what goals they want to achieve through dialogues, etc.

Being given Japanese sentence 'kaigi-ni sanka-shitai' without any contexts, for example, even a human interpreter of telephone dialogue cannot determine whether this should be translated into (1) I would like to attend the conference, or (2) I would like to attend a conference, because the Japanese sentence doesn't contain any cues for deciding whether the noun phrase 'kaigi' is definite or not. However, if he/she knew that the speaker of the sentence would like to attend a conference and get more detailed information about the conference from a conference secretary (the other participant of the dialogue), he/she could easily judge that it should be translated into (1).

Dialogue participants in translation experiments conducted by ATRL were instructed to make enquiries to conference secretaries, and presupposing the partners of dialogues were conference secretaries, they usually started conversation with the above ambiguous Japanese sentence. Because the human interpreters in the experiments were also informed in advance about the situations, they translated the sentence into (1) without any difficulties. The sentence, however, should be translated into (2) in different contexts, for example a context where the client asks a travel agent to book a hotel in a city where a conference he attends will be held.

Furthermore, Japanese words 'kaigi' and 'sanka-suru'

are somewhat ambiguous (or translationary ambiguous). 'kaigi' should be translated, depending on contexts, to several different English words including 'conference', 'meeting', and even 'council', and the verb 'sanka-suru' means a rather broad concept like 'to take part in', so that in a certain context the same sentence has to be translated as (3) I would like to be a member of the council.

These facts show that language translation is typical of 'under-constrained' problems, which we often encounter in the field of artificial intelligence. That is to say, source sentences themselves do not convey all information necessary for translation. The same sentences (or more accurately, the same fragments of source expressions) can and should be translated differently, depending on contexts, which are often not expressed explicitly in source texts or utterances.

We have to compensate this genuine property of language translation in actual MT systems by one way or another. One can think of providing an MT system with background knowledge about subject domains or extending units of translation from sentences to texts to gather information from linguistic contexts. Or we can also imagine a system which, as human interpreters or translators do, interact directly with writers (speakers) to gather necessary information for fixing contexts relevant to translation.

The conventional MT systems which are already on the market, however, cope with this genuine property of language translation by very rude ways. Instead of introducing 'extra' information sources such as discourse processings, interactions with writers, etc., which facilitate 'right decisions' in translation, they stick only to structural analysis of source sentences and the transfer of the structures to the target and introduce 'heuristics' for selecting single translations. Because 'heuristics' built in the systems often lead to wrong decisions, human translators have to verify produced translations and correct errors.

Which types of systems (i.e. conventional types of MT systems, systems with extra-linguistic knowledge of limited domains, systems with contextual processing facilities or highly interactive systems) are preferable and feasible may depend not only on the current MT technologies (we do not have, for example, feasible frameworks for contextual processing in MT) but also on the environments in which systems to be developed will be used. More importantly, different environments require different sorts of MT technologies.

Before discussing a possible integration of MT with NLU research, we will first examine the environments where MT systems are to be used.

3. Environments—MT as an engineering problem

The MU project, with which I had been engaged in for four years since 1982, was a project which stimulated research and development activities of MT in Japan. As a result, more than ten Japanese computer makers including Fujitsu, Hitachi, NEC, Toshiba, etc are now actively engaged in research in this field and some of them have already brought their products on to the market, most of which are English to/from Japanese systems.

Because research results of the MU project (Nagao *et al.* 1985), and the current situation of Japanese MT research/development (Preceedings of MT Summit I, in Tokyo, 1987) have been reported elsewhere, I would like to avoid repetition and only to summarize the lessons I personally learned through the experience of the MU project and the observation of Japanese commercial MT systems, the lessons which seem relevant to the following discussions.

The lessons I have learned can be summarized by the following two statements: (1) MT projects never fail, and (2) MT projects never succeed.

(1) is true because: if researchers involved in a project were serious or diligent enough, they could certainly develop a system which would produce 'translations' for a certain set of source sentences, and whatever theories or formalisms they might believe in, they could hack a system which would produce 'some' translations.

On the other hand, unfortunately, (2) is also true because: even if researchers in a project were extraordinarily clever, they could not develop a system which could produce 'right' translations for all possible source sentences, whatever excellent theories or formalisms they adopted for their system. Note that even a human translator cannot always produce 'right' translations autonomously without any interactions with writers of texts or without any research for relevant background materials. We cannot expect to have autonomous, complete 'translators', whether they may be human or machines.

All in all, success or failure of an MT system is a matter of degree and an MT system should be evaluated only by considering environments where it will be used, i.e. we have to consider whether an MT system is effective in a specific environment where it will be used.

Among various factors determining environments, users of MT systems are the most crucial factor. What sorts of users we envisage for our systems determine feasible architectures or formalisms for MT systems. Here, almost all MT projects including the MU project share the same assumption that their systems would be used in translation services and that the users or the persons who directly interact with their systems would be professional translators. We have presupposed so far the users to be bilingual.

In the conventional view, MT systems are used by a group of professional translators who belong to translation sections of large organizations and are trained how to use specific MT systems. They use MT systems to translate texts which have been prepared in advance by some other writers.

This view has characterized largely the architectures of the current MT systems. That is:

1. Emphasis on Post-Editing: human translators naturally prefer post-editing to pre-editing, because the effect of pre-editing is indirect compared with post-editing. They also dislike interaction during the translation process, because they can translate by themselves much faster.
2. Single Translations: MT systems are required to

produce single translations for single units of translation (usually sentences), because translators rather prefer correcting errors in wrong translations than selecting correct ones from a large number of possible translations.

In short, the current MT systems on the market try to determine single translations for source sentences without any significant evidences for it. They select single translations from possible candidates simply by guessing, usually based on very poor information.

In order to guess the most 'plausible' translations based on poor information, system designers inevitably introduced some 'dirty' mechanisms or rules which are not theoretically well founded, called 'heuristics'. In the MU system, for example, most of the 'rules' in the analysis and transfer phases are heuristic rules in nature which resolves structural ambiguities of source sentences and translation ambiguities based on various, mostly syntactic, cues. Those rules are mixed up in the system with ordinary linguistic rules which define possible translation relationships between the two languages, English and Japanese.

Though we prepared in the MU project certain software frameworks (rule packages, control graphs, etc) which allow us to accumulate various sorts of rules in modular ways, the whole system became huge and hard to maintain in the final stage of the project.

This course of development was inevitable if a system had to produce single translation results autonomously. We have to accumulate a huge number of tiny and dirty heuristics in a system. However, as we noticed above, this is an implication of the assumption that users of MT systems were professional translators and that they do not like to interact with systems during translation.

If we removed this assumption and if we envisaged different sorts of users such as monolingual users preparing texts in a language about which they have not enough knowledge, the situation would be quite different. They certainly prefer interaction in source language during the translation process than post-editing in target language. Furthermore, what is more important is that the users of this sort really know what they want to communicate by their texts and own background knowledge which are not expressed in texts but necessary for making the 'texts' meaningful.

We can think of a system which has conversations similar to those which are made by human interpreters in the translation service of international telephone calls. That is, through the interaction, a system will gather information which is necessary for translation but which is usually not expressed explicitly in source language texts.

So called 'automated offices' are becoming common, where ordinary office workers exploit various sorts of modern information technologies such as electronic mails, flexible editing facilities, file systems, etc. to prepare and store their documents, business letters, etc. It is quite reasonable to think of automated office environments which contain an interactive multilingual document preparation system which helps *ordinary* people (not professional translators) to prepare texts in a language about which they do not have enough knowledge.

Such multilingual text preparation systems are also a sort of translation systems, because users express in their native languages what they want to say and the system transfers them to another language. However, obviously such systems will have very different organizations from those of conventional MT systems, and we need different technologies from conventional MT systems.

The systems can directly gather necessary information from writers and have to be able to formulate target texts. They can ask writers to provide whatever information necessary for formulating target texts.

Both the multilingual text preparation systems and the dialogue translation systems share the advantage that they can interact directly with the persons who, though they usually lack linguistic knowledge, really want to communicate and have complete understanding of background contexts. On the other hand, conventional MT systems have presupposed users to be translators who have enough knowledge about target language but lack complete understanding about what source texts want to convey.

4. Linguistic problems vs. understanding problems

Structural correspondence of two languages can be very complicated especially when we consider two languages belonging to quite different language families such as English and Japanese, and well deserves to be research topics in linguistics. In order to develop MT systems systematically, we certainly need to have formal frameworks by which we can specify structural correspondences of two languages in neat ways. We have to accumulate in MT systems linguistic knowledge which relate expressions of two languages.

In translation of English and Japanese, we have to treat, for example, the following phenomena:

1. Japanese prefers sentences with intransitive verbs, while English prefers sentences with transitive verbs. English sentence 'The typhoon destroyed many houses' should be translated into 'taifuu-de ookuno ie-ga kowareta' in Japanese whose literal translation would be 'Due to the/a typhoon many houses collapsed'.
2. We often have to use complex expressions in one language in order to express 'concepts' which can be expressed in the other language by single lexical items. A lot of English adjectives, for example, should be translated into clauses in Japanese. English phrases 'lustrous surface' and 'efficient methods' should be translated to Japanese clauses 'koutaku-ga aru hyoumen' and 'kouritsu-ga takai houhou' respectively, whose literal translation would be 'surface on which lustre exists' and 'method whose efficiency is high'.
3. Some English adverbs like 'even', 'also', 'only' etc., correspond to particles in Japanese which follow noun phrases. Some sentential adverbs in English should be expressed in the form of subordinate clauses (adverbial clauses) in Japanese.
4. Because Japanese has only sentence negation, the English noun phrase negations like 'No students

passed the exams' should be expressed by sentence negations.

5. Because the two languages have quite different tense and aspect systems, some aspectual expressions in English should be paraphrased in Japanese. For example, 'I have been to U.S.' should be paraphrased in Japanese something like 'I have experiences of visiting US'.

These are only a few examples of correspondences which we had to deal with in the MU English-Japanese system. Though the correspondences listed above are complicated and difficult enough to formulate in formal and general means, specifying these correspondences can be deemed as linguistic problems. What we have to do is to establish formal frameworks by which we can specify the equivalence relationships of linguistic structures of the two languages.

On the other hand, the difficulty we discussed in section 2 is different in nature and more serious in actual MT systems. The difficulty comes from the fact that the 'translation equivalence relations' specified in linguistic means are not complete. They only specify possible translation relations which should be selected in actual MT systems, depending on surrounding contexts. The sentence 'kaigi-ni sanka-shitai' can be translated into three (or more) different Japanese sentences, all of which can be 'right' translations in certain contexts. In order to select 'right' translations in particular contexts, however, we have to refer to information which is not contained in this sentence.

Determining 'right' translations often requires information which can be obtained only through processings or inferences based on 'extra' linguistic knowledge. Consider the following examples.

Example 1

A: I met Mr Smith yesterday.
B: Who is he?
A: He is a lawyer who ...

Example 2

A: I met Mr Smith yesterday.
B: He now lives in Tokyo, doesn't he?
C: No, he is now in Kyoto and ...

There are several occurrences of English pronoun 'he' in the above examples, but they should be translated differently. In example 2, they can be translated into Japanese personal pronoun 'kare', while the occurrences in example 1 should be translated as 'sono-hito' (the man), 'Mr Smith-to iu hito' (the man so called Mr Smith) etc. This is because the Japanese personal pronoun 'kare' can be used to refer to the person, only when the speaker knows him and the speaker knows the hearer knows him. Otherwise, we have to use a definite noun phrase such as 'the man' or 'the man so called Mr Smith'.

In conventional MT research we are forced to develop autonomous systems which produce single translations based on very poor information. Researchers tend to ignore information which is necessary for formulating and selecting appropriate target expressions, simply because it cannot be extracted from source sentences. However, if we think of other types of MT systems such as dialogue translation systems, multilingual text preparation systems, etc., we could concentrate on formulating what sorts of factors are relevant for determining surface target expressions, and whether it can be extracted from source sentences. What we need to do in this framework is first to specify various sorts of information necessary for determining appropriate target expressions, and then to proceed with the research which aims to clarify how to get those sorts of information, i.e. from source sentences, linguistic contexts, extra-linguistic knowledge or interaction with writers (speakers).

I also would like to emphasize that problems in translation cannot be fully reduced to the problems of 'understanding'. Translation is basically a linguistic problem and the 'understanding' components can only provide the translation component with information which are not expressed explicitly in the source. What sorts of information is relevant for formulating appropriate target expressions would highly depend on target languages, and we cannot discuss absolute level of 'understanding texts' which are valid for any language-pairs. This means that we had better not to think of 'language independent' interlingual representations which can be used for representing 'understanding results' of source texts (Tsujii, 1986).

5. Conclusions

I have discussed the relationship between translation and understanding, especially about the possible architectures of MT systems in which we can pursue what sorts of roles the 'understanding' components should play in translation.

By removing the assumption that an MT system should produce single translations and the assumption that source texts convey all necessary information for translation, we can imagine frameworks which are interesting from both the practical and theoretical view points. Though the discussion is still at a speculation stage, we hope that we can have a fruitful research pattern in which we would be able to integrate the results of the two research streams, MT and NLU.

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