A Model for Natural Machine Translation

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Neither the transfer model nor the interlingua model account well for free translations. This paper presents a new model for machine translation intended to lead to systems able to produce more natural outputs.

1. The Need for Natural Translation

Consider sentence 1:

(1)アメリカ人が日本語を学ぶときの誤りの一つは和英辞典に頼りすぎることである。

where the context is a discussion of how to learn to read Japanese in real time. A conservative translation is sentence 2:

(2) When Americans learn Japanese one of the mistakes is excessive reliance on Japanese-English dictionaries.

A freer translation is:

(3) Americans learning Japanese tend to rely too much on Japanese-English dictionaries.

The latter is more natural English, and hence more readable. Interesting deviations from the structure of the original include: omission of the idea of "time-when," use of only one clause, and use of "tend" to convey both the negative affect of "誤り" and the softening nuance of "の一つ".

This example illustrates the need to sometimes sacrifice the structure of the original in order to produce a more readable sentence. This sort of radical restructuring is something which human translators and post-editors do freely, but which existing machine translation systems are very poor at.

This is partly because both the transfer and the interlingua models are inherently conservative. They err on the side of preserving the syntactic or conceptual structure of the input. Thus their output is faithful to the original text even at the cost of poor readability. In a word, they are not "reader-friendly." While any system can, of course, be extended ad hoc to produce an output like sentence 3 for one input, it is not clear that adding more transformations, for example, will enable free translation in general.

It is often argued that the interlingua model is the way to better quality translation (Carbonell 81). It is true that the output of an interlingua system can be very natural and very different from its input. But this is generally because it parses into an impoverished representation, and then uses very specific script-based, template-like generation knowledge. The unfortunate side-effect is that information implicit in the way the input is worded is lost, and distinctions made in the source language get blurred together unnecessarily. For example, the distinctions between "my head hurts," "I have a headache," and "there is a pain in my head," are blurred together (Carbonell 87). Thus, there is a need for a model of translation that can produce natural and yet faithful translations.

2. The F Model

I propose a new model for machine translation, the "F" (for "free" or "flexible") Model. It is based on the realization that *translation has two goals, namely (a) the need to express the input, and (b) the need to produce a natural utterance of the target language.* Moreover, it is often necessary to make trade-offs between these two goals. This view of translation is compatible with analyses of human translation (Kelly 77).

In the F Model *both (a) and (b) are active goals at run-time.* This constrasts with existing systems, which implicitly preserve the "content" while working toward a grammatical (though perhaps not natural) utterance.

To be more specific, this model entails:

First, an understanding phase. The result is a structure resembling a disambiguated, decorated parse tree, with pointers to the appropriate world knowledge. (This phase differs from the understanding phase of the interlingua model, in that it does not attempt to make a representation which is closer in structure to the target-language.)

Second, a generation phase. This is where goals (a) and (b) are active. This phase differs from usual generation phases in being a "creative" process, rather than a simple mapping, ordering, and inflecting process. In particular, *generation is largely a matter of finding and assembling words and structures to produce a natural sentence of the target language (goal b).*

Figure 1 summarizes the architecture of the F Model.

To build a generator able to produce natural utterances it is necessary to make it able to:

1.*access many possible words and structures,* in order to come up with utterances which include words which are only

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自然な機械翻訳のためのモデル
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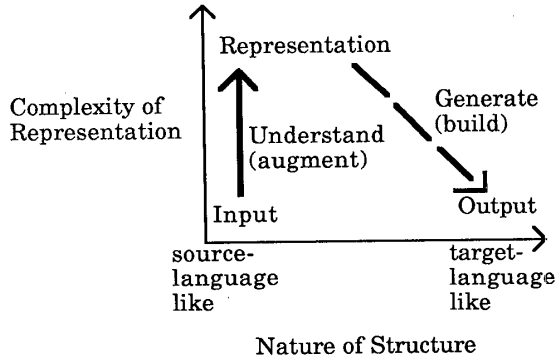

Figure 1: Overview of the F Model

tenuously related to any single input word or meaning component, for example, "tend" in sentence 3.

2. *choose a consistent, legal, and natural set of words,* since no matter how appropriate a word choice is in isolation, it is worthless unless it can be part of a coherent sentence.

3. Implementation

This model has led to implementation of a prototype machine translation system. This system is based on a semantic network encoding world knowledge, syntactic knowledge, and lexical knowledge. The understanding phase results in a structure of nodes embedded in the network. The key innovation is the use of spreading activation in the generator, "FIG" (Ward 88). In particular, the nodes resulting from understanding are sources of activation, representing goal (a). The network is designed so that there are self-reinforcing patterns of activation corresponding to natural utterances, thus representing goal (b). The basic process is that activation flows through the network, via links representing world knowledge, to words. This allows generation of free (paraphrase-like) translations, since it makes word choice more flexible (requirement 1 above). Ultimately, highly activated words are selected and emitted, one by one, to form the utterance. Thus FIG is an incremental generator; and the syntactic structure of its outputs is emergent. Its outputs are grammatical and natural largely due to the presence of syntactic information in the network and the use of connectionist-style "settling" to arrive at a set of highly activated nodes which is "consistent," that is, able to constitute a natural utterance of the target (requirement 2 above).

Figure 2 illustrates FIG's semantic network. The dots represent nodes; the links are not shown, for clarity.

This implementation has shown that the F Model is workable (for example, it translates"aru hi ojiisan wa yama e shibakari ni ikimashita" as "one day the old man went to a mountain to gather wood") but it has not yet been scaled up enough to demonstrate that it is adequate for natural translation.

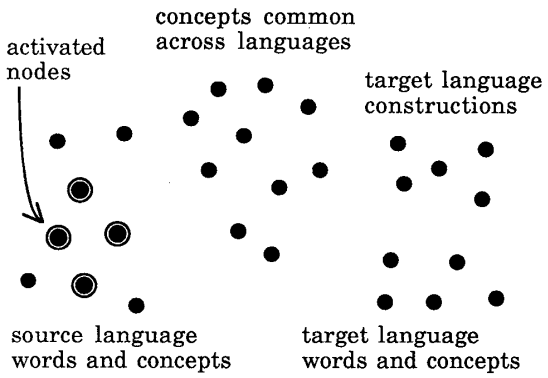

Figure 2: FIG's Network: Initial State

4. Comparisons

The F Model resembles the interlingua model (and differs from the transfer model) in: 1. using only one intermediate representation, 2. requiring inference and the use of world knowledge, 3. relating the tasks of translation to other language tasks, 4. rejecting the use of contrastive syntactic knowledge, and 5. not relying directly on the structure of the original.

However, the F Model, unlike the interlingua model, escapes the pitfall of assuming that language differences simply disappear as a result of "deeper understanding" (Tsujii 86). The F Model can cope with deep differences among languages and their conceptual systems because its generation phase has the power and flexibility to build up new, natural, target language utterances.

Although the F Model is not likely to be of immediate practical use, it is a possible way to write programs to produce natural translations.

References

Carbonell, J. G., A. Cullingford and A. V. Gershman, Steps Toward Knowledge-Based Machine Translation, *IEEE Transactions on Pattern Analysis and Machine Intelligence* 3,4 (July 1981). also Yale CS Research Report #146, Dec. 1978.

Carbonell, J. G., Knowledge-Based Machine Translation: the CMU Approach, in Nirenburg, S., *Machine Translation*, Cambridge University Press, 1987.

Kelly, L. G., The True Interpreter: a history of translation theory and practice in the West, St. Martin's Press, New York, 1977.

Tsujii, J., Future Directions of Machine Translation, in *Proceedings, Computational Linguistics*, Bonn 1986.

Ward, N., Issues in Word Choice, in *Proceedings, Computational Linguistics*, Budapest 1988.

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