Improving Performance of Transfer-Driven Machine Translation with Extra-Linguistic Information from Context, Situation and Environment

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Abstract

This paper describes an improvement in the performance of Transfer-Driven Machine Translation (TDMT) by the use of extra-linguistic information. In evaluating what constitutes natural speech, particular attention was paid to word usage that depended on the extra-linguistic information from the context, situation, environment and so on. We discuss what types of extra-linguistic information a spoken-language translation system requires to create naturally communicative dialogs. We then propose a method of improving the precision of translation by utilizing this extra-linguistic information. Preliminary experimentation showing performance improvements in TDMT makes us believe that the proposed scheme can improve the performance of dialog MT.

1 Motivation

We have been developing a method of Transfer-Driven Machine Translation (TDMT) [Furuse et ah, 1995][Furuse and Iida, 1996] in producing an efficient multilingual spoken-language translation system. Systems that deal with spoken dialogs generally require different techniques than systems that deal with written languages. The main requirements for the former are techniques to handle 1) spoken languages containing ungrarnmatical expressions, 2) real-time translation to avoid the interruption of smooth communications [Sumita et al., 1993], and 3) appropriate expressions under environmentally influenced situations.

In TDMT, constituent boundary patterns [Furuse and Iida, 1996] are applied to an input, which contrasts with the linguistic manner of applying grammar rules. The result of doing this provides for robust parsing that can even handle ungrammatical phenomena such as derivations in metonymical relationships [Iida et al., 1996]. Additionally, by dealing with best-only substructures utilizing empirical knowledge, the explosion of structural ambiguities is significantly constrained. Accordingly, robust and efficient translation of spoken-language input can be achieved.

In this paper, we primarily review an interim evaluation of the performance of a TDMT prototype system, i.e., a multi-lingual spoken language translation system in order to establish a criterion for subsequent performance improvements.

Additionally, in handling situationally appropriate expressions required by spoken-language translation, particular attention is paid to word usage that depends not only on the linguistic information, e.g., linguistically referred context, but also on the extra-linguistic information from the context, situation and environment in order to achieve natural communications.

In particular, the selection of euphemistic expressions [1], depends solely on the situational influences. However, although a conventional MT system provides a large-scale dictionary, it gives little information on word usage selection for appropriate situations or contexts. The analysis process works only for individual sentences, separating them from the context.

Thus, we describe extra-linguistic information, such as the speaker's role, social rank, and gender, which the system can use to naturalize communications with respect to word usage. We will also propose a method to improve the translation accuracy by utilizing such information.

From the performance improvement of a TDMT system that utilizes our method in comparison with the conventional TDMT system, we can state that our proposed scheme can be expected to improve the performance of dialog MT systems.

The next section presents an overview of TDMT and its advantages in comparison with related research efforts. Section 3 describes the performance evaluation of a conventional TDMT prototype system. Section 4 presents our proposed method for improving the system's performance together with preliminary experimental findings and evaluations. In section 6, we state our conclusions.

[1] In this paper, we define euphemistic expressions as expressions paying one's respects to the hearer indirectly, such as by offering superficial choices to the hearer even if the real intention is a command. For example, it is more polite to say "I would appreciate it if you could help me" rather than saying "Will you help me", when you ask something of your superior, in general.

2 TDMT and Related Research

In attempts to develop a multi-lingual translation system [Lavie et al., 1996][Frederking and Brown, 1996][Wahlster et al., 1993], an interlingua-based approach has been studied as a theoretically efficient mechanism. Several schemes have been proposed recently based on this approach. The semantic pattern-based parsing in JANUS [Levin et al., 1995][Lavie et al., 1996] uses frame-based semantics [Goddeau et al., 1994] with a semantic phrase grammar, and the operation of the parser is viewed as phrase spotting. In this scheme, a recognized speech input is paraphrased actively into a concrete and simple expression that conforms to one of the system's internal representations, which can make the utterance's meaning easy to understand.

Although the above inference schemes are powerful in explaining a speaker's intention or the propositional content of an utterance even from a keyword or phrase, plausible default values have to be prepared for achieving heuristic inference while extracting the meaning of an input sentence. For example, it is impossible to accept a sentence that includes a metonymical expression like:

(1) "A cheap and clean election is nice."

without preparing features able to bridge the semantic gap between cheap (clean) and election *a prion.*

Therefore, such an approach may work well within a certain domain, but less scalability may be the result when trying to extend a prototype system in practice. Additionally, even if a semantic concept unit for at least three languages were to be defined, designing a basic generation mechanism able to bridge the semantic gap between languages would still remain one of the more difficult problems.

On the other hand, it is generally accepted that people learn source-to-target expression pairs when they learn a foreign language. Therefore, it would seem practical to design reasonable pairs of expressions for each pair of languages based on a common MT mechanism. In other words, to achieve a practical multi-lingual translation system, it would be reasonable to analyze the source language to suit the target language.

From this point of view, TAG (Tree-Adjoining Grammar)-based MT [Abeille et al., 1990] and TDMT share many important properties for the successful implementation of practical MT systems. Both schemes f>roduce translations based on the synchronization Shieber and Schabes, 1990] of the source and target language structures. However, the algorithm for TAG has a worst-case time complexity of $0(\backslash G\backslash n^6)$, where \G\ stands for the size of grammar G and n is the length of the input string. With regard to the speed required for smooth communications, it is unrealistic to apply TAG-based parsing to practical spoken-language translation systems.

In contrast, TDMT has the advantages of:

- The existence of an efficient parsing algorithm;
- The capability to handle various linguistic phenomena by utilizing translation examples with a simple best-first mechanism.

TDMT's Constituent Boundary Parsing (CBP) can be implemented according to bottom-up left-to-right chart parsing algorithms [Furuse and Iida. 1996] whose worst-case time complexity is merely $0(n^3)$.

In addition, using best-first syntactic/semantic similarity would make TDMT more flexible [Sumita et al., 1993].For example, TDMT can accept the previous example sentence (1) by utilizing a similar example like "a cheap and clean room would be good"[2].

Therefore, TDMT can achieve both scalability and efficiency in multi-lingual spoken-language translation. The transfer module, which is an essential component of TDMT, is a common part of the translation mechanism for every language pair, whereas language-oriented modules, such as morphological analysis and sentence generation, are provided for each source/target language. Furthermore, transfer knowledge is provided for each source/target language pair. TDMT has already been applied to three language pairs: Japanese-English, Japanese-Korean, and Japanese-German.

3 Evaluation of TDMT

The TDMT system, whose domain is travel conversation, is implemented in LISP and runs on UNIX-based machines. A system dealing with spoken-languages requires a quick and accurate response, rather than a grammatical response, in order to provide smooth communications. Moreover, since every process, including speech recognition, translation and speech synthesis, runs automatically from start to finish, there is no room for manual pre/post-editing of input/output sentences in order to make the sentence easier for either the translation process or the user to read. In other words, assuring both efficiency and acceptability in spoken-language translation are the most crucial tasks in devising such a system. Therefore, we evaluated TDMT for both speed and acceptability of translation and analyzed the evaluation results from this point of view.

3.1 The Evaluation Procedure

We evaluated TDMT's translation quality by separately using morphological analysis, a translation module (including a generation module) and a parsing scheme (CBP). Manually analyzed morpheme sequences were used to avoid errors and unknown words in testing the translation module itself. This allowed us to assess how well the TDMT would function individually. Details of the evaluation on the morphological analyzer are not described here[3].

Table 1 shows the conditions of our experiment and evaluation. The reader should note that as the JG and

[2]Although 'room' and 'election' are semantically rather distant, their syntactic similarity enables TDMT to translate the first example sentence into acceptable Japanese while preserving the metonymical nuance of the meaning.

[3]The success rate in perceiving morphemes was more than 99%, and that in assigning linguistic categories was more than 98% while the analysis speed was less than 0.2 second for each source language measured using a SPARC Station 10 workstation.

Table 1: Experimental conditions.

	JE	JK	JG	EJ	KJ
Vocabulary size		10000		6000	3000
No. of training sentences(diff.)	2602	1195	1553	2431	493
average morphemes/sentence	10.1	9.0	9.3	8.4	7.5
No. of patterns for transfer	887	624	787	1194	320
No. of examples for transfer	10227	3605	2941	7008	1701

KJ translation project have just started, the transfer knowledge will not always be of the same quality for all language pairs. In addition, though the quality of the thesaurus for each language is an important topic for example-based frameworks, according to our experimental results obtained by applying some kinds of thesauruses into TDMT, no remarkable differences in the translation quality were observed except for a difference in the number of translation outputs.

Translations for 69-87 unseen dialogs (about 1,000 unseen different sentences) were manually evaluated by assigning a grade. Two or three native speakers of each of the target languages performed the assessments; all of the examiners were also familiar with their respective source language in order to judge the correctness of the information.

We used the same dialogs for all of the translations whose source language was Japanese: .IE, JK, and JG translations. This allowed us to compare the differences in the training (patterns, examples, etc), the linguistic distance between languages, and so on. Each sentence was assigned one of four grades for translation quality: (A) Perfect - a fluent translation with all information conveyed correctly; (B) Fair - a translation that makes it easy to understand the expressions but with some unimportant expressions missing grammatical elements; (C) Acceptable - an acceptable translation; (D) Nonsense, wrong sense - an unacceptable translation or where important information has been translated incorrectly. The parse structure of each source sentence was also manually evaluated by assigning it a grade indicating: (1) Success or (2) Failure. The translation speed was measured on a SPARC Station 10 workstation.

3.2 Results

Table 2 shows the evaluation results for the TDMT, where "acceptability" is the sum of the (A), (B) and (C) grade sentences. The translation speed does not include the time needed for morphological analysis. All ratios are taken from the average of two or three examiners. As the table shows, almost 70% acceptability was achieved in the JE result, and almost 60% acceptability was achieved in the EJ result; remarkably, more than 90%) acceptability was achieved in the JK translations, although the JK translations needed less transfer knowledge (Table 1) than the others. This observation can be explained from the viewpoint of linguistic similarity; while the Japanese-English (German) language pair is linguistically distant, the Japanese-Korean pair is rather close.

Table 2: Evaluation results.

(a) Evaluation results of TDMT

	JE	JK	JG	EJ	KJ
No. of test dialogs	69 (1247 sentences)			73 (1323)	87 (1169)
average morphemes/sentence	9.4			7.1	8.0
(A) (%)	30.1	46.6	27.6	23.7	34.4
(B) (%)	18.1	29.1	11.4	17.2	17.5
(C) (%)	20.6	14.4	10.6	18.5	21.2
(D) (%)	31.2	9.9	50.4	40.5	26.9

(b) Evaluation results

	JE	JK	JG	EJ	KJ
i. Translation quality					
Acceptability ((A)+(B)+(C)) (%)	68.8	90.1	49.6	59.5	73.1
ii. Parsing quality					
Success ratio of CBP (%)	70.9	60.2	58.7	63.9	43.3
iii. Translation time (sec.)					
Average	0.4	0.3	0.3	0.3	0.1
max (No. of morphemes)	4.4(26)	3.7(31)	3.1(31)	3.3(16)	9.2(15)

The main problem in the translations involved insufficient examples for CBP. However, an increase in the ratio with the number of examples can be observed in the results. Thus, the total accuracy and acceptability should improve in proportion to an increase in the transfer knowledge [4]. This trend was observed in the parsing quality results. However, in spite of the rate of false parsing, the quality of both the JK and KJ translations were very high. We consider this finding to be due not only to the linguistic distance between the languages but also to the TDMT pattern-based approach having the ability to translate phrases while preserving the nuance even for ungrammatical input sentences.

In addition, some sentences were judged as of the (D) grade because of their lack of adequate politeness in the EJ translation.

Although the speed depends on the amount of knowledge and sentence length, the average times remain less than 0.4 sec; thus, TDMT can be seen as an efficient translation mechanism.

4 Improving Conversational Naturalness

4.1 Extra-Linguistic Information

As we have already mentioned, the selection of euphemistic expressions generally depends solely on situ-

[4] This is accepted in general for the example-based framework, since the exact match ratio is certain to increase in proportion to the increase in translation examples. In fact, a total accuracy of more than 93% was achieved in our closed test evaluation for over 1,000 sentences for EJ TDMT translation. However, we have to ascertain the practical satiation limit, or how much the transfer knowledge can be expanded.

ational influences. Similarly, Japanese donatory auxiliary verbs such as 'ageru' have multiple possible expressions depending on the speaker's honorific attitude to the hearer[5]. Maeda et al. presented a unification based approach to Japanese honorifics [Maeda et al., 1988]. Any contextual constraint should be described in a certain domain, that is, in a sub-language, and the real utterance should be expressed based on the appropriate usage under every situation (Fig. 1). Consequently, a spoken dialog translation system must work in situations where the following are understood: speaker properties (role, gender, and rank), focus in the utterances, dialog domains, objects mentioned, actions mentioned, and derivational forms of the words used.

However, whereas a conventional MT system provides a large-scale dictionary, there is little information on word usage under typical situations or context. The analysis process works only on individual sentences by separating them from the context without considering information on the current environment.

In this section, several examples show the typical extra-linguistic information that a dialog translation system can utilize to resolve contextual ambiguity with respect to word usage selection, zero-subject resolution, and so on, in order to naturalize conversations. Furthermore, we propose a scheme for utilizing this information in dialog MT systems to enable preferences appropriate for varying types of communications to be established while preserving the efficiency.

4.2 Social Role and Dialog Domain

In the travel dialog domain, a clerk in a hotel, as opposed to a traveler, is usually not dining, boarding or using a tourist-oriented transportation system. Such information can constrain the possibilities of word selection with respect to polite remarks. For example, the word 'eat' can be translated into Japanese as *'taberu', 'meshiagaru-honorific',* or *'itadaku-humble'.* However, if the dialog domain is travel, and the speaker is a clerk but not a traveler, 'eat' is never translated into '*itadaku*-humble'. In the same way, we can consider the translation of 'your' in the following sentence:

(2) "Could you please tell me your telephone number?"

If the speaker's social role is a clerk and the listener's is a guest, "your telephone number" should be translated as "*o-kyaku-sama-no o-denwa-bangou"*(guest-poiite-possessive telephone-number-polite).

In addition, it is well-known that the subject tends to be omitted in spoken Japanese. Thus, having this knowledge would clearly be helpful in predicting the English for missing Japanese subjects. For example, if a cook says,

(3) *"Moshi o-meshiagaru no deshitara, sugu tsukuri-masu"*
(if eat-honorific, immediately cook-polite)[6]

The complexity of word usage selection for verbs of Giving and Receiving is presented on the web at *http: //central, itp.berkeley.edu/" eal/Jpnotes/donatory-verbs.html.*

In this paper, sample Japanese sentences are Romanized in italic based on the Hepburn system, and the corresponding

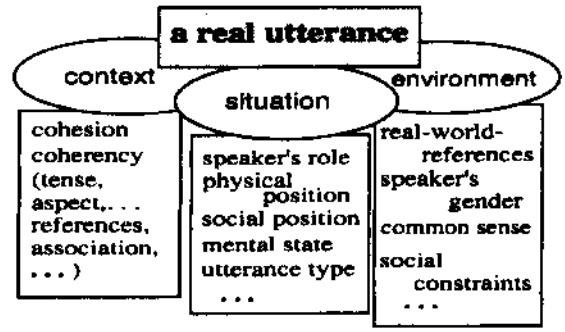

Figure 1: Determination of an utterance in a situation

it is appropriate to translate this by supplying "I" as the subject of "eat" and "you" as the subject of "cook".

4.3 Gender

There are several differences between male expressions and female expressions in Japanese. For example, men can use 'boku' or 'ore' to mean "I". However, women never use these words in standard Japanese. It has also been reported that women usually use euphemistic expressions more frequently than do men, and likewise women tend to use softer expressions than do men. Therefore, information on whether the speaker/listener is male or female allows the translation system not only to assign the correct honorific title, such as Mr. or Ms., but also enables the translation to preserve expressions appropriate to the speaker's gender.

4.4 Social Rank

There are various types of expressions: polite, honorific, humble, and euphemistic. These expressions are used depending on the social interactions between speakers[7]. For example, in making a hotel reservation,

(4) "How many people will there be?"

'will there be' can be translated into Japanese in at least two forms, *'i-masu-ka'* or *'irasshai-masu-ka'.* If the listener in this case is at a socially higher position than the speaker (e.g., the relationship between a guest and a clerk), the latter expression would be preferred as it bears more esteem. In the same way,

(5) "Then, we will confirm your reservation."

should be translated into:

(5') "*Yoyaku-o kakunm-sasete-itadaki-masu"*
('reservation-objective', 'confirm-euphemism')

by using the euphemistic alternative.

English words with usage modifiers follow in parentheses.

Although this type of word usage selection seems a little bit Japanese (or Korean) oriented, the authors thought that handling this kind of difference between languages is very important for smooth dialog translation such as in the case of diplomatic meetings. In fact, some sentences were judged as incorrect translations only because of their lack of adequate politeness, in our experimental evaluation with an EJ translation system.

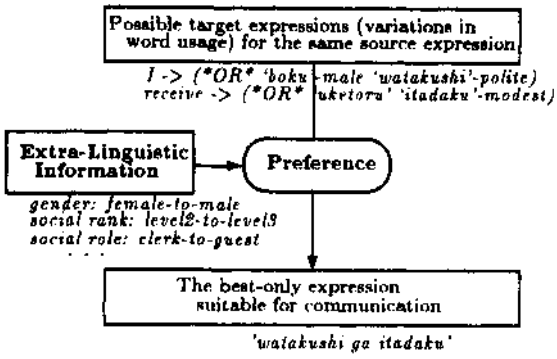

Figure 2: Preference of the best-only expression.

5 Utilization of Extra-Linguistic Information in TDMT

In this section, we propose a scheme for utilizing extra-linguistic information in spoken dialog MT systems to enable preferences appropriate for varying types of communications to be established while preserving the efficiency.

At first, to illustrate the utterance selection mechanism in relation to the extra-linguistic information, we assume that the model is as simple as that shown in Fig. 2. For example, the word 'receive' is translated into the Japanese word *'itadaku'* if a more polite expression is required than the possible translation *'uketoru'* However, the model should independently work for each reasonable unit within a sentence. This is because each object (e.g., a person who should be respected) of a predicate of a unit might differ depending on the subject. For instance, let us consider the sentence:

(6) "Could you tell me the telephone number where I can contact you please?"

Since the object in the unit phrase "I can contact you" must be the listener, an honorific expression is required in contrast to that of the object in the unit phrase "Could you tell me ...", which must be the speaker. In order to achieve word usage preferences for each unit phrase of the sentence, we propose a scheme that incrementally applies the model to each phrase transfer of the translation. In TDMT, constituent boundary patterns are applied to an input sentence, and by dealing with best-only substructures utilizing translation examples, a deterministic translation can be achieved for each pattern incrementally [Furuse and Iida, 1996]. Consequently, the design principles of our scheme are:

- Word usage information with relation to extra-linguistic parameters is attached to each transfer pattern
- The best-only phrase structure selection mechanism using examples and the word usage selection model with extra-linguistic parameters are combined(Fig. 3)
- Candidates for word usage is selected simultaneously when each phrase transfer is settled

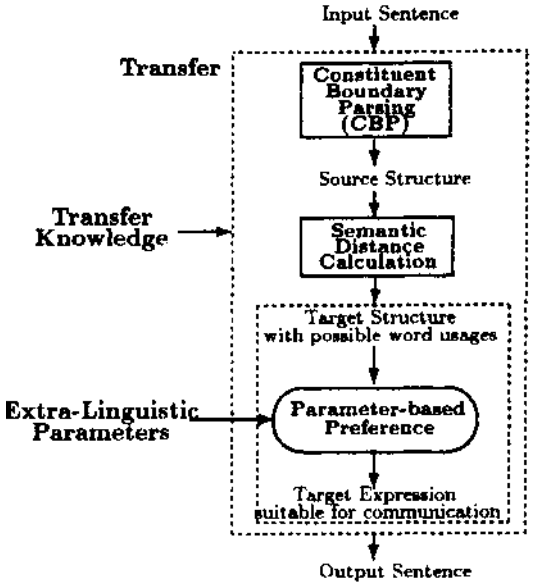

Figure 3: Utilizing extra-linguistic information in TDMT.

Furthermore, since this extension preserves the graduality for phrase chunk transfer in TDMT, it is reasonable to extend our method to simultaneous interpretation even for lengthly inputs in order to achieve real-time translation. By utilizing our scheme in TDMT, the previous sample sentence can be translated into more plausible Japanese:

(6') "*o-kyaku-sama-ni go-renraku-dekiru denwa-bangou-o uketamawaremasu-ka.*"
('you-guest-role-objective' 'contact-polite-humble-possible' 'telephone-number-objective' 'tell-me-humble-polite')

5.1 Preliminary Experiment

We conducted a preliminary experiment to examine the performance of this scheme while using the current TDMT EJ system. We first tested principally to improve the politeness with regard to social rank and social role. Each word usage information was installed within the transfer knowledge as follows.

X <*noun-verb*> *Y* =>
X' *ga* *Y'* ((I , receive), ...),
(I (*OR* '*boku*'-male '*watakushi*-polite' ...))
(receive (*OR* '*uketoru*' '*itadaku*-polite-humble' ...)) ,
:

X <*verb-noun*> *Y* =>
Y' *ni* *X'* ((contact , you), ...),
(you (*OR* '*anata*' '*okyaku-sama*-guest-role' ...))
(contact (*OR* '*renraku*' '*go-renraku*-polite-humble' ...)) ,
:

This type of transfer knowledge with a word usage information for about 50 words was prepared for the experiment. In this preliminary experiment, we assigned the

extra-linguistic parameters manually to independently evaluate this scheme. In order to evaluate the effectiveness of T D M T while utilizing the word usage preferences, we used 316 of the "clerk's" sentences previously graded (B)(C)(D) from the evaluation results shown in Table 2.

Translation examples of an utterance from the clerk to a guest (modified by ") compared to the same utterance from a guest to the clerk (modified by '), are shown as follows.

(7) "We have a question for you."

(7') Guest-to-Clerk: *"shitsumon-ga ari-masu"*
('question' 'we-have-poiite')

(7") Clerk-to-Guest: "*o-kyaku-sama-ni go-shitsumon-ga go-zai-masu"*
('you -guest-role-polite-objectivel
'question-polite-objective2' 'we-have-humble-polite')

The following results were obtained in the evaluation.

- 115 (36.4%) sentences were changed into other expressions.
- 84 (26.5%) sentences were improved by at least one grade.
- The rest of the changed sentences were still assigned the same grades because of different problems.

By upgrading all results having a (D) grade, the total acceptability can be improved by about 8% using this scheme, indicating that these results are fairly good. However, one problem is the possibility of constructing overly polite expressions in Japanese. This basically derives from the fact that the current generation of this software does not yet have sufficient knowledge to treat collocational constraints of politeness between constituent boundary patterns. Nevertheless, the problem can be easily overcome by using statistical/stochastic methods such as n-grams or the co-occurrence of phrases. Consequently, it is clear that the proposed scheme should be able to improve the performance of a dialog MT system.

6 Conclusions

For handling the situationally appropriate expressions required for spoken-language translation, we have discussed contextual constraints on word usage that utilize extra-linguistic information. Furthermore, we have proposed a method to improve the accuracy of translations by utilizing this information. Preliminary experimentation of our new T D M T has shown that the proposed scheme can be expected to improve the performance of dialog MT.

One important area of future research will involve a method to extract the extra-linguistic information from a situation efficiently. Some information types, such as a speaker's social role, should for now be assigned manually in the system. Other information types, such as various preferences for social position, gender and conversational domain, can potentially be found in large corpora of linguistic expressions with some kind of stochastic information, such as usage frequency and word usage n-grams. Thus, the automatic extraction of extra-linguistic information from dialogs by utilizing statistical/stochastic approaches is one area of interest for future work.

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