

# A Method of Utilizing Domain and Language specific Constraints in Dialogue Translation

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## Abstract

One of the characteristics of dialogue translation is that it is strongly dependent on the situation or the communicative goal where the utterance is spoken. Moreover, the distance between the language pair is great, the possibilities of the transfer diverse and it would be difficult to guarantee the equivalence of translation.

In this article, we propose a method of utilizing domain and language specific constraints from the viewpoint of transfer phase in a dialogue translation system. Transfer processing sometimes requires various kinds of information: e.g., domain knowledge for ellipsis resolution, language dependent communicative structures (focus, theme, rheme, ...).

Our standpoint is that there are certain language specific strategies on producing utterances in communication. As steps towards clarifying those strategies, we first discuss the issue of typical idiosyncratic gaps between two language pairs. Next, to resolve such problems we suggest a new framework of incorporating domain and language specific knowledge as transfer rules for dialogue translation from the viewpoint of transfer phase. Finally we will mention related issues and further investigation.

## 1 Introduction

The difficulty of translating spoken dialogues between two languages is often greater than that of translating written text. This is because translation of certain expressions in a source language are affected by previous context or communicative goals under common knowledge for dialogue participants. If the two languages are quite different from each other, possible expression candidates increase. This further complicates the problems of producing utterances in dialogue translation.

In the author's recent work [12], the factors which affect lexical choices and setting the default translation considering those factors were discussed for selecting appropriate verbs. Of course the selection of an appropriate verb in given situations is only a small part of the great theme of translation in various levels of expression: e.g., selection of modality correspond-

ing to illocutionary forces, correct choice of articles, etc. The problem, however, includes important aspects of linguistic phenomena related to other levels.

In that article, some examples of relationships between Japanese and English verbs were investigated using a dialogue corpus translated by human interpreters. Through comparing corresponding verbs in Japanese and English, some tendencies were envisaged concerning the characteristics specific to dialogue translation.

In another work [13], we discussed the issue of translating dialogue utterances through a partitioned semantic network, part of which is actually lexicalized. A method was proposed for managing the semantic network, i.e. re-partitioning of the network, which yields a more natural translation of utterances. We assumed three kinds of partitions: theme vs. rheme, old vs. new information, and fore- vs. back-ground. The producing of target utterances starts with processing along the lines suggested by the source language, and then the given partition can be repartitioned according to properties of the target language.

Along this examination, we started to describe actual transfer rules for certain kinds of Japanese utterance that seem to be difficult to translate directly into English, because of lacking substantial words in Japanese. This is the background and the motivation of the current study.

Our presuppositions are as follows.

- The analysis of input utterances are limited in the source language.

Basically, definite/indefinite or plural/singular markers are not indicated in Japanese explicitly. Moreover, various kinds of arbitrary/obligatory ellipses of subjects/objects/predicates (occasionally) are difficult to resolve within sentential information.

- A transfer processing is performed between language dependent feature structures.

The analysis module outputs a feature structure, which indicates the relationships between predicates and their complements and other information including some pragmatic features. See the examples in the next page.

## 2 Idiosyncratic Gaps between two Languages

### 2.1 The Problem

For instance, in Japanese a verb may have certain number of complements (or the verb has its own valency). Those complements are often eliminated if they are already known as old information. When honorific expressions (respective, condescending, polite) are used, a certain kind of the ellipses (zero-pronouns referring the speaker or the hearer) can be resolved by using these key expressions in many cases. [1]

However, there are another sort of utterances which lack substantial words and are difficult to understand individually. As a target of our examinations, we selected an expression called "da-expression". Though there are a lot of variations for da-expressions[14], we consider one of their types that has a structure : Copula(A, B). It means that A and B is identical (in a certain sense). In many cases, we cannot translate such a da-expression without knowing the context where the utterance is spoken.

Our current target domain for dialogue translation is "conference registration task". The example sentences referred in this article are from the domain. Suppose that the following Japanese utterances should be translated.

J1: *sankaryou wa donoyouni shiharae*  
       (fee) (topic) (how) (pay)  
       *bayoi deshou ka.*  
       (acceptance) (copula) (interrogation)

J2: *sankaryou wa ginkou-furikomi desu\*.*  
       (fee) (topic) (bank-transfer) (copula)

```
[[SEM [[reln S-REQUEST]
  [agen !X3[[LABEL *SPEAKER*]]]
  [recp !X2[[LABEL *HEARER*]]]
  [obje [[parm !X9[[parm !X6]]
    [restr [[reln DONOYOUNI-1]
      [entity !X5]]]]]
  [restr [[reln BAYOI-SHOULD]
    [aspt STAT]
    [agen !X7[]]
    [obje !X8[[reln SHIHARAU-1]
      [agen !X7]
      [obje !X6[[parm !X4[]]
        [restr [[reln SANKARYOU-1]
          [entity !X4]]]]]
      [mann !X9]]]]]]]]]
[PRAG [topic [[focus !X6]
  [topic-mod WA]
  [scope !X8]]]
[speaker !X3]
[hearer !X2]]]
```

#### FS-J1. Analysis Result of J1

The analysis result of J1 is shown below.

The translation of J1 into English may be the next sentence.

E1: How can I pay for the (attendance) fee?

```
[[SEM [[reln DA-identical]
  [aspt STAT]
  [obje !X3[[parm !X2[]]
    [restr [[reln SANKARYOU-1]
      [entity !X2]]]]]
  [iden [[parm !X1[]]
    [restr [[reln GINKOU-FURIKOMI-1]
      [entity !X1]]]]]]]
[PRAG [topic [[focus !X3]
  [topic-mod WA]]]
[speaker [[LABEL *SPEAKER*]]]
[hearer [[LABEL *HEARER*]]]]]
```

#### FS-J2. Analysis Result of J2

The feature structures of J1 and J2 are as FS-J1 and FS-J2.<sup>1</sup>

The literal translation of J2 may be :

E2: The (attendance) fee is bank-transfer.

Of course this English sentence is not acceptable in ordinary situations. Accordingly a certain way of complementation is required. There can be several alternatives and it might be difficult to choose one appropriate expression among them. For instance, J2 could be translated in various ways if such a complementation is performed.

E2a: The payment should be made by bank-transfer.

E2b: Please pay by bank-transfer.

E2c: Would you please pay by bank-transfer?

...

<sup>1</sup>These feature structures are partially modified for explanation.

There are some Japanese expressions (typically "da-expressions") which lack a substantial word(s) known for the dialogue participants. In the previous example sentence J2, the substantial words are : *sankaryou*(fee) and *ginkou-furikomi*(bank-transfer). The word *sankaryou* is the *Theme*<sup>2</sup> of this utterance and it is already known (old information) in the previous utterance. And the word "shiharanu" does not appear in J2, while it appeared in J1. J2 is a typical *da*-expression (a kind of copula sentence) in Japanese.<sup>3</sup>[14]

The *Rheme*<sup>2</sup> of the sentence J2 is obviously *ginkou-furikomi* (bank-transfer) and it meets the focus of the previous question J1. Accordingly the utterance J2 satisfies the Grice's maxim of informativity. In English, however, we can't say "The fee is bank-transfer." We have to elaborate the utterance with some substantial or functional words.

Generally such kinds of knowledge for elaboration have been provided with domain knowledge which are commonly accessed by respective processing modules. We propose that the concept of Mel'čuk's lexical functions can be extended for designing special sets of domain-dependent lexical functions. This idea is as follows.

## 2.2 How to elaborate an elliptical sentence?

For introducing our methodology, we use the following predicate-complements notation (hereafter PS).

```
[[Pred Predicate-symbol]
 [Case-label1 Complement1]
 [Case-label2 Complement2]
 [Case-label3 Complement3]
 . . . ]
```

The Japanese utterance J2(PS-J2) can be illustrated as follows.

```
[[Pred COPULA]
 [Obje SANKARYOU]
 [Iden GINKOU_FURIKOMI]]
```

PS-J2. corresponding to J2

If we transfer it into English, we have to modify the structure using definite semantic relationships.

```
[[Pred PAY]
 [Agen []]
 [Obje FEE]
 [Manu BANK_TRANSFER]]
```

PS-E2. for translation of J2

<sup>2</sup>The contrast of Theme and Rheme is described as follows. Theme: Topic, what is communicated about Rheme: Comment, what is communicated

<sup>3</sup>There are a lot of variations of *da*-expressions observed in our dialogue corpus.

The structure PS-E2 could yield two sentences :

The fee is paid by bank-transfer.  
You pay the fee by bank-transfer.

However, it is still unnatural because the speaker's intention doesn't appear in these sentences. Therefore another elaboration is needed for producing a more sophisticated utterance.

The previous utterance J1 is apparently a question that demands a value referred with the interrogative "donoyoumi" (how). During our pre-transfer phase, an Illocutionary Force Type (IFT) of the given sentence is extracted.[7] In this case, the IFT of J1 is determined as QUESTIONREF.

So far the assignment of IFTs was decided with matching surface expressions. Accordingly the IFT of J2 is first recognized as INFORM (default IFT), because the predicate DA-identical (copula) does not specify any explicit intention.

```
[[IFT QUESTIONREF]
 [Agen *SPEAKER*]
 [Recp *HEARER*]
 [Obje HOW(!X) [[Pred PAY]
 [Modal OBLIGATION]
 [Obje SANKARYOU]
 [Manu !X]]]]
```

PS-E1. corresponding to E1<sup>4</sup>

Then, we need supplementary information on PS-E2. For example :

```
[[IFT REQUEST]
 [Agen *SPEAKER*]
 [Recp *HEARER*]
 [Obje [[Pred PAY]
 [Agen []]
 [Obje FEE]
 [Manu BANK_TRANSFER]]]]
```

PS-E2\*. for translation of J2

For rewriting from PS-J2 into PS-E2\*, the following knowledge should be provided.

- Elliptical predicate
- Elliptical relationship(s)

For translating the above mentioned *da*-expressions we have to complement appropriate substantial words, which are relatively domain dependent.

- Knowledge on IFT

Though the system of IFT was formerly thought to be language independent, this assumption turned out too naive. We now consider that there can be some situations where a transfer of IFT is required, according to the language dependent strategies of producing utterances.

<sup>4</sup>The expressions !X indicate that they are coreferential tags, as in FSs.

### 3 A method of Incorporating Domain and Language specific Constraints

When we limit the target domain of translation, the associate knowledge is also restricted. However, we have to be careful that even in such a presupposition some general knowledge (meta knowledge) is indispensable to make elaboration for elliptical sentences.

#### 3.1 Domain knowledge

Within our task domain, we have some kinds of empirical knowledge of "registration for a conference". We observe several frequent verbs with specifically dominant cooccurrence of nouns. Though these nouns do not always appear explicitly, we can assume their existence in the background of utterances. For example, we can describe preferable candidates of complements which have strong relationships with a verb "pay" in our target domain.<sup>5</sup> The *italic letter* symbols indicate conceptual categories.

pay - object - (attendance) fee, *amount of money*  
pay - agent - *dialogue participant*(speaker / hearer)  
pay - manner - bank-transfer, credit card, in cash  
pay - time-destination - *date*, deadline  
...

Here we define a set of domain dependent knowledge after the notation of lexical functions proposed by Mel'čuk[8].

Objc(pay) ⇒ fee  
Agen(pay) ⇒ participant  
Mann(pay) ⇒ bank-transfer  
Tdes(pay) ⇒ date  
...

Note that the above descriptions have a direction. The righthand symbols can be *conceptual categories*. Then the relationship between *fee* and *bank-transfer* can be obtained through an indirect path. Such kinds of knowledge can be extracted semi-automatically from our dialogue corpus, to a certain extent.

#### 3.2 Language specific strategies of producing utterances

It is natural to consider that there exist certain *language specific strategies of producing utterances*, intuitively from the previous example dialogue. In other words, some language dependent communicative structures are recognized. Pragmatic constraints are derived from the difference of communicative strategies with languages. So far, this importance has been relatively less regarded compared with other linguistic aspects in translation.[2]

<sup>5</sup>Though we do not mention here, it is significant for prediction of words for speech-to-speech translation systems.

In Japanese dialogues, the speaker's intention tends to appear in the sentence final expressions and it is quite often rendered indirectly.

J2: sankaryou wa ginkou-furikomi desu\*.

This is a neutral da-expression and there is no additional information other than indication of the method of payment. However, the following examples includes some special nuances in their final expressions. Both of them are quite natural as responses to the question J1.

J2a: sankaryou wa ginkou-furikomi

to natte orimasu. (polite da-expression)

J2b: sankaryou wa ginkou-furikomi

de onegai shimasu. (polite request)

We think that these Japanese utterances are equivalent under the given situation (or the communicative goal). In any cases, the method of payment is designated. The point is how it should be communicated. We can assume the attitude of the speaker is kept consistent in principle. The translation should also follow this rule, especially in case of the utterances by the secretary of the conference. It could affect the style of expressions. In fact, we found many **INFORM** utterances really mean indirect **REQUEST**.

The indirectness is remarkable in Japanese (using da-expressions) and a direct translation can be abrupt or not informative, partly because there seems to be no polite copula expressions in English. Therefore, a certain transfer of IFT might be required.

We have to consider some constraints for applying such a rule. In this case, the IFT of the previous utterance (**QUESTIONREF**) should be known. Additionally the focus of the question is needed. Furthermore, thesaurus knowledge about predicates and complements might be referred.

#### 3.3 Incorporating two kinds of constraints

In our dialogue translation system, a feature structure rewriting system(RWS)<sup>6</sup> is used for transferring between Japanese and English.[3] An efficient control mechanism for rewriting rules in the RWS is realized using *Rewriting Environment and Application Constraints*.

The Rewriting Environment(RE) is introduced in order to control rule application and to maintain rule flexibility and modularity. Each RE is composed of a combination of parameters and their values, which provides the condition of rewriting and is dynamically changed through the transfer processing.

<sup>6</sup>It has been extended for introducing a type system and a preference mechanism.

Each rewriting rule has its specific application constraints(AC). When the ACs unify with the RE in a certain phase, the application of the rule fires. Thus, the transfer process is procedurally performed, according to the REs. This allows individual rules to be rather declarative and include few procedural decisions for lexical choice.

We implemented the rules that contain domain and language specific constraints, extending this RWS. Several example rule are shown below.<sup>7</sup>

```
'on < Pred > SHIHARAU in
  :PHASE :J-E
  :TYPE :GENERAL
  in = [[Pred SHIHARAU]
        ?rest]
  out = [[Pred PAY]
        ?rest]
end''
```

#### Rule-1. Transfer rule for a verb "pay"

```
'on < Pred > COPULA in
  :PHASE :English
  in = [[Pred COPULA]
        [Objø ?objø]
        [Iden ?iden]]
  if Previous.Theme is ?objø
  then set ?pred to pred of Previous.Theme
  set parameter :STATUS :COMPLEMENT
  out = [[Pred ?pred]
        [Objø ?objø]
        [Iden ?iden]]
end''
```

#### Rule-2. Transfer rule for complementation

```
'on < IFT > INFORM in
  :PHASE :English
  :STATUS :COMPLEMENT
  :PREVIOUS-IFT :QUESTIONREF
  in = [[IFT INFORM]
        ?rest ]
  if type of Input.Objø.Pred is :action
  then set ?output to [[IFT REQUEST]
                       ?rest ]
  out = ?output
end''
```

#### Rule-3. Transfer rule for IFT

<sup>7</sup>A concise description for notation of rewriting(transfer) rules: The first line of a rule indicates the target feature path of rewriting, followed by Application Constraints with combinations of parameters and their values; e.g. :Type :General. The patterns in = ... and out = ... indicate the input and the output (sub)feature structure respectively. Some additional conditions can be described using if sentences. For referring a feature value, a feature path in top-to-down direction can be used like as Input.Objø.Pred

Note that the above rules are partly modified for explanation using PSs instead of FSs.

The explanation for the rules is described as follows, though the allowed space precludes the detail. The whole transfer process are composed of several sub-procedures according to the *Rewriting Environments* designated by the main rule (the top level rule). The general framework is as follows.

First, the rewriting of ellipsis resolution process provides the missing zero-pronouns referring the speaker or the hearer. Then an Illocutionary Force Type is given to the top level of the feature structure. After this a kind of normalization is performed (so called Japanese-to-Japanese transfer) in order to make the (Japanese-to-English) transfer easier. The processing of these sub-procedures are regarded as a pre-transfer phase.

The main transfer phase contains 3 sub-procedures : idiomatic, general and default. The Rule-1 is an example of simple general transfer rules.

After the main transfer phase, the transfer within the English feature structures is performed. The Rule-2 and the Rule-3 are applied in this phase.

Using the Rule-2, a Copula predicate structure is transferred to another substantial predicate structure. When this rule is applied, a local parameter is set to the Rewriting Environment. After this, under the new RE the transfer of cases (e.g. Iden → Mann) is carried out with another rewriting rule including domain knowledge.

The Rule-3 designates a rewriting of IFT from INFORM to REQUEST under certain conditions. As mentioned in the previous section, such a transfer yields a more natural utterance.

At present the flexibility of the system is still insufficient from the viewpoint of context processing. However, it is possible to control applying rules by means of local parameter setting (like :status :complement), to a certain extent.

### 3.4 Other Examples and the current status

The following examples were described as domain and language specific knowledge for translating typical "da-expressions" that appear in our target domain. The frequency of "da-expressions" in ATR Dialogue Database is as follows. This investigation (by Tomokiyo) recognized about 200 different word sequences as da-expressions in predicate parts of sentences in the conference registration dialogues.

The occurrence of da-expressions: 1,845

The occurrence of all predicates: 5,200

(approximately)

The numbers of sentences and words appeared the corpus are respectively 1,666 and 38,258. The rate of da-expressions is roughly 35 %. Though the exact percentage of copula da-expressions is not yet calculated, it is estimated at 150 ~ 200. Besides, we envisage some copula expressions which are not included in the above investigation, like "to natte orimasu" (mentioned in the subsection 3.2). The current task

is to classify the types of copula expressions which require certain complementation of substantial words. Among them, two typical examples are shown as follows.

J3: Tsugi no iinkai wa ikkagetsu go desu.

E3: The next committee will be held after one month.

J4: XXX-hoteru wa ZZZZ-yen to natte orimasu.

E4: As for XXX-hotel, it(the room charge) costs ZZZZ yen.

Both of the above Japanese sentences lack substantial predicates: e.g. corresponding to "will be held" or "costs". For translation of J3, an associative knowledge(a kind of common sense) is required:

committee - time location → *be held*

In this example, J3 is the answer for the question that demands the date of the next committee. Whether or not a substantial predicate indicating *the event* lead by the committee and the date(interrogation) appears in the previous utterances, that kind of associative knowledge (relatively specific to the target domain) is applicable.

As for J4, an implicit comparison (actually the local topic of the dialogue is "the expense of hotel rooms") is underlying. In this case, the key to complementation can be obtained from the preceding utterances. It implies that the XXX-hoteru with topic marker "wa" (it seems to be the subject of the sentence like J3) only designates *the field* of the copula equation. In our current framework of analysis of sentence by sentence, it is impossible to distinguish the difference between J3 and J4. Therefore certain domain knowledge is required. For achieving a suitable translation, it should be connected with the language specific constraint of producing (discourse) utterances. The input PS-J4 (corresponds to the analysis result of J4) could be rewritten into PS-E4, as shown below.

[[Pred COPULA]  
[Obje XXX-hoteru]  
[Iden ZZZZ-yen]]

PS-J4. corresponding to J4

[[Pred COST]  
[Obje []]  
[Degree ZZZZ-yen]  
[Field XXX-hotel]]

PS-E4. for translation of J4

As the lexicalization from the PS-E4, we could give several variations for the case, Field: *as for, in the*

*case of, ...* If we adopt the generating strategy of the prior position of theme (equivalent with the input), the result output may be as E4.

## 4 Discussion

### 4.1 Related Issues

Ellipsis is one of the prominent characteristics of Japanese spoken dialogue. Concerning the issue of identifying Japanese zero pronouns, we have some previous works. A theoretical foundation was given by Yoshimoto[15] and an implementation was performed by Dohsaka[1], in which zero pronouns referring dialogue participants (speaker/hearer) are identified based on the usage of honorifics and the speaker's territory within a sentence. As such ellipses occur almost obligatorily in dialogue, the formalization seems to be relatively simple. Of course, the resolution of some phenomena requires more complex information from the context.

Kudo[5] showed that another kind of ellipsis indicating objects in the previous sentence could be resolved with local cohesive knowledge extracted from actual corpora. This knowledge consists of pair template patterns of successive two sentences and enables certain complementation of elliptical objects. The value of his work is to have proposed a method of semi-automatic acquisition of such knowledge from real dialogue corpora.[6]

The primary objective of these approaches was to resolve ellipses. Therefore, problems of translation have not been sufficiently focused. Hereafter we have to pay attention to the insight suggested in the previous sections.

As approaches from the other viewpoint of knowledge based translation, we find some representative works in which semantic networks are used for representing meaning structure including context (and sometimes world knowledge) information. [10] [4] Mel'čuk's Meaning Text Theory is remarkable in considering communicative structure of text. The attempt of knowledge based generating multilingual text at CMU is also notable, while it does not seem to have clearly mentioned about the relationships between their interlingua and language specific communicative strategies.

Stanwood and Suzuki suggested that the communicative structures sometimes differ with languages and showed a concept of repartitioning the given network configuration. In this study, a semantic network is assumed to have been divided into contrastive partitions: Theme vs. Rheme, Old- vs. New-information etc. An input utterance in the source language is represented as a part of the network. From this start point, the producing a target language utterance is processed through repartitioning the network, if necessary. [11] [13] This processing model motivated the current issue of utilizing domain and language specific constraints in our dialogue translation system.

## 4.2 Future Directions

According to Narita[9], we can assume two kinds of syntactic systems for any languages. The first is a core syntactic structure that is generally recognized as a universal system of syntax. The second syntactic structure is rather language dependent and peripheral. However, this does not mean that the second syntactic system is unimportant. Though it is difficult to translate into other languages, the second syntactic system just reflects the characteristics of a certain language. It includes many favorite expressions in the language. This issue is quite interesting also from the standpoint of sociolinguistics and cross language communication.

From the viewpoint of translating dialogues, if an expression of a source language is peripheral and there is no corresponding structures in a target language, the source structure could be transformed into a universal structure before translation. In order to perform this idea, such a transformation should be possible to be formalized. Furthermore, certain implicit (domain- and language-specific) knowledge might be needed in some cases.

The target expression in this article, a certain kind of "da-expressions", is regarded as a typical second syntactic structure described above. Our future efforts will be directed to investigating various structures and for refining and extending the methodology proposed here.

## 5 Conclusion

In order to provide a effective method of translating a kind of copula sentences lacking some substantial words, a method of utilizing domain and language specific constraints are proposed. In this attempt, it has been examined that both domain knowledge and language specific strategies of producing utterances should be incorporated. The feasibility was shown through typical examples and transfer rules, while we need still more investigation into those linguistic phenomena and have to develop the method of knowledge extraction. Furthermore, the related issues and our future directions were discussed.

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