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Restricting Bidirectional Translation Correspondences to the Appropriate Context

Abstract

This paper addresses the resolution of translational ambiguities in a lexicalist transfer approach, which is realized in the translation system **Verb*mobil***. It is particularly concerned with the use of various kinds of constraints that restrict the translation mapping of ambiguous lexical items to the appropriate context. They range from structural, semantic and prosodic information to discourse and speech act information.

Keywords: Transfer Lexicon, Disambiguation, Contextual Constraints

1. Introduction

This paper describes the use of contextual constraints to resolve translational ambiguities in the transfer component of **Verb*mobil*** (Dorna and Emele, 1996).[1] **Verb*mobil*** is a multilingual speech-to-speech translation system which is applied to the task of translating spoken language in the domain of appointment scheduling and travel planning (Wahlster, 1993). Currently, the system includes modules for German, English and Japanese. Here, only the language pair German – English is considered.

The transfer between source language (SL) and target language (TL) is carried out on semantic representations. On the semantic level, many of the ambiguities specific to the speech processing task are already resolved by preceding components. However, those that influence the choice of the appropriate translation correspondence often remain up to the translation step (Kay et al., 1994).

In our system, the selection of alternative translation candidates is determined by the rules in the transfer lexicon. They substitute one or more SL semantic predicates by the corresponding TL ones if the constraints imposed on the particular mapping are fulfilled in the input representation. First, we used only structural, semantic and prosodic information from the immediate utterance context to formulate restrictions. This turned out to be not sufficient. Caused by a high frequency of anaphora and ellipses in spoken language, selectional restrictions can rarely be verified. To achieve an acceptable translation quality we extended the context restrictions to discourse and dialogue information, domain-specific world knowledge and probability measures for co-occurrences.

The paper is organised as follows: Section 2 shows the embedding of the translation component in the **Verb*mobil*** system and briefly introduces the used representation language. In Section 3, the transfer approach is sketched. Section 4 describes the encoding of bidirectional translation correspondences and contextual restrictions in the transfer lexicon. Finally, Section 5 presents some examples of transfer rules the application of which depends on contextual restrictions of various kinds.

2. Architecture and Representation Language

Figure 1 shows the embedding of the translation component in the Verb*mobil* system. The semantic construction (Bos et al., 1996) produces semantic representations that form the input to the transfer module. To choose the appropriate translations, the transfer component obtains additional information from the context evaluation that provides discourse information and speech acts, from the dialogue processing that keeps track of the dialogue history (Alexandersson et al., 1997), and a statistical evaluation component that allows the transfer to access probability measures of TL co-occurrences. The transfer module reports its TL semantic representations to the generator which maps them to TL expressions.

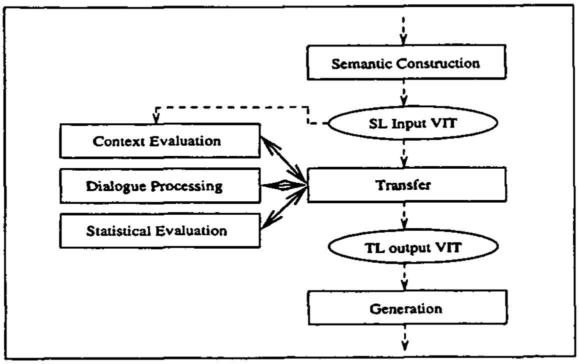

Figure 1: Interfaces of the Transfer Component

The semantic representation together with additional information, such as sorts, tense, aspect, prosodic information, etc., is encoded in a multi-dimensional data structure called Verb*mobil* Interface Term (VIT) (Dorna, 1996). It serves as interface representation for all components that operate on semantic structures, see Figure 1.

Let us shortly describe the semantic slot of a VIT, since this is the part to which the transfer mappings apply. The semantic slot contains a set of semantic predicates. Each one has a unique label l which is used as an address for linking information within the VIT. Besides their label, referential predicates introduce an instance i. Argument roles and modifier relations are represented in a Neo-Davidsonian way (Parsons, 1991). Semantic operators like quantifiers, modals or scopal adverbs take extra label arguments for referring to other elements which are in the relative scope of these operators. For representational details, see (Kasper et al., 1997).

(1) Wollen sie zu mir kommen? (Do you want to come to my place?)

Consider the utterance in (1) and its representation in the SEMANTICS slot of Figure 2. The control verb *wollen*(l1,i1) is in the relative scope of the sentence mood operator quest(l0,l1) (indicated by the coindexation of label l1). Its argument arg1 points via i2 to a pronoun that refers to the hearer and its argument arg3 embeds the main verb *kommen* (l2,i3) via the label l2. The main verb's arg1 is again coreferent with the hearer (indicated by the shared instance i2). The prepositional modifier *zu*(l3,i3,i4) is attached to the main verb by the instance i3. Its internal argument with the instance i4 is coindexed with a pronoun with speaker reference.

The remaining VIT layers contain additional information of the predicates encoded in the SEMANTICS slot.

```
vit(vitID(sid(102,a,de,0,4,1,de,y,synsem),
                                  [word(wollen,1,[l1]),              % SURFACE ORDER
                                   word(sie,2,[l4]),
                                   word(zu,3,[l3]),
                                   word(mir,4,[l5]),
                                   word(kommen,5,[l2])],
                                  [quest(l0,l1),                     % SEMANTICS
                                   wollen(l1,i1),
                                   arg1(l1,i1,i2),
                                   arg3(l1,i1,l2),
                                   kommen(l2,i3),
                                   arg1(l2,i3,i2),
                                   zu(l3,i3,i4),
                                   pron(l4,i2),
                                   pron(l5,i4)],
                                  [sort(i1,mental_sit),              % SORTS
                                   sort(i2,human),
                                   sort(i3,move_sit)
                                   sort(i4,human)],
                                  [prontype(i2,hearer),              % DISCOURSE
                                   prontype(i4,speaker)],
                                  [num(i2,sg),                       % MORPHO-SYNTAX
                                   num(i4,sg)],
                                  [ta_tense(i1,pres),                % TENSE & ASPECT
                                   ta_mood(i1,ind),
                                   ta_perf(i1,nonperf),
                                   ta_aspect(i1,nonprogr),
                                   ta_perf(i3,nonperf),
                                   ta_aspect(I3,nonprogr)],
                                  [pros_accent(l5),                  % PROSODY
                                   pros_mood(l0,quest)])
```

Figure 2: VIT Representation for Example (1)

3. A Two-Level Transfer Approach

The transfer employs a two-level approach, see Figure 3. The actual translation mapping precedes a refinement step. It introduces partially language-independent representations by applying a set of monolingual refinement rules.

There are several motivations for a refinement step within the transfer module. It is well known that the more abstract the representation to be transferred the easier the mapping (Vauquois, 1975). Hence, the refinement module produces a partially language-neutral representation in order to keep the distance between the two languages small. This is reached by mapping contextually synonymous expressions to abstract predicates and by decomposition.

For demonstration, consider a simple example. German and English employ different prepositions to express temporal localisation. Occurring with time expressions, such as

Monday, May, nine o'clock or *Easter,* the use of English *in, on, at,* or German *in, um, an, zu* is rather idiosyncratic. The encoding of translation correspondences between these

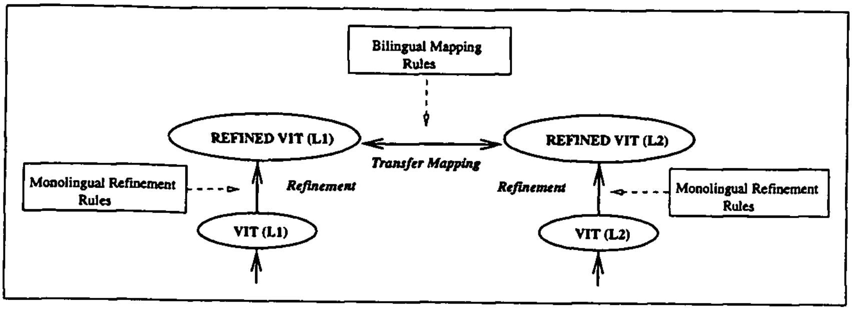

Figure 3: The Two-Level Transfer Approach

prepositions would lead to a large number of rules that hold only in very specific contexts. This can be avoided by bundling the German and English prepositions wrt. their meaning in the refinement step and consider the produced abstraction as an interlingual predicate, such as temp_loc for temporal localisation in Figure 4. Moreover, the information encoded in the abstract predicate can be used for the resolution of translational ambiguities in the actual transfer mapping. It allows for a compact representation of contextual restrictions.

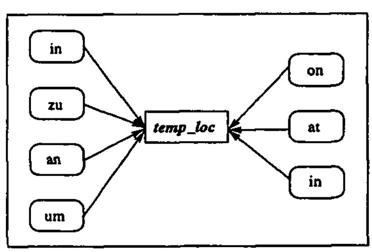

Figure 4: Abstraction over Contextually Synonymous Expressions

Abstractions are introduced for all kinds of contextually synonymous expressions (Buschbeck-Wolf and Tschernitschek, 1996). These are, e.g., attitude expressions that occur very frequently in our domain, prepositions that are disambiguated by the mapping to meaning relations, as well as collocations. Collocates are mapped to abstractions that can be compared to lexical functions (Heylen and Maxwell, 1994).

4. The Transfer Lexicon

4.1. Mapping Rules

The format of a mapping rule is shown in (2). It establishes the equivalence between sets of SL semantic predicates (SL_Sem) and sets of TL semantic predicates (TL_Sem). The operator TauOp indicates the direction of the rule application, i.e., bi-directional (↔) or uni-directional (→ or ←).[2]

(2) SL_Sem # SL_Cond TauOp TL_Sem # TL_Cond.

In order to restrict the mapping of ambiguous predicates to the appropriate context, the rules are optionally provided with a condition part (SL_Cond and TL_Cond). The # sign separates it from the mapping part. The condition to the left of TauOp restricts the application direction →, and vice versa. The condition part contains only tests. On the one hand, these are tests on information that is contained in the actual VIT representation, see Section 4.2.1. On the other hand, these are interface predicates that encode calls to other components for providing information that is not part of the actual VIT, see Section 4.2.2.

Consider the ambiguous verb *verlegen,* which gets translated, among others, into *put off, publish, move* and *misplace.* The different readings can be identified by sortal restrictions on the theme argument (arg3). (3) shows the mapping of *verlegen* to *put off.* It is constrained to contexts in which the theme argument is realized by a noun of the sort situation, see Figure 5. The capitalised symbols L and I stand for logical variables which are bound to concrete values when applying a rule to a given input.

(3) verlegen(L,I) # arg3(L,I,I1),sort(I1,situation) ↔ put off(L,I).

Monolingual refinement rules (4) follow the same pattern. Here, the direction is fixed and the conditions are specified only on the SL side.

(4) SL_Sem # SL_Cond → SL_RefinedSem

(5) shows the mapping of the prepositions *in, um, an* and *zu* to the abstraction temp_loc, see Section 3.

(5) stat_temp_prep(L,I,I1) # sort(I1,time) → temp_loc(L,I,I1) .

stat_temp_prep is an *abstract predicate type* that allows to map the considered prepositional predicates in one step. Its declaration is shown in (6).

(6) type(german,stat_temp_prep,[in,um,an,zu]) .

In the transfer lexicon, all rules are encoded by the use of templates. They considerably simplify the rule writing, capture generalisations of cross-linguistic translation patterns and ensure the adaptation and reusability of transfer rules independently of the concrete front and back end of the transfer component.

4.2. Contextual Constraints for Lexical Disambiguation

To restrict the transfer mapping of ambiguous SL lexical items, we follow the principle of *cascading disambiguation,* i.e., the local information available in the actual input VIT is used first. When it is exhausted global contextual information is exploited, see (Buschbeck-Wolf, 1997).

4.2.1. Information from the Local Utterance Context

For disambiguation, among others, the information shown in (7) is used. It is encoded in the input representation.

(7)
- Sortal information
- Meaning abstractions
- Structural information
- Semantic predicate classes
- Operator scope
- Tense, mood, aktionsart and number
- Prosodic information
- Adjacency

Sortal information is frequently used for the disambiguation of verbs, prepositions and adjectives. Figure 5 shows the sort hierarchy used by the transfer module. Another important method is the specification of particular predicates or previously introduced abstract meanings, see Section 3, that occur as arguments or modifiers of an ambiguous lexical item. There are cases in which the semantic class of a predicate, operator scope as well as particular kinds of categorial features allow to choose among different translation candidates. Prosodic and adjacency information is required for the disambiguation of German particles.[3]

For illustration of the use of local context information, see Section 5.

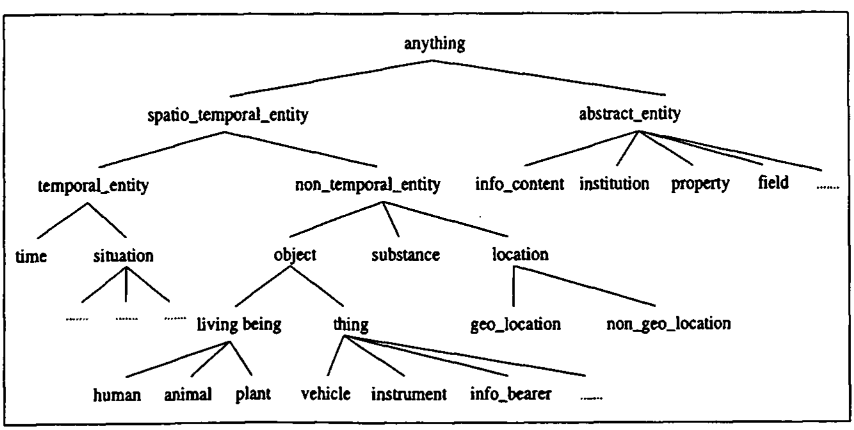

Figure 5: Sort Hierarchy for the Disambiguation of Translational Ambiguities

4.2.2. Information from the Broader Context

There are cases in which the transfer component needs more global information, such as listed in (8), to choose a particular TL correspondence. It is obtained from the dialogue processing, context evaluation and statistical evaluation modules via interface predicates, see Figure 1 in Section 2.

(8)
- Antecedents of anaphora and ellipses
- Dialogue stage
- Propositional utterance content
- Illocution or dialogue act
- Temporal referents
- Probability measures of particular co-occurrences

For anaphora and ellipses, the transfer requires the identification of their antecedents. On the one hand, the antecedent might be required for the appropriate translation of the anaphor or the ellipsis itself. On the other hand, information about antecedents might be necessary to verify constraints in the condition part of other transfer rules.

Dialogue stage and propositional content information is exploited for lexical disambiguation. Illocutional information is often relevant for the translation of discourse particles and routine formulas (Stede and Schmitz, 1997).

The identification of temporal referents is used, among others, to translate holiday names into dates if they are unknown in the culture of the addressee.

We rely on probability measures for the disambiguation of nouns (Gale et al., 1992), which is notoriously difficult, since it is impossible to manually fix all contextual constraints. We use pre-processed probabilities of verb-noun and modifier-noun co-occurrences from large parsed corpora (Carroll and Rooth, 1994) in order to determine the appropriate TL noun in a given context.

5. Examples

For illustration, let us discuss some of the transfer rules of the German verb *vorziehen,* which means either *prefer* or *schedule earlier.* In (9) - (12), there are listed some contexts in which the mapping of *vorziehen* to one of its equivalents is quite obvious. (The contextual trigger is underlined.)

(9a) Ich würde <u>den Dienstag</u> *vorziehen.*
(9b) I would *prefer* Tuesday.

(10a) Ich würde das Treffen <u>gerne</u> *vorziehen.*
(10b) I would like to *schedule* the meeting *earlier.*

(11a) Wir <u>sollten</u> das Treffen *vorziehen.*
(11b) We should *schedule* the meeting *earlier.*

(12a) Ich würde es *vorziehen,* <u>am Montag zu kommen</u>.
(12b) I would *prefer* to come on Monday.

If the theme argument is a time expression, as in (9), *prefer* is the only correspondence. This is captured by rule (13). The translation into *schedule earlier* is not feasible here, because, in the arg3 role, it would require an object movable in time; and times, such as Tuesday, are fixed.

(13) vorziehen(L,I) # arg3(L,I,I1),sort(I1,time) ↔ prefer(L,I).

In one of its meanings *vorziehen* is an attitude verb. If it is modified by an adverb that expresses the speakers attitude, as in (10), it cannot have an attitude reading itself. This excludes *prefer* as correspondence. (14) encodes this restriction with the abstract predicate attitude(L1,I) (a type for attitude adverbs) as the verb's modifier.

(14) vorziehen(L,I) # attitude(L1, I) ↔ schedule(L,I),early(L2,I),comp(L2,I,I1).

In (11), the "prefer" reading of *vorziehen* is odd for similar reasons as in the previous example. Here, the attitude meaning is contributed by the modal verb. Within the scope of a modal verb, the "move" reading of *vorziehen* is dominant. The corresponding rule in (15) encodes the embedding of *vorziehen* by a modal verb in its condition part. It is indicated by the coindexation of the label L.

(15) vorziehen(L,I) # class(modal,L1,I1,L) ↔ schedule(L,I), early(L2,I), comp(L2,I,I2).

Finally, if *vorziehen* has a propositional theme argument realisation, as in (12), *prefer* is the appropriate translation equivalent. This constraint is encoded in the condition part of (16). The arg3 embeds a verbal predicate via the label L1.

(16) vorziehen(L,I) # arg3(L,I,L1),class(verb,L1,I1) ↔ prefer(L,I).

Consider some of the readings of the discourse particle *doch* in (17) – (20). For its translation we consider its place of occurrence in the utterance, illocutional as well as prosodic information.

(17a) *DOCH,* das geht bei mir.
(17b) *Yes,* this would suit me.

(18a) *Doch* das geht bei mir nicht.
(18b) *But* this does not suit me.

(19a) Dann würde das *DOCH* gehen.
(19b) Then it would be possible, *after all.*

(20a) Dann würde das *doch* gehen?
(20b) Then it would be possible, *wouldn't it?*

In (17a), the particle *doch* is stressed and occurs in the beginning of an utterance that expresses a positive feedback to a previously made suggestion. It emphasises the speakers attitude and might be translated into *yes,* as in (17b). The rule in (21) fixes the context for this translation. The predicate int(L) tests the sentence-initial occurrence of the particle, and pros_accent(L) checks whether it bears prosodic accent. The dialogue act pos_feedback is verified by the context evaluation module.

(21) doch(L,H) # init(L),pros_accent(L),dialogue_act(L,pos_feedback) → yes(L,H) .

The meaning of *doch* changes if it is unstressed and comes along with a dialogue act other than positive feedback, as in (18a). Although being in the same position as in (17a), it now denotes contrast, and is consequently translated into *but* (18b). Rule (22) restricts the context of this mapping correspondingly ('~' means negation).

(22) doch(L,H) # init(L),not(pros_accent(L)),dialogue_act(L,~pos_feedback) →
but(L,H).

In (19a), the particle *doch* occurs in the middle of an utterance with declarative mood and bears an accent. Here, it gets translated into *after all,* as in (19b). It functions as a pointer to a previous dialogue stage. Something that was impossible before turned out to be feasible at the utterance time. For the mapping of *doch* to *after all,* the rule in (23) contains constraints on its position, the prosodic mood (pros_mood(L,decl)) of the utterance it occurs in, and its prosodic accent.

(23) doch(L,H) # not(init(L)),pros_mood(L,decl),pros_accent(L) → after_all(L,H).

In (20a), *doch* occurs in exactly the same context as in (19a), but here it is not stressed and the utterance has a rising intonation. The particle signals the speaker's expectation of the hearer's approving response. In English, this meaning is conveyed by a question tag (20b). The corresponding rule in (24) restricts the mapping to utterances with the intonation of a yes-no question, in which *doch* occurs sentence-initial and unstressed.

(24) doch(L,H) # not(init(L)),pros_mood(L,quest),not(pros_accent(L)) →
quest_tag(L,H).

Note that for the translation of *doch* in (19a) and (20a) prosodic mood is essential since both utterances have the word order of a declarative sentence. For more examples of the use of prosodic information for disambiguation, see (Lieske et al., 1997).

6. Summary

In this paper, a lexicon-based disambiguation method was presented. First, a preprocessor produces bilingual meaning abstractions for synonymous expressions by the application of monolingual refinement rules and thus, reduces the number of bilingual transfer rules to the minimum. In the actual translation step, bilingual transfer rules are applied. They are provided with various kinds of contextual constraints that determine the appropriate translation candidate in a given input.

Further work concerns the problem of bidirectional equivalence and contextual restrictions for lexical items that are ambiguous in both languages, as well as on the tradeoff between symbolic and statistical disambiguation methods.

7. Notes

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2 A rule application reduces the SL input by the set of semantic entities in SL_Sem if they form a matching subset of the input. On the other hand, the TL semantic entities TL_Sem are added to the TL output, see (Dorna and Emele, 1996).

3 To treat clusters of German particles we often need to know their surface order that usually gets lost in the semantic representation. This information is derived from the order of the predicate labels that point to the words of the input utterance, see the slot SURFACEORDER in Figure 2.

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