Abstract

Possessive pronouns are used as determiners in English when no equivalent would be used in a Japanese sentence with the same meaning. This paper proposes a heuristic method of generating such possessive pronouns even when there is no equivalent in the Japanese. The method uses information about the use of possessive pronouns in English treated as a lexical property of nouns, in addition to contextual information about noun phrase referentiality and the subject and main verb of the sentence that the noun phrase appears in. The proposed method has been implemented in NTT Communication Science Laboratories’ Japanese-to-English machine translation system ALT-J/E. In a test set of 6,200 sentences, the proposed method increased the number of noun phrases with appropriate possessive pronouns generated, by 263 to 609, at the cost of generating 83 noun phrases with inappropriate possessive pronouns.

1 Introduction

Possessive pronouns are often used as determiners in English when no equivalent would be used in a Japanese sentence with the same meaning. For example, when referring to specific family members in English, it is normal to specify whose relations they are. In Japanese these are only specified if they are not obvious from the context. For a machine translation system to generate appropriate English when translating from Japanese, it is necessary to determine which pronouns should be used and when.

The similar problem of determining article usage and noun phrase number has recently been approached in three ways: using expert-system-like rules to determine the referential property and number of nouns (Murata and Nagao 1993); using heuristic rules based on the meaning of the Japanese sentence and the properties of the generated English to determine the referentiality and number of English noun phrases (Bond et al. 1994) and using a Context Monitor to maintain contextual information dynamically (Cornish et al. 1994). The problem of generating possessive pronouns as determiners in translation where there is no equivalent in the Japanese has not previously been addressed; it requires not only contextual information such as that used to determine noun phrase referentiality, but also information about the conventional usage of possessive pronouns in English.

In this paper, we propose a method of generating possessive pronouns as determiners for noun phrases where there is no equivalent in the Japanese, based on treating information about the conventional use of possessive pronouns in English as a lexical property of nouns. In addition, the method uses contextual information about noun phrase referentiality, the meaning and modality of the main verb and the denotation of the subject of the sentence that the noun phrase appears in. The method has been implemented in NTT Communication Science Laboratories’ Japanese-to-English machine translation system ALT-J/E (Ikehara et al. 1991; Ogura et al. 1993).

†Japanese does not have articles, and noun phrases are normally not marked for number.

†This paper was presented at the 2nd Pacific Association for Computational Linguistics Conference (PACLING ’95) and appears in the proceedings.
The rest of this document is organized as follows: We begin in Section 2 by examining the distribution of possessive pronouns in 6,200 Japanese sentences with English translations. 657 noun phrases containing possessive pronouns were found in the translations. Existing algorithms, described in Section 3, are capable of translating 52% of these 657 noun phrases, mainly those in which there was a possessive construction in the Japanese. The proposed method for appropriately generating possessive pronouns for the remaining 48% is presented in Section 4. The result of implementing the proposed method is evaluated in Section 5. Finally some concluding remarks are given in Section 6.

2 Differences in the use of possessive pronouns in Japanese and English

In order to examine the use of possessive pronouns when translating from Japanese to English, a study was made of 6,200 sentence pairs of Japanese sentences with English translations, produced by a professional translator. These pairs make up a test set (taken mainly from written Japanese such as in newspaper articles) designed to test the capabilities of Japanese-to-English machine translation systems. A description of the test set and it’s design is given in Ikehara et al. (1994). The use of possessive pronouns is not one of the criteria specifically tested by the test set.

The English translations of the test set contain 657 noun phrases with possessive pronouns. The sentences containing these noun phrases were examined in order to determine how the possessive pronouns could be generated by a machine translation system. The noun phrases were divided into three groups, according to whether the possessive pronoun had an equivalent in the original Japanese, or could be predicted as an obligatory part of an English expression, and if neither of the above conditions held.

There were 193 noun phrases (30%) in the first group (I) where the original Japanese noun phrase contains a possessive expression, either a pronoun or the reflexive jibun ‘self’ followed by the genitive postposition no ‘of’ that indicates possession. The genitive pronoun construction (PRONOUN-no) can be directly translated into English as a possessive pronoun. An example is shown in sentence 2.

2 Examples are given with the (romanized) Japanese orig-

Jap: kanojo-wa kare-no kau-o mita
Gloss: she-top he-gen face-obj saw
Eng: ‘She saw his face’

The genitive reflexive construction jibun-no ‘one’s own’ appears in 25 cases (4% of the total). jibun-no is translated as POSSESSIVE PRONOUN own. The relation between the pronoun and its antecedent is not given explicitly, it depends on the context. An example of this is shown in sentence 3. When the subject is kanojo ‘she’ jibun-no ‘one’s own’ is translated as her own. If the subject were changed to kare ‘he’ or John then jibun-no ‘one’s own’ would be translated as his own.

Jap: kanojo-wa jibun-no namae-o wasureta
Gloss: she-top self-gen name-obj forgot
Eng: ‘She forgot her own name’

The second group (II), with 105 noun phrases (16%), consisted of those in which the possessive pronoun appeared as part of an English expression where both the use of a possessive pronoun and its antecedent could be deduced from the form of the expression, but there was no equivalent possessive construction in the Japanese original sentence. For example, in the expression 20-dai-no-josei ‘20 generation GEN woman’ a women in her twenties the possessive pronoun her is an obligatory part of the English expression, and its antecedent is always the modificant of the prepositional phrase. An expression may be based on a verb, as in sentence 3 where the Japanese idiom chic-o shiboru ‘wring knowledge’ is translated into an English idiom rack POSSESSIVE PRONOUN brains in which the antecedent of the possessive pronoun is the noun phrase that is the subject of the verbal idiom.

Jap: kanojo-wa chie-o shibotta
Gloss: she-top knowledge-obj wrung
Eng: ‘She racked her brains’

Groups I and II can be translated straightforwardly by a machine translation system. A discussion of how this is done in ALT-J/E is given in Section 3.

The third and final group (III) consists of 359 noun phrases (54%) where the original Japanese

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Table 1: Distribution of possessive pronouns

| Noun phrase type: | Number of occurrences | Percentage of occurrences |
|-------------------|-----------------------|--------------------------|
| I Possessive expression in the original Japanese | 193 | 30% |
| II English expression requires possessive pronoun | 105 | 16% |
| III Noun-triggered possessive pronoun | 359 | 54% |

had neither a possessive construction, as in group I, nor arose in an English expression in which it was obligatory, as in group II. These noun phrases were those where English conventionally uses a possessive pronoun to indicate a relationship such as ownership, as in my wallet, or a family relationship, my father, but Japanese does not. The use of possessive pronouns with the nouns which head the noun phrases in group III seems to be tied to the particular words. In particular, words which denote body parts, work, personal possessions, attributes and relational nouns such as kin and people defined by their relation to another person (e.g. assailant, partner, subordinate) were commonly translated with possessive pronouns. The semantic hierarchy of 2,800 categories used in ALT-J/E was not fine-grained enough to identify the words by their denotation alone. We therefore identified the nouns manually and marked them with a special flag in the lexicon. These nouns will be referred to as ‘trigger-nouns’ as they trigger the use of possessive pronouns when they are used in English. We are investigating automating the identification process using a parsed bilingual corpus aligned at the noun phrase level.

There were 205 different trigger-nouns in the test set used. They headed 825 noun phrases. The human translations of 355 out of the 825 noun phrases headed by trigger-nouns (43%) contained possessive pronouns, even though the original Japanese did not contain a possessive construction, and the possessive pronoun was not part of an English expression in which it was obligatory. A new heuristic method for translating these cases that uses the head noun’s lexical information as a trigger to generate possessive pronouns, in conjunction with contextual information is proposed in Section 4.

3 Elided subjects are supplemented using information both from within the sentence being translated and from the surrounding paragraph (Nakaiwa and Ikehara 1992).
if the antecedent is a simple noun phrase
  if it is 1st per
    use my
  else if it is Pl (we)
    use our
  if it is 2nd per (you)
    use your
  else (treat it as 3rd per)
    if it is Si
      if it is the generic pronoun one
        use one’s
      else if it is MALE (he/Mr Bond)
        use his
      else if it is FEMALE (she/Ms Bond)
        use her
      else if it is HUMAN (Dr Bond)
        use their (gender unknown)
      else (it is Si and non-human) (it/NTT)
        use its
      else (it is Pl) (they/the G7 Nations)
        use their
    else (the antecedent is a compound noun phrase)
      if one element is 1st per
        use our
      else if one element is 2nd per
        use your
      else (treat as 3rd per)
        use their

Figure 1: Determination of a possessive pronoun given its antecedent

The translation rules for English expressions with obligatory possessive pronouns identify the antecedent within the rule. For example the rule used in translating sentence \(3\) can be glossed as follows:

\[ N1\text{-}wa\ chie\text{-}o\ shiboru ‘N1\text{-}TOP knowledge\text{-}OBJ wring’ \]
\[ \rightarrow N1\ racks\ N1\text{’s}\ brains^{4} \]

When the Japanese analysis stage has parsed the sentence correctly and an appropriate pattern has been chosen in the transfer stage then the correct possessive pronoun will be generated.

For the 105 sentences of group II where the translator uses an idiom containing a possessive pronoun, the machine translation system does not always choose the same idiom as the human translator. In the cases where the machine generates an idiom that does use a possessive pronoun it is generated correctly.

4 Generating possessive pronouns in noun phrases headed by trigger-nouns

This section describes the proposed method for appropriately generating possessive pronouns for noun phrases headed by trigger nouns. The discussion will be illustrated with examples of translations from two versions of ALT-J/E. The original version (hereafter the ’93 version) does not use the proposed method for generating possessive pronouns. The version that uses the proposed method will be referred to as the ’94 version.\(^5\)

The generation of possessive pronouns in noun phrases headed by trigger-nouns occurs at the end of the transfer phrase. We shall call the pronouns generated for these noun phrases ‘default possessive pronouns’ because they are generated as a default, not as a result of being explicitly indicated in the Japanese or in the translation pattern.

The proposed algorithm is outlined in Figure 2. First, the noun phrase’s referential property is determined as described in Section 4.1. If the noun phrase’s determiner slot is already filled, then it cannot have a possessive pronoun. Some of the ways that the determiner slot can be filled are described in Section 4.2. Finally, if the noun phrase is headed by a trigger-noun and is neither the subject of the sentence nor the direct object of a verb with meaning POSSESSION or ACQUISITION, then it will be generated with a possessive pronoun whose antecedent is the subject of the sentence. The significance of the verb meaning is discussed in Section 4.3.

The extra rules for noun phrases headed by trigger-nouns denoting KIN or BODY PARTS are described in Section 4.4.

\(^5\)Translations made by ALT-J/E before the proposed processing was included are marked “MT-93”. Translations done by the current version of ALT-J/E which includes the proposed processing are marked “MT-94”.

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\(^4\)N1’s represents a possessive pronoun with N1 as its antecedent.
1. A noun phrase that fulfills all of the following conditions will be generated with a default possessive pronoun with deictic reference determined by the modality of the sentence it appears in.
   
   (a) The noun phrase is headed by a trigger-noun that denotes KIN or BODY PARTS
   (b) The noun phrase is the subject of the sentence
   (c) The noun phrase is referential
   (d) The noun phrase has no other determiner

2. A noun phrase that fulfills all of the following conditions will be generated with a default possessive pronoun whose antecedent is the subject of the sentence the noun phrase appears in.
   
   (a) The noun phrase is headed by a trigger-noun
   (b) The noun phrase is not the subject of the sentence
   (c) The noun phrase is referential
   (d) The noun phrase has no other determiner
   (e) The noun phrase is not the direct object of a verb of POSSESSION or ACQUISITION

Figure 2: Proposed method of generating possessive pronouns

4.1 Effects of noun phrase referentiality

The use of heuristic rules to determine the referentiality of noun phrases in the machine translation system ALT-J/E is discussed in detail in Bond et al. (1995). In the following discussion we assume that the referentiality of a noun phrase can be correctly determined.

Consider the translation of hana ‘nose’ in sentences (4) and (5).

(4) Jap: hana-wa kankakukikan da
   Gloss: nose-TOP sensory organ is
   Eng: ‘The nose is a sensory organ’
   MT-93: A nose is a sensory organ
   MT-94: Noses are sensory organs

In sentence (4) the subject ‘nose’ is determined by the human translator to have generic reference and no possessive pronoun is used. In sentence (5) the subject is determined to refer to a specific person’s nose, and so a possessive pronoun is used. In general, noun phrases with generic reference are not modified by possessive pronouns. Similarly, noun phrases used ascriptively, to ascribe an attribute to another noun phrase, do not use possessive pronouns, e.g. That is a big nose! Therefore, we restrict the problem of determining when possessive phrases should be used to referential noun phrases.

In sentence (4), the ‘93 version does not differentiate between generic and referential noun phrases. By chance, the translation given (A nose is a sensory organ) has a generic interpretation so the translation is judged as correct. In the ‘94 version, the system determines that the sentence is generic, because it is stating a general truth, and thus the subject has generic reference. The judgment is done with the following rule: if the semantic category of the subject of a copula is a child of the semantic category of the object then the noun phrase in the subject position has generic reference. In this case, the semantic attributes stored in the lexicon for nose and sensory organ are NOSE and ORGAN respectively, and the category NOSE is a child of ORGAN, that is, a NOSE IS-A ORGAN. Generic noun phrases headed by countable nouns are translated as bare plurals and are not candidates for the generation of default possessive pronouns. In sentence (5), however, the subject is determined to be referential. Therefore, as nose is a trigger-noun a possessive pronoun with deictic reference is generated.

4.2 Filling the determiner slot

Default possessive pronouns will not be generated if the determiner slot has been filled. The determiner slot can be filled by elements directly translated from the Japanese: e.g. the demonstrative kono ‘this’ fills the determiner slot as kono ‘this’. It can also be filled by the rules that generate definite and indefinite articles: e.g., in the noun phrase in example (4) even though it is headed by the trigger-noun saifu ‘wallet’ the determiner slot is filled by the definite article so the noun phrase is not a candidate
for a default possessive pronoun. In contrast, a possessive pronoun is generated in example (4) where there is no definite article generated. The rules that can fill the determiner slot are too numerous to be enumerated here.

\[
\text{(4) Jap: watashi-wa kinō katta saifu-o nakushita} \\
\text{Gloss: I-TOP yesterday bought wallet-OBJ lost} \\
\text{Eng: 'I lost the wallet I bought yesterday'} \\
\text{MT-93: I lost the wallet I bought yesterday} \\
\text{MT-94: = MT-93}
\]

\[
\text{(5) Jap: watashi-wa saifu-o nakushita} \\
\text{Gloss: I-TOP wallet-OBJ lost} \\
\text{Eng: 'I lost my wallet'} \\
\text{MT-93: I lost a wallet} \\
\text{MT-94: I lost my wallet}
\]

4.3 Restrictions determined from the meanings of verbs

Examining the test set showed that the meanings of verbs can be used to determine whether a possessive pronoun should be generated or not for noun phrases headed by trigger-nouns. Noun phrases which are the direct objects of verbs that express possession, such as your, have or possess and noun phrases that are the object of verbs that express that the object has just been acquired, for example, the direct object of buy, acquire or steal are translated with an indefinite article rather than a possessive pronoun even when headed by trigger-nouns.

Both these cases can be explained by considering the verb's meaning. In the first case the verb itself shows that the subject is the possessor of the object, so a possessive pronoun is not needed to show the meaning. If a possessive pronoun is used, it especially emphasises the fact that the subject's referent possesses the referent of the object. In the second case, in which the subject 'acquires' the object, the object is not 'possessed' by the subject until after the action described by the verb is completed, so a possessive pronoun is not used.

ALT-J/E classifies verb meanings using the system of 97 verbal semantic attributes introduced in 4.3. Nakaiwa et al. (1994) Verbs with similar meanings share the same verbal semantic attributes which allows a rule to be written as follows:

- If a noun phrase headed by a trigger-noun is the direct object of a verb of possession or acquisition then do not generate a possessive pronoun.

This rule is exemplified in sentence (5). If this rule were not implemented then because kuruma 'car' is a trigger-noun the sentence would have been incorrectly translated as 'Do you have your car?' which introduces an emphasis that the original Japanese lacks.

\[
\text{(6) Jap: watashi-wa kinō katta saifu-o nakushita} \\
\text{Gloss: I-TOP yesterday bought wallet-OBJ lost} \\
\text{Eng: 'I lost the wallet I bought yesterday'} \\
\text{MT-93: I lost the wallet I bought yesterday} \\
\text{MT-94: = MT-93}
\]

\[
\text{(7) Jap: watashi-wa saifu-o nakushita} \\
\text{Gloss: I-TOP wallet-OBJ lost} \\
\text{Eng: 'I lost my wallet'} \\
\text{MT-93: I lost a wallet} \\
\text{MT-94: I lost my wallet}
\]

4.4 KIN and BODY PARTS

In the test set, noun phrases denoting KIN or BODY PARTS are modified by possessive pronouns used dictically when they are the subject of the sentence. Therefore, the pronoun is determined according to the modality of the sentence: e.g. for declarative sentences the pronoun is first person singular (giving my), whereas for imperative or interrogative sentences it is the second person (giving your).

Two special cases were identified. Nouns which explicitly denote PARENTS or CHILDREN are only translated with possessive pronouns if they appear together in the same sentence. In this case, they are translated as though they are related to each other but not to the speaker. Therefore the following special rule has been implemented: Only generate a possessive pronoun for trigger nouns which explicitly denote PARENTS or CHILDREN if a sentence contains one of each category, in which case the first to appear is the antecedent of the second to appear.

The second special case was for sentences with compound subjects that include nouns that denote KIN. For example, if the subject is me and my spouse and the person in the noun phrase in question is a member of the family other than 'our'...

6A Japanese sentence that emphasises this possessive relationship would explicitly use jibun-no ‘self-gen’. In this case ALT-J/E will generate a possessive pronoun. For example, jibun-no kutsushita-o motteimasu-ka ‘self-gen sock-OBJ have-Q’ Do you have your own socks?

7Furthermore if the noun phrase has no pre-determiner, determiner or post-determiner then maybe generate the determiner some (or any depending on the sentence aspect and noun phrase countability and number).

8That is nouns such as child but not nouns such as son.
children (or grandchildren) then they will normally be either related to me or to my spouse, but not both, therefore they will be modified by my rather than our: e.g. My wife and I gave my sister a book but My wife and I gave our child a book. Similarly siblings will not normally have children or grandchildren in common so my will be used for children and grandchildren: My sister and I gave our mother a book but My sister and I gave my child a book. These rules have not yet been implemented.

5 Results

A preliminary evaluation of ALT-J/E’s generation of possessive pronouns was conducted on the test set of 6,200 sentences described in Section 2. All save two of the 168 noun phrases in group I, in which the original Japanese contained an explicit possessive expression, are translated correctly. Two of the 25 sentences containing jibun-no in the test set were translated incorrectly. Both of the errors were caused by the subject being incorrectly identified in embedded sentences. For the 105 noun phrases in group II, in which a possessive pronoun is required by an English expression in the human’s translation but there is no possessive expression in the Japanese, ALT-J/E did not always select the same expression as the human translator. When ALT-J/E selected an expression that requires a possessive pronoun, such as to rack one’s brains in sentence (2) or to wash one’s hands in sentence (1), it was generated correctly.

\[\text{Jap: } \text{kare-wa kono-shigoto-kara te-o} \]
\[\text{Gloss: he-top this work from hands-obj hiita} \]
\[\text{Eng: ‘He washed his hands of this work’} \]

There were 825 noun phrases in the test set headed by trigger-nouns. In 9% of the noun phrases (73), there were errors in the analysis or transfer stages which made evaluation of the appropriateness of the possessive pronoun impossible. The results of the generation of the remaining 752 noun phrases are given in Table 2. The evaluation was conducted by comparing the machine generated translation of the noun phrases headed by trigger-nouns with the human translations. A machine generated possessive pronoun is judged to be appropriate if it also appears in one or more of the human translations. If a pronoun is generated that does not appear in the human translations, it is judged to be not appropriate.\(^9\) 429 (57%) of the noun phrases headed by trigger-nouns do not require a possessive pronoun to be generated by the proposed method. For example the noun phrase phrase is non-referential, or the determiner slot is already filled, or the noun phrases was dominated by a verb of possession or acquisition. These noun phrases are all translated correctly by the ‘93 version as it has no special processing for generating possessive pronouns. It fails, however, to generate possessive pronouns when they are judged as necessary in the remaining 323 noun phrases (43%). Thus the accuracy of the ‘93 version (the number judged correct over the total number) is only 57% (429/752)\(^10\).

In the ‘94 version, using the proposed method, noun phrases are generated when wanted 80% of the time (the number of noun phrases with appropriate possessive pronouns generated (263) over the number of noun phrases where a possessive pronoun was judged appropriate (323)). The errors caused by not generating the appropriate pronoun are mainly due to errors in the parse selected in the analysis stage and conflicts with other rules. We estimate that overall improvements in the parsing and transfer stages can solve these problems for 30 of the noun phrases considered. Thus the estimated potential success rate is 91% (293/323).

The proposed method, however, introduces a new source of errors, over-generation of possessive pronouns. Possessive pronouns are inappropriately generated for 83 noun phrases headed by trigger-nouns (11% of the total number). Two solutions are proposed. First, to improve the processing that determines the noun phrase referentiality and definiteness, this would block possessive pronouns from being generated by filling the determiner slot with a more appropriate determiner. Second, to introduce explicit semantic constraints (e.g.: only generate a possessive pronoun for trigger-nouns that denote clothing in the object position if the subject denotes a human), these would stop pronouns from being generated unnecessarily. We estimate that a

\(^9\)In 25% of the noun phrases in which the human translation had no possessive pronoun but ALT-J/E generated one the developers judge that generating a possessive pronoun gives an interpretation as appropriate as the human translation. For the purpose of this evaluation however they are treated as incorrect.

\(^10\)Note that the original method only actually handles 52% of the total noun phrases correctly, however for the purpose of evaluating the algorithm we are ignoring the 73 noun phrases where the errors in the analysis and transfer stages are so great as to make the output unevaluable.
Table 2: Results of the generation of noun phrases headed by trigger-nouns (Total 752 noun phrases).

| Result | Possessive pronoun | MT-93 | MT-94 | Example |
|--------|-------------------|-------|-------|---------|
| Good   | Not generated     | 429   | 346   | I hit him in the face |
|        | Generated         | 0     | 263   | I hid my face |
| Total  |                   | 429   | 609   |         |
| Bad    | Not generated     | 323   | 60    | * I scratched a face |
|        | Generated         | 0     | 83    | * I lost my face |
| Total  |                   | 323   | 143   |         |

Table 3: Overall evaluation of proposed method.

| Result | MT-93 | MT-94 |
|--------|-------|-------|
| Accuracy | 57%   | 81%   |
| Precision | —     | 88%   |

6 Conclusion

In order to examine when possessive pronouns should be generated when translating between Japanese and English, 6,200 Japanese sentences with English translations were examined. 657 examples of noun phrases containing possessive pronouns were found in the human translations. The existing algorithms used by the Japanese-to-English machine translation system ALT-J/E were sufficient for 46% of the noun phrases. A heuristic method for appropriately generating possessive pronouns for the remaining 54% was proposed. The method uses cue words we call trigger-nouns, along with contextual information about noun phrase referentiality and the subject and main verb of the sentence that the noun phrase appears in. The proposed method was implemented in ALT-J/E. It increased the number of noun phrases with appropriate possessive pronouns generated by 263 to 609, but at the cost of generating 83 noun phrases with inappropriate possessive pronouns. We intend to increase the number of appropriate possessive pronouns generated by resolving rule conflicts and to reduce the number of inappropriate possessive pronouns generated by adding more semantic constraints.

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