A Method of Ordering English Adverbs — as exemplified in Japanese-to-English Machine Translation —

Kentaro Ogura,† Francis Bond† and Satoru Ikeharat

This paper proposes a new method for ordering English adverbs. First, we propose a classification of adverbs for English adverb generation. Adverbs are classified into 41 classes by grammatical function (adjuncts, subjuncts, disjuncts and conjuncts), meaning (process, space, time etc.) and their default positions in sentences (initial, medial, end, pre, and post). Then a method to order English adverbs correctly is described, using the proposed adverb classification and principles of word ordering for adverbs (principles of ordering between adverbs and other sentence constituents and principles of ordering between adverbs). In particular we give detailed rules for deciding precedence when two adverbs have the same default position. Exceptions to the default adverb generating process are also described. Finally, the proposed method is examined in three experiments from the point of view of Japanese-to-English machine translation. The first experiment focuses on aspects of various types of adverbs and a comparison of the proposed method and the previous method. The second experiment focuses on aspects of quantitative coverage, and the third looks at aspects of practical use. The results show an accuracy of 97% or more in all experiments which highlights the efficiency of the proposed method. The third experiment, in particular, with an accuracy of 99%, confirms that the proposed method is effective in practical applications.

Key Words: adverbs, generation, ordering, machine translation

1 Introduction

Adverbs express a wide variety of meanings in sentences. An examination of adverb frequency in English newspaper sentences showed that adverbs appeared 585 times in 1,000 sentences, that is, there was an adverb in one of every two sentences on average. Thus the correct generation of English adverbs is important for accurate machine translation. However, in natural language processing, the study of adverbs has not developed very far to date, in comparison with verbs and nouns, because adverbs often do not construct the main parts of sentence meaning. In addition they have various complex grammatical functions in sentences, so they are very difficult to deal with in machine translation.

† NTT Communication Science Laboratories, NTT
‡ Faculty of Engineering, Tottori University
†† In this paper we treat idiomatic adverbial phrases, such as on purpose as adverbs.
Linguists have examined adverb grammatical functions and meanings in detail (Quirk, Greenbaum, Leech, and Svartvik 1985; Otsuka and Nakajima 1982; Rivero 1992). In particular, conjuncts and disjuncts, usually called sentence adverbs, are extensively treated in Greenbaum (1983). Our method is based on studies by these linguists about the grammatical functions and meanings of adverbs. However, adverb studies by linguists show only prototypical examples. To get a more comprehensive view, we compiled a Japanese and English bilingual corpus of sentences which contained 6,264 examples of different English adverbs (2,402 different English adverbs) and which also contained peripheral examples. The corpus was collected from English-to-Japanese, Japanese-to-English and English-to-English Dictionaries and grammar books. In the corpus, adverbs were classified according to our classification of English adverbs. Bilingual data clarified the different grammatical functions and meanings of the English adverbs. Referring to the adverb corpus, we classified English adverbs in a 15,000-entry Japanese-to-English adverb transfer dictionary, for machine translation.

There have been various studies of specific adverbs by linguists, such as even (Berckmans 1993), still and already (van der Auwera 1993) and temporal adverb studies which handle temporal semantics in sentences (Vlach 1993). There are also studies of adverb position in English in general (Ernst 1984) and positions of specific adverbs, such as however (Sugiura 1991). Studies of adverbs by linguists are written for fellow humans and it is difficult to transfer the results directly to natural language processing. The adverb corpus is, therefore, used to examine and determine the default position of adverbs and the most suitable order between adverbs with the same default position. It is also used to determine the principles of ordering between adverbs and other sentence constituents and the principles of ordering between adverbs.

In natural language processing, however, few studies (Conlon and Evans 1992; Glasbey 1993) have considered adverbs. Conlon and Evans (1992) aimed to decrease ambiguity in adverb meanings and to select words during generation by applying information about adverb semantics and syntax from linguistic studies to an adverb lexicon. They did not use grammatical function clearly and do not show the ordering between adverbs and other constituents in sentences.

In research into adverb processing in machine translation, Kamei, Okumara, and Muraki (1990) studied a syntactic analysis method for English-to-Japanese machine translation. The technique uses the positions of English adverbs and the relationship between an adverb modifier and its modificant. However the authors do not show the effectiveness of the method for

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2 Some adverbs are very difficult to classify. But we must classify them to treat them with a computer.
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English-to-Japanese machine translation quantitatively nor do they show the ordering between adverbs and other constituents in sentences.

There are four main problems of adverb processing in Japanese-to-English machine translation:

**Problems of analysis:**
the multiplicity of adverb meanings

**Problems of transfer:**
differences in expression between Japanese and English for adverbial meaning

**Problems of generation:**
word ordering of English adverbs in English generation

**Problems of knowledge representation:**
representation of adverbs in a computer (Ogura 1992; Shimazu, Naito, and Nomura 1983; Iida, Ogura, and Nomura 1983; Moor 1993)

In this paper, we focus our attention on the third problem: word ordering in English adverb generation. Among the four problem areas, word ordering is comparatively easy to treat in a superficial manner, but is much harder to study in detail.

In Section 2, we classify English adverbs into 41 classes by their grammatical functions, meanings and default positions in sentences. In Section 3, we propose an order for English adverbs based on their default positions and the principles which govern the order of English adverbs. We present a word ordering method, based on our proposed classification, order and principles. In Section 4, we consider three sets of English sentences generated in a test of the proposed word ordering method. The proposed method was tested in these three experiments by focusing on aspects of various types of adverbs, comparing the proposed method and a previous method, ascertaining the quantitative coverage, and confirming its practical use. The results show an accuracy of 97% or more in all experiments and show the efficiency of the proposed method. Finally, Section 5 summarizes the main values of the proposed method and suggests some directions for further work.

This method has been implemented in the Japanese-to-English machine translation system **ALT-J/E** (the Automatic Language Translator — Japanese to English) (Ikehara, Miyazaki, Shirai, and Yokoo 1989; Ikehara, Shirai, Yokoo, and Nakaiwa 1991; Ogura, Yokoo, Shirai, and Ikehara 1993).
2 Classification of English Adverbs

2.1 Basic Position

Adverbs (or Adverbials) can be put in different positions in a sentence. Figure 1 illustrates the various possible positions of the adverbial by then.

By then the book must have been placed on the shelf. \( I \)
The book by then must have been placed on the shelf. \( iM \)
The book must by then have been placed on the shelf. \( M \)
The book must have by then been placed on the shelf. \( mM \)
The book must have been by then placed on the shelf. \( eM \)
The book must have been placed by then on the shelf. \( iE \)
The book must have been placed on the shelf by then. \( E \)

Fig. 1 Positions of Adverbials [from (Quirk, et al., 1985:490)]

In our adverb position system for English adverb generation, 5 positions are provided. The first is initial position, the beginning of the sentence, as illustrated by “I” in Figure 1. The second is medial position, between the subject and predicate, or if auxiliary verbs are involved in the sentence just after the first auxiliary verb. It is illustrated by “M”, “iM”, “mM” and “eM”. Adverbs do not normally appear in positions “iM”, “mM” and “eM”, so they are not supported in our adverb position system. The third is end position, after a predicate. It is illustrated by “iE” or “E”. In our system, whether an adverb should be at “iE” or “E” is decided by its position order between adverbs (see Figure 11 in 3.2).

Pre position and post position are provided for adverbs used as modifiers. A pre position adverb comes before its modificant and a post position adverb comes after its modificant.

pre position: (1) He had only two dollars.
post position: (2) The Scots in particular are very proud of their separate nationality.

2.2 Classification

Adverbs usually have many grammatical functions and meanings, especially adverbs which are used frequently in our daily life. Normally differences in grammatical function and meaning are reflected by the position in the sentence.

Example sentences using again are shown in Figure 2. When it is a conjunct, it appears in the initial position, when it is an additive focusing subjunct, in the post position, and when it is a time adjunct, in the end position.

Other examples are shown in Figure 3. In the case of frankly, it can be used as an adjunct, subjunct or disjunct. When it is a manner adjunct it appears in the end position, and when it is a subjunct or a disjunct it appears in the initial position.
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- Conjunct (Initial position)
  (3) Again, the psychologist can observe the child at work and at play.

- Additive Focusing Subjunct (Post position)
  (4) The psychologist, again, can observe the child at work and at play.
  (= The psychologist also can observe ...)

- Time Adjunct (End position)
  (5) The psychologist can observe the child at work and at play again.
  (= The psychologist can observe ... once more.)

  Fig. 2 Example sentences with again [from (Greenbaum 1983:65)]

- Manner Adjunct (End position)
  (6) She told me frankly that she did not like him.
  (= She told me in a frank manner ...)

- General Subject-orientation Item Subjunct (Initial position)
  (7) Frankly, he explained his position to me.
  (= He was frank when ...)

- Style Disjunct (Initial position)
  (8) Frankly, I cannot afford to buy the car.
  (= Frankly speaking, ...)

  Fig. 3 Example sentences with frankly

Even if two adverbs have the same grammatical function and meaning, their default positions in a sentence may be different. For example, the indefinite time-frequency adjunct always normally takes the medial position, while the indefinite time-frequency adjunct at all times, which has the same meaning, is normally put in the end position.

(9) No man is always wise.
(10) No man is wise at all times.

To handle these linguistic phenomena, in this paper we classify adverbs by grammatical functions, meanings and default positions in sentences.

Adverbs can be roughly divided into adjuncts (Figure 4), subjuncts (Figure 5), disjuncts (Figure 6), conjuncts (Figure 7) and post position numeral modifiers (Figure 8), according to their grammatical functions.

Adjuncts modify predicates and are central elements in sentence structure, while subjuncts, disjuncts, conjuncts, and post position numeral modifiers, are peripheral elements. When considering order, adjuncts need to be treated along with other case elements, such as subjects and objects. We treat all adjuncts as case elements, following Shimazu et al. (1983). Subjuncts modify various levels of sentence elements, for example, clauses, predicates and case elements, and some subjuncts express modality. They express the degree of their modificant, and they play a subordinate role in comparison with other clause elements. Pre-and-End position subjuncts are placed Pre position when they modify an adjective, passive voice verb or adverb and in End position otherwise. a little in (11) and (12) is an example of a pre-and-end position...
Disjuncts and conjuncts are usually called sentence adverbs. Disjuncts modify sentences to show the speaker's emotional attitudes or comment. Conjuncts connect sentences or other
sentence elements and show the relationships of connected elements.

We also have the special class of post position numeral modifiers which are not subjuncts, adjuncts, disjuncts or conjuncts. They are used to modify noun phrases consisting of a numeral and a unit. They are located in the sentence after the noun phrase they modify, for example:

(13) The river is fifty yards across.

Across is a post position numeral modifier and it modifies the noun phrase “fifty yards”.

2.3 How to classify adverbs

A problem in classifying adverbs is that adverbs have various meanings and their division is not always clear. Grammar books examine proto-typical examples but often omit peripheral examples.

1983; Tada 1977; Konishi 1989). Any one dictionary does not have enough examples of adverbs and the examples may be unbalanced, therefore many dictionaries were examined. At present, 6,264 sentences using 2,402 different adverbs have been collected.

How adverbs are used in sentences can be examined by checking newspaper articles and manuals, but this requires a large volume of text to examine adverbs comprehensively, so we did not adopt this procedure.

We added adverb class information, determined from this classification, to adverbs in our dictionary (about 15,000 entries).\(^3\)

This adverb classification could be applied not only to adverbs but also to prepositional phrases with adverbial usage. Prepositional phrases express more diverse meanings than adverbs, so we expect that additional classes will be needed.

3 Determining Word Order for English Adverbs

The basic adverb position in the sentence, that is, initial, medial, end, pre or post position is given by the adverb classification in a dictionary, once its meaning has been determined. The precise position is determined by the relations between the adverb and other sentence elements. The scope of the adverb is one of the important factors influencing order, thus our method considers the scope of adverbs. Context information such as topic, or new/old information, or importance of information, can affect adverb positions, but this is beyond the range of this paper. Our method determines the default positions of adverbs.

First, we show the principles of ordering between adverbs and other sentence constituents and the principles of ordering between adverbs. In particular, we deal with cases in which two or more adverbs (or adverbial phrases) occur in the same basic position (initial, medial, end, pre or post position), and show how they should be ordered. Finally we show how to process exceptions. This method can be applied not only to adverbs but also to adverbials, so we show examples of both.

3.1 Principles of ordering between adverbs and other sentence constituents

The position of an adverb depends not only on the adverb's meaning but also on the relationship between the adverb and the other sentence elements.

\(^3\) In fact, in the implementation of ALT-J/E, this information was added to the Japanese-to-English adverb dictionary which shows correspondence between Japanese adverbial expressions and English adverbs. Each dictionary entry consists of the meaning expressed by a Japanese adverbial expression and the meaning expressed by the corresponding English adverb.
Order in sentence initial position

In the sentence initial position, the order between a conjunction, an interjection and an initial position adverb is a problem. We use the following principle:

Principle 1

*Conjunctions and interjections precede initial position adverbs.*

(Conjunctions precede interjections.)

(14) Children need many things, **but above all** they need love.4

Conjunction < Initial position adverb

(15) Would you like a cup of tea? **Yes, please!**

Interjection < Initial position adverb (Courtesy Subjunct)

(16) Can I use your telephone? **Sure, go ahead.**

Initial position adverb (Content Disjunct with degree of truth) < Interjection

(14) is an example which has an initial position adverb and a conjunction in a sentence. (15) is a standard example which has an initial position adverb and an interjection. (16) is an exception to Principle 1. Probably, it is because the interjection go ahead is an idiom which retains verb function. Idiomatic expressions tend to require exceptional treatments in generation.

Order in sentence medial position

In the sentence medial position, the order between adverbs, the predicate and auxiliary verbs is a problem.

Principle 2

*Medial position adverbs are placed just before the verb.*

*If the predicate is the verb “be”,*

then medial position adverbs are placed just after the verb.

*If there are one or more auxiliary verbs,*

then medial position adverbs are placed just after the first auxiliary verb.6

(17) She must **always get up** at six.

(18) He is **already** here.

(19) She **would never have** believed that story.

(20) He will **soon be** here.

(17), (18), (19) and (20) follow Principle 2.

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4 Adverbs and adverbials are shown in italics, other relevant constituents are shown in bold font.

5 "A < B" shows the order at a given position. "A" comes before "B" in the sentence.

6 The later condition is stronger than former condition.
Order in sentence end position

In the generation of adjuncts, the order of adjuncts and noun phrase case elements is important. Our method places complements (obligatory or semi-obligatory case elements licensed by the predicate) closer to the predicate than adjuncts (optional case elements), unless the complement is a clause or a phrase which is modified by a clause.

Principle 3

Optional case elements (adjuncts) come after obligatory or semi-obligatory case elements (complements).

Except: non-subject case elements with embedded clauses come after optional case elements.

(21) I go to school slowly.

In (21), to school is a "Direction adjunct" and slowly is a "Manner adjunct". Usually the order between "Direct adjunct" and "Manner adjunct" is:

Manner adjunct < Direction adjunct (from Figure 11, Section 3.2)

However, because to school is a semi-obligatory case element of go and slowly is an optional case element, to school is placed before slowly.

(22) He studied them carefully that night.
(23) He studied them that night with the kind of care his wife had suggested.

In (22), carefully is a "Manner adjunct" and that night is a "Time-position adjunct" and the order between a "Manner adjunct" and a "Time-position adjunct" is:

Manner adjunct < Time-position adjunct (from Figure 11, Section 3.2)

Therefore carefully comes before that night. But in (23), with the kind of care his wife had suggested is a "Process adjunct with embedded clause", so the exception is triggered and that night comes before with the kind of care his wife had suggested.

3.2 Principles of ordering between adverbs

When there are two or more adverbs in the same basic position, the order is based on the scope of the adverbs. We have prepared tables of default scopes for each of the basic positions, which gives the scope for most combinations of adverb classes (Figures 9, 10, 11, and 12). If adverbs can be ordered by these tables, then we do so (Principle 4). Otherwise, for the combinations of classes not given by default, we must determine the scope explicitly (Principles 5 and 6).

7 The Japanese-to-English machine translation system ALT-J/E has a pattern dictionary which shows relationships between predicates and their case elements. Obligatory cases or semi-obligatory cases and their positions are shown in the pattern dictionary entries.
Adverbs with the same basic position — default scope

Principle 4

If two or more adverbs occur in the same default position consult the default orders given in Figures 9, 10, 11, and 12 use the ordering given, if it exists.

Figures 9–13 show the default order for adverbs in initial position, medial position, end position, pre position and post position, for when two or more adverbs come in the same basic position. The order reflects the scope of the adverbs. For example, conjuncts usually have wider scope than disjuncts, so at the initial position conjuncts come before disjuncts.

Initial position

Conjuncts

Style Disjuncts,
Content Disjuncts with value judgment for non-subject,
Content Disjuncts with value judgment for subject,
Content Disjuncts with degree of truth

Viewpoint Subjuncts,
General Subject-orientation Item Subjuncts,
Courtesy Subjuncts

Additive Focusing Subjuncts

Fig. 9 Default Order of Initial Position Adverbs

Medial position

Additive Focusing Subjuncts

Indefinite Time-frequency Adjuncts

Time-position Adjuncts

Span Adjuncts,

Volitional Subject-orientation Item Subjuncts,

Courtesy Subjuncts

Fig. 10 Default Order of Medial Position Adverbs

These default orders were constructed after examining English corpora about adverbs (about 7,000 sentences) and handmade corpora in which English native speakers composed sentences which involve two or more adverbs in the same position. We also considered the scope of adverbs to determine the order.

For example, by then in Figure 1 is an end position time-position adjunct and on the shelf is a position adjunct, so according to the order at end position shown in Figure 11 “Position Adjunct” comes before “Time-position Adjunct”. The proposed ordering system generates the sentence as follows.

(24) The book must have been placed on the shelf by then.

Position Adjunct < Time-position Adjunct (Fig 11)
End position
Amplifiers, Downtoners
< Manner, Means, Instrument Adjuncts
< Direction Adjuncts
< Position Adjuncts
< Span Adjuncts
< Time-frequency Adjuncts,
< Time-position Adjuncts
< Volitional Subject-orientation Item Subjuncts
< Emphasizers
< Additive Focusing subjuncts
< Conjuncts

Fig. 11 Default Order of End Position Adverbs

Pre position
Restrictive Focusing Subjuncts
< Additive Focusing Subjuncts
< Emphasizers
< Downtoners
< Amplifiers

Fig. 12 Default Order of Pre Position Adverbs

Post position (no default order)
Focusing Subjuncts, Amplifiers, Numeral modifiers

Fig. 13 Default Order of Post Position Adverbs

(25), (26) and (27) are examples of the proposed ordering system, in medial position, initial position and pre position respectively. Note, there is no default order for post position adverbs.

Medial Position:
(25) He is still purposely against our plan.
Time-position Adjunct < Volitional Subject-orientation Item Subjunct (Fig 10)

Initial Position:
(26) There are two reasons why I think she cannot graduate from college.
First, probably she failed the examination.
Second, she has no time to study for the next examination.
Conjunct < Content Disjunct with degree of truth (Fig 9)

Pre Position:
(27) This room is just about big enough.
Restrictive Focusing Subjunct < Downtoner (Fig 12)
Adverbs with the same basic position — dynamic scope

Some adverb classes have no order between them, such as manner, means and instrument adjuncts in end position, or two adverbs of the same class. In such cases, this system orders the English sentence by the following two principles (Principle 5 and 6).

Principle 5
If two or more adverbs occur in the same default position and there is no default order, order according to the scope.

For example, in Japanese-to-English machine translation, when the order between adverbs is not given by Principle 4, the scope of the Japanese adverbials which correspond to the English adverbs may be available. If one Japanese adverbal expression is put nearer to the predicate than the other Japanese adverbal expression, the English translated adverb is also put nearer to the English translated predicate than the other translated adverb. This uses a heuristic that the scope of the source language will be preserved in the target language by translation. (28), (29) and (30) are examples in which adverbs are placed by Principle 5.

(28) Jpn: fuyu-niwa taiyō-wa hayaku shizumu
Gloss: in winter the sun [TOP] early sets
Eng: The sun sets early in winter.

(29) Jpn: kare-wa asa hayaku shuppatsu-shi-ta
Gloss: He [TOP] in the morning early started
Eng: He started early in the morning.

(30) Jpn: Kurushii omoi-wo shi ikan-to-wa omoi-nagara-mo sono kōfu-tachi-wa
chisei-wo omonji, jibun-tachi-no kumiai-ni hantai-shita
Gloss: Painfully resentfully the miners have stood by their loyalty,
stand by their loyalty their own conference went against
Eng: Painfully, resentfully, the miners have stood by their loyalty,
and gone against their own conference.

In (28) and (29) early, in winter and in the morning are all “End position Time-position adjuncts”. In Japanese (the source language), hayaku “early” is put nearer to the predicate than either fuyu-niwa “in winter” and asa “in the morning”. Therefore early has a narrower scope, and we put it nearer to the English translated predicates (“sets” and “started”) than in winter and in the morning respectively.8 In (30) painfully and resentfully are “General Subject-orientation Item sub juncts”, Kurushii omoi-wo shi “painfully” comes before Ikan-to-wa omoi-nagara-mo “resentfully”, thus in the translation painfully comes before resentfully.

A more specific rule is applied when there are two or more adverbials in the same basic position, they are both “Time-position adjunct” or “Position adjunct” and one includes the other.

8 In (29) a possible interpretation is that early modifies in the morning, thus early comes just before in the morning.
Principle 6

When there are two or more adverbials in the same basic position and they are both “Time-position adjunct” or “Position adjunct”, an included adverbial must be placed before an including adverbial.

The following sentences exemplify this, taken from Hornby (1977).

[End position Time-position adjuncts]
(31) I saw the film on Tuesday evening last week.
(32) I’ll meet you at three o’clock tomorrow.
(33) We arrived at five o’clock yesterday afternoon.

[Position adjuncts]
(34) He lives in a small village in Kent.
(35) We spent the holidays in a cottage in the mountains.

For example, in (31) on Tuesday evening is a narrower time span than last week, that is, on Tuesday evening is included last week, thus on Tuesday evening comes before last week. In (34) in a small village is a narrower space than in Kent, that is, a small village is in Kent, thus in a small village comes before in Kent.

Ordering between adverbs of different basic positions

It is possible that two adverbs with different basic positions (initial, medial, or end position and pre or post position), may be generated in the same position in a sentence. When the possible order is between an initial or end position adverb and a pre or post position adverb, each adverb modifies a different sentence element, so the order is determined by the modificants. But when the decision is between a medial position adverb and a pre position adverb, they both modify the predicate, and thus have the same modificant. In this case, we consider the strength of the connection between the adverb and the predicate. A pre position adverb is more tightly coupled to the predicate than a medial position adverb, so pre position adverbs will be placed nearer to the predicate than medial position adverbs. We express these rules in principle 7.

Principle 7

Adverbs are grouped with the constituent they modify. A medial position adverb comes before a pre position subjunct when both adverbs modify the same predicate.

In (36) probably modifies the sentence and even modifies “Bob”, the subject of the sentence. An initial position adverb must come before a sentence subject, and even is part of the subject, so probably comes before even. (37) is an example of order between a medial position adverb and a pre position adverb.
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(36) Probably *even* Bob will pass the examination.

**Content Disjunct with degree < Pre position Additive Focusing Subjunct**

(initial position adverb < pre position adverb)

(37) The price raise is *still too* small.

**Medial position Time-position Adjunct < Pre position Amplifier**

3.3 Exceptional adverb-position generating process

This analysis includes special handling for exceptions to the above principles. Figure 14 shows the exceptional adverb-position generating process that has been implemented in ALT-J/E.

In (38) *please* is placed in the initial position though *please* is a “Courtesy subjunct”, because the sentence is an imperative sentence. In (39) *please* is placed in the medial position. In (40) *please* modifies “do” with “not” which is to-infinitive, thus *please* is just put before “not to do”. Sometimes end position adjectives such as “Time-position adjunct” and “Manner adjunct” are not placed in the end position. In (41), a “Time-position adjunct” *newly* pre-modifies the past participle “discovered” which pre-modifies “land”. In (42) *that is* connects adverbial phrases and it shows “in 1955” is an apposition of “three years later”, thus *that is* is put between them.

Other exceptional processing is needed for interrogative adverbs and relative adverbs. Figure 15 shows the exceptional processing which is not directly adverb processing.

Interrogative adverbs (or interrogative elements) and relative adverbs must be put in the initial position of the sentences, such as in (43), (44) and (45).

4 Experimental Results

The proposed method was tested in three experiments focusing on aspects of various types of adverbs and a comparison of the proposed method and the previous method, quantitative

**Courtesy Subjunct (1)**

*kindly, please* and *graciously* are generated at initial position in an imperative sentence.

(38) *Please* come in.

(39) Will you *please* show me the way to the station?

**Courtesy Subjunct (2)**

In a to-infinitive phrase with *not*, a courtesy subjunct is put before “to”.

(40) I asked him *please* not to do that.

**End position Adjunct**

If an adjunct pre-modifies a present participle, a past participle, a gerund or an adjective which further pre-modifies something, the adjunct is put just before its modificant

(41) a *newly discovered* land.

**Conjunct**

If a conjunct connects phrases, it is put between the phrases.

(42) It happened *three years later, that is, in 1955*.

Fig. 14 Exceptional Processing for English Adverb Generation
Processing of interrogative

(43) Why didn’t you come to our party? ; interrogative adverb
(44) How well do you know him? ; a part of interrogative element

Processing of relative

(45) Monday is the day when I have the most work to do. ; relative adverb

coverage, and practical use. All experiments were made under conditions in which the right English adverbs were given, so we tested word order, not word selection.

4.1 Experiment 1

The first experiment had the Japanese-to-English machine translation system ALT-J/E translate Japanese sentences to test various English adverb functions (Ikehara, Shirai, and Ogura 1994). The goal was to confirm that this adverb ordering method could handle various types of English adverbs.

The experiment considered 200 arbitrary sentences which ALT-J/E was known to analyze correctly. This method was compared to a previous version of ALT-J/E which did not use adverbs’ grammatical functions and meanings but only the basic adverb positions. The experiment was performed with sentences out of context. The result is as follows.

<table>
<thead>
<tr>
<th>Method</th>
<th>Accuracy rate</th>
<th>Correctly ordered sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>This Method</td>
<td>98%</td>
<td>196/200</td>
</tr>
<tr>
<td>Previous Method</td>
<td>86%</td>
<td>172/200</td>
</tr>
</tbody>
</table>

Table 1 Results of Experiment 1

Improved Sentences: 27 sentences (13.5%)
Sentences changed for the worse: 3 sentences (1.5%)

An accuracy of 98% in ordering accuracy was achieved compared to 86% achieved by the previous method.9

The first improvement came from the fact that the proposed method took account of the grammatical functions of adverbs. The previous methods could not handle subjuncts adequately, but the proposed method can. The second improvement comes from correctly ordering the adverbs when two or more appear in the same position. Of the sentences that changed for the worse, two contain verbal idioms. The problem was in generating the idiomatic

9 We believe the previous method is comparable with the common treatment of adverb ordering in current machine translation systems.
expression.

<table>
<thead>
<tr>
<th>This Method</th>
<th>Human Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(46) * I have <em>completely</em> got wet.</td>
<td>(47) I have <em>got</em> <em>completely</em> wet.</td>
</tr>
<tr>
<td>(48) * This cloud looks <em>even</em> like an airplane.</td>
<td>(49) This cloud <em>even</em> looks like an airplane.</td>
</tr>
</tbody>
</table>

In (46), the pre position amplifier *completely* modifies “got wet”, thus the proposed method placed *completely* just before “got wet”. However, “get” is only a light verb, the main meaning of “get wet” is carried by “wet”, as a result *completely* must be put just before “wet”. In (48), the pre position additive focusing subjunct *even* modifies the prepositional phrase “like an airplane”, but “look” and “like” are strongly connected, thus *even* can not be placed just before “like an airplane”. These linguistic phenomena can be handled correctly by reinforcement of the generation of idiomatic expressions.

The remaining sentences were sentences whose Japanese originals were successfully analyzed at a shallow level but were not successfully analyzed at a deep level; as a result the focusing subjuncts modified the wrong modificants.

<table>
<thead>
<tr>
<th>This Method</th>
<th>Human Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(50) * I had <em>exactly</em> got up at 6:00.</td>
<td>(51) I had got up <em>exactly</em> at 6:00.</td>
</tr>
</tbody>
</table>

4.2 Experiment 2

The second experiment was performed to test the quantitative coverage of the proposed method. It was tested on 1,906 Japanese sentences with at least one Japanese adverb taken from the “Dictionary of Basic Japanese Usage for Foreigners” (Asano et al. 1990). The sentences were translated by a human translator. We manually examined whether the English adverbs in the translation (1,035 English adverbs) would be generated correctly using the proposed method. The experiment was also performed with sentences out of context. Results of experiment 2 are shown in Figure 16.

In this experiment 97% accuracy in the adverb order was achieved and it was confirmed that the proposed word ordering method can handle a large amount of adverbs correctly.

However, there are some adverbs which might be incorrectly placed. The adverbs generated in incorrect positions are adverbs which have many possible positions for one meaning and it is difficult to determine a default position for them. For example, *soon* which we classified as a medial position time-position adverb also appears at the end position in example sentences.

10 The case that a Japanese adverb is translated into an English adverb is relatively simple for Japanese-to-English machine translation. Thus the result of the second experiment shows the immediate effect of implementing our method.
Examined Objects
Japanese adverb entries: 362 words
sentences: 1,906 sentences
(sentences with two adverbs: 7 sentences)
examined Japanese adverbs: 1,913
English adverbs (or adverbials) translated from Japanese adverbs: 1,053
Accuracy rate 97.3%
Adverbs generated in incorrect positions: 28 (2.7%)
absolutely incorrect position: 12 (1.1%)
strange position\(^ {11} \): 16 (1.5%)
Adverbs generated in suboptimal but acceptable position: 7 (0.7%)

Soon must be placed at the end position, when the sentence is a imperative sentence.

(52) *I have something for you to do, so please soon come.
(53) I have something for you to do, so please come soon.

Other cases are when the position of the adverb gives rise to ambiguity. For example we classified especially as a pre position restrictive focusing subjunct. Therefore when especially modifies “many shrines and temples”, the proposed method placed it before “many shrines and temples”. This could be interpreted as especially modifies “many”. It would be better in the medial position in this example.

(54) * There are many things I want to see while I’m in Japan, I want to see especially many shrines and temples.
(55) There are many things I want to see while I’m in Japan, I especially want to see many shrines and temples.

We need to investigate under what conditions adverbs should not be generated in the default position. Exceptional processing also needs to be refined, especially for special adverbs.

4.3 Experiment 3

The third experiment was performed to test the applicability of the proposed method for practical use. The proposed method is applied to 525 English adverbs whilst translating 1,000 Japanese sentences from newspaper articles into English. The results showed 99% accuracy in the ordering of the adverbs. Detailed results of experiment 3 are shown in Figure 17. The accuracy of experiment 3 is higher than the accuracies of experiment 1 and 2, thus this confirms that the proposed method is effective in practical applications.

In Figure 18, we show the adverbs which were not evaluated in experiment 3. They are generated by using other processing instead of the processing described in Section 3. Figure 19 shows the sentence in which the proposed method placed adverbs in the wrong position. Figure 20 shows the examples which are acceptable but not in the best position.

\(^ {11} \) This position gives a possible, but unlikely interpretation
Examined Objects from newspaper articles on industry and economics
examined sentences: 1,000
adverbs in English sentences: 646
evaluated adverbs: 525
non-evaluated adverbs: 121
Accuracy rate (acceptable position) 99.4% (522/525)
Accuracy rate (best position) 98.5% (517/525)

Fig. 17 Results of Experiment 3

non-evaluated adverbs
idiom: 70
verb+adverb type verbal idioms: pull apart
other type idiom: not only ... but (also), neither ... or
appositive structure: 48
such as
comparative structure: 2
(as brisk) as usual, (as) much (as possible)
noun phrase modifier: 2
(by the end of June) next year,
(two days) off

Fig. 18 Non-evaluated adverbs in Experiment 3

This Method As well as making itself known better, the company will increase its capital supply and actively open business hotels and restaurant chains.
Human Translation As well as making itself better known, the company will increase its capital supply and actively open business hotels and restaurant chains.
(better: Amplifier, End position)

This Method Tokyo Nissan Motors, a major dealer of Nissan automobiles, will establish a monitoring system, outside company channels actively, to raise the quality of customer service in its stores.
Human Translation Tokyo Nissan Motors, a major dealer of Nissan automobiles, will actively establish a monitoring system, outside company channels, to raise the quality of customer service in its stores.
(actively: Manner Adjunct, End position)

This Method Fujitsu Laboratory has developed the measuring device to measure the delay time between input signal entering and the output signal coming precisely.
Human Translation Fujitsu Laboratory has developed the measuring device to measure precisely the delay time between input signal entering and the output signal coming.
(precisely: Restrictive Focusing Subjunct, Post position)

Fig. 19 Failures in Experiment 3

5 Conclusion
A new classification (41 classes) of adverbs based on the grammatical functions and meanings of adverbs and their basic positions is proposed for the generation of English adverbs. After examining the actual use and position of adverbs in English, principles are proposed which then enable a default order of adverbs to be compiled. The proposed method has been tested both by using the ALT-J/E machine translation system and also by manually reordering human translations according to the proposed order, and evaluating the results.
This Method  Olympus will use this opportunity to pursue earnestly the development of information machinery it started at the end of last year.

Human Translation  Olympus will use this opportunity to earnestly pursue the development of information machinery it started at the end of last year.

(earnestly: Manner Adjunct, End position)

This Method  The company has been receiving many orders from finance companies, but will now start selling actively to the increasingly international manufacturing industry.

Human Translation  The company has been receiving many orders from finance companies, but will now start actively selling to the increasingly international manufacturing industry.

(actively: Manner Adjunct, End position)

Fig. 20  Examples of acceptable position in Experiment 3

The effectiveness of our English adverb ordering method is shown, in Japanese-to-English machine translation, based on the classification of adverbs and the default ordering principles for adverbs. When correct English adverbs are selected after Japanese analysis and Japanese-to-English transfer, about 97% or more of adverbs can be put in the correct position by this method. The accuracy rate of the proposed method improved by 12% compared with the previous adverb ordering method. In the experiment to confirm the practical use of the proposed method, it achieved an accuracy of 99%, which confirms its efficiency with real problems.

The proposed method is not restricted to Machine Translation, but can be used for English generation in general, both for adverbs and adverbial prepositional phrases. To achieve a more precise order of adverbs, the generation of idioms must be improved and the generation of special adverbs like “however”, “already” and “still” must be refined. We must also refine adverb classification, for example, developing more detailed classes of conjuncts. To apply this method to context sensitive text where marked order may be important, we will also need to consider old/new information, topic and importance of the information.

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Reference

Ogura, K. et al. A Method of Ordering English Adverbs

Affairs of Japan.


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**Kentaro Ogura:** Kentaro Ogura received a B.E. and an M.E. in administrative engineering from Keio University, in 1978 and 1980 respectively. In 1980, he joined the NTT Musashino Electrical Communication Laboratories. From 1986 to 1990, he worked at ATR Interpreting Telephony Research Laboratories. He is now a senior research scientist at the NTT Communication Science Laboratories. He has been engaged in machine translation research since 1980. He was awarded the Dissertation Prize in 1995 from the JSAI. He is a member of the IPSJ, the IEICE and the JSAI.

**Francis Bond:** Francis Bond received a B.A. in Japanese and mathematics from the University of Queensland in 1988 followed by a B.Eng in electrical systems engineering in 1990. He joined NTT in 1991 and is currently researching machine translation in the NTT Communication Science Laboratories. He is a member of the IEEE, the ANLP and the Australian Linguistic Society. His current research interests include lexical structure, machine translation, and corpus linguistics.

**Satoru Ikehara:** Satoru Ikehara received a B.E., an M.E. and a Dr. Eng. from Osaka University in 1967, 1969 and 1983. From 1969 to 1996, he was a researcher at the NTT Electrical Communication Laboratories where he developed a formal algebraic manipulation language, traffic theories and several natural language processing systems. From 1996, he is a professor of Information and Knowledge Engineering at Tottori University and also a visiting professor of Stanford University. He was awarded the Dissertation Prizes in 1982 and 1993 from the IPSJ, in 1995 from JSAI and got the Achievement Award in 1995 from the Information Center for Science and Technology. He is a member of the IPSJ, the IEICE, the JSAI and the AAMT.

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