

# WRITING SUPPORT SYSTEM BASED ON A CONTEXT SENSITIVE VARIANT DICTIONARY

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**Abstract:** In Japanese, it is difficult to learn which variant is suitable for various contexts in official, business, and technical documents because there are a large number of notational variants of Japanese words and Japanese writing rules have many exceptions. From the viewpoint of information retrieval, a considerable number of studies have been made on notational variants, however, previous Japanese writing support systems were not concerned with them sufficiently. To solve this problem, we developed a writing support system which detects notational variants unsuitable for the contexts in students' reports and shows suitable ones to the students. This system is based on the idea that context suitable variants are used dominantly in the context of official, business, and technical documents. In this study, we first show the diversity of notational variants of Japanese words and how to develop a context sensitive variant dictionary by which our system determines which variant is suitable for the contexts in official, business, and technical documents. Finally, we conducted a control experiment and show the effectiveness of our system.

## 1 INTRODUCTION

In English, there are few words which are spelled in several different ways, such as, color and colour. In contrast, in Japanese, there are a large number of notational variants of words. This is because Japanese words are written in three kinds of characters:

- kanji (Chinese) characters,
- hiragana letters, and
- katakana letters.

For example, *kagi* [key] is written in three ways, as shown in Figure 1. Basic rules of Japanese writing are announced by the Cabinet, and Japanese students study them in school for many years. However, it is difficult to learn the rules because they have many exceptions. In fact, we often find the confusion of variant selection in Japanese university students' reports, including unsuitable notational variants for official, business, and technical documents. As a result, it is important for students to learn which notational variant is suitable for official, business, and technical documents. To solve this problem, (Nishikawa

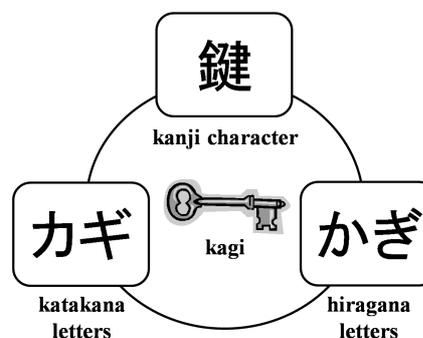


Figure 1: Notational variants of “*kagi* [key]”.

09a) developed a writing support system which detects unsuitable notational variants in students' reports and shows suitable ones to the students. This system is based on the assumption that suitable variants are used dominantly in official, business, and technical documents. If the assumption is proper, unsuitable notational variants can be detected by confirming whether they are used dominantly in official, business, and technical documents. We think the sys-

	hiragana	katakana	kanji
<i>kagi</i>	かぎ	カギ	鍵
[key]	1	279	198

Figure 2: The frequencies of notational variants of noun “*kagi* [key]” in the newspaper articles [Mainichi Newspaper (January 2006 – June 2006)].

	hiragana	katakana	kanji
<i>kagi</i>	かぎ	カギ	鍵
[key]	0	10	64

Figure 3: The frequencies of notational variants of noun “*kagi* [key]” in the newspaper articles [Mainichi Newspaper (2005 – 2007)] in the case that the word is used with “*kakeru* [lock]”.

tem of (Nishikawa 09a) is promising, however, it has a problem: The system was based on a context free variant dictionary. As a result, it is possible that the system lets users select variants which are most frequent but unsuitable for the contexts. Take *kagi* [key] for example. As shown in Figure 2, in newspaper articles, *kagi* is dominantly written in katakana letters. However, as shown in Figure 3, *kagi* is dominantly written in a kanji character when it is used with *kakeru* [lock]. As a result, it is important that writing support systems show variant information of Figure 3, not Figure 2, when *kagi* [key] and *kakeru* [lock] are used together. To solve this problem, we developed a writing support system based on a context sensitive variant dictionary.

Our system shows the frequencies of notational variants to students because they are objective and concrete measures. As a result, the system gives students chances to consider the reasons why they used variants unsuitable for the contexts. There are two reasons why our system does not replace unsuitable variants to context suitable ones automatically.

- it is not appropriate to restrict the use of various variants because it is one of the sources of the richness of Japanese expressions.
- it is important to consider the reasons why they used variants unsuitable for the contexts and choose context suitable ones, especially, in educational institutions.

From the viewpoint of information retrieval, a considerable number of studies have been made on notational variants (Kubomura 03) (Kouda 06) (Bamba 08), however, spell checkers in Japanese word processor, such as Microsoft word 2007, and previous Japanese writing support systems were not concerned with notational variants sufficiently (Shimomura 92) (Araki 93) (Murata 01). This is because their main purposes were misspelling detection. Students often use variants which are not misspelling,

names of plants	hiragana	katakana	kanji
<i>sakura</i>	さくら	サクラ	桜
[cherry blossom]	184	39	736
<i>bara</i>	ばら	バラ	薔薇
[rose]	0	217	0
<i>himawari</i>	ひまわり	ヒマワリ	向日葵
[sun flower]	42	8	0
<i>tsubaki</i>	つばき	ツバキ	椿
[camellia]	9	25	83
<i>tsutsuji</i>	つつじ	ツツジ	躑躅
[azalea]	5	15	0
<i>ringo</i>	りんご	リンゴ	林檎
[apple]	8	71	10
<i>mikan</i>	みかん	ミカン	蜜柑
[orange]	66	37	2

Figure 4: The frequencies of notational variants of nouns (plant names) in the newspaper articles [Mainichi Newspaper (January 2006 – June 2006)].

however, unsuitable for the contexts in official, business, or technical documents. In contrast, Yokoyama dealt with variants of kanji characters (Yokoyama 06), but not with variants of words. Furthermore, he did not consider this variant problem from the viewpoint of contexts.

In this study, we first show the diversity of notational variants of Japanese words and how to develop a context sensitive variant dictionary by which our system determines which variant is suitable for the context in official, business, and technical documents. Finally, we conducted a control experiment and show the effectiveness of our system.

## 2 NOTATIONAL VARIANTS OF JAPANESE WORDS

In this section, we show the diversity and exceptions of notational variants of Japanese words.

First, we show the diversity and exceptions of notational variants of Japanese nouns. We have shown an example of notational variants of Japanese nouns, *kagi* [key], in section 1. Furthermore, Figure 4 shows the frequencies of notational variants of plant names in the Mainichi newspaper articles (January 2006 – June 2006). As shown in Figure 4, dominant ways of writing plant names are inconsistent. In this study, we will use the term *dominant variant* of a word to refer to the most frequent variant of the word, as (Nishikawa 09a) did. One of the reasons of this inconsistent is that writers choose variants considering the contexts.

Next, we show the diversity and exceptions of notational variants of Japanese declinable words. Figure 5 shows the frequencies of notational variants of *hiki*-

	hiragana	kanji+(1)	kanji+(2)	kanji+(3)
<i>hikiageru</i>	ひきあげる	引きあげる	引き上げる	引き揚げる
[pull up]	1	4	774	146

Figure 5: The frequencies of notational variants of verb “*hikiageru* [pull up]” in the newspaper articles [Mainichi Newspaper (January 2006 – June 2006)].

	hiragana	kanji+(1)	kanji+(2)	kanji+(3)
<i>hikiageru</i>	ひきあげる	引きあげる	引き上げる	引き揚げる
[pull up]	0	0	2	15

Figure 6: The frequencies of notational variants of verb “*hikiageru* [pull up]” in the newspaper articles [Mainichi Newspaper (2005 – 2007)] in the case that the word is used with “*toushi* [investment]”.

*ageru* [pull up] in the Mainichi newspaper articles. As shown in Figure 5, *引き上げる* is the dominant variant of *hikiageru* [pull up]. However, as shown in Figure 6, a nondominant variant of *hikiageru*, *引き揚げる*, is used dominantly when *hikiageru* is used with *toushi* [investment]. This kind of exceptions often confuse learners of Japanese, not only foreign students but Japanese students. In fact, the authors are often confronted with the confusion of variant selection in their reports.

### 3 WRITING SUPPORT SYSTEM BASED ON A CONTEXT SENSITIVE VARIANT DICTIONARY

#### 3.1 System Overview

Figure 7 shows the overview of our system based on a context sensitive variant dictionary. Figure 8 shows an example of how to use our writing support system. As shown in Figure 7, users can access and send input sentences to the system via web browsers by using CGI based HTML forms. Input sentences are segmented into words by using a Japanese morphological analyzer, JUMAN (JUMAN 05). Then, the dependency relations between the words were analyzed by using a Japanese parser, KNP(KNP 05). Finally, by using the context sensitive variant dictionary, the system confirms whether variants are suitable for the contexts in official, business, and technical documents. When the system detects a variant unsuitable for the context in an input sentence, the system underlines and turns it red, shows the frequency information of the variant in the context, and gives users chances to consider the reasons why they used the

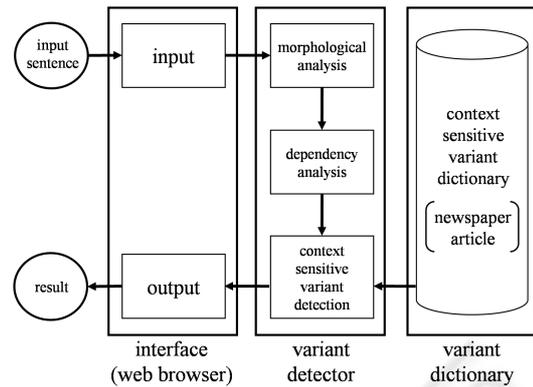


Figure 7: System overview.

variant. In Figure 8 (a), a user gives the following two input sentences to the system.

- *kakugi de zeikin wo hikiageru koto ga kettei sareta* [the plan to raise taxes was approved by the Cabinet]
- *New York no sijyo kara toushi wo hikiageru koto ni shita* [we decided to withdraw our investments from the New York market]

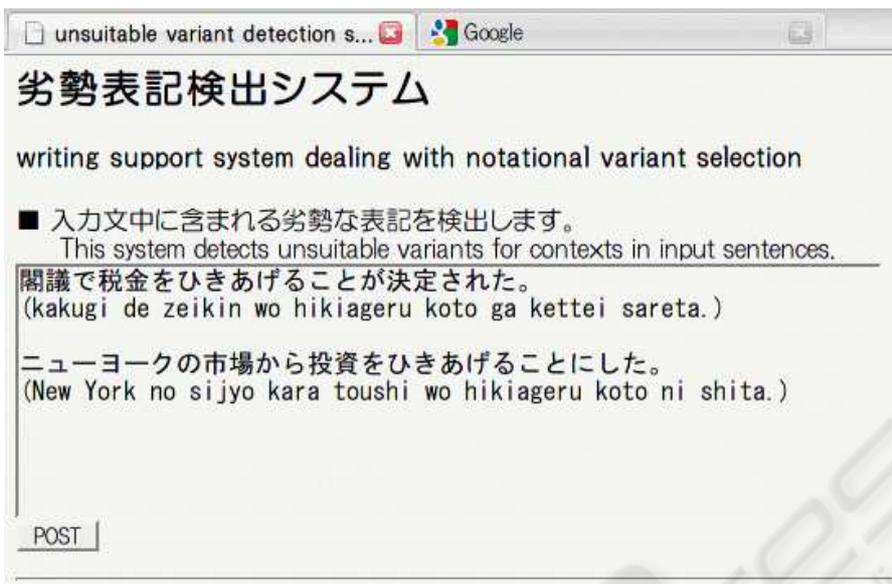
Then, as shown in Figure 8 (b), the system detects that variants of *hikiageru* in both input sentences are unsuitable for the contexts. In each sentence, the variant of *hikiageru* is underlined and turns red, and the context sensitive frequency information of the variant is shown. In this way, the key to detecting variants unsuitable for the contexts is a context sensitive variant dictionary. In section 3.2, we show how to develop a context sensitive variant dictionary.

#### 3.2 Context Sensitive Variant Dictionary

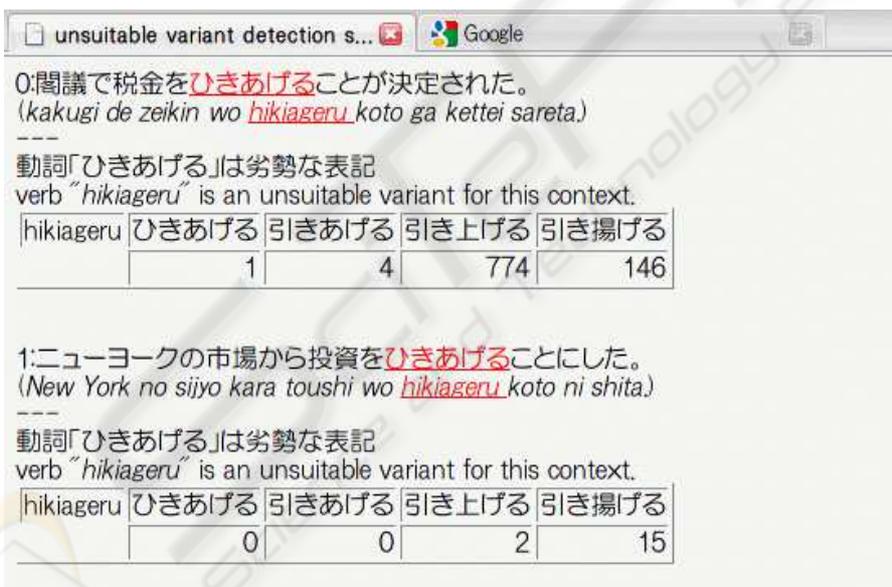
In order to develop a context sensitive variant dictionary, we expand a context free variant dictionary by adding information of context suitable variants and the contexts. The context free variant dictionary (Nishikawa 09b), which we used and expanded in this study, contains dominant variants of 20929 words which were extracted from 296364 articles published in the Mainichi Newspaper from January 2006 to June 2006 (Mainichi 06-08) credibly by using binomial tests. These words can be classified into two types:

**TYPE I** a word of this type has actually two or more variants, however, only one of them was found in the newspaper articles. 14659 TYPE I words were extracted from the Mainichi Newspaper (January 2006 – June 2006).

**TYPE II** a word of this type has two or more variants found in the newspaper articles. 6270 TYPE



(a) two input sentences, both of which include “*hikiageru* [pull up]”, are given to the system.



(b) the system detects unsuitable variants of “*hikiageru* [pull up]” for the contexts in the input sentences and shows the context sensitive frequency information of the variants.

Figure 8: An example of how to use our writing support system. English system messages are inserted ad hoc for convenience of non-Japanese readers of this paper.

II words were extracted from the Mainichi Newspaper (January 2006 – June 2006). Words which have context suitable variants are classified into TYPE II words.

In order to show how much the dominant variant of a word is used dominantly, (Nishikawa 09b) introduced *dominant degree*. Suppose that a word has variant *i*

( $\in I$ ) and the utilization rate of variant *i* is calculated as follows:

$$u_i = \frac{f_i}{\sum_{i \in I} f_i}$$

where  $u_i$  and  $f_i$  is the utilization rate and frequency of variant *i*, respectively. The dominant degree of the

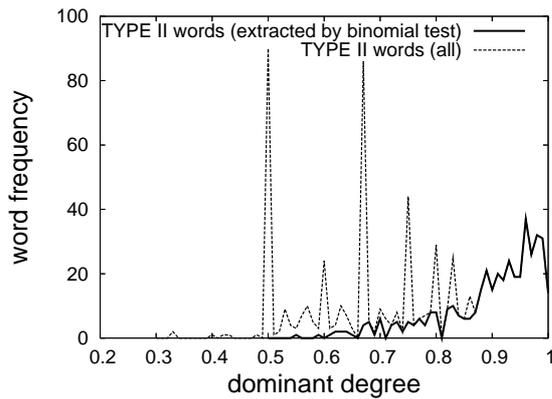


Figure 9: The histograms of the dominant degrees of TYPE II words in the newspaper articles [Mainichi Newspaper (January 2006 – June 2006)].

word is calculated as follows:

$$d = \max_{i \in I} u_i$$

where  $d$  is the dominant degree of the word. Figure 9 shows the histograms of the dominant degrees of TYPE II words extracted from the Mainichi Newspaper (January 2006 – June 2006). The broken line in Figure 9 shows the histogram of the dominant degrees of all the TYPE II words extracted from the Mainichi Newspaper (January 2006 – June 2006). On the other hand, the thick line shows the histogram of the dominant degrees of TYPE II words the variants of which were extracted credibly by using binomial tests from the Mainichi Newspaper (January 2006 – June 2006). We expanded this variant dictionary by adding the following kinds of information

- context suitable variants and
- the contexts where the variants are used dominantly.

The information was extracted in the next way.

Suppose that word  $A$  has a variant which is a non-dominant variant of word  $A$  but is used dominantly in the context that word  $A$  is used with  $B$ . We extracted

- the context suitable variant of word  $A$  and
- the context that word  $A$  is used with word  $B$

in the next steps.

**Step 1** apply Japanese morphological analysis and dependency analysis to newspaper articles. In this study, we used a Japanese morphological analyzer, JUMAN (JUMAN 05) and a Japanese parser, KNP(KNP 05).

**Step 2** From the results of the analyses, extract variants of word  $A$  which have the dependency relation to word  $B$ . In the morphological analysis, JUMAN gives variant labels to variants. Variants of

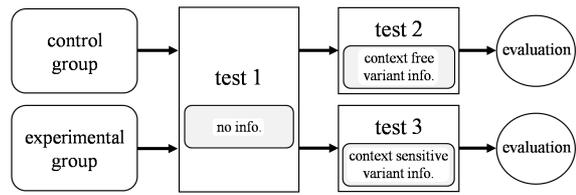


Figure 10: The outline of the experiment.

a certain word can be detected because JUMAN gives the same variant label to them.

**Step 3** determine which variant of word  $A$  is used dominantly in the context that word  $A$  is used with word  $B$ . If the variant is not the dominant variant of word  $A$ , go step 4. Otherwise, terminate the process. The dominant variant of word  $A$  is registered in the variant dictionary (Nishikawa 09b).

**Step 4** In order to confirm that the variant is a credible context suitable variant, measure the credibility of the context suitable variant by using binomial tests: the variant is regarded as a credible context suitable variant, when the lower limits of one-sided 95% binomial confidence interval of the utilization rates of the variant in the context is more than 0.5.

In this study, we extracted 3598 context suitable variant and the contexts from 1786752 articles published in the Mainichi Newspaper from 2005 to 2007 (Mainichi 06-08).

## 4 EXPERIMENTAL RESULTS

To evaluate our method, we conducted a control experiment. Figure 10 shows the outline of the experiment. 20 subjects, university students in computer science, were classified into two groups: control group and experimental group. As shown in Figure 10, we conducted test 1 and 2 to the control group, and test 1 and 3 to the experimental group. In these three tests, we gave the same five problems of variant selection with the following kinds of information:

**test 1** no information

**test 2** context free variant information

**test 3** context sensitive variant information

Each problem consisted of two sentences, one word of which was underlined, and variant choices of the word. From the variant choices of the underlined word, the subjects were requested to choose one variant which seemed to be suitable for the contexts in official, business, and technical documents. One sentence in each problem had a context for which the

Table 1: The choosing rate of variants suitable for the contexts.

group	test 1	test 2 / 3
control	68%	77%
experimental	73%	81%

dominant variant was suitable. The other had a context for which the dominant variant was not suitable. For example, the following two sentences were used in a problem of the experiment.

**Problem 1(a)** *kakugi de zeikin wo hikiageru koto ga kettei sareta* [the plan to raise taxes was approved by the Cabinet]

**Problem 1(b)** *New York no sijyo kara toushi wo hikiageru koto ni shita* [we decided to withdraw our investments from the New York market]

The dominant variant of *hikiageru* [pull up] is suitable for the context of problem 1(a), on the other hand, unsuitable for the context of problem 1(b) because *hikiageru* was used with *toushi* [investment]. When subjects in the control group tried to solve problem 1(a) and 1(b) in test 2, they received the frequency information which is shown in Figure 5 and unsuitable for the context of problem 1(b). On the other hand, subjects in the experimental group received context sensitive frequency information which

- is shown in Figure 5 when they tried to solve problem 1(a) in test 3
- is shown in Figure 6 when they tried to solve problem 1(b) in test 3

In other words, subjects in the experimental group received the same context sensitive frequency information which our system gives to users. Figure 8 (b) shows the advices of our system when problem 1(a) and 1(b) are given to the system.

Table 1 shows the choosing rate of variants suitable for the contexts in test 1, 2, and 3. Table 1 shows that the notational variant selection is a serious problem. In test 1, some subjects chose unsuitable variants for no particular reason and they were totally unaware of doing it. However, Table 1 also implies that students do not have confidence in their notational variant selection and flexibly change their decisions when the reasons are given to them. Actually, in test 3, five subjects in the experimental group changed their decisions, and two other subjects did not change but felt sure of their decisions. Some of them said that they could obey system's advices more simply than teacher's instructions without concrete evidences. On the other hand, in test 2, five subjects in the control group changed their decisions, and two of them selected variants unsuitable for the contexts because of the context free variant information.

## 5 CONCLUSIONS

In this paper, we first proposed a method of developing a context sensitive variant dictionary by which our writing support system determines which variant is suitable for the contexts in official, business, and technical documents. Then, we conducted a control experiment and show the effectiveness of our system.

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