Doctoral Dissertation

Computer-assisted Japanese Functional Expression Learning for Chinese-speaking Learners

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June 18, 2019

Graduate School of Information Science
Nara Institute of Science and Technology

A Doctoral Dissertation
submitted to Graduate School of Information Science,
Nara Institute of Science and Technology
in partial fulfillment of the requirements for the degree of
Doctor of ENGINEERING

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Computer-assisted Japanese Functional Expression Learning for Chinese-speaking Learners*

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Abstract

In Japanese language learning, learners must study a large number of vocabulary words as well as various functional expressions. Because a large number of Chinese characters are commonly used both in Japanese and Chinese, Chinese-speaking learners of Japanese as a second language (JSL) find learning Japanese functional expressions more challenging than learning other Japanese vocabulary.

The goal of this thesis is to develop ***Jastudy***, a computer-assisted language learning (CALL) system designed specifically for Chinese-speaking JSL learners studying Japanese functional expressions. Given a Japanese sentence as an input, the system automatically detects Japanese functional expressions using a character-based bidirectional long short-term memory with a conditional random field (BiLSTM-CRF) model. Then the whole sentence is segmented and part-of-speech (POS) tagged (word segmentation and POS tagging) by a Japanese morphological analyzer, ***Mecab*** (a CRF model). In the meanwhile, difficult Japanese functional expressions are simplified with easier Japanese functional expressions or phrases, using a "Simple Japanese Functional Expression Replacement List". In addition, the system provides learners with appropriate example sentences of Japanese functional expressions based on their individual Japanese language proficiency

* Doctoral Dissertation, Graduate School of Information Science, Nara Institute of Science and Technology, June 18, 2019.

levels. A support vector machine for ranking (***SVMrank***) algorithm evaluates the sentence readability, using Japanese-Chinese common words as an important feature. Furthermore, a k-means clustering algorithm is applied to cluster the example sentences that contain functional expressions with the same meaning, based on part-of-speech, conjugation form and semantic attribute.

Correcting spelling and grammatical errors of Japanese function expressions shows practical usefulness for JSL learners. However, the collection of these types of error data is fairly difficult. To address this problem, the BiLSTM-CRF model is used to detect Japanese functional expressions and extract phrases which include Japanese functional expressions as well as their neighboring words from native Japanese and learners' corpora. Then a large scale of artificial error data is generated via substitution, injection or deletion. The generated artificial error data is utilized to train a character-based sequence-to-sequence (seq2seq) neural machine translation model for error correction on Japanese functional expressions.

Finally, to evaluate the effectiveness of our proposed methods and our system, we have conducted some experiments and reported on a preliminary user study involving Chinese-speaking JSL learners.

Keywords:

Japanese functional expression, Text simplification, Text readability evaluation, Automatic error correction, Computer-assisted language learning

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Chapter 1

1. Introduction

This chapter sets the general view of the dissertation. The background and the motivation for developing a computer-assisted language learning (CALL) system for Chinese-speaking learners of Japanese as a second language (JSL) studying Japanese functional expressions are described in Section 1.1 and Section 1.2. The contributions of this dissertation are summarized in Section 1.3 and the outline of the whole dissertation is given in Section 1.4.

1.1 Background

The number of Japanese language learners around the world has increased in the past several decades. According to a "Survey on Japanese-Language Education Abroad" conducted by the Japan Foundation in 2015, the number of Japanese language learners overseas has increased from approximately 580,000 in 1984 to approximately 3,650,000 in 2015 (Figure 1, [30], p.8) and the country that has the

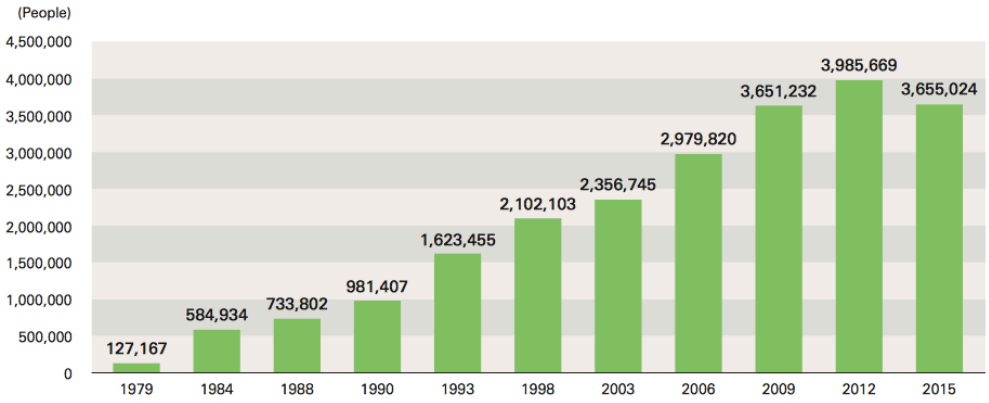

Figure 1: The changes in number of JSL learners

greatest number of JSL learners in the world is China, with 953,283 people (Figure 2, [30], p.12).

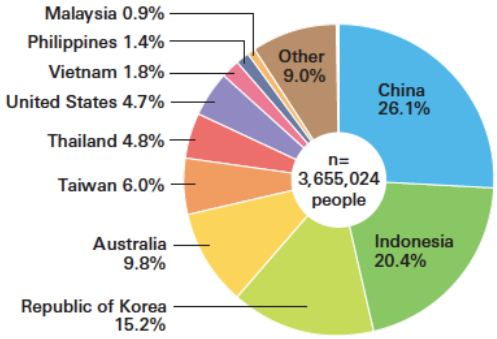

Figure 2: Percentage of JSL learners in each country and region

In 1984, the joint organization of the Japan Foundation and Japan Educational Exchanges and Services firstly conducted the Japanese-Language Proficiency Test (JLPT) as a reliable means of evaluating the Japanese proficiency of non-native speakers, with approximately 7,000 examinees in 15 countries worldwide. In 2010, the Japan Foundation and Japan Educational Exchanges introduced a revised version of a new JLPT. The new JLPT is offered in five different levels, ranging from N1 (the most difficult level) to N5 (the easiest level) [1]. N4 and N5 measure the beginning level of understanding of basic Japanese. N1 and N2 measure the advanced and intermediate level of understanding of Japanese applied in a broad range of scenes in actual everyday life. N3 is a bridging level between N1/N2 and N4/N5. The JLPT not only evaluate learners' Japanese knowledge, such as vocabulary and grammar, but also the ability to apply the knowledge in real life, such as reading and listening.

The acquisition of vocabulary and grammar is often viewed as an essential part in second language learning. In Japanese language learning, learners are required to study a large number of vocabulary words as well as various functional expressions in Japanese grammar. Chinese-speaking JSL learners find it is easier to

[1] https://www.jlpt.jp/e/about/levelsummary.html

understand Japanese vocabulary, because a large number of Chinese characters are common to both Japanese and Chinese. However, because Japanese functional expressions are different from Chinese language, the Chinese-speaking JSL learners find them completely new. It is occasionally more difficult and challenging for Chinese-speaking learners to learn Japanese functional expressions ([18]).

Many languages have functional expressions, which consist of more than one word and behave as single functional words. For example, in English, a typical example is “even though”, which behaves like a single conjunction. Various types of functional expressions also exist in the Japanese language, which can be classified into three types according to their functionality: postpositions, auxiliary verbs, and conjunctions, as shown in Table 1. These functional expressions form important grammatical information in Japanese sentences because they determine sentence structure and meaning ([51]). Therefore, the acquisition of Japanese functional expressions is always viewed as an important part in Japanese language learning.

Types	Japanese functional expressions
postpositions	を踏まえて (based on) について(about)
auxiliary verbs	なければならない(should) てはいけない (must not)
conjunctions	といっても (although one might say) とすると (supposing)

Table 1: Types of Japanese functional expressions

1.2 Motivation

There are two main basic contents in Japanese language teaching and learning. One is the knowledge of Japanese vocabulary and the other is the knowledge of Japanese grammar. Chinese-speaking learners benefit substantially from Chinese

characters commonly used both in Japanese and Chinese, when they read Japanese sentences or documents. However, because functional expressions in Japanese grammar are completely new for Chinese-speaking JSL learners, they find it more difficult to read and understand. Therefore, developing a Japanese functional expression learning system is crucial for Chinese-speaking JSL learners studying Japanese.

On the basis of the above discussion, in this work, we generally aim at developing a computer-assisted language learning system that assists Chinese-speaking JSL learners to study Japanese functional expressions.

1.3 Contribution

The contributions of this thesis are summarized as follows:

- We develop a computer-assisted language learning system, designed particularly for Chinese-speaking JSL learners studying Japanese functional expressions. This system detects Japanese functional expressions using a character-based bidirectional long short-term memory with a conditional random field (BiLSTM-CRF) model, followed by word segmentation and POS tagging by a Japanese morphological analyzer ***MeCab***[2] (a CRF model). In the meanwhile, the system simplifies difficult Japanese functional expressions in the sentences. In addition, the system suggests appropriate example sentences containing Japanese functional expressions to learners.
- We constructed three Japanese language resources: "Japanese Functional Expression List", "Simple Japanese Functional Expression Replacement List" and "Japanese-Chinese Common Word List". These three lists are effectively used for detecting Japanese functional expressions, simplifying difficult Japanese functional expressions and evaluating example sentence readability, respectively. We also believe these three lists can become useful references in Japanese language research and study.

[2] http://taku910.github.io/mecab/

- We propose a method to improve the performance of detecting Japanese functional expressions, using a character-based BiLSTM-CRF model. The advantage of this model is that it can detect not only correct Japanese functional expressions but also the misspelled Japanese functional expressions. The final test shows that our method obtains competitive results of the word-based CRF model.
- We set Japanese-Chinese common words as an important feature for example sentence readability evaluation, using a support vector machine for Ranking (***SVMrank***)[3] algorithm. The experimental results show significant improvement of the sentence readability evaluation performance, compared with the baseline features.
- We cluster the example sentences containing Japanese functional expressions with the same meaning based on the following features: parts-of-speech, conjugation forms and semantic attributes of the neighboring words, using k-means clustering algorithm in Scikit-learn[4].
- We define a new framework for correcting spelling and grammatical errors on Japanese functional expressions as well as the error data collection problem. We utilize the generated artificial error data to train a character-based seq2seq neural machine translation model. The final experimental results indicate that our character-based method outperforms word-based method both on artificial error data and real error data.

1.4 Outline of Dissertation

This dissertation is organized as follows:

Chapter 1 describes the general introduction for this topic as well as the motivation and the contributions.

[3] https://www.cs.cornell.edu/people/tj/svm_light/svm_rank.html

[4] http://scikitlearn.org/stable/modules/clustering.html#clustering

Chapter 2 introduces an overview of the related work on Japanese functional expressions, text simplification, text readability, error correction and Japanese language learning systems.

Chapter 3 explains the corpora resources used in this work and the construction of three language resources.

Chapter 4 presents our proposed approach on how to automatically detect and simplify Japanese functional expressions and describes the detailed experiments and evaluation results.

In Chapter 5, we apply ***SVMrank*** to evaluate the example sentence readability, using Japanese-Chinese common words as an important feature and apply k-means algorithm to cluster example sentences containing Japanese functional expressions with the same meaning to suggest more appropriate example sentences for Chinese-speaking JSL learners.

In Chapter 6, we propose a frame work to correct the spelling and grammatical errors of Japanese functional expressions, using a character-based seq2seq neural machine translation model and describe the methodology of artificial error generation and experimental settings, experimental results and error analysis.

In Chapter 7, we describe the development of a Japanese functional expression learning system and report a preliminary user study involving Chinese-speaking JSL learners to evaluate the usefulness of our system.

We conclude this dissertation and discuss the future work for our research in Chapter 8.

Chapter 2

2. Related Work

This chapter provides an overview of related studies. In Section 2.1, we introduce some related work on Japanese functional expressions, including construction of Japanese functional expression resources and automatic detection of Japanese functional expression resources. In Section 2.2, we introduce some previous studies about text simplification, especially Japanese simplification for JSL learners. Section 2.3 describes some related studies on text readability evaluation, especially an online Japanese text readability evaluation system. We give some previous research work about automatic error correction on spelling check and grammatical error correction fields in Section 2.4. We also describe several current online Japanese language learning systems and summary the featured functions of current online Japanese language learning systems in Section 2.5.

2.1 Japanese Functional Expressions

There are many Japanese grammar books or dictionaries about Japanese functional expression available for Japanese language education ([29, 39, 40, 88, 104]). However, these paper-based dictionaries cannot be used for automatic detection of Japanese functional expressions. Several previous studies have constructed some useful resources including dictionaries and databases for automatic detection of Japanese functional expressions in natural Japanese processing. Hori, Lee and Hasebe [22] developed and released a usage database of function words in Japanese with 1,848 headwords aiming to assist non-native teachers and learners in Japanese language education. Hyodo, Murakami and Ikeda [26] proposed a dictionary of Japanese functional expressions with 375 headwords and 13,882 surface forms. Matsuyoshi, Sato and Utsuro [51] proposed an approach to compiling a dictionary

of Japanese functional expressions with hierarchical organization, which consists of 292 headwords and 13,958 surface forms. Shudo, Kurahone and Tanabe [77] introduced an overview of the comprehensive dictionary (JDMWE) of Japanese multiword expressions, which contains about 104,000 expressions, potentially 750,000 expressions. Tanabe, Takahashi and Shudo [84] presented an overview of a comprehensive lexicon of Japanese multiword expressions (Japanese MWE Lexicon: JMWEL) for natural Japanese processing systems, which contains 111,000 header entries written in kana (phonetic characters) and their almost 820,000 variants written in kana and kanji (ideographic characters). Tsuchiya et al. [91] presented the details of the developed example database of Japanese compound functional expressions, which includes 337 surface forms.

Several approaches have been proposed to detect Japanese functional expressions ([41, 75, 78, 83, 90]). However, automatic detection of functional expressions is still a challenging problem in Japanese language processing because one functional expression may possess both literal and non-literal usages. Kubo [41] worked on tasks to detect Japanese functional expressions using a neural network such as Feed-forward Neural Network and Bidirectional LSTM and performing unsupervised clustering of Japanese functional expressions to train the detection model corresponding to the type of Japanese functional expression. Shime et al. [75] and Tsuchiya et al. [90] formalized the task of identifying 52 types of Japanese compound functional expressions in a text as a chunking problem using support vector machines (SVM). Shudo et al. [78] have collected 2,500 surface forms and applied manually created rules to the task of resolving the functional/literal ambiguities of Japanese functional expressions. Suzuki et al. [83] reported a framework for identifying more than 16,000 functional expressions in Japanese text by utilizing a large scale hierarchical lexicon of Japanese functional expressions in which each derived functional expression is to be identified by referring to the most similar occurrence of its canonical expression.

The major drawback of previous studies is in the scale of Japanese functional expressions that can be automatically detected, which is insufficient to meet the JSL learners' practical learning needs based on their individual language abilities.

2.2 Text Simplification

Text simplification, defined narrowly, is the process of reducing the linguistic complexity of a text, while retaining the original information contents and meaning ([79]). The goal of text simplification is to make sentences less challenging to read by replacing difficult words or transferring sentence structure ([92, 101]). Many previous studies have been worked on English simplification, because there are a lot of available parallel corpora and databases, such as LSeval ([2]), Wordnet ([10]), LexMtrurk ([24]), Simple Wikipedia ([34]), CW Corpus ([72]), Newsela Data ([102]). Several studies applied Statistical machine translation (SMT) system for simplification tasks ([65, 100]). Some researches proposed unsupervised approaches for learning word embeddings from large corpora to rank the simplification candidates according several features ([16, 62]. Pereira, Liu and Lee [63] proposed an approach for ranking substitution candidates in lexical simplification using a Deep Structured Similarity Model (DSSM).

Recently, more studies have paid attention on Japanese simplification for Japanese language learners. Hading [17] proposed a method of supervised regression learning to estimate the difficulty ordering words with statistical features obtained from Japanese corpora for Japanese lexical simplification. Kajiwara and Yamamoto [32] constructed an evaluation dataset for Japanese lexical simplification. They extracted 2330 sentences from a newswire corpus and simplified only one difficult word using several Japanese lexical paraphrasing databases. Kaneniwa and Kawamura [33] used the same list to rewrite difficult vocabulary automatically for Japanese learners who have non-kanji backgrounds. Kodaira, Kajiwara and Komachi [38] built a controlled and balanced dataset for Japanese lexical simplification. They extracted 2010 sentences with only one difficult word in each sentence from a balanced corpus and collected simplification candidates using crowdsourcing techniques. Matsuyoshi and Sato [50] proposed a method of paraphrasing of Japanese functional expressions under style and readability specifications using a dictionary with two hierarchies: a morphological hierarchy and a

semantic hierarchy. Watanabe and Kawamura [93] introduced a Japanese simplification system with the use of a "Simple Japanese Replacement List".

Different from the previous research mentioned above, we focused on the simplification of Japanese functional expressions, aiming to construct a "Simple Japanese Functional Expression Replacement List" for Chinese-speaking JSL learners.

2.3 Text Readability Evaluation

Evaluating text readability is a challenge in natural language processing (NLP) due to the linguistic complexities involved in both vocabulary and grammar. Numerous popular formulas for estimating text readability exist, such as Dale-Chall readability formula ([4]), Flesch Reading Ease ([13]), and Flesch-Kincaid Grade Level ([36]). All these formulas have been used in numerous applications, such as compiling reading materials for English language learners. Tateisi, Ono, and Yamada ([85, 86]) introduced a formula for evaluating Japanese text readability, based on six surface characteristics: average number of characters per sentence, average number of Roman letters and symbols, average number of hiragana characters, average number of kanji characters, average number of katakana characters, and the ratio of commas to periods. Formula-based approaches have also been used to teach Japanese to young native speakers ([70, 73, 74]).

To evaluate text readability for JSL learners, Wang and Andersen [99] introduced an approach that focused on grammar, utilized grammar templates and employed the K-Nearest Neighbor (KNN) and support vector machines (SVM) algorithms. Some general systems for evaluating Japanese text readability have also been developed. For example, ***JReadability [19]***[5] can analyze input text and estimate its readability, categorizing texts into one of six difficulty levels (Figure 3). However, ***JReadability*** does not sufficiently consider the varying difficulty levels of Japanese functional expressions; instead, the system provides

[5] https://jreadability.net/ja/

prediction values that are reliable for longer texts (approximately 1000 characters) but not for single sentences.

Figure 3: The interface of ***Jareadability***

In contrast to previous work, we propose a method aimed at Chinese-speaking JSL learners that can evaluate the readability of a single sentence containing Japanese functional expressions.

2.4 Automatic Error Correction

Spelling correction is an automatic algorithm for detecting and correcting human spelling errors in every written language, which has been an active research in Natural Language Processing (NLP) ([5, 46, 47, 81]).

Grammatical error correction (GEC) is a task of detecting and correcting grammatical errors in text written by native language writers or non-native foreign language writers. over the past few decades, GEC in English has been widely researched, such as Helping Our Own ([8, 9]), CoNLL Shared Task ([56, 57]). Many shared tasks on GEC for Chinese Second Language Learners have also been held, such as the NLP-TEA Shared Task ([44, 45, 66, 67, 105]. On Japanese GEC, much work has been done on particle error correction for JSL learners ([27, 53, 58, 61]).

Several approaches of using Statistical machine translation (SMT) for GEC have been proposed ([3, 54]. Recently, neural networks have shown success in many NLP tasks, such as machine translation (MT) ([11, 14]), named entity recognition (NER) ([43, 52]) and etc. For GEC, several studies have applied neural machine translation (NMT) approach ([7, 106]). NMT is applied in the GEC task as it may be possible to correct erroneous phrases and sentences that have not been seen in the training data more effectively ([48]). NMT-based systems thus may help ameliorate the shortage of large error-annotated learner corpora for GEC.

As previous research mentioned above, few studies have aimed at spelling and grammatical error corrections on Japanese functional expressions. Therefore, our study is an attempt to do this work using neural machine translation.

2.5 Japanese Language Learning Systems

In recent years, many Japanese language learning systems have been constructed with the help of natural language processing (NLP) technology. For example, Han and Song [18] attempted to develop a Japanese learning system for learning Japanese sentence patterns using illustrative examples extracted from the web. Hazelbeck and Saito [20] developed an e-learning system that assists JSL learners studying Japanese vocabulary and Kanji. The system uses sentences from a corpus to generate context-based exercises. The sentences in these context-based exercises are selected using a readability formula. Ohno et al. [59] developed a web application to provide appropriate suggestions and different learning materials

targeted to each JSL learner based on their individual Japanese language abilities. Omura and Matsumoto [60] introduced a Japanese grammatical error correction system, named ***Chantokun***[6], which discovers misuse of case particles in a learner's input sentence and suggests the potential alternatives. Pereira, Manguilimotan and Matsumoto [64] presented a ***Collocation Assistant*** for Japanese language learners, which flags possible collocation errors and suggests corrections with example sentences. Tolmachev and Kurohashi [87] proposed an example extraction system for use in a flashcard system that uses the determinantal point process – a method for modelling diverse datasets as a framework – to simultaneously select non-similar, high quality sentences for JSL learners studying Japanese vocabulary.

Certain online public available Japanese language learning systems such as ***Asunaro [21]***[7], ***HAGOROMO [22]***[8], ***Reading Tutor [35]***[9], ***Rikai***[10], and ***WWWJDIC***[11] and are highly effective. These systems provide an online learning environment where learners can make complete use of information from the Internet for their Japanese language study, and some of these systems are specifically designed to enable language learners to understand Japanese texts by offering words accompanied by corresponding difficulty level information or translations ([80, 89]).

Asunaro is a multi-lingual reading assistance system for a range of languages (Figure 5, [21], p. 105). The main purpose of the system is to assist Japanese language learners read and understand academic material in Japanese. The main target of the system is Japanese language learners enrolled in Japanese universities

[6] http://cl.naist.jp/chantokun/

[7] https://hinoki-project.org/asunaro/

[8] https://www.hagoromo-text.work

[9] http://language.tiu.ac.jp/

[10] http://www.rikai.com/perl/HomePage.pl?Language=Ja

[11] http://nihongo.monash.edu/cgi-bin/wwwjdic?1C

majoring in the fields of science and engineering. This system presents morphological analysis of sentences in Japanese texts with information about part of speech categories and meanings using the Japanese morphological analyzer ***MeCab***. Moreover, it displays syntactic structures of individual sentences using various methods (i.e., tree diagrams, box structures, and dependency structures) with the help of a Japanese dependency structure analyzer ***CaboCha***[12].

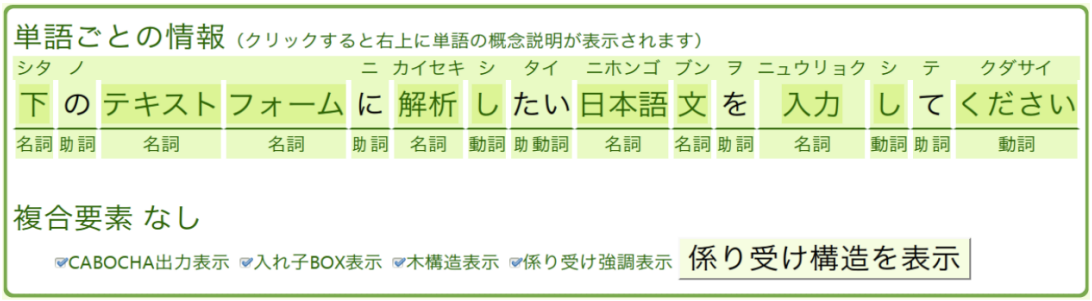

Figure 4: The morphological output of user input suggested by ***Asunaro***.

HAGOROMO is a database of Japanese function words aiming to support Japanese language teachers, especially non-native teachers overseas, and learners at the intermediate and advanced levels (Figure 8). The system allows users to search function words, which are essential for Japanese language education/learning, and access authentic example sentences extracted from spoken and written language corpora. The levels of difficulty of the function words were determined by the subjective judgment of five Japanese language teachers, each with experience of more than ten years.

[12] http://taku910.github.io/cabocha/

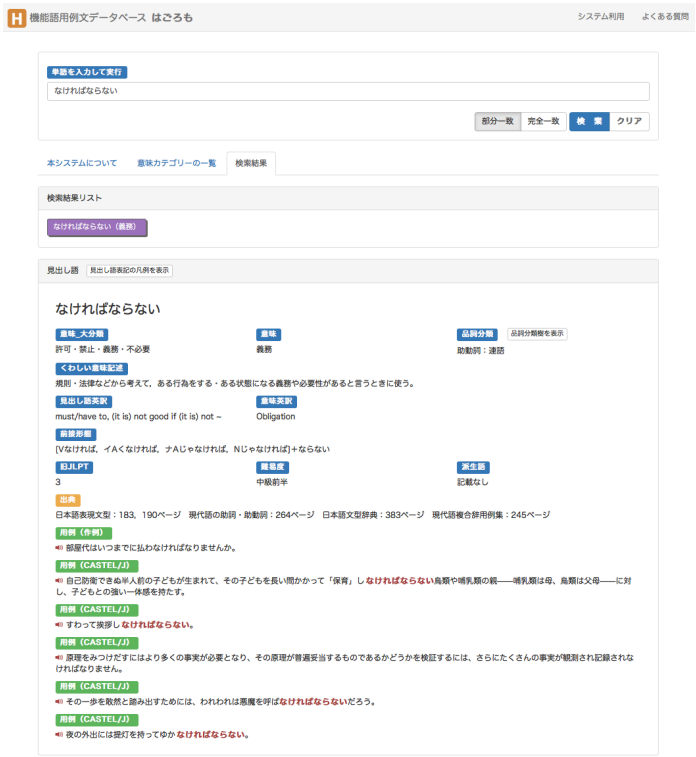

Figure 5: The interface of ***HAGOROMO***

Reading Tutor was designed to help Japanese language learners improve their reading skills (Figure 4). This system was developed specifically to help learners study written Japanese at their own pace. Given a text in Reading Tutor, all the words that appear in the text are morphologically analyzed according to their level of difficulty on the JLPT with the help of a Japanese morphological analyzer ***ChaSen***[13]. Learners can also find all the words with an explanation in various foreign languages: English, Spanish, Slovene, German and etc. with the help of dictionary tools in Reading Tutor.

[13] http://chasen-legacy.osdn.jp

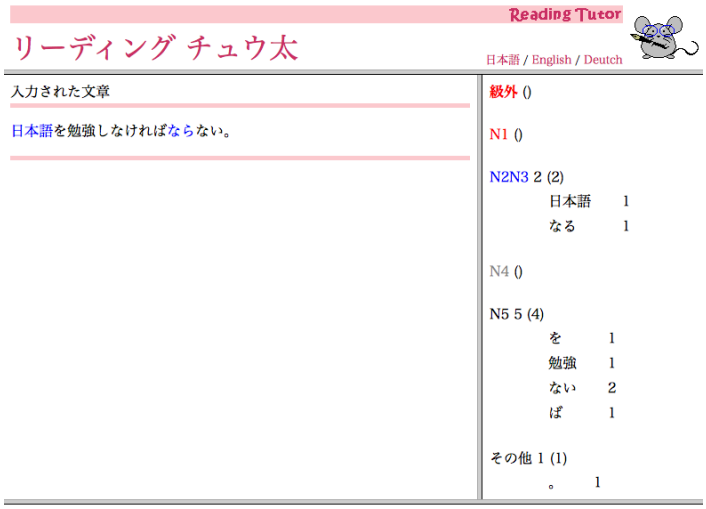

Figure 6: The interface of ***Reading Tutor***

Rikai is a reading support tool which shows learners how to read Japanese words (Figure 6). This tool embeds a bilingual dictionary in any Web page so that it opens pop-up windows displaying the readings and meanings of the Japanese words when learners move the mouse over Japanese words on a Japanese website.

Figure 7: The interface of ***Rikai***

WWWJDIC is an online Japanese dictionary server (Figure 7). This server provides word search with lexical entries including furigana, translation, examples, part of speech annotation and pronunciation with the help of various bilingual dictionaries. Moreover, WWWJDIC divides a Japanese text into sentences and then provides the lexical entries for each word in a sentence including translations and other information. It also offers example sentences from the Tanaka corpus, a collection of Japanese/English sentences initially compiled by Professor Yasuhito Tanaka at Hyogo University and his students.

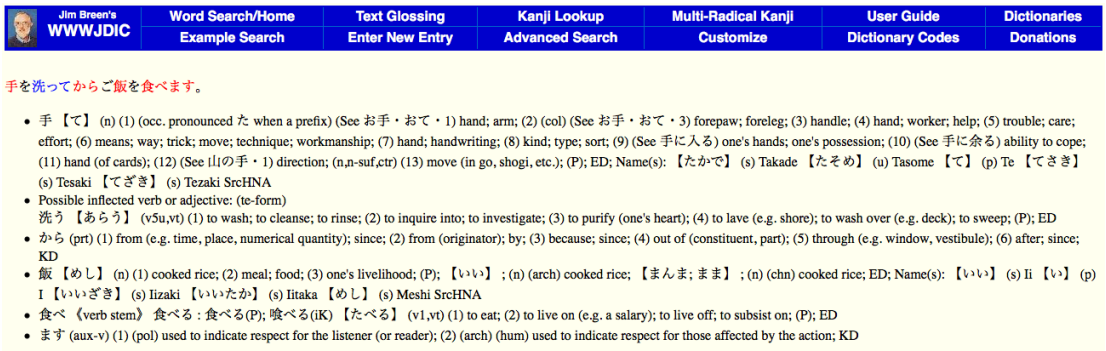

Figure 8: The interface of ***WWWJDIC***

We summarized the featured functions of current online systems that have been developed for Japanese language learners with the following findings (also shown in Table 2):

1. These systems can not automatically detect Japanese functional expressions from sentences in Japanese texts very well. Some systems such as ***Reading Tutor*** and ***HAGOROMO*** only allow users to input function words/expressions.

2. Noun of these systems has taken the simplification of Japanese functional expressions into account.

3. A few of these systems such as ***Rikai*** and ***WWWJDIC*** provide learners with limited information of some Japanese functional words/expressions, which

does not reach the JSL learners' practical learning needs in the procedure of Japanese language learning. For example, the ***WWWJDIC*** only provides learners with the translation information of some easy and short Japanese functional words, such as "それから (then)", "したがって (therefore)" , but not complex and long functional expressions, such as "なければならない(should)", "よりほかにはない (to have no choice but)".

4. Example sentences extracted from corpora are offered by some of these systems such as ***WWWJDIC*** and ***HAGOROMA***. However, Noun of these systems has considered the readability of these example sentences for JSL learners. Some example sentences provided by these systems are fairly difficult for JSL learners to read and understand.

5. Noun of these systems has considered sentence clustering for learners' study of Japanese functional expressions sharing the same meaning.

System	Reading Tutor	Asunaro	Rikai	WWWJDIC	HAGOROMO
Words search	○	○	○	○	×
Functional expressions detection	×	×	×	×	×
Functional expressions simplification	×	×	×	×	×
Sentence suggestion	×	×	×	○	○
Sentence readability evaluation	×	×	×	×	×
Sentence clustering	×	×	×	×	×

Table 2: Summary of the featured functions of the existing online Japanese language learning systems

Chapter 3

3. Resources Used in This work

This chapter introduces some existing corpora and language resources. We first describe the corpora we used for detecting Japanese functional expressions and suggesting example sentences in section 3.1. In addition, we describe three language resources we constructed for the purpose of detecting and simplifying Japanese functional expressions in section 3.2.

3.1 Corpora Data

We have used the following corpora to train the BiLSTM-CRF model and ***MeCab*** to detect Japanese functional expressions and to perform segmentation and POS tagging. We have also used the ***Tatoeba***, ***Hiragana Times*** and ***BCCWJ*** corpora to suggest appropriate example sentences for Chinese-speaking JSL learners. The details of these corpora are as follows:

- ***Tatoeba Corpus***[14]: This corpus is a free collaborative online database of example sentences geared towards foreign language learners. Tatoeba corpus provides a tool for learners to see examples of how words are used in the context. We have used only Japanese example sentences (approximately 176,100) from this website.
- ***Hiragana Times Corpus***[15]: This is a Japanese-English bilingual corpus of magazine articles from the Hiragana Times, which introduces Japan to non-Japanese, covering a wide range of topics including culture, society,

[14] https://tatoeba.org/eng/

[15] http://www.hiraganatimes.com/

history, and politics. We have used only Japanese example sentences (approximately 150,700) from this corpus.

- ***BCCWJ***[16]: The Balanced Corpus of Contemporary Written Japanese (BCCWJ) is a corpus created for comprehending the breadth of contemporary written Japanese; it contains extensive samples of modern Japanese text to create as uniquely balanced a corpus as possible. The data comprises 104.3 million words, covering genres including general books and magazines, newspapers, business reports, blogs, internet forums, textbooks, and legal documents.
- ***Lang-8 Learner Corpora***[17]: This is a large-scale, error-corrected learner corpus containing both learner-written texts in their learning language and corrections by native speakers. The corpora cover 80 languages. We have used only the Lang-8 corpus for Japanese learners which contains approximately 2,246,000 Japanese sentences.

3.2 Resources Construction

3.2.1 Constructing a Japanese Functional Expression List

A problematic characteristic of Japanese functional expressions is that each functional expression can take different surface forms. Automatic detection of Japanese functional expressions requires a list that contains both headwords and their various surface forms. Although several Japanese functional expressions dictionaries ([29, 39, 40, 88, 103]) are available for JSL learners, not all surface forms are enumerated in these dictionaries for the task of detection of Japanese functional expressions. For example, the surface forms “なければならず (must)” or “かもしれぬ (maybe)” are not available in any of the above dictionaries.

[16] http://pj.ninjal.ac.jp/corpus_center/bccwj/en/

[17] http://cl.naist.jp/nldata/lang-8/

Because our system is designed for the JSL learners' practical learning needs based on their individual language abilities, we construct a list of Japanese functional expressions with varying difficulty levels following the standard of the JLPT. We referenced some paper-based dictionaries ([39, 40, 88, 103]) and online Japanese learning websites[18,19], all of which divide Japanese functional expressions into N1–N5 levels. Moreover, to collect as many surface forms of each Japanese functional expression as possible, we also referenced some other language resources, including dictionaries ([29, 51]) and BCCWJ. Ultimately, we collected 909 headwords (298 N1; 245 N2; 199 N3; 133 N4; 34 N5) and 4017 surface forms (849 N1; 765 N2; 1269 N3; 1016 N4; 118 N5) in our list of Japanese functional expressions. A few examples of Japanese functional expressions from our list are presented in Table 3.

3.2.2 Constructing a Simple Japanese Functional Expression Replacement List

There are many functional expressions in Japanese language to express different meanings in various situations. Learning Japanese functional expressions seems to be more difficult and challenging than learning vocabulary words for Chinese-speaking JSL learners. Providing appropriate simplified suggestions of difficult Japanese functional expressions in sentences shows usefulness for JSL learners to understand the meaning of sentences and study Japanese functional expressions through example sentences [50]. Therefore, we construct a "Simple Japanese Functional Expression Replacement List", hoping this list can be helpful to study Japanese functional expressions for JSL learners.

For the difficulty levels of the Japanese functional expressions, we follow the standard of the JLPT. We consider levels N3 and lower as easy level, levels N2

[18] http://www.tanos.co.uk/jlpt/skills/grammar/

[19] https://japanesetest4you.com/flashcard/category/learn-japanese-grammar/

and above as difficult level according to the “Japanese Functional Expressions List” we constructed in Section 3.2.1.

Headwords	Surface Forms	Difficulty Level
嫌(きら)いがある (have a tendency to)	嫌(きら)いがあり 嫌(きら)いがあっ	N1
ざるを得(え)ない (have to)	ざるを得(え)ぬ ざるを得(え)ず ざるを得(え)なく ざるを得(え)なかっ ざるを得(え)ません	N2
に比(くら)べて (compared with)	に比(くら)べ に比(くら)べると	N3
かも知(し)れない (maybe)	かも知(し)れなかっ かも知(し)れず かも知(し)れぬ かも知(し)れません かも知(し)れん	N4
ではない (be not)	ではなかっ ではなく ではありません じゃない じゃありません じゃなかっ じゃなく	N5

Table 3: Examples of Japanese functional expressions with various surface forms

In our work, we applied ***Word2vec*** to extract simplification candidates of difficult Japanese functional expressions for constructing our “Simple Japanese

Functional Expression Replacement List". ***Word2vec*** is an open source tool to calculate the words distance provided by Google. It can be used by inputting a word and output the ranked word lists according to the similarity. We applied the Python's Gensim implementation[20] for training a Word2vec model. The Figure 9 shows the steps for extracting simplification candidates of difficult Japanese functional expressions.

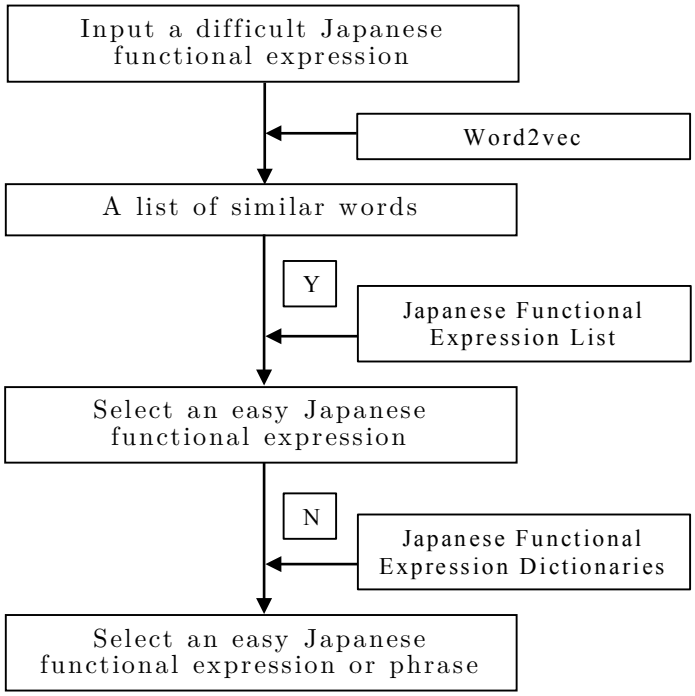

Figure 9: The steps for extracting simplification candidates of difficult Japanese functional expressions

To train the Word2vec model, we need to segment the Japanese functional expressions as a whole word first. However, current Japanese morphological ana-

[20] https://radimrehurek.com/gensim/models/word2vec.html

lyzer, ***Mecab***, can only detect a limited number of Japanese functional expressions. For example, the output obtained using ***MeCab*** for the following two sentences: “明日雨が降るかもしれない。 (It may rain tomorrow.)”, are as follows:

Input: 明日雨が降るかもしれない。
Output: 明日/雨/が/降る/かも/しれ/ない/。

where the slashes indicate word boundaries. In the output sentence, the Japanese functional expression“かもしれない(may)”cannot be correctly recognized. To address this issue, we train a new CRF model, hoping ***MeCab*** can detect more Japanese functional expressions. This model is exactly the same as ***MeCab*** in which all possible forms of functional expressions are registered in the dictionary. We collected 120,000 sentences from the ***Tatoeba***, ***Hiragana Times***, ***BCCWJ*** corpora and some Japanese functional expression dictionaries ([29, 39, 40, 88, 103]) as the training corpus. Then we divided each sentence into word level using ***MeCab*** and manually tagged part-of-speech information for each Japanese functional expression. Figure 10 represents an example sentence “仕事を終えてから帰った。 (I went home after I finished my work.)” after pre-processing for the CRF model. As the training data for the Word2vec model, we used the sentences (approximately 4,232,000 sentences) in BCCWJ, all of which were segmented by ***MeCab*** trained with our new CRF model.

With the help of Word2vec model, we inputted difficult Japanese functional expressions which we are going to use for replacement and obtained a list of similar words associated with each difficult Japanese functional expression. Based on the list of similar words, we selected the easy Japanese functional expressions which are included in the “Japanese Functional Expression List”. If there are no appropriate easy Japanese functional expressions in the list of similar words, we manually simplify the difficult with easy Japanese functional expressions or easy phrases by referencing some Japanese functional expression dictionaries. Ultimately, we constructed a “Simple Japanese Functional Expression Replacement

List" which consists of approximately pairs of original Japanese functional expressions and their corresponding simplified Japanese functional expressions. Table 4 shows some examples in our "Simple Japanese Functional Expression Replacement List".

仕事　名詞,サ変接続,*,*,*,*,仕事,シゴト,シゴト
を　助詞,格助詞,一般,*,*,*,を,ヲ,ヲ
終え　動詞,自立,*,*,一段,連用形,終える,オエ,オエ
てから 助詞,接続助詞,機能表現,*,*,*,てから,テカラ,テカラ
帰っ　動詞,自立,*,*,五段・ラ行,連用タ接続,帰る,カエッ,カエッ
た　助動詞,*,*,*,特殊・タ,基本形,た,タ,タ
。　記号,句点,*,*,*,*,。,。,。

Note: In this figure, the Japanese functional expression "てから(after)" and its POS information are in bold.

Figure 10: An example sentence after pre-processing for the CRF model.

Original Japanese Functional Expressions	Difficulty Level	Simplified Japanese Functional Expressions	Difficulty Level
(よ)うにも(cannot even though want to)	N1	たくても	N4
が早いか(no sooner than)	N1	と	N5
如何によって(in accordance with)	N1	によって	N3
に関わらず(regardless of)	N2	によらず	N5
ざるをえない(have to)	N2	ないわけにはいかない	N4
た覚えがある(have the experience of)	N2	たことがある	N4

Table 4: Examples of the simple Japanese functional expression replacement list

3.2.3 Constructing a Japanese-Chinese Common Word List

Japanese and Chinese share a large number of common words that use identical Chinese characters (in both simplified and traditional Chinese). These common words can be divided into three categories based on their meanings: identical (I type), similar (S type) and dissimilar (D type). The I type words have identical meanings in both languages. The S type words share the same meaning, but either (or both) of them has some extra meaning. The words in D type words share the same characters but have different meanings. Table 5 shows some examples of Japanese-Chinese common words of these three types.

According to a report by Wang [98], approximately 80–95% of Japanese-Chinese words are used to express identical or similar meanings. The similarities between Japanese and Chinese words help Chinese-speaking JSL learners master Japanese vocabulary efficiently. Moreover, they can understand the meaning of Japanese words according to Chinese characters in a straightforward manner despite never having learned Japanese before. Therefore, in our work, we constructed a "Japanese-Chinese common Word List" that share identical or similar meanings (I and S types) to investigate whether these words are truly helpful in sentence readability evaluation.

Japanese	Chinese	Types
漢字 (Chinese character)	汉字 (Chinese character)	Identical
法律 (law)	法律 (law)	Identical
東西 (east and west)	东西 (east and west; thing)	Similar
柔軟 (soft; flexible)	柔软 (soft)	Similar
手紙 (letters)	手纸 (toilet paper)	Dissimilar
人参 (carrot)	人参 (ginseng)	Dissimilar

Table 5: Examples of Japanese-Chinese common words

To accomplish this task, we first extracted the Japanese words written only by Chinese characters from the following two electronic dictionaries: IPA (mecab-ipadic-2.7.0-20070801)[21] and UniDic (unidic-mecab 2.1.2)[22]. These dictionaries are used as the standard dictionaries for the morphological analyzer ***MeCab*** and contain POS information.

We then replaced all the traditional Chinese characters with the corresponding simplified Chinese characters because the Japanese language uses both simplified Chinese characters such as "雨 (rain), 政治 (politics), and 宇宙 (cosmos)" and traditional Chinese characters such as "雲 (cloud), 緊張 (tension), and 業績 (achievements)".

We deleted the Japanese words such as "財布(wallet)", "心配 (worry)" that exist only in Japanese dictionaries while its corresponding simplified Chinese character words "财布", "心配" are not included in Chinese dictionary, because these Japanese words are not Japanese-common words.

We extracted the Chinese translations or Japanese translations of the Japanese-Chinese common words from the following online dictionary websites: ***Wiktionary***[23], ***Weblio***[24] ***and Hujiangxiao D***[25].

We compared each Japanese/Chinese word with its Chinese/Japanese translation to determine whether the Japanese-Chinese common word was type I or S. When the character form of a Japanese/Chinese word is the same or similar to its Chinese/Japanese translation, the word is regarded as a Japanese-Chinese common word in type I or S. Table 6 shows some examples of how to identify Japanese-Chinese common word types.

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[21] https://sourceforge.net/projects/mecab/files/mecab-ipadic/2.7.0-20070801/mecab-ipadic-2.7.0- 20070801.tar.gz/download

[22] http://osdn.net/project/unidic/

[23] https://ja.wiktionary.org/wiki/メインページ

[24] http://cjjc.weblio.jp

[25] https://dict.hjenglish.com/jp/

Original Japanese word	Simplified Chinese characters	Chinese translation	Type I or S
技術 (technology)	技术	技术	Yes
書店 (book shop)	书店	书店	Yes
大学 (university)	大学	大学	Yes
社会 (society)	社会	社会	Yes
手紙 (letters)	手纸	信件	No

Table 6: Examples of how to identify Japanese-Chinese common word types

Regarding words not listed in the above online dictionary websites, we used an online Chinese dictionary: ***Baidu Chinese***[26] and a Japanese paper dictionary, ***Kojien 5th Edition*** ([76]) to manually check whether the Japanese word and its corresponding Chinese word shared identical or similar meanings and the appropriate classification (I, S, or D) for the Japanese word. Finally, we created a "Japanese-Chinese Common Word List" which consists of approximately 14,000 words.

[26] https://dict.baidu.com

Chapter 4

4. Detection and Simplification of Japanese Functional Expressions

This chapter describes two tasks: automatic detection of Japanese functional expressions and simplification of Japanese functional expressions. Section 4.1 describes the background. We introduce in detail the method proposed to detect Japanese functional expressions in Section 4.2 and simplify Japanese functional expressions in Section 4.3.

4.1 Introduction

It has been widely acknowledged that learning functional expressions in Japanese grammar are challenging for JSL learners. As we discussed in previous Section, most of current online public Japanese language systems are not particularly developed for learning Japanese functional expressions and most of these systems cannot suggest information about various Japanese functional expressions. Therefore, developing a Japanese functional expression learning system is important and helpful for JSL learners to improve their grammar knowledge.

In this study, we want to develop a Japanese language learning system that automatically detect functional expressions from sentences in Japanese texts. Many researchers have proposed effective approaches to detect Japanese functional expressions. However, the number of the Japanese functional expressions they can detect is limited. In an attempt to make up the deficiency, we apply a character-based BiLSTM-CRF model, hoping to detect more Japanese functional expressions.

Simplifying Japanese texts also shows practical usefulness for JSL learners, especially for the beginners. Chinese-speaking JSL learners find it more difficult to understand the example sentences containing difficult Japanese functional expressions. Therefore, we also hope our learning system can provide Chinese-speaking JSL learners with example sentences containing easy Japanese functional expressions. To implement this function, we have an attempt to simplify the difficult functional expressions in Japanese sentences using the "Simple Japanese Functional Expression Replacement List" we constructed in Section 3.2.2. In addition, considering the different conjugation replacement rules of some Japanese functional expressions between the original sentences and the simplified sentences, we also manually created some conjugation replacement rules to avoid grammatical errors in the simplified sentences.

4.2 Detecting Japanese Functional Expressions

4.2.1 Motivation

Japanese functional expressions are important in helping JSL learners read and write Japanese texts. Because we develop a system that help JSL learners with their study of Japanese functional expressions, we hope our system can automatically detect Japanese functional expressions from sentences given by JSL learners.

The number of Japanese functional expressions that previous work can detect is limited. Moreover, current online Japanese language learning systems have drawbacks in automatic detection of Japanese functional expressions. Therefore, we try to propose a method for detecting Japanese functional expressions.

4.2.2 Character-based BiLSTM-CRF Model

In this work, we apply a character-based BiLSTM-CRF model to automatically detect Japanese functional expressions. The reason for applying a character-based analysis is because functional expressions are mainly composed of Japanese phonetic characters (hiragana) and are often appear with misspelling.

The BiLSTM-CRF model ([25]) consists of three major parts: the embedding layer, the bi-directional LSTM layer, and the CRF layer. As shown in figure 11, every character in sentence is represented as character embedding as input. The bidirectional LSTM layer is used to operate sequential information in two opposite directions. The CRF layer predicts correlated tag sequence under consideration of outputs from the LSTM layer.

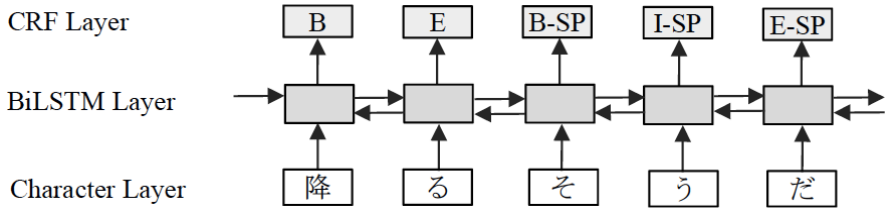


Figure 11: The structure of BiLSTM-CRF model

4.2.3 Experimental Settings

When training the BiLSTM-CRF model, we treat the Japanese functional expression detection task as a character-based sequence labelling problem. We split the words in a sentence to the character level by attaching position labels from a tag set: {B, I, E, O, B-SP, I-SP, E-SP, O-SP}. Here, the tags 'B', 'I', and 'E' indicate the beginning, middle, and end positions of a word, respectively. 'O' indicates a single character word. 'B-SP', 'I-SP', 'E-SP' indicate the beginning, middle and the end positions of a Japanese functional expression, respectively. 'O-SP' indicates a Japanese functional expression with a single character word. Figure 12 shows an example sentence "仕事を終えてから帰った。" (I went home after I finished my work.) after pre-processing.

In this work, we adopt a BiLSTM-CRF implementation[27] with the following empirical hyper-parameter setting. We apply 300-dimensional randomly initialized

[27] https://github.com/Determined22/zh-NER-TF

character embddings and 300-dimensional hidden state for LSTM. We choose Adam as the optimizer and set the learning rate equal to 0.001.

We also trained a word-based CRF model as a baseline for comparison. For the baseline, we registered all possible surface forms of Japanese functional expressions in the IPA dictionary and used them in ***MeCab***. We used CRF++[28], an open source implementation of CRF, for training. The training corpus was pre-processed as the example shown in Figure 10 so that all the occurrences of multi-word functional expressions were conjoined into single tokens. The CRF++ learns the training corpus and outputs a model file as the learning result. We then applied ***MeCab*** to the trained model file to detect Japanese functional expressions. This is the standard technique for segmentation and POS tagging technique for non-segmented languages such as Japanese ([42]).

Character	Label
仕	B
事	E
を	O
終	B
え	E
て	B-SP
か	I-SP
ら	E-SP
帰	B
っ	E
た	O
。	O

Figure 12: An example sentence after pre-processing for the BiLSTM-CRF model

[28] https://taku910.github.io/crfpp/

We selected 123,641 example sentences containing Japanese functional expressions from the ***Tatoeba***, ***Hiragana Times***, ***Lang-8 Learner***, ***BCCWJ*** corpora and some Japanese functional expression dictionaries ([29, 39, 40, 88, 103]) as the training data. To train the BiLSTM-CRF model, all the sentences are first segmented into individual words using ***MeCab*** and then the words are split into characters and manually annotated with tags after pre-processing.

4.2.4 Evaluation and Results

For test data, we randomly collected 12,000 example sentences from the ***Tatoeba***, ***Hiragana Times***, ***Lang-8 Learner, BCCWJ*** corpora and some Japanese functional expression dictionaries ([29, 39, 40, 88, 103]). As evaluation metrics, we adopted precision, recall and F_1-score, which are calculated as shown in the following equations. We evaluate the output of Japanese functional expressions as a whole word level. The final evaluation results are shown in Table 7. Table 8 shows examples of Japanese functional expressions detected by the BiLSTM-CRF and the CRF models.

$$Precision = \frac{correctly\ identified\ results\ of\ system}{identified\ results\ of\ system}$$

$$Recall = \frac{correctly\ identified\ results\ of\ system}{results\ in\ test\ data}$$

$$F_1 - score = \frac{2 * Precision * Recall}{Precision + Recall}$$

Model	Precision	Recall	F_1-score
BiLSTM-CRF	89.69%	88.47%	89.08%
CRF	88.57%	84.06%	86.26%

Table 7: Experimental results on automatic detection of Japanese functional expressions

No	Example sentence	Model	Result
1	Input: 今、雪が降っている。 (It is snowing now.) Output: 今 、 雪 が 降っ **ている** 。 Output: 今 、 雪 が 降っ **ている** 。	BiLSTM-CRF CRF	Correct Correct
2	Input: この箱を開けてください。 (Please open this box.) Output: この 箱 を 開け **てください** 。 Output: この 箱 を 開け **てください** 。	BiLSTM-CRF CRF	Correct Correct
3	Input: それは本当かもしれない。 (That may be true.) Output: それ は 本当 **かもしれない** 。 Output: それ は 本当 **かもしれない** 。	BiLSTM-CRF CRF	Correct Correct
4	Input: 彼女は火にあたってからだを暖めた。 (She warmed herself by the fire.) Output: 彼女 は 火 に あたっ **てから** だ を 暖め た 。 Output: 彼女 は 火 **にあたって** からだ を 暖め た 。 Gold result: 彼女 は 火 に あたっ て からだ を 暖め た 。	BiLSTM-CRF CRF	Incorrect Incorrect
5	Input: 絵がテーブルの上にかかっている。 (The picture hangs over the table.) Output: 絵 が テーブル の 上 **にかかっている** 。 Output: 絵 が テーブル の 上 **にかかっている** 。 Gold result: 絵 が テーブル の 上 に かかっ **ている** 。	BiLSTM-CRF CRF	Incorrect Incorrect
6	Input: 字幕を読めなければなりない。 (You must read the subtitles.) Output: 字幕 を 読め **なければなりない** 。 Output: 字幕 を 読め なけれ ば なり ない 。	BiLSTM-CRF CRF	Correct Incorrect

Note: In this table, Japanese functional expressions are in bold.

Table 8: Examples of Japanese functional expressions detected by BiLSTM-CRF model and CRF model.

4.2.5 Analysis

As shown in Table 8, the BiLSTM-CRF model achieved an F_1-score of 89.08%, which is an improvement of 2.82%, compared with the CRF model. Cases of failures of functional expression identification can be attributed to the following two causes. First, the lack of discriminative contextual information causes failure. For example, the functional expressions "にあたって (on the occasion of)" in Example 4 and "にかかっている (in accordance with)" in Example 5, are incorrectly recognized as functional usages in both models. Here, both literal usages and functional usages of these expressions share almost the same contexts and cannot be distinguished solely by the surrounding information. Second, Example 6 contains a spelling error, where "なければなりない" should have been written as "なければならない(have to)". Thus, the CRF model fails to analyze the sentence correctly. In contrast, the character-based BiLSTM-CRF model detects the functional expression correctly despite the character error.

4.3 Simplifying Japanese Functional Expressions

4.3.1 Motivation

Our system is developed not only for the advanced and intermediate JSL learners, the JSL learners who begin to learn Japanese functional expressions have been considered as the main users. Therefore, we should provide the JSL learners with as easy as possible example sentences so that they can understand the meanings and the usages of the Japanese functional expressions quickly. Because Japanese functional expressions are more difficult than vocabulary words for Chinese-speaking JSL learners to study, we have an attempt to improve the usability of our system by simplifying difficult Japanese functional expressions.

4.3.2 Japanese Functional Expression Replacement

When a user input a Japanese sentence, the system will detect Japanese functional expressions from the input sentence using the BiLSTM-CRF model. Then the whole sentence will be segmented and POS tagged by ***MeCab***. If there exists a difficult Japanese functional expression, its corresponding simplified Japanese functional expression or phrase will be shown in an output sentence by searching the "Simple Japanese Functional Expression Replacement List" we constructed in Section 3.2.2.

Original conjugation forms	Original functional expressions	Replaced conjugation forms	Replaced functional expressions
Volitional form of verb	(よ)うにも (N1)	Masu form of verb e.g. 行こ => 行き	たくても (N4)
Negative form of verb Negative nu(ぬ) form of sahen-verb[29] / "する"	んがために (N1)	Dictionary form of verb / sahen-verb / "する" e.g. 行か => 行く 勉強せ => 勉強する	ために (N4)
Volitional form of verb	うではないか (N2)	Masu form of verb e.g. 行こ => 行き	ませんか (N5)
Negative nu(ぬ) form of sahen-verb / "する"	ざるをえない (N2)	Negative form of sahen-verb / "する" e.g. 勉強せ=> 勉強し	ないわけにはいかない (N3)

Table 9: Examples of verb conjugation form replacement rules

During the procedure of Japanese functional expressions simplification, we not only consider the replacement of Japanese functional expressions but also the

[29] In Japanese, sahen-verb (e.g. "勉強する(study)") is a verb that is composed of noun (e.g. "勉強(study)") and a generic verb "suru (する(do))".

neighboring words of Japanese functional expressions. For example, the system detect a difficult Japanese functional expression “うにも” in the sentence “旅行しようにも時間がない。” and simplify it with an easy functional expression “たくても”. The conjugation rule of the verb that appears before “たくても” is different from “うにも”. That is to say, “たくても” is followed by “masu” form of the verb, while “うにも” is followed by volitional form of the verb. Therefore, we also need to replace the Japanese verb “旅行しよ” (volitional form) with “旅行し” (masu form) to avoid grammatical errors in the simplified sentence. Given this, we manually created verb conjugation form replacement rules for simplifying some Japanese functional expressions, as shown in Table 9.

No	Example sentences	Difficulty Level
1	Input: 宿題が多くて、遊ぼ**うにも**遊べない。 (I have so much homework that I can’t go out to play.) Output: 宿題が多くて、遊びたくても遊べない。	N1 N4
2	Input: 彼女は仕事を手抜きする**きらいがある**。 (She tends to neglect some of her duties in her work.) Output: 彼女は仕事を手抜きする傾向がある。	N1 N3
3	Input: 英語は**言わずもがな**、スペイン語もできる。 (He can speak English, too, to say nothing of Spanish.) Output: 英語は言わないほうがいい、スペイン語もできる。	N1 N5
4	Input: 玄関を出る**や否や**、急に雨が降り出した。 (As soon as I went out the door, it began to rain.) Output: 玄関を出るとすぐ、急に雨が降り出した。	N1 N4
5	Input: 宿題をやら**ないかぎり**、遊びに行ってはいけません。 (You can’t go out to play until you finish your homework.) Output: 宿題をやらなければ、遊びに行ってはいけません。	N2 N4

Note: In the sentences, difficult Japanese functional expressions are in bold, while simplified Japanese functional expressions are underlined.

Table 10: Examples of simplified Japanese sentences.

4.3.3 Evaluation

In this section, we evaluate the simplified sentences from the following two main aspects: fluency and readability. We randomly extracted 200 sentences from Japanese functional expressions dictionaries ([29, 39, 40, 88, 103]) with 100 sentences in each level as the evaluation data. For the evaluation of fluency, we invited three Japanese native speakers to check the simplified sentences whether they are natural Japanese sentences. Meanwhile, for the evaluation of readability, we invited three Chinese-speaking JSL learners, one people who has learned Japanese for about one year and two people who have learned Japanese for about one half year. We assumed that they are in JLPT N4/N5 and JLPT N3, respectively. We asked them to read and judge which sentence is easier to understand. Table 10 shows some examples of simplified Japanese sentences. Tables 11 and 12 show the evaluation results of fluency and readability respectively.

Natural sentences	175 (87.5%)
Unnatural sentences	25 (12.5%)
Total	200 (100%)

Table 11: Evaluation results of fluency of the simplified sentences

Easy to understand	165 (82.5%)
Difficult to understand	35 (17.5%)
Total	200 (100%)

Table 12: Evaluation results of readability of the simplified sentences

From Tables 11 and 12, we can see that 87.5% original sentences are naturally simplified and 82.5% simplified sentences are really easy to understand. One cause is likely because we created conjugation replacement rules for some difficult Japanese functional expressions.

4.3.4 Discussion

There are four reasons why causes simplification failure.

The first one is lack of appropriate simplified functional expressions or phrases. For example, “理解しうる” contains a functional expression “うる(possible)” with the difficulty level of N2. However, no corresponding simplified functional expressions or phrases for the functional expression “うる” has been found in the current “Simple Japanese Functional Expression Replacement List”. This case is difficult to be coped with lexical simplification.

The second one is the Japanese functional expressions with one or more meanings. For example, the Japanese functional expression “言わずもがな” has two meanings: 1) should rather be left unsaid; 2) need not be said. In our “Simple Japanese Functional Expression Replacement List”, we can only find one simplified phrase corresponding to the Japanese functional expression “言わずもがな”. In our “Simple Japanese Functional Expression List”, we only considered one meaning of the Japanese functional expression “言わずもがな” and created its corresponding simplified phrase. Therefore, the simplified sentence “英語は言わないほうがいい、スペイン語もできる。” in Table 10 has not kept the similar meaning with its original sentence, which is difficult to understand for JSL learners.

The third one is that redundancy causes unnatural sentences. The simplified sentence “玄関を出るとすぐ、急に雨が降り出した。” in Table 10 is an example of redundancy. In the Japanese functional expression “とすぐ”, “とすぐ” is redundant and can be omitted. The Japanese functional expression “とすぐ” contains words “すぐ” which have the similar meaning with the word “急に”, which generated a redundant simplified sentence.

The last one is lack of sufficient vocabulary knowledge, which is the main reason for generation of unreadable sentences. Learners in beginning levels (N4/N5) and lower intermediate level (N3) felt that it is difficult to read and understand the simplified sentences because there are still some difficult words in the simplified sentences although the difficult functional expressions have been simplified. It

would be better to simplify both difficult words and difficult functional expressions in our future work.

4.4 Summary

In this chapter, we claim that detecting functional expressions is an important and difficult task in Japanese NLP. To fulfill this task, we applied a character-based BiLSTM-CRF model to automatically detect Japanese functional expressions. Comparing to the word-based CRF model we trained for ***MeCab***, this model can better detect Japanese functional expressions, especially Japanese functional expressions with misspelling. In addition, we reported a small-scale experiment of simplifying example sentences containing difficult Japanese functional expressions. Using a "Simple Japanese Functional Expression Replacement List" we constructed in Section 3.2.2 and conjugation replacement rules of some Japanese functional expressions we manually created in Section 4.3.2, example sentences containing difficult Japanese functional expressions are well simplified for JSL learners. We believe that the simplified sentences are helpful for JSL learners in studying Japanese functional expressions.

Chapter 5

5. Example Sentence Suggestion

In this chapter, we describe two tasks for example sentence suggestion: sentence readability evaluation and sentence clustering. We first introduce the background in Section 5.1. We propose our method for the readability evaluation of example sentences containing Japanese functional expressions in Section 5.2. We introduce how to cluster example sentences containing Japanese functional expressions with the same meaning in Section 5.3. The summary is made in Section 5.4.

5.1 Introduction

It is fairly challenging for a foreign language learner to read and understand texts containing words of high difficult levels or low frequency and complicated linguistic structures. The selection of appropriate reading material matching the learners' individual capabilities is highly likely to enable language learners to read in a more focused and selective manner. To support JSL learners in gathering useful information from texts effectively, certain online public Japanese reading-assistance systems such as ***Reading Tutor*** and ***Asunaro*** we mentioned in Section are developed. However, these systems have not considered the different learners' native language background. Learning materials are provided by these systems without taking account of the readability for JSL learners. Moreover, these systems provide JSL learners with limited information on the difficulty levels of all the various types of Japanese functional expressions, which learners actually intend to learn as a part of the procedure for learning Japanese.

In this study, we adopt ***SVMrank*** to evaluate the readability of example sentences, using Japanese-Chinese common words as an important feature. Moreover, we clustered the example sentences containing Japanese functional expressions

with the same meaning based on parts-of-speech, conjugated forms and semantic attributes, using k-means clustering algorithm.

5.2 Sentence Readability Evaluation

5.2.1 Motivation

Enhancing reading capability is one of the important purposes in second foreign language teaching and learning. There are various factors that impact learners' reading comprehension. A few of these factors involve the learners' vocabulary knowledge, grammar knowledge, reading strategies, interest, attitude and motivation ([15, 23, 37]). Reading comprehension is also influenced by the readability of the reading material. Texts containing highly demanding vocabulary words and complex sentence structures are likely to disturb the learners' reading comprehension.

For Chinese-speaking JSL learners, an important challenge is to study a large number of functional expressions with different meanings and usages. Providing appropriate example sentences for JSL learners based on their individual Japanese language abilities are highly likely to aid the enhancement of the efficiency of learning various Japanese functional expressions.

One of our goals in this work is to develop a Japanese functional expression learning system which can provide appropriate example sentences for each JSL learner so that they can understand the meanings and usages of Japanese functional expressions easily. To achieve this goal, we need to evaluate the sentence readability first.

5.2.2 Features Selection

In our work, we applied the support vector machine for ranking (***SVMrank***) algorithm, which transforms ranking into a pair-wised classification problem and uses a SVM for learning to rank the example sentence pairs. To estimate the readability of example sentences, we adopt a publicly available implementation

named ***SVMrank*** ([31]) for training a SVMrank model. We employ the following 14 features as the baseline feature set:

- Numbers of N0[30] and N1–N5 Japanese words in a sentence
- Numbers of N1–N5 Japanese functional expressions in a sentence
- Length of a sentence
- Numbers of verbs in a sentence
- Numbers of syntactic dependencies in a sentence

We follow the JLPT standard regarding the difficulty level of Japanese words and Japanese functional expressions. For Japanese words, we referenced some Japanese vocabulary books ([94, 95, 96, 97, 104]) and online Japanese language learning websites[31,32], all of which provide the Japanese vocabulary list for the JLPT ranging from N1 to N5. The final Japanese vocabulary list contained a total of 17,506 words (7,392 N1 words; 3,573 N2 words; 3,742 N3 words; 1,675 N4 words; 1,124 N5 words). We define the difficulty level for Japanese functional expressions in the same way as we do for Japanese vocabulary words, using the "Japanese Functional Expressions List" we constructed in Section 3.2.1. Longer example sentences tend to be more difficult to read and understand. We calculated sentence length (disregarding punctuations) after word segmentation using ***MeCab***. Verbs used in a sentence can also be considered as a significant factor that affect the sentence readability. We also calculated the numbers of verbs in a sentence after word segmentation using ***Mecab***. The last feature is used to measure the syntactic readability of a sentence. We used a well-known Japanese dependency structure analyzer named ***CaboCha*** to divide an example sentence into base phrases (called bunsetsu in Japanese) and to obtain its syntactic dependency structure. For example, the example sentence "彼は人生に満足して死んだ。(He

[30] Here, N0 implies unknown words in the JLPT vocabulary list

[31] http://www.tanos.co.uk/jlpt/skills/vocab/

[32] https://japanesetest4you.com/flashcard/category/learn-japanese-vocabulary/

died content with his life.)" is divided into four phrases: "彼は", "人生に", "満足して", "死んだ". In this sentence, the first and the third phrases depend on the fourth phrase, and the second phrase depend on the third phrase. Therefore, the numbers of syntactic dependencies in this sentence is 3.

In the Japanese vocabulary list for the JLPT, many Japanese-Chinese common words are classified at difficult levels (N2 or N1) without considering the differences in the learners' mother tongues. Rather than adopting the standard of difficulty level evaluation from the JLPT, we separately categorized the Japanese words in the "Japanese-Chinese Common Word List" as a new level, and labelled them as J-C. For type D words, we followed the standard difficulty levels of the JLPT. Our hypothesis was that an example sentence containing a higher number of N3–N5 words, N3–N5 Japanese functional expressions, and Japanese-Chinese common words of type I or S would be easier for Chinese-speaking JSL learners to read and understand. Therefore, we combined the following new feature with the baseline features (all 15 features), forming our feature set.

- Numbers of J-C common words of type I or S in a sentence

5.2.3 Experimental Settings

We first collected 5,000 example sentences from the ***Tatoeba***, ***Hiragana Times*** and ***BCCWJ*** corpora. We then randomly paired them and constructed 2,500 sentence pairs. Fifteen native Chinese-speaking JSL learners were invited to read the pairs of example sentences and then choose the example sentence that was easier to understand. The participants had been studying Japanese for approximately one or half a year. Regarding their Japanese language proficiency level, seven were beginners (N4 level) and eight were intermediate level (N3 level) based on the JLPT. We asked three learners to compare each pair of example sentences and the final decision was made by majority voting. We finally applied a set of five-fold cross-validations to each combination of 4,000 sentences as the training data and 1,000 sentences as the test data.

5.2.4 Results

Table 13 shows the experimental results using the baseline feature set and our feature set.

Features	Accuracy (%)					Average (%)
	1	2	3	4	5	
Baseline	83.2	83.4	81	82.4	83.2	82.64
Baseline + H	87.2	86.2	85.8	84	85.4	85.72

Note: In this Table, ***H*** *indicates the feature: numbers of J-C common words of type I or S in a sentence.*

Table 13: Experimental results using the baseline feature set and our feature set

According to the experimental results shown in Table 13, our feature set "Baseline + H" achieved a higher average accuracy of 85.72%, significantly outperforming the average accuracy of the baseline feature set by 3.08%. The experimental results demonstrate the effectiveness of our feature set when considering Japanese-Chinese common words. We applied this model to rank the example sentences in the order of increasing difficulty level and select example sentences from the ***Tatoeba***, ***Hiragana Times*** and ***BCCWJ*** corpora that are easy for Chinese-speaking JSL learners to read and understand.

5.3 Sentence Clustering

5.3.1 Motivation

Some Japanese functional expressions reflect two or more different meanings. For example, the following two example sentences contain the identical Japanese functional expression "そうだ", but they have different meanings. We can distinguish

the meaning of “そうだ” through POS and conjugation forms of the words that appear just prior to the functional expression “そうだ”.

雪が降り**そうだ**。 (**It looks like** it will snow.)
雪が降る**そうだ**。 (**I’ve heard that** it will snow.)

We hoped our system to be able to suggest example sentences containing Japanese functional expressions with the same meaning, so that the learners can grasp the meaning and the usage of the Japanese functional expression without mixing up its meaning.

5.3.2 Features Design

To collect example sentences that contain a particular Japanese functional expression with a given meaning, we used the k-means clustering algorithm. K-means clustering is a type of unsupervised learning, which is used when you have unlabeled data (i.e., data without defined categories or groups). The goal of this algorithm is to find groups in the data, with the number of groups represented by the variable K. The algorithm works iteratively to assign each data point to one of K groups based on the features that are provided. For the clustering features, we utilized the following feature set:

- part-of-speech
- conjugation form
- semantic attribute

For the information about part-of-speech and conjugation form, we referenced the IPA dictionary (mecab-ipadic-2.7.0-20070801) because it contains POS information about each Japanese word. For the information about semantic attribute, we referenced a Japanese thesaurus, Bunrui goihyo (Revised and Enlarged Edition) [55] which is a collection of Japanese words classified and arranged by their meanings, comprising approximately 100K words. We only referenced the semantic attribute information about the Japanese nouns. We focused on parts-

of-speech, conjugation forms and semantic attributes of the words that appear before or after the target Japanese functional expression.

5.3.3 Experimental Settings

In this experiment, we used ten different types of Japanese functional expressions as examples. To assemble the data, we collected ten example sentences for each functional expression from the Japanese functional expression dictionaries; these were annotated as references. Then, for each functional expression, twenty unannotated example sentences were collected from the ***Tatoeba***, ***Hiragana Times***, and ***BCCWJ*** corpora and used as the test data. We applied the k-means clustering algorithm to each set of functional expressions (thirty sentences each), setting the number of clusters ranged from four and six.

5.3.4 Results

The clustering result was evaluated based on whether the test sentences in each cluster shared the same meaning and usage of the Japanese functional expression. The experimental results are shown in Table 14. The average accuracy values for cluster numbers ranging from four to six are 90.4%, 92.9%, 92.6%, indicating the usefulness of our sentence clustering method.

5.4 Summary

In this chapter, we have proposed approaches to suggest appropriate example sentences that are easy to understand for Chinese-speaking JSL learners. We first applied ***SVMrank*** to evaluate the example sentence readability, especially using Japanese-Chinese common words as an important feature. Furthermore, we used the k-means clustering algorithm to cluster the example sentences containing Japanese functional expressions with the same meaning, based on parts-of-speech, conjugated forms and semantic attributes. The experimental results have demonstrated the effectiveness of our proposed approaches.

Japanese Functional Expressions	Difficulty Level	Accuracy (%)		
		k=4	k=5	k=6
いわずもがな (should rather be left unsaid / needn't be said)	N1	93	93	93
かぎりだ (for this time / extremely)	N1	100	100	100
かたわら (by the side of / besides)	N1	87	93	93
につき (about / because of / every)	N2	80	83	83
しだい（だ） (as soon as / depends on)	N2	93	93	93
とともに (together with / at the same time)	N2	87	97	87
にしたがって (obey / as)	N3	97	97	97
にたいして (to / every / in contrast to)	N3	87	93	93
そうだ (it looks like / it's heard that)	N4	97	97	97
ため（に） (because / in order to)	N4	83	83	90
Average (%)		90.4	92.9	92.6

Table 14: Experimental results of example sentence clustering

Chapter 6

6. Automatic Error Correction

In this chapter, we define a new task of correcting spelling and grammatical errors on Japanese functional expressions. We first briefly introduce the background of automatic error detection/correction on Japanese functional expressions in Section 6.1. Section 6.2 describes the method for generating artificial error data. In section 6.4, we explain a character-based neural sequence-to-sequence (seq2seq) model for error correction. We conducted the experiments using neural machine translation in Section 6.4 and analyzed the experimental results in Section 6.5. The summary is made at the last section.

6.1 Introduction

The Japanese Language has various types of functional expressions. When learning Japanese functional expressions, a learner must study their meanings, usages and written forms. Because functional expressions tend to have multiple meanings and complicated usages in various situations, spelling and grammatical errors are often made by JSL learners when they use Japanese functional expressions in their writings.

We observed some example sentences in ***Lang-8 Learner Corpora*** and summarized some typical types of spelling and grammatical errors of Japanese functional expressions, including word selection error (S), missing word error (M), redundant error (R), and word spelling error (W). Some example sentences of grammatical errors are shown in Table 15. Much previous research has paid special attention to the automatic detection of Japanese functional expressions ([41, 75, 78, 83, 90]) while relatively few grammatical error correction applications have

been developed to support JSL learners. Given this situation, automatic grammatical error correction of sentences written by JSL learners is essential in Japanese language learning.

Error Type	Example Sentences
word selection error (S)	Incorrect Sentence: 綺麗な日本に行く**ましょう**。 Correct Sentence: 綺麗な日本に行き**ましょう**。 (Let's go to the beautiful Japan.)
missing word error (M)	Incorrect Sentence: このドラマのかげで、やる気をもらいました。 Correct Sentence: このドラマの**おかげで**、やる気をもらいました。 (I got motivated because of this drama.)
redundant error (R)	Incorrect Sentence: 辞職したの後で新しい会社で働きました。 Correct Sentence: 辞職し**た後で**新しい会社で働きました。 (I worked in a new company after retirement.)
word spelling error (W)	Incorrect Sentence: 私にもできるかもしらない。 Correct Sentence: 私にもできる**かもしれない**。 (Maybe I also can do it.)

Note: In the sentences, Japanese functional expressions are in bold, while errors are underlined.

Table 15: Typical examples of spelling and grammatical errors of Japanese functional expressions.

In this study, we define a new task of correcting spelling and grammatical errors on Japanese functional expressions as follows. Given a phrase of a Japanese functional expressions and its neighboring words, our system aims to correct errors inside this phrase. For instance, a phrase "行く**ましょう**。 (Let's go.)" where the Japanese functional expression is in bold will be expected to be corrected as "行

きましょう。”, because the correct usage of Japanese verb conjugation rules in this phrase depends on the Japanese functional expression “ましょう (Let's)”. However, collecting a large number of available real error phrases written by JSL language learners is not easy because of relying on detecting Japanese functional expressions first. To solve this problem, we first detect the Japanese functional expressions using the BiLSTM-CRF model. Next, we extract phrases including Japanese functional expressions as well as their neighboring words for generating artificial error data. For automatic error correction, we utilize a neural seq2seq model to treat spelling and grammatical error correction as a translation process from incorrect character sequences to correct character sequences. We also conduct our experiments with the word-based method as a baseline for comparison.

6.2 Artificial Error Generation

Collecting large-scale real error data written by second language learners is not so easy. To cope with real error data scarcity, several previous studies have proposed effective approaches for generating artificial error data. Foster and Andersen [12] developed a tool to automatically generate artificial errors by substituting, removing, inserting or relocating a correct word in a sentence. Rozovskaya and Roth [69] proposed an artificial error generation method by selectively injecting errors into native sentences based on error distributions in learners' sentences. Irmawati, Shindo and Matsumoto [28] applied a selection process on the native data injected by artificial errors to remove uninformative instances for generating artificial preposition data. Rei, Felice and Yuan [68] proposed two methods for creating error data: using textual patterns learned from an annotated corpus, which can be used to insert errors into correct sentences and treating error generation as a machine translation task, where correct sentences are translated to incorrect sentences.

In this section, we apply our Japanese functional expression detector, which is trained with the BiLSTM-CRF model in Section 4.2 to extract phrases which

include Japanese functional expressions with their neighboring words for generating artificial error data. Our method mainly consists of two steps, as shown in Figure 13.

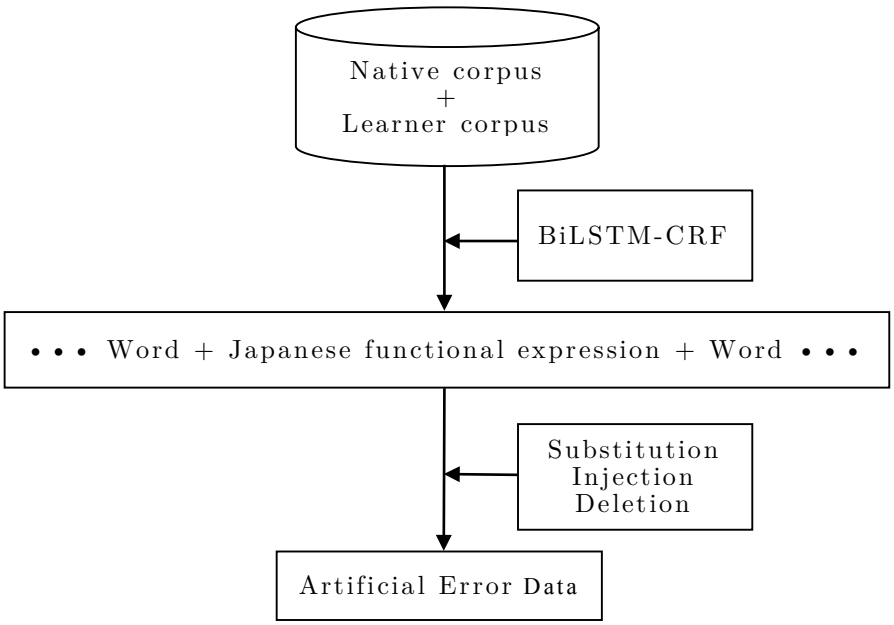


Figure 13: The steps in artificial error generation

In Step 1, we first extracted real error phrases from the ***Lang-8 Learner Corpora*** using the BiLSTM-CRF model. As the results, we extracted total 609 real error phrases. According to our observation, every real error phrase contains only one grammatical error or one spelling error on Japanese functional expression. Since the data of real error phrases is very small, which is not far from enough for training data, we then extracted phrases in corrected sentences from the ***Lang-8 Learner Corpora***, and native phrases from the ***Tatoeba*** and ***Hiragana Times*** corpora. Table 16 shows several extraction results of phrases of Japanese functional expressions.

In Step 2, we randomly selected 309 real error phrases extracted in Step 1 as the error templates and the remaining 300 real error phrases were used as test

data in our error correction task. We generated artificial error data by using the following three operations to imitate typical errors: Substitution, Injection and Deletion. In particular, we generated artificial error data by imitating the error templates when using injection and deletion operations accounted for the majority. Table 17 shows a few examples of artificial error generation. As the results, we generated 396,663 phrase pairs of artificial error data. The same as the real error phrase, every artificial error phrase also involves only one grammatical error or one spelling error on Japanese functional expression.

・**Substitution**:

This method replaces a correct verb that appear just before a Japanese functional expression with its other conjugated forms.

・**Injection**:

This method injects a redundant character in a Japanese functional expression or in its neighboring word.

・**Deletion**:

This method deletes a character in a Japanese functional expression or in its neighboring word.

Input: あなたは薬を飲ま**なければならない**。 (You must take the medicine.) Output: あなた は 薬 を 飲ま **なければならない** 。 Extracted phrase: 飲ま **なければならない** 。
Input: ラジオを修理する**ために**分解した。 (I took the radio apart to repair it.) Output: ラジオ を 修理 する **ために** 分解 し た 。 Extracted phrase: する **ために** 分解
Input: 彼は天才**かもしれない**。 (He may be a genius.) Output: 彼 は 天才 **かもしれない** 。 Extracted phrase: 天才 **かもしれない** 。

Note: In this table, Japanese functional expressions are in bold.

Table 16: Extraction results of phrases of Japanese functional expressions.

Method	Example
Substitution	Extracted phrase: 飲ま **なければならない** 。 Artificial error data: 飲む **なければならない** 。 飲み **なければならない** 。 飲ん **なければならない** 。 飲も **なければならない** 。
Injection	Extracted phrase: する **ために** 分解 Artificial error data: する **の****ために** 分解
Deletion	Extracted phrase: 多い **おかげで** 彼 Artificial error data: 多い **かげで** 彼

Note: In this table, Japanese functional expressions are in bold, while artificial errors are underlined.

Table 17: Examples of artificial error generation.

6.3 Character-based Neural Seq2Seq Model

In this study, spelling and grammatical error correction is treated as a translation task from incorrect phrases into correct phrases. Based on empirical observation, correcting spelling and grammatical errors on Japanese functional expressions can be mainly seen as substitution, injection, deletion operations of characters. The character-based translation process is a natural choice to handle this task. In the meanwhile, the word-based process will suffer from the sparsity of error types, especially when facing the real data. Therefore, we proposed a character-based neural seq2seq model for the task of correcting grammatical errors on Japanese functional expressions. We also perform the word-based process as a baseline for comparison.

The neural seq2seq model consists of two main pieces: an encoder that processes the input and a decoder that generates the output. Both the encoder and the

decoder are recurrent neural network (RNN) layers that can be implemented using a vanilla RNN, a Long Short-term Memory (LSTM), or a gated recurrent unit (GRU).

In the basic seq2seq model, the encoder processes the input sequence into a fixed representation that is fed into the decoder as a context. The decoder then uses some mechanism to decode the processed information into an output sequence. The basic architecture is shown in Figure 14 ([6, 82]). In this study, we trained a 2-layer LSTM seq2seq model with 128-dim hidden units and embeddings for 12 epochs. We used a drop value of 0.2.

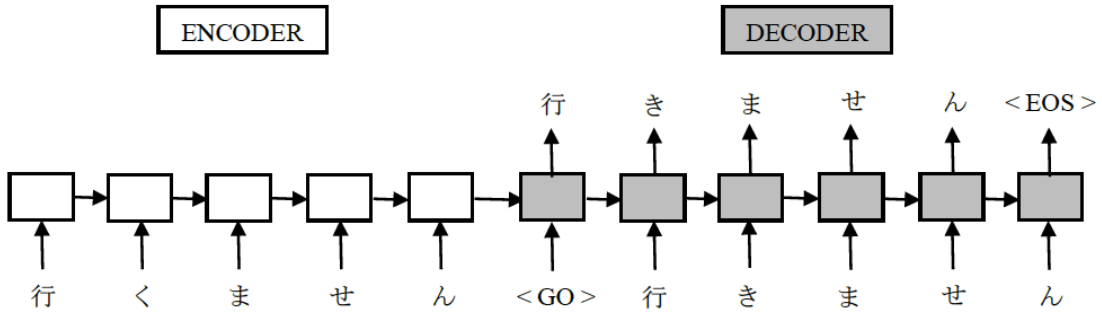


Figure 14: The basic architecture of seq2seq model

6.4 Experimental Settings

As mentioned in Section 6.2, we ultimately got 396,663 artificial error phrase pairs. In the first experiment, we used 326,663 phrase pairs for training data, 35,000 phrase pairs for development data, and 35,000 phrase pairs for test data. In the final experiment, we used the remaining 300 real error phrase pairs mentioned in Section 6.2 for another test data.

In both experiments, we proposed two methods: one is the word-based method where the input phrase is split to word sequences, the other is character-based method where the input phrase is split to character sequences. We performed the word-based method as a baseline for comparison.

6.5 Results and Analysis

In this section, we evaluate our error correction model in both the artificial data and the real data. As we described in Section 5, the generation of the artificial data is based on 309 error templates. It suggests that the error types in the artificial test data are relatively more overlapped to the training data, compared to the real situation. For this reason, we perform the experiment with 300 real error data, which contain more unseen error types. The results can fairly reflect the generalization ability of our model.

As evaluation metrics, we use precision, recall and F_1-score based on words and characters. Table 18 shows the final experimental results of spelling and grammatical error correction tested both on artificial error data and real error data. According to the results, the character-based method achieved much higher F_1-score than the word-based method both on artificial error data and real error data, indicating that the character-based neural seq2seq model is more effective than the word-based neural seq2seq model. When using the character-based method, we also got a higher F_1-score tested on the artificial error data than real error data. As expected, the real test data results are lower than the artificial test data. The real test data contains more unknown error types, which provides a more practical and meaningful evaluation.

Data	**Method**	**Precision**	**Recall**	**F_1-score**
Artificial error	word-based	71.86%	71.74%	71.80%
	character-based	94.20%	93.98%	94.09%
Real error	word-based	63.88%	63.67%	63.77%
	character-based	92.25%	87.33%	89.72%

Table 18: Experimental results of automatic error correction on Japanese functional expressions.

Some examples of system results tested on real data are shown in Table 19. On primary cause of deterioration of F_1-score using the word-based method is that the system wrongly corrected the neighboring words into other words, such as examples 1–4 and examples 6–8 in Table 19, although the system was able to correct Japanese functional expressions. Similarly, the errors occurred when using the character-based method, such as examples 6 and 8 in Table 19. Additionally, the failure of detecting grammatical errors also caused errors, such as the example 5 when using the word-based method and example 7 when using the character-based method.

6.6 Summary

In this section, we proposed an automatic spelling and grammatical error correction on Japanese functional expressions. We applied the BiLSTM-CRF model we trained in Section 5 to automatically detect Japanese functional expressions and extract phrases which include Japanese functional expressions as well as their neighboring words as the correction targets. Considering the real error data is insufficient, we generated artificial error data via substitution, injection, deletion of characters in correct data. To do error correction, we utilized neural machine translation, to train a word-based seq2seq model and a character-based seq2seq model, respectively. The experimental results indicated that the character-based method achieved much higher F_1-score than the word-based method.

No.	Word-based		Character-based
1	input	助ける **ましょう** ！	助 け る **ま し ょ う** ！
	output	閉じ ましょう ！(×)	助 け **ま し ょ う** ！(o)
2	input	員 のかげで 、	員 の か げ で 、
	output	呼びかけ **のおかげで** 、(×)	員 **の お か げ で** 、(o)
3	input	飾る **のために** 、	飾 る **の た め に** 、
	output	助ける **ために** 、(×)	飾 る **た め に** 、(o)
4	input	思い浮かぶ かもしりません 。	思 い 浮 か ぶ か も し り ま せ ん 。
	output	近い **かもしれません** 。(×)	思 い 浮 か ぶ **か も し れ ま せ ん** 。(o)
5	input	直せ **ないといけません** ね	直 せ **な い と い け ま せ ん** ね
	output	直せ **ないといけません** ね (×)	直 さ **な い と い け ま せ ん** ね (o)
6	input	する **後に** 埃	す る **後 に** 埃
	output	し **た後に** 眠く (×)	し **た 後 に** 資 (×)
	gold result	し **た後に** 埃	し **た 後 に** 埃
7	input	探せ **ないといけません** 。	探 せ **な い と い け ま せ ん** 。
	output	とら **ないといけません** 。(×)	探 せ **な い と い け ま せ ん** 。(×)
	gold result	探さ **ないといけません** 。	探 さ **な い と い け ま せ ん** 。
8	input	それの **ために** 流行	そ れ の **た め に** 流 行
	output	それの **ために** 通り過ぎ (×)	そ れ **た め に** 行 眠 (×)
	gold result	その **ために** 流行	そ の **た め に** 流 行

Note: In this table, the Japanese functional expressions are in bold, while errors are underlined.

Table 19: Examples of system outputs tested on real error data.

Chapter 7

7. Japanese Functional Expression Learning System

This chapter describes the development of a computer-assisted language learning system that helps Chinese-speaking JSL learners to study Japanese functional expressions. Section 7.1 describes in detail the system design including the main processes and featured functions. In Section 7.2, we report a preliminary user study involving some Chinese-speaking JSL learners.

7.1 System Design

As we discussed earlier in Chapter 1, Japanese functional expressions are more challenging for Chinese-speaking JSL learners to study and. Moreover, current online Japanese language learning systems provide JSL learners with limited information about Japanese functional expressions. Therefore, we have an attempt to develop ***Jastudy***[33], a computer-assisted Japanese functional expression learning system for Chinese-speaking JSL learners. The main processing stages and the featured functions of this system will be presented in the following section 7.1.1 and section 7.1.2, respectively.

7.1.1 Main Processes

As shown in Figure 15, the general architecture of ***Jastudy*** follows the main processes including detection and simplification of Japanese functional expressions, sentence readability evaluation and sentence clustering.

[33] http://jastudy.net/

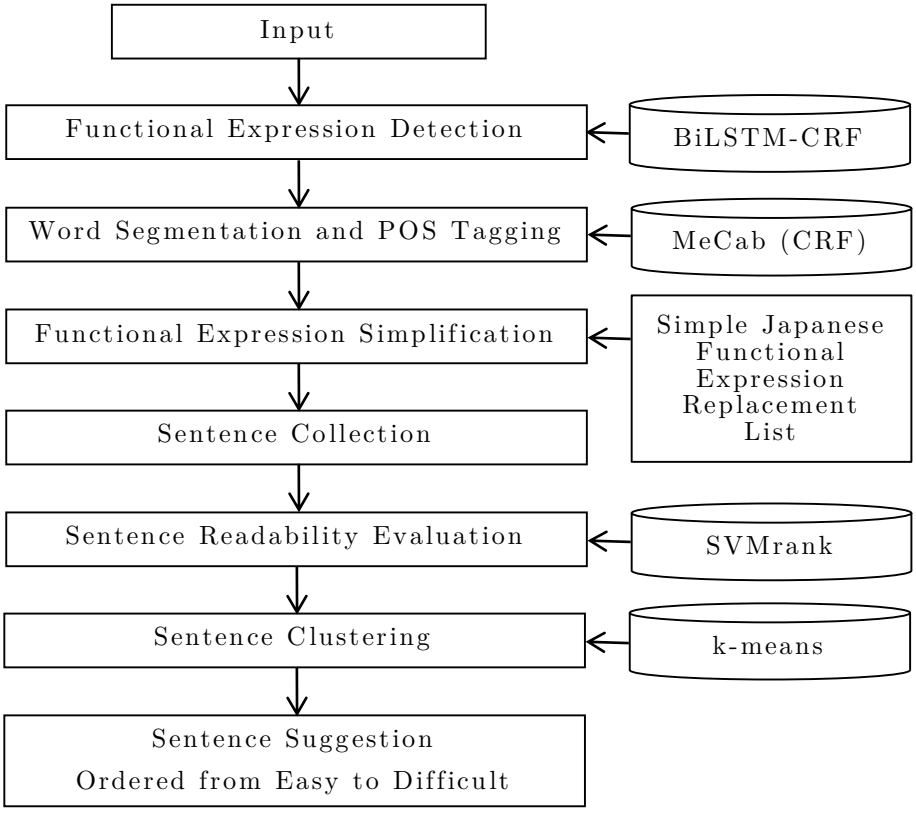


Figure 15: The main processing stages of the system

- **Detection and simplification of Japanese functional expressions**: Given a Japanese sentence as an input, ***Jastudy*** automatically detects Japanese functional expressions using the BiLSTM-CRF model. The input sentence is also segmented and POS tagged by a Japanese morphological analyzer ***MeCab***, trained with a CRF model. In the meanwhile, difficult Japanese functional expressions (difficulty levels of N1 and N2) in the input sentence are simplified by easier functional expressions (difficulty levels of N3 and below) or phrases, using the "Simple Japanese Functional Expression Replacement List" we constructed in Section 3.2.2.
- **Sentence readability evaluation**: The readability of example sentences collected in ***Jastudy*** are evaluated by ***SVMrank***, using Japanese-Chinese common words as an important feature.

- **Sentence clustering**: The example sentences containing the Japanese functional expressions with the same meaning are clustered based on the following features: parts-of-speech, conjugation forms and semantic attributes, using the k-means clustering algorithm.

7.1.2 Featured Functions

We have attempted to implement the following featured functions in our Japanese functional expression learning system.

1. Detecting and simplifying Japanese functional expressions. For example, as shown in Figure 16, when a learner inputs a sentence, ***Jastudy*** detects a difficult Japanese functional expression "うにも" " (difficulty level of N1), using a character-based BiLSTM-CRF model. Then ***Jastudy*** replaces "うにも, with an easier functional expression "たくても" (difficulty level of N4) and shows the simplified functional expression in the output sentence.

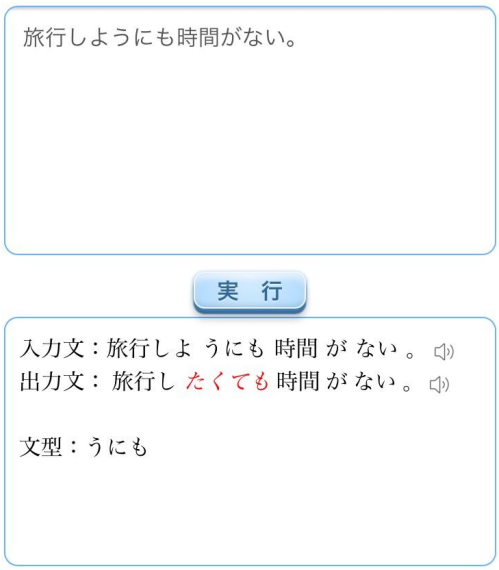


Figure 16: An example sentence "旅行しようにも時間がない。 (I have no time, although I want to travel.)" is typed into the system.

2. Providing JSL learners with detailed results of morphological analyses of the input and output sentences, including reading, part-of-speech, difficulty level and etc. As shown in Figure 17, ***Jastudy*** displays detailed information concerning the morphological analysis results of the input and output sentences, which are POS tagged by ***MeCab***.

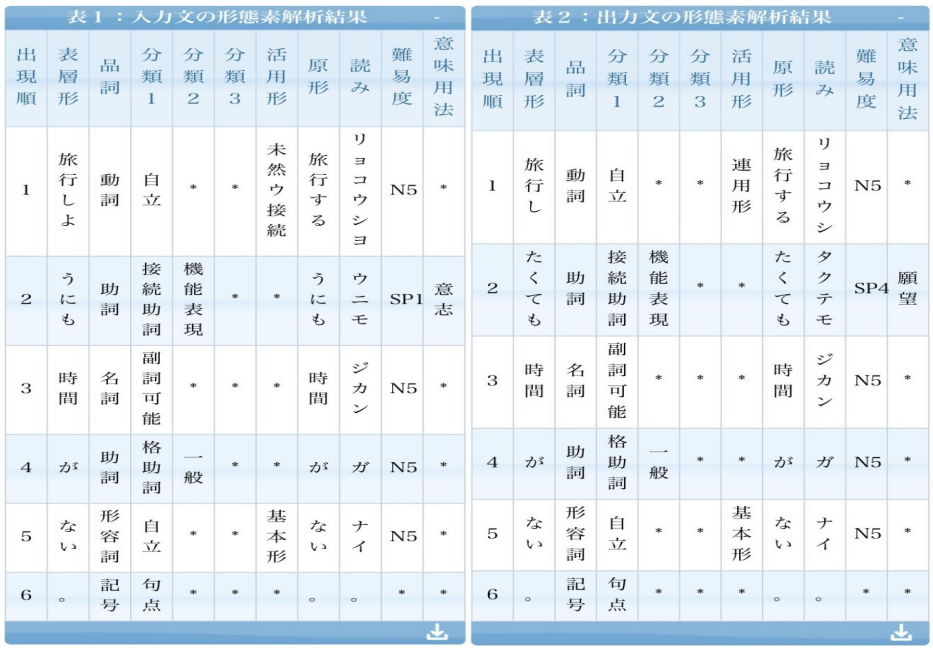


表１：入力文の形態素解析結果

出現順	表層形	品詞	分類1	分類2	分類3	活用形	原形	読み	難易度	意味用法
1	旅行しよ	動詞	自立	*	*	未然ウ接続	旅行する	リョコウシヨ	N5	*
2	うにも	助詞	接続助詞	機能表現	*	*	うにも	ウニモ	SP1	意志
3	時間	名詞	副詞可能	*	*	*	時間	ジカン	N5	*
4	が	助詞	格助詞	一般	*	*	が	ガ	N5	*
5	ない	形容詞	自立	*	*	基本形	ない	ナイ	N5	*
6	。	記号	句点	*	*	*	。	。	*	*

表２：出力文の形態素解析結果

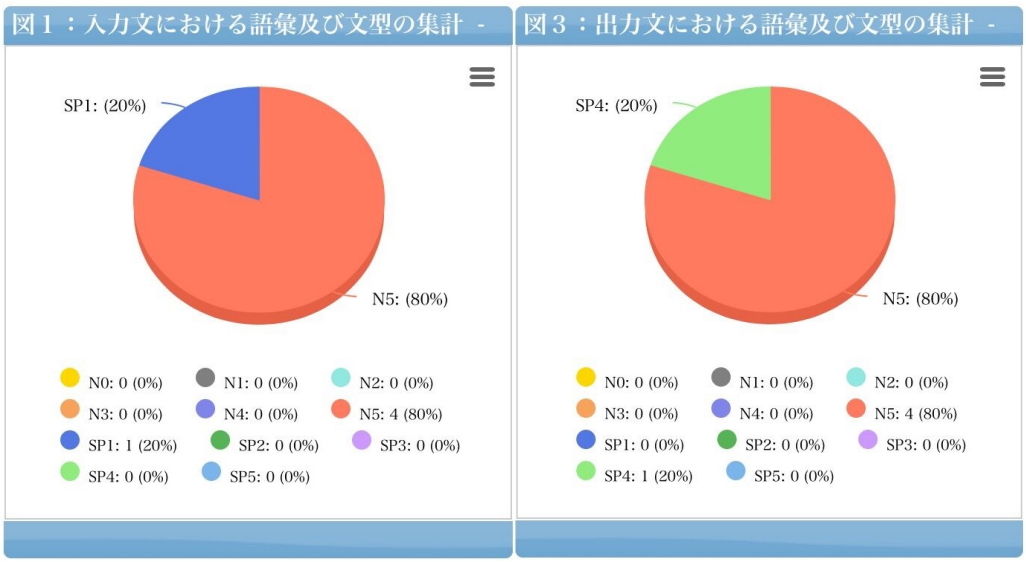
出現順	表層形	品詞	分類1	分類2	分類3	活用形	原形	読み	難易度	意味用法
1	旅行し	動詞	自立	*	*	連用形	旅行する	リョコウシ	N5	*
2	たくても	助詞	接続助詞	機能表現	*	*	たくても	タクテモ	SP4	願望
3	時間	名詞	副詞可能	*	*	*	時間	ジカン	N5	*
4	が	助詞	格助詞	一般	*	*	が	ガ	N5	*
5	ない	形容詞	自立	*	*	基本形	ない	ナイ	N5	*
6	。	記号	句点	*	*	*	。	。	*	*

(a) (b)

Note: In this figure, the input sentence (a) is "旅行しようにも時間がない。" and the output sentence (b) is "旅行したくても時間がない。". Both of them mean "(I have no time, although I want to travel.". The former includes more formal and less frequent functional expression than the latter.

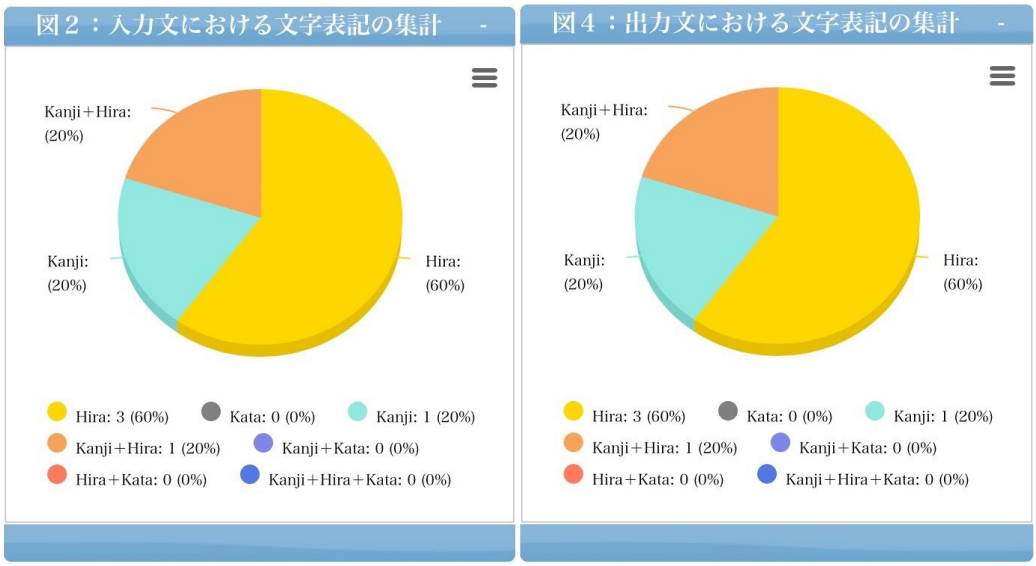
Figure 17:Morphological analysis results of the input (a) and output (b) sentences.

3. Presenting the basic statistics of the input and output sentences, including the distribution of vocabulary and functional expressions, as shown in Figure 18, and the character-type distribution, as shown in Figure 19.



(a) (b)

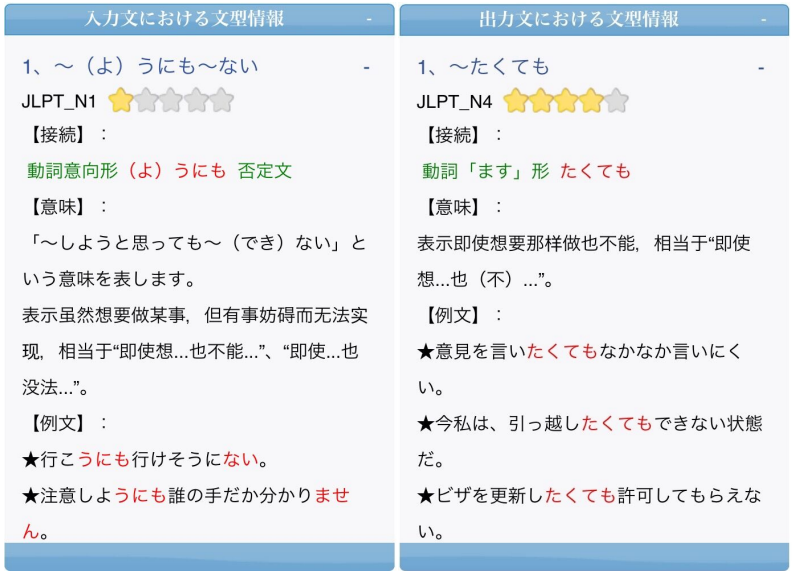
Figure 18: Basic statistics related to the distribution of vocabulary and functional expressions in the input (a) and output (b) sentences shown in Figure 17.



(a) (b)

Figure 19: Basic statistics related to the distribution of character types in the input (a) and output (b) sentences shown in Figure 17.

4. Providing learners with detailed information and example sentences illustrating the meaning and usage of the Japanese functional expressions in the input and output sentences, respectively, as shown in Figure 20. Moreover, based on their individual Japanese language abilities, learners can select the Japanese functional expressions for further study by clicking the buttons labelled with difficulty levels (from N5 to N1).



(a) (b)

Figure 20: Detailed information about Japanese functional expressions appears in the input (a) and output (b) sentences shown in Figure 17.

5. Suggesting comprehensive example sentences. JSL learners who wish to search more example sentences can use any of the three following methods: keyword, meaning, or both keyword and meaning. For example, if the learner types the Japanese functional expression "そうだ" as the keyword and selects its meaning "伝聞 (I've heard that)" from the drop-down list, a list of example sentences containing the functional expression sharing the same meaning is retrieved from the corpus, as shown in Figure 21. These example sentences are collected through

clustering by the k-means clustering algorithm. Only sentences whose difficulty is equal to or below the learner's level are retrieved.

Figure 21: Example sentences suggested by the system, given the input "そうだ" which means "伝聞 (I've heard that)".

7.2 Preliminary Learner Use of the System

In this section, we conducted a preliminary questionnaire survey of JSL learners to evaluate the learning effect of the Japanese functional expressions and gather feedback from learners using ***Jastudy***.

7.2.1 Participants

In our work, eighteen Chinese-speaking JSL learners, all graduate students from the same institution as the author, were invited to participate. Participants ranged in age from 23 to 31 years, and the average age was 25.4. Among the participants, fourteen were male and four were female, and they had different

research backgrounds (information science, bioscience, material science). All the participants were divided into three groups, with six learners in each group consisting of beginning, intermediate and advanced learners, who were studying at levels at N4–N5, N2–N3 and level N1 of the JLPT, respectively.

7.2.2 Procedure

We administered three questionnaires (for the beginning, intermediate and advanced learners) to examine how helpful ***Jastudy*** was in assisting JSL learners in studying Japanese functional expressions. Each questionnaire included ten example sentences extracted from the ***Tatoeba***, ***Hiragana Times*** and ***BCCWJ*** corpora. Each example sentence contained one Japanese functional expression with different difficulty levels (levels N4–5 for beginning learners, levels N2–N3 for intermediate learners and level N1 for advanced learners) in JLPT. For each questionnaire, the participants were subdivided into two groups with three participants in each group. One group was told to use a paper Japanese functional expressions dictionary ([29]), and the other group used ***Jastudy*** to compose a Japanese sentence using the Japanese functional expression in each question. The time spent for completing the questionnaire was measured and recorded in seconds.

7.2.3 Evaluation on the Sentence Composition Results

The results of the three questionnaires are shown in Tables 20–22. The letters A, B, C, D, E and F denote the six participants. The results indicate that it takes less time to compose an example sentence when using ***Jastudy*** than when using the paper dictionary, especially for the intermediate and advanced learners.

7.2.4 Evaluation on the Learning Effect

We evaluated the learning effect of studying Japanese functional expressions by examining the example sentences they composed in the three questionnaires. The examinations were conducted by three Japanese language teachers, all of whom have more than ten years of experience teaching Chinese-speaking students learn-

ing Japanese. All the composed example sentences were shown to the three educators, who assigned a score of 0, 1 or 2 to each composed example sentence, where a 0 denotes an incorrect sentence, a 1 denotes an acceptable but imperfect sentence and a 2 denotes a correct sentence.

The three educators were asked to focus on two aspects of the composed sentences when assigning scores. The first aspect assessed whether the composed example sentence was natural and grammatically correct in Japanese. For example, the composed sentence, “風が吹きています。 (The wind is blowing.)”, is considered an incorrect sentence because it contains a grammatical error in the conjugation form of a verb (underlined in the sentence). The other aspect assessed whether the meaning of the Japanese functional expression in the composed sentence was the same as the Japanese functional expression in the original example sentence. This approach was selected because we wanted the learners to be able to distinguish the different meanings and usages of the Japanese functional expressions. Using this approach, the composed sentence “明日友達とともに公園へ行く。 (I go to the park with my friends tomorrow.)” would be judged acceptable but imperfect because the meaning of the Japanese functional expression “とともに (together with)” in the composed sentence is not the same as the meaning of the Japanese functional expression “とともに (as)” in the original example sentence, which was “彼は年とともに賢くなった。 (He became wiser as he grew older.)”.

The evaluation results are shown in Tables 23–25. The row “total average” presents the overall average scores given by the three evaluators. According to the evaluation results, the total average score is higher for learners using ***Jastudy*** than learners using the paper dictionary, which indicates that our system better assists JSL learners in studying Japanese functional expressions and in composing sentences with Japanese functional expressions.

Group	Using a paper dictionary			Using ***Jastudy***		
	A	B	C	D	E	F
Beginning learners	400	414	427	407	383	405
Average	414			398		

Table 20: Time required by beginning learners to compose sentences (measured in seconds)

Group	Using a paper dictionary			Using ***Jastudy***		
	A	B	C	D	E	F
Intermediate learners	628	639	635	577	584	580
Average	634			580		

Table 21: Time required by intermediate learners to compose sentences (measured in seconds)

Group	Using a paper dictionary			Using ***Jastudy***		
	A	B	C	D	E	F
Advanced learners	802	818	817	775	767	770
Average	812			771		

Table 22: Time required by advanced learners to compose sentences (measured in seconds)

Group	Evaluators	Using a paper dictionary			Using ***Jastudy***		
		A	B	C	D	E	F
Beginning learners	E1	18	16	16	20	18	20
	E2	18	16	16	20	18	20
	E3	18	16	16	20	18	20
Average		18	16	16	20	18	20
Total Average		16.67			19.33		

Table 23: Evaluation of sentences composed by beginning learners

Group	Evaluators	Using a paper dictionary			Using ***Jastudy***		
		A	B	C	D	E	F
Intermediate learners	E1	14	17	14	18	18	20
	E2	16	17	14	18	18	20
	E3	14	17	14	18	18	20
Average		14.67	17	18	20	18	20
Total Average		15.22			18.67		

Table 24: Evaluation of sentences composed by intermediate learners

Group	Evaluators	Using a paper dictionary			Using ***Jastudy***		
		A	B	C	D	E	F
Advanced learners	E1	14	16	14	20	16	18
	E2	14	16	12	20	16	18
	E3	14	16	12	20	16	18
Average		14	16	12.67	20	16	18
Total Average		14.22			18		

Table 25: Evaluation of sentences composed by advanced learners

7.2.5 Discussion

To summarize the above results, ***Jastudy*** shows a substantial advantage both in the time spent and in the learning effect in composing sentences. There are three major reasons for this. First, the system automatically detects the Japanese functional expressions in the input sentence and presents detailed information from bespoke databases regarding the meanings and usages of the Japanese functional expressions as well as appropriate sample sentences. These features successfully enhance the learner's efficiency when studying Japanese functional expressions. The second reason seems to be largely attributable to the feature that retrieves appropriate example sentences containing the Japanese functional expressions. These example sentences are ranked based on their difficulty levels: those that are easier to understand assist the JSL learners to compose similar example sentences. A third possible reason seems to be that the system provides the beginning and intermediate learners with simplified Japanese functional expressions when difficult Japanese functional expressions appear in the input sentence, helping them to understand the meanings and usages of the Japanese functional expressions more quickly.

7.2.6 User Survey

After performing the task, a survey was also administered to the learners to collect valuable feedback that could help shape the further development of our system. The eighteen Chinese-speaking JSL learners who took part in the previous questionnaires, were invited to complete this survey, which asked them to answer several questions. The results of the survey are shown in Table 26.

The participants' opinions from the survey were quite useful in improving our system in future. Most of the participants thought ***Jastudy*** was easy to use. However, a few disagreed, all of whom were beginning learners with less than one year of Japanese learning experience. This result occurred because the system provided instructions only in Japanese, which made it difficult for the beginning learners to understand how to use the system. This highlights the need for system

instructions in Chinese translation so that the learners with low Japanese proficiency levels can use the system easily. All of the participants felt that the example sentences used in the system were easy to understand and that the system was helpful in studying Japanese functional expressions. This encouraging feedback suggested that the participants enjoyed using our system for learning Japanese functional expressions. However, one disadvantage of our system is that it cannot detect those discontinuous Japanese functional expressions such as "も...ば...も (both...and...)"; therefore, some participants reported they were unable to study such Japanese functional expressions through their input sentences.

Other comments from the learners focused mostly on the functions that they hoped the system would improve or to extend. For example, the system allows the learners to input only Japanese sentences. Learners at advanced or intermediate levels could study Japanese functional expressions by inputting Japanese sentences. However, inputting an entire sentence is fairly difficult for beginning learners. Therefore, a feasible alternative would be to allow the learners, especially beginning learners, to input sentences or phrases in Chinese. This approach would help learners find the corresponding Japanese functional expressions they want to study. Moreover, some learners commented that the system was useful for learning Japanese functional expressions, but some example sentences might contain difficult vocabulary words. This highlights the need for the system to provide support for studying Japanese vocabulary as well as Japanese functional expressions. Most of the learners hoped that the system would provide Chinese translations of the example sentences and exercises for Japanese functional expressions. We plan to consider all these issues during the future development of our system.

Question 1: Do you think it is difficult to learn Japanese functional expressions?	
Fairly difficult to learn	16
Difficult to learn	2
Not very difficult to learn	0
Easy to learn	0
Question 2: Is the system easy to use?	
Fairly easy to use	12
Easy to use	2
Not very easy to use	4
Difficult to use	0
Question 3: Are the example sentences easy to understand?	
Fairly easy to understand	15
Easy to understand	3
Fairly difficult to understand	0
Difficult to understand	0
Question 4: Are there any functional expressions that you could not study in the system?	
Yes	14
No	4
Question 5: Is the system helpful in your study of Japanese functional expressions?	
Fairly helpful	17
Helpful	1
Not very helpful	0
Not helpful	0
Question 6: Will you use the system to study Japanese functional expressions?	
I will use it all the time	13
I will use it some of the time	4
I will hardly use it	1
I will never use it	0

Table 26: Results of the learner survey

Chapter 8

8. Conclusion and Future work

8.1 Conclusion

In this thesis, we developed a computer-assisted language learning system, named ***Jastudy***, designed particularly for Chinese-speaking JSL learners with their study of Japanese functional expressions. To accomplish this task, we mainly solved two important challenges: automatic detection of Japanese functional expressions and example sentence suggestion.

To address the first challenge, we manually constructed a "Japanese Functional Expression List" in advance for the task of detection of Japanese functional expressions. Then, we applied a character-based BiLSTM-CRF model to detect various functional expressions from Japanese sentences. We also trained a word-based CRF model as the baseline for comparison. The experimental results show our BiLSTM-CRF model achieved a higher F_1-score, compared with the CRF model. Furthermore, we constructed a "Simple Japanese Functional Expression Replacement List" through manual selection of simplification candidates for Japanese functional expressions with the help of Word2vec and some Japanese functional expression dictionaries. Given a Japanese sentence as an input, ***Jastudy*** detects Japanese functional expressions using the BiLSTM-CRF model and simplifies difficult Japanese functional expressions (difficulty levels of N2 and above). A small-scale experiment was conducted to evaluate the effectiveness of our proposed method for simplifying Japanese functional expressions. The experimental results show that the simplified example sentences are helpful in Chinese-speaking JSL learners' study of Japanese functional expression.

For the second challenge, we first constructed a "Japanese-Chinese Common Word List" for the readability evaluation of example sentences containing Japanese functional expressions. Our hypothesis is that Japanese-Chinese common words sharing the identical or similar meanings are helpful in sentence readability evaluation, because Chinese-speaking JSL learners can straightforwardly understand the meaning of these common words according to Chinese characters. We then utilized a ***SVMrank*** algorithm to evaluate sentence readability, using Japanese-Chinese common words as an important feature. The experimental results show a significant improvement of our feature set compared to the baseline feature set without considering Japanese-Chinese common words. Moreover, to suggest more comprehensive example sentence, we clustered the example sentences containing Japanese functional expressions with the same meaning, based on parts-of-speech, conjugation forms and semantic attributes, using the k-means clustering algorithm.

In addition, we defined a new task of correcting spelling and grammatical errors on Japanese functional expressions. Our method first applied the BiLSTM-CRF model to automatically detect Japanese functional expressions and then extracted phrases including Japanese functional expressions as well as their neighboring words. Due to the lack of real error data, we generated artificial error data via substitution, injection and deletion of characters in correct data. Finally, we used the generated artificial error data to train a character-based seq2seq neural machine translation model. We also trained a word-based seq2seq neural machine translation model as the baseline for comparison. The experimental results indicated that the character-based model outperforms the word-based model both on artificial error data and real error data.

Finally, to evaluate the usefulness of our system, we conducted several questionnaires and reported a preliminary user study involving Chinese-speaking JSL learners. We received positive feedback from Chinese-speaking JSL learners and most of them felt that the system was helpful and they would like to use the system to study Japanese functional expressions.

8.2 Future Work

In recent years, NLP technologies have been widely applied in the area of language education. The application of NLP for educational purpose not only helps in developing efficient educational software systems, but also it is also significant for assisting the progress and improvement in the learning ability of learners based on development and implementation of advanced techniques in educational settings ([1, 71]).

In this work, we demonstrate that the character-based BiLSTM-CRF model can improve the performance of automatic detection of Japanese functional expressions. However, there are some limitations in the present study. For example, one limitation is the detection of the discontinuous Japanese functional expressions such as "も...ば...も(both...and...)". In future work, it is natural to consider if integrating POS information can help in increasing the performance of our learning system. In addition, our current learning system only simplifies the difficult Japanese functional expressions without taking the difficult Japanese vocabulary words into account. A further extension is to apply Japanese-Chinese common words into simplification of example sentences for Chinese-speaking JSL learners. Another limitation is the lack of contextual information. Our current system does not provide contextualized usage of functional expressions, which could be the future enhancement, the current system provides different usages of functional expressions when they have multiple senses and can provide example sentences within their context.

Another important and challenging direction is how to provide Chinese-speaking learners with appropriate example sentences that are easy understand for Chinese-speaking JSL learners. In our work, the experimental results indicate that there is a better improvement on the accuracy of sentence readability evaluation, applying Japanese-Chinese common words as an important feature. We plan to verify if other features (e.g. numbers of Chinese characters in a sentence, average length of syntactic dependencies) can improve the performance of the sentence readability evaluation.

In our current automatic error correction system, we only consider the Japanese functional expression and its neighboring words. In the future, expanding a wider context size might help in correcting more grammatical errors. For example, as we mentioned in previous Section, the Japanese functional expression “そうだ” can be followed by dictionary form of verb or “ます(masu)” form of verb to express different meanings respectively. However, our current system cannot detect and correct error in the following example sentence “天気予報によると、明日は雨が降りそうだ。(According to the weather report, it is going to rain tomorrow.)” where the grammatical error is underlined. In this example sentence, the Japanese functional expression “そうだ” can only be followed by the dictionary form of verb (降る), because its meaning depends on the previous context “天気予報によると (according to the weather report)” , which indicate the meaning of the Japanese functional expression “そうだ” should be “伝聞 (I’ve heard that)” and followed by the dictionary form of verb. Furthermore, our real learners’ error data is very small. It is crucial to collect more real learners’ error data in future.

In summary, we have applied many NLP technologies to develop a computer-assisted language learning system for Chinese-speaking learners with their study of Japanese functional expressions. In the future, development of our learning system will largely concentrate on developing the system’s new functions, such as Japanese vocabulary words learning, computer-assisted translation and etc., that will better assist Chinese-speaking JSL learners to learn Japanese language.

Acknowledgements

First and foremost, I would like to express my deepest gratitude to my supervisor, Professor Yuji Matsumoto, who has provided me with valuable and patient guidance during the whole period of my PhD course in Nara Institute of Science and Technology (NAIST). Although I hardly knew natural language processing and programing language in my master and undergraduate courses, he accepted me as his student without hesitation. His kindness and vigorous academic ability encourage me not only in my research but also in my future study. It is my honor to be a member of Matsumoto Laboratory.

I am also grateful to all the other members of my thesis committee, Professor Kenichi Matsumoto, Associate Professor Masashi Shimbo and Assistant Professor Hiroyuki Shindo for their insight comments and advices on this thesis.

All thanks to the members of Matsumoto Laboratory, especially, Fei Cheng, Lis Pereira, Budi Irmawati, Phan Duc-Anh, Jun Liang, Kodai Sudo, Yuichiro Sawai, Shanshan Liu, Yiran Wang, and Phi Van-Thuy, who gave much help in my study or life. Special thanks to the administrative assistant, Yuko Kitagawa, who helped me a lot on my business trips for international academic conferences. I am also thankful to the staff in International Student Affairs of NAIST. They all gave much help to the international students.

I would also like to thank the anonymous reviewers of international conference/journal for their valuable comments and suggestions that further improved my works. There are also many thanks to all those who allocated their time to complete the online survey and gave positive feedback.

I wish to express my sincere gratitude to the China Scholarship Council (CSC) for giving me opportunity to study for a PhD in Japan. Also thanks to the Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT) for providing me scholarship to complete my PhD course.

Finally, I will not forget to appreciate my family and friends for their support, caring and help. I dedicate my thesis to all of them.

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