Multilingual Translation Support for Web Pages Using Structural and Semantic Analysis

Fuminori KIMURA, Hiroshi URAE, Taro TEZUKA, and Akira MAEDA

***Abstract*—Translating web pages by machine translation is the easiest and fastest way a webmaster can multilingualize his/her web pages. Machine translation, however, often causes unnatural and mistranslated sentences with meanings that webmasters do not intend. Therefore, we propose a method that helps the webmaster to create multilingual web pages while avoiding mistranslations by adding metadata about analyzed sentence structures and word meanings. We have developed a prototype system that implements our proposed method. We evaluate our system and prove that it is able to translate sentences that machine translation mistranslates.**

***Index Terms*—sentence structure analysis, word meaning analysis, machine translation.**

I. Introduction

The World Wide Web has enabled us to access information from across the whole world. However, differences in the languages in which webmasters write the contents of web pages are an obstacle to us accessing all the information on the Internet. To overcome this problem, web pages have been multilingualized in various ways. One of the most precise and natural ways to translate web pages is using a professional translation service. However, this is usually costly, so most webmasters of small businesses or personal web sites cannot use these services. In such cases, they translate web pages in one of the two ways. One is self-translation and the other is automatic translation. Self-translation refers to webmasters translating web pages manually and publishing them by themselves. The translated web pages may have relatively natural sounding sentences, depending on the webmaster's proficiency in the target language. This imposes, however, a burden on webmasters. Automatic translation refers to visitors using web translation services, such as Google Translate[1], and Bing Translator[2]. This does not impose any burden on webmasters. However, it often produces unnatural and mistranslated sentences with meanings webmasters do not intend.

To solve this problem, we propose a new method for supporting translation of web pages that produces natural sentences by analyzing sentence structures and what each word means[1]. This system lightens the burden on webmasters by doing this almost automatically. Webmasters are able to correct the system results if these results contain incorrect sentence structures or word meanings. Then the translated sentences become more precise and natural.

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[1]Google Translate http://translate.google.com/

[2]Microsoft Translator http://www.microsofttranslator.com/

The rest of this paper is organized as follows. First, we describe related works in Section II. After that, we describe two steps of our method ("creating phase", and "viewing phase") in Section III and system implementation in Section IV. Finally, we evaluate our system in Section V, and conclude the paper in Section VI.

II. Related Work

A. Describing Grammar of Several Natural Languages in the Same Way

Recently, it has become clear that only using statistical methods for analyzing natural language is not enough. Thus, there is a trend to combine statistical methods with linguistic theories to analyze natural language more deeply. There are various points of view about what the deep analysis of natural language means. Butt et al. [2] defined it as "not only analysis of relations of modification between the structural elements but also analysis of predicate argument structure." They developed a system that enables grammar of several natural languages to be described in the same way and the natural sentences to be restored from this grammar by deeply analyzing natural language. They use Lexical Functional Grammar (LFG)[3][4] to describe the grammar of several natural languages in the same way. LFG produces two types of structure. One is c-structure and the other is f-structure. C-structure describes sentence structures as trees. F-structure describes sentence structures as a matrix. The languages using c-structure differ greatly. In contrast, the languages using f-structure differ little.

In this paper, we resolve sentences into their elements like f-structure to describe the grammar of several natural languages in the same way.

B. Translation Repair Using Back Translation

"Translation repair" is the method to repair incorrect translations by changing words of original text that may cause incorrect translations. It is, however, difficult to find words of original text that may cause incorrect translations. To solve this problem, Miyabe et al. [5] proposed a method that use back translation. In this method, they estimate the words that make incorrect translations by finding words that differs between original text and the result of back translation. Thus, translators can easily find these words to repair the original text. Repaired text shows that the method is effective to decrease incorrect translations. It imposes, however, a burden on translators that they have to consider new words to replace the words that makes incorrect translations.

In contrast, we propose a method that repairs incorrect translations directly by using the results of analyzing original text. The translator does not have to change the original text, and only has to select what each word means.

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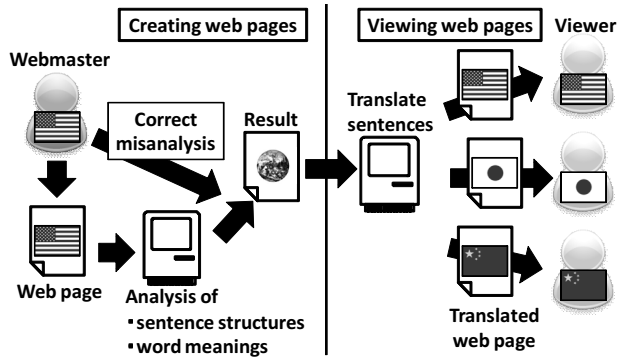

Fig. 1. Outline of the proposed system.

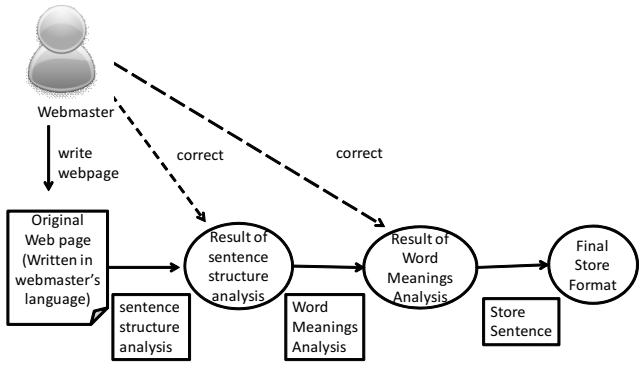

Fig. 2. Processing flow of creating phase.

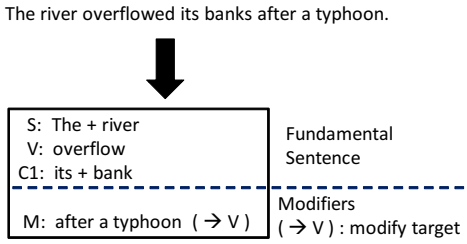

Fig. 3. Example of resolving the rentence "The river overflowed its banks after a typhoon" into a fundamental sentence structure and modifiers.

III. Proposed Method

Our proposed method has two phases:"creating phase" and "viewing phase". The outline of the system is shown in Fig 1.

"Creating phase" is processed when webmaster creates web pages. "Creating phase" has two steps: "analysis of sentence structures" and "analysis of word meanings". The first step is "analysis of sentence structures". In this step, the system performs syntax analysis of the sentences in the web page. The result of syntax analysis is shown to the webmaster. The webmaster is able to correct the result manually, if there are mistakes in the result. The second step is "analysis of word meanings". In this step, the system analyzes meanings of each word in the sentence. This result is also shown to the webmaster, and the webmaster is able to correct the result manually. The results of these two steps are preserved as the structural and semantic indices.

"Viewing phase" is processed when users browse the web page. In "viewing phase", the system translates sentences in the web page using the structural and semantic indexing preserved in "creating phase". The sentences represented by the structural and semantic indexing are translated into the user's native language through three processes: "restoration of fundamental structures", "correction of mistranslations" and "restoration of modifiers".

A. Creating Phase

Creating phase preserves sentence structure and word meanings that are represented by the language-independent format. In order to achieve such aim, the system performs two steps: "analysis of sentence structures" and "analysis of word meanings". This phase aims to reduce mistranslation owing to complexity of sentences, by dividing input sentences into principal elements and modifiers. Fig 2 shows the processing flow of creating phase.

1) Analysis of Sentence Structure: This step consists of two processes. In the first process, the system analyzes sentence structure of the sentences entered by the webmaster, and shows the analysis result to the webmaster. In the second process, the webmaster corrects the result manually, if there are mistakes in the result.

In the first process, the system analyzes sentence structure of the sentences entered by webmaster in order to decompose the input sentences into principal elements and modifiers. In this process, we define that principal elements of sentence are subjects (S), predicates (P), complements or objects (C), and modifiers (M). In this definition, both complements and objects are represented by "C" , because these need not to be distinguished in translating. Modifiers (M) also have information of what element it modifies. We name a sentence that consists only of principal elements as a "fundamental sentence".

Each modifier has metadata by which a principlal element is modified. We use the Apple Pie Parser (APP), which is a tool for analyzing English sentence structures automatically, and our system determines whether each word is a principal element or a modifier. If this determination fails, the webmaster can correct a misanalyzed word manually. For example, suppose we resolve the sentence "The river overflowed its banks after a typhoon" into a fundamental sentence and modifiers. The results are shown in Fig 3.

a) Analysis of Sentence Structure by the System: Analysis of sentence structure is performed by the system automatically. In this paper, we use Apple Pie Parser (APP)[3] which is an English morphological analyzer, since our system assumes English as the input language.

For example, if APP analyzes the sentence "The river overflowed its banks after a typhoon.", APP returns the result "(S (NPL The river) (VP overflowed (NP (NPL its banks) (PP after (NPL a typhoon)))) -PERIOD-)". The result of each pair consists of semantic information and words fall under it. The result of APP is composed of nested parentheses. This nest of parentheses can be regarded as tree structure. Fig. 4 shows the APP result of the above input sentence represented by tree structure.

In some cases, for example a sentence including conjunctions, one sentence has several basic sentence structures. When APP analyzes the sentence "Thank you but I am full.", APP returns the result "(S (SS (VP Thank (NPL you))) but

[3]http://nlp.cs.nyu.edu/app/

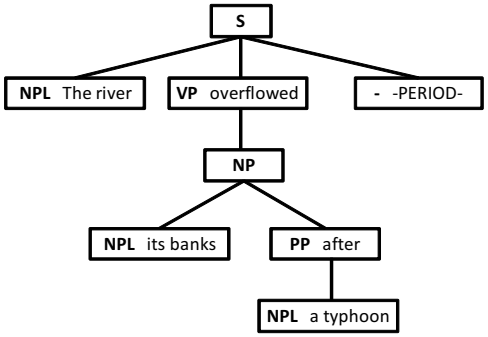

Fig. 4. The analysis result by Apple Pie Parser which is represented by tree structure.

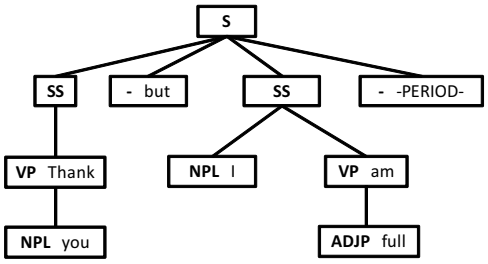

Fig. 5. The analysis result by Apple Pie Parser which is represented by tree structure. (The case that the sentence has several basic sentence structures.)

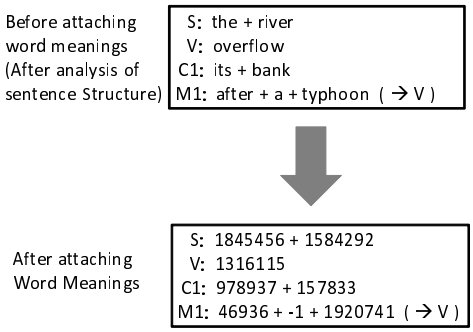

Fig. 6. The example of attaching word meanings in the case of the sentence "The river overflowed its banks after a typhoon".

(SS (NPL I) (VP am (ADJP full))) -PERIOD-)". Fig. 5 shows the result of this sentence represented by tree structure. In these sentences, the result of APP sometimes contains phrase "SS" that is subset of the S in the whole sentence. In this system, we treat each "SS" as one basic sentence structure.

b) Correcting Sentence Structure: The system sometimes mistakes the analysis of sentence structure. In such a case, the webmaster can correct the result of it manually. The webmaster can correct the basic sentence structure of each word and the modified element of each modifier. After the system has finished the analysis of sentence structure, the system proceeds to the step of "attaching word meanings".

2) Attaching Word Meanings: This step consists of two processes: the analysis of word meanings and the correction of them by the webmaster. The purpose of this step is to reduce mistranslations by attaching the meanings to each word in a sentence. The system uses "meaning ID" in order to identify the meaning of each word. We assign a unique ID number for each word meaning. Figure 6 shows the example of attaching word meanings in the case of the sentence "The river overflowed its banks after a typhoon".

The system assigns a meaning ID to each word of a sentence analyzed in "analysis of sentence structure" step. In figure 6, the meaning ID "-1" means that the word is assigned no meaning. The meaning ID "-1" is assigned in two cases; the case that the system cannot select a word meaning because there are no proper meanings for the word in meaning ID database, and the case that the webmaster does not attach word meanings deliberately.

TABLE I
THE EXAMPLE OF MEANING ID LIST IN THE MEANING ID DATABASE.

Meaning ID	Meaning	English	Japanese
157833	a geographic bank	bank	土手, 岸
157844	pile up it something	bank	～を積み上げる ～を山にする
157850	a financial institution	bank	銀行

a) Meaning ID Database: The meaning ID is assigned by referring to the meaning ID database. The meaning ID database is a language resource created from a bilingual dictionary. In our system, we created it from the Japanese-English dictionary "Eijiro[4]". Generally, a word in a dictionary may have several word meanings. This might cause mistranslation, because such a word usually have different translation in a different context. We extract all these word meanings and assign a unique ID number for each of them in order to distinguish each word meaning. Table I shows the example of meaning ID list in the meaning ID database.

Meaning ID is assigned not only to words but also to phrases and idioms. There are two reasons why meaning ID is assigned to them. One reason is to consider special meanings. The meanings of phrases and idioms are not always equal to simply combined meanings of words in the phrases and the idioms. In this case, it is impossible to represent the meanings by combining meanings of words in the phrases and the idioms. Therefore, a unique ID for the meanings of phrases and idioms are needed in order to select proper meanings.

Another reason is to reduce the webmaster's burden. Even if it is possible to represent the meanings of phrases and idioms by combining meanings of words in them, the number of possible meaning candidates will be the product of the numbers of meanings of each word in them. Although there are many meaning candidates, the most of them should be improper. It is a much burden for the webmaster to find the correct meaning from many candidates. Assigning unique IDs for the meanings of phrases and idioms can reduce these improper meaning candidates.

b) Analysis of Word Meanings by the System: Analysis of word meanings is performed by the system automatically. The system converts each word in an original sentence into the original form of the word. This original form of the word is used as a query to find the candidate meanings from the meaning ID database. Besides, if the sequence of words constitutes phrases or idioms, the system accesses the meaning ID database using the sequence of words as the query. If the proper meaning exists in the meaning ID database, the system converts the words, phrases or idioms into the found meaning ID.

[4]Eijiro http://www.eijiro.jp/

TABLE II
DETAILS OF FINAL STORAGE FORMAT.

Data Type	Description
sentence number	the sentence's number of the sequential order from original documents
langage	written language of the original sentence
original sentence	original sentence before analysis of sentence structure and store of word meanings
basic structure	original sentence without all of modifiers, that using the result of analysis of sentence structure
analysis result	input sentence represented by structure information and meaning ID that are made by analysis of sentence structure and store of word meanings

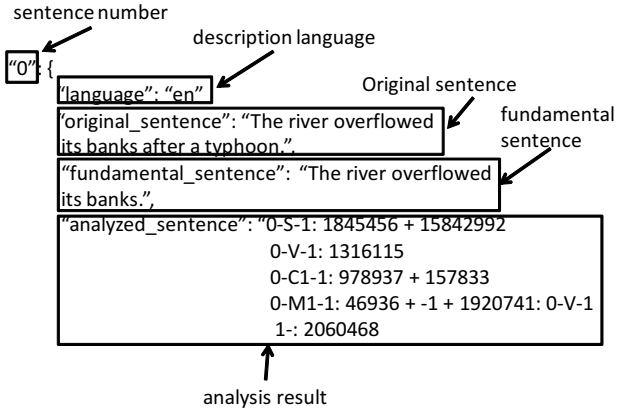

Fig. 7. An example of final store format in the case of the sentence "The river overflowed its banks after a typhoon".

c) Correcting Word Meanings: The system exhibits the result of the analysis of word meanings to the webmaster. The webmaster can correct the result manually, if there are mistakes in the result. The webmaster can correct mistakes by combining words into phrases and idioms, dividing incorrect phrases and idioms into words, and selecting different meaning ID for words, phrases or idioms. After the system has finished the analysis of word meanings, the system proceeds to the step of "storing analyzed sentences",

d) Storing Analyzed Sentences: The system converts the original sentences into the final storage format. Table II shows the details of the final storage format. We call a sentence represented in the final storage format "analyzed sentence". Fig 7 shows an example of final storage format in the case of the sentence "The river overflowed its banks after a typhoon".

B. Viewing Phase

In viewing phase, the system translates the stored sentences represented in final store format into the user's native language (hereafter "target language"). When a user browses the web page, the system translates the sentences in the web page into the target language automatically. In viewing phase, the system processes two steps: "restoring fundamental sentence structures" and "restoring modifiers". Fig 8 shows the processing flow of viewing phase.

Restoring sentences heavily depends on the target language. It is, however, difficult to understand features of sentence structure for all languages. Therefore, we use the

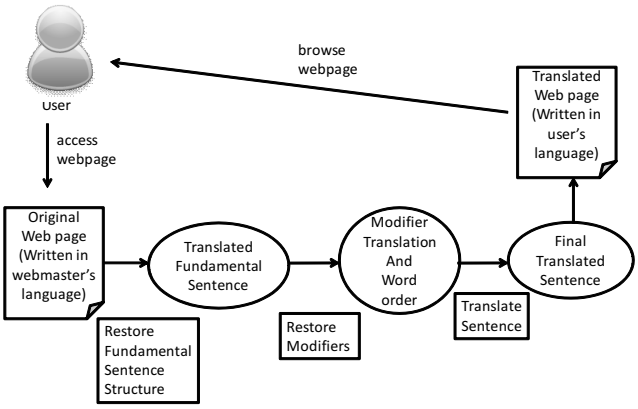

Fig. 8. Processing flow of viewing phase.

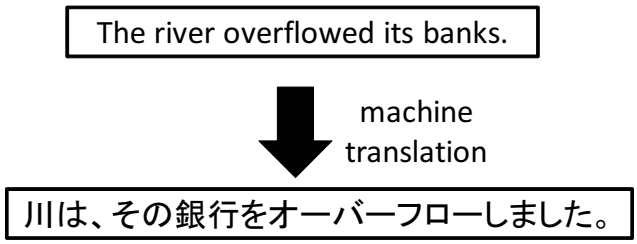

Fig. 9. An example of machine translation of a fundamental sentence.

results of machine translation and correct them in order to translate the original sentences. We use Google Translate as the machine translation API in our system.

e) Restoring Fundamental Sentence Structures: When a user accesses a web page, the system translates the fundamental sentences of the original sentences in its page into the target language. In this translation, the system translates only the fundamental structure without modifiers in order to reduce mistranslation caused by the complexity of sentences. Fig 9 shows an example of machine translation of a fundamental sentence. In fig 9, the input sentence is "The river overflowed its banks after a typhoon." and its fundamental sentence is "The river overflowed its banks."

The system corrects the translation result of the fundamental sentence by comparing with the result of the creating phase. First, the system checks for all the meaning IDs in the analyzed result of the sentence in the creating phase and obtains their representation in the target language from the meaning ID database. We call these obtained representations in the target language "converted meanings". Table III shows the obtained representation in the target language (Japanese in this case) for all the word IDs in the fundamental sentence "The river overflowed its banks."

Second, the system checks where the representation in the target language for each word ID in the fundamental sentence appears in the translated fundamental sentence. The system performs string matching in order to this check. Owing to this process, it is possible to obtain the word order of the sentence in the target language, even if the system does not understand the word order of all natural languages. Fig 10 shows an example of acquiring word order in the target language.

If the translated fundamental sentence contains all of the converted meanings, the system assumes that the machine translation has translated the sentence successfully. If, however, the translated fundamental sentence does not contain

TABLE III
EXAMPLE OF OBTAINED REPRESENTATION IN THE TARGET LANGUAGE (JAPANESE IN THIS CASE) FOR ALL THE WORD IDS IN THE FUNDAMENTAL SENTENCE "THE RIVER OVERFLOWED ITS BANKS".

Meaning ID	Element	Representation in Target Language (Japanese)
1845456	S	その
1584292	S	川
1316115	V	あふれる あふれ出る
978937	C1	それの あれの
157833	C1	土手 岸
2060468	Else	。

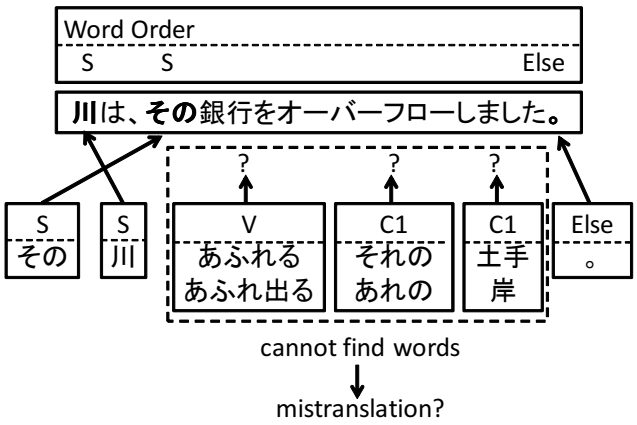

Fig. 10. An example of acquiring word order.

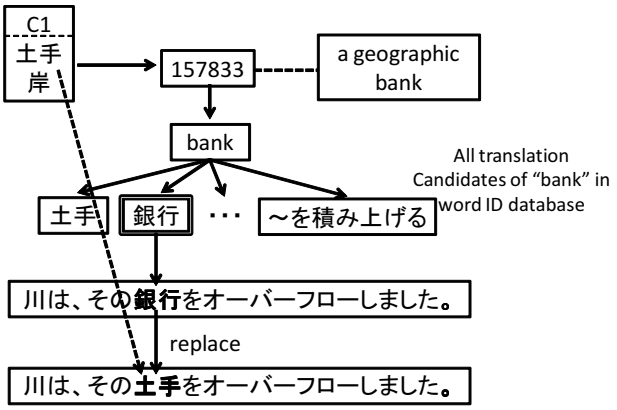

Fig. 11. To replacing of mistranslation word into the better translation candidate.

all of the converted meanings, the system assumes that the machine translation has mistranslated the sentence. The machine translation cannot always translate all words into correct translation in the target language. The representation in the target language that is obtained from the meaning ID database sometimes does not correspond with the representation in the translated fundamental sentence due to mistranslation. In our proposed method, the system corrects the result of the translated fundamental sentence considering the mistranslation words in order to resolve this problem. The example of this processing is shown in Fig 11 and 12.

The system restores the original word that the webmaster spelled by using the meaning ID database. Then we obtain all

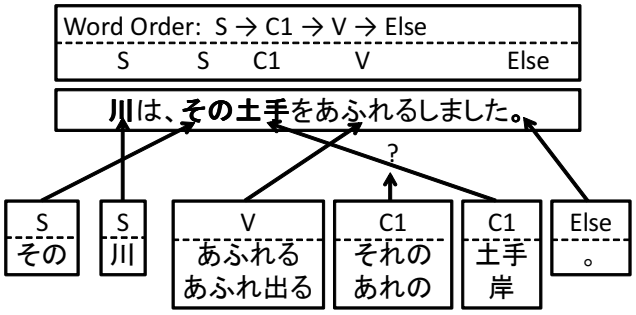

Fig. 12. Correcting the translated fundamental sentence considering the mistranslation words.

of the converted meanings into which the original word may be translated from the meaning ID database. We call them "possible mistranslated meanings". In Fig 11, the system restored the word ID "157833" to the original representation "bank". Next, the system obtains all of the representations in the target language for the original representation by using the meaning ID database. In Fig 11, the system obtained possible mistranslated meanings "土手", "銀行" and "～を積み上げる" in the target language. These words are ambiguous words that may cause mistranslation. The system checks whether these words correspond to the strings in the result of translated fundamental sentence. If there is a corresponding word, the system considers this word as mistranslation, and replaces with the correct representation in the target language. In Fig 11, the word "銀行" appears in both the result of translated fundamental sentence and the possible mistranslated meanings. Therefore the word "銀行" is considered as mistranslation, and the system replaces it into the correct representation "土手". If the translated fundamental sentence contains any possible mistranslated meanings, our system assumes that these possible mistranslated meanings are mistranslations of the converted meanings and replaces these possible mistranslated meanings with the converted meanings.

Fig 12 shows the result of correcting the translated fundamental sentence considering the mistranslation words. In this example, the system corrects the translated fundamental sentence "川は、その銀行をオーバーフローしました。" that a machine translation translates the original fundamental sentence "The river overflowed its banks." into. Finally, the system obtains the corrected translated fundamental sentence "川は、その土手をあふれるしました。" and the word order "S → C1 → V → Else".

f) Restoring Modifiers: After correcting the translated fundamental sentence, our system restores modifiers to the translated fundamental sentence. In the same way as for principal elements, our system obtains the converted meanings modifiers. By referring to the results of the first step (analysis of sentence structures), our system obtains the metadata of which of the principal elements is modified by each modifier, and uses them to restore each modifier to the translated fundamental sentence.

In the example that the system translates the sentence "The river overflowed its banks after a typhoon.", the system obtained the modifier "M: 46936 + -1 + 1920741 (→ V)" in the creating phase (Fig 7).

Fig 13 shows the example of obtaining modifier transla-

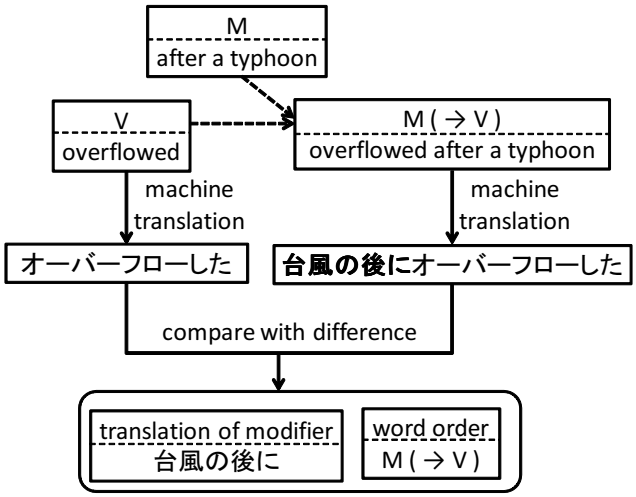

Fig. 13. The Example of obtaining modifier translation and word order.

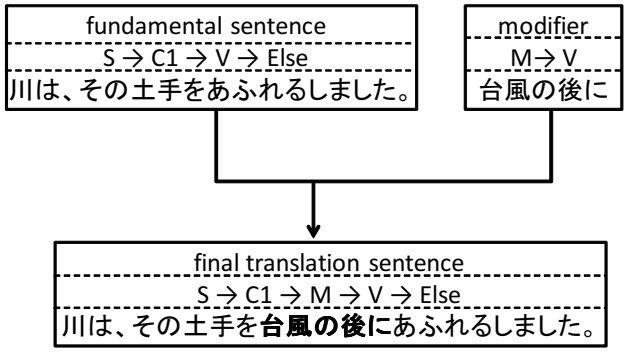

Fig. 14. An Example of a modifier Restoration.

tion and word order. First, the system obtains the original representation of element M. In this example, it is "after a typhoon". The system also obtains the original representation of element V, because this element M modifies element V. The system obtains "overflowed" as the original representation of element V. Besides, the original representation that element M modifies element V is "overflowed after a typhoon" because the word order of elements M and V in the original sentence is "V → M".

Second, the system translates the phrases "overflowed" and "overflowed after a typhoon" into the target language by machine translation, and obtains the translations "オーバフローした" and "台風の後にオーバーフローした". The system compares these two translations and obtains the difference "台風の後に". The system considers the difference as the translation of element M. This process is performed in order to connect the modifier and the modified element naturally. The proposed method cannot create the connection of modifiers and the modified elements that depends on the language, although it can correct mistakes of meaning selection. Therefore, the system uses machine translation in order to create the connection of them. Besides, the system obtains the word order in the target language from the machine translation result of "overflowed after a typhoon". The word order in this example is "M → V". The system restores modifiers using this word order information. Fig 14 shows an example of a modifier restoration using these information.

Fig. 15. Combining the meanings of several words.

In Fig 14, the system inserts the modifier "台風の後に" before the modified words "あふれる" according to the word order information. As a result, the original sentence "The river overflowed its banks after a typhoon." is translated into "川は、その土手を台風の後にあふれるしました。", and the system shows the user this translated sentence as the result.

IV. System Implemantation

In this section, we describe the functions and features of the user interface of our system.

A. Part of Sentence and Sub-element

A sentence does not always have only one fundamental sentence. If a sentence contains conjunctions, it consists of more than one fundamental sentence. To handle these complex sentences, we divide such a sentence into parts. Each part contains either a fundamental sentence and modifiers or other elements such as conjunctions and periods. Sometimes, an element contains a description of a parallel relationship between the words. If these words are modified, the element becomes long and complex. Therefore, we divide the element into sub-elements. Modifiers can have metadata by which a sub-element of an element is modified. Finally, the elements and Word IDs that are the results of analyzing sentence structures are described like "part - element - sub-element : word ID".

B. Combining the Meanings of Several Words

If several words consist of a phrase or an idiom, the webmaster is able to select their meanings as a phrase or an idiom. If the webmaster wants to combine words into a phrase, he/she can click the combine/separate button as shown in Fig 15.

V. Evaluation

We experimented to evaluate the effectiveness of our system. In this experiment, we translated sentences from English into Japanese by using our system. We prepared 25 sentences for this evaluation. We obtained these sentences from a Japanese-English corpus and a dictionary. In the same way, we used Google Translate as a comparative translation system for our system. We evaluate the results of experiment in two ways. One is an automatic evaluation using BLEU (Bilingual Evaluation Understudy)[6], and the other is a subjective evaluation.

TABLE IV
LIST OF SENTENCES IN INPUT SENTENCE SET 1 (ISS1).

Sentence Number	Input Sentence
1-1	The river overflowed its banks after a typhoon.
1-2	Thank you but I am full.
1-3	I saw an unidentified flying object.
1-4	It always seems like it is there.
1-5	I honestly feel like there is too much.
1-6	I think that Yamada is the type everybody likes.
1-7	I think this was made around the Momoyama Period.
1-8	I think this movie is from the early Showa Period.
1-9	Who thinks they're going to win?
1-10	I don't think he was able do it.
1-11	I don't want to be better than him.
1-12	I don't think that's an exaggeration.
1-13	If I spend fifty hours, I feel like I wasted my time.
1-14	The expressway might be the long way.
1-15	It felt empty.
1-16	He's going to talk about that night.
1-17	He works at a company.
1-18	He's making that a criterion.
1-19	It makes a noise when it turns.
1-20	I got a look like that on my face.
1-21	He set a within-the-year deadline for the proposed plans.
1-22	I'm just looking out for number one.
1-23	I think 2000 is good.
1-24	A lot of people are active.
1-25	He shares living expenses with me.

TABLE V
LIST OF SENTENCES IN INPUT SENTENCE SET 2 (ISS2).

Sentence Number	Input Sentence
2-1	The river overflowed its banks after a typhoon.
2-2	Thank you but I am full.
2-3	The choice is right for me.
2-4	Tom does not have a drop of pity.
2-5	The goods come in many different colors.
2-6	He drains his glass in one gulp.
2-7	He realized a mistake.
2-8	He makes a pile.
2-9	Get a doctor.
2-10	The forecast calls for rain.
2-11	I hammer a nail into the wall.
2-12	Tom is dead right.
2-13	I feel blue today.
2-14	My wife went to a ball.
2-15	He is bright.
2-16	He takes a bow.
2-17	There is a chest of tea.
2-18	Do you have change?
2-19	Roosters crow in the morning.
2-20	I have a corn on my foot.
2-21	She ate an ear of corn.
2-22	Some people fast at Easter.
2-23	I sleep on a firm mattress.
2-24	We hunt game to eat.
2-25	I'm just looking out for number one.

A. Input Sentences Set

We prepared two input sentence sets (hereafter "ISS1" and "ISS2") for this experiment. ISS1 consists of 25 sentences that are randomly picked from the example sentences in the English-Japanese dictionary and the English-Japanese translation corpus[7]. The sentences in ISS1 have more simple sentence structure than ISS2. Table IV shows the list of sentences in ISS1. ISS2 consists of 25 sentences that are randomly picked from example sentences in the English-Japanese dictionary and the web page that lists English homographs and the example sentences using them[8]. All of the sentences in ISS2 have complex sentence structure that the machine translation mistranslates. Table V shows the list of sentences in ISS2.

These sentences in both ISS1 and ISS2 went through the creating phase and the analyzed sentences are stored as mentioned in section III-A1 before this translation experiment. In this experiment, the proposed system translates these stored results of analyzed sentences into the target language (Japanese) and we consider them as the result of translations. In the restore of the sentences, the proposed system uses Google Translation as a machine translation.

B. Translation Result

Table VI and VII show the translation results of ISS1 by the propose method and the machine translation. Table XIV show the translation results of ISS2 by the propose method and the machine translation. The precisions of the translation results are mentioned in following sections V-C3 and V-D.

C. Automatic Evaluation

Automatic evaluation evaluates correctness of translation results. In automatic evaluation, the correctness indicates how similar translation results to the correct sentences. We adopt BLEU as the correctness indicator.

1) BLEU: BLEU is a method for automatically evaluating the quality of machine-translated text by comparing the reference human-translated text and the system result. BLEU is calculated as follows:

$$BLEU = BP \cdot \exp(\sum_{n=1}^{N} \frac{1}{N} \log P_n)$$

$$P_n = \frac{\sum_{c \in \{Candidates\}} \sum_{n-gram \in C} Count_{clip}(n-gram)}{\sum_{c' \in \{Candidates\}} \sum_{n-gram' \in C'} Count(n-gram')}$$

where N is n-gram length, C is references, $Count_{clip}(n-gram)$ is the number of n-grams in which reference and system result match, C' is system results, $Count_{clip}(n-gram')$ is the number of system result n-grams, c is the total length of system results, and r is the total length of references.

A score of BLEU takes the value between 0 and 1. The score becomes 1 if the input sentence corresponds to the correct sentence perfectly. In using BLEU, we set the parameter N to 4. Before evaluation, we manually changed the references to the best match of each result because Japanese natural sentences have the following features.

2) Reference Translation for BLEU: BLEU compares the translations with reference translation concerning string

TABLE VI
THE TRANSLATION RESULT OF ISS1 BY THE PROPOSED METHOD.

Sentence Number	Translation Result
1-1	川は、その土手を台風後のあふれるしました。
1-2	ありがとう、私はおなかがいっぱいのです。
1-3	私は未確認飛行物体を見ました。
1-4	それはそれは常に、のように思える。
1-5	あまりにも多くがであるような気がします。
1-6	私は山田がタイプの誰もが好きだとを考えるます。
1-7	私はこれが作られたと思う。
1-8	私はこの映画だとを考えるます。
1-9	誰が彼らが勝つするつもりだと考えている？
1-10	私は彼がそれを行うことができたとは思わない。
1-11	私はなることは望ましくありません。
1-12	私は誇張だとは思わない。
1-13	私は 50 時間使うなら、私は私は自分の時間を無駄にしたいと感じがするています。
1-14	高速経路路は長い道のりかもしれない。
1-15	それは、空っぽのを感じる。
1-16	彼は話をその夜についてするつもりだ。
1-17	彼は動作します。
1-18	彼はそれ基準を作っている。
1-19	それは、それが回転する音がする。
1-20	私は私の顔のようにような一見を得た。
1-21	彼は内、年間の期限を設定します。
1-22	私はナンバーワンを探しています。
1-23	私は 2000 が良いと考えるます。
1-24	多くの人々の参加しているです。
1-25	彼は生活費を私と一緒に共同使用するしています。

TABLE VII
THE TRANSLATION RESULT OF ISS1 BY THE MACHINE TRANSLATION.

Sentence Number	Translation Result
1-1	川は台風の後に、その銀行をオーバーフローしました。
1-2	ありがとう、私は完全です。
1-3	私は未確認飛行物体を見ました。
1-4	それがあるように、それはいつもだ。
1-5	あまりにも多くがあるように私は正直に感じています。
1-6	私は山田がタイプの誰もが好きだと思います。
1-7	私はこれは桃山時代の周囲に作られたと思う。
1-8	私はこの映画は昭和初期からだと思う。
1-9	誰が彼らが勝利するつもりだと考えている？
1-10	私は彼が行うことができたとは思わない。
1-11	私は彼よりも良いようにしたくない。
1-12	私は誇張だとは思わない。
1-13	私は 50 時間を費やしている私は私の時間を無駄に同じように、私は感じています。
1-14	高速道路は長い道のりかもしれない。
1-15	それは、空の感じ。
1-16	彼はその夜の話になるだろう。
1-17	彼は会社で働いている。
1-18	彼はその基準を作っている。
1-19	それが回転するときに音がする。
1-20	私は私の顔にそのような一見を得た。
1-21	彼は提案された計画の内、年間の期限を設定します。
1-22	私はナンバーワンを探しています。
1-23	私は 2000 が良いと思います。
1-24	多くの人々が活躍しています。
1-25	彼は私と一緒に生活費を共有しています。

matching. This comparison causes difference in BLEU scores in the case of using synonyms, different position of a modifier, and different auxiliary verbs even if these represent the same meaning as the reference translation. In such cases, even though the BLEU score becomes low, the translations are not necessarily wrong. Therefore, we customized the reference translation for each translation by the proposed method and machine translation. In the following paragraphs, we explain the way to customize reference translation.

a) Synonym and Difference of Characters: Japanese, like other languages, has many synonyms. Moreover, Japanese has three types of script: Hiragana, Katakana and Kanji. Japanese natural sentences are mainly written in a mix of these three scripts. For example, tempura, a Japanese dish, is usually written “天ぷら”. “天” is Kanji, while “ぷ” and “ら” are Hiragana. Sometimes, tempura is written “てんぷら” (only using Hiragana), “テンプラ” (only using Katakana), or “天麩羅” or “天婦羅” (only using Kanji). All of them mean the same thing, and the only difference being the characters. Therefore, we manually changed these words of references into other words or other characters to best match each result.

b) Position of Modifier in the Sentence: Modifiers in Japanese natural sentences do not always set a position related to modified words. It, of course, cannot be placed anywhere. Thus, we changed some positions of modifiers as long as these changes were not unnatural.

c) Differences in These Auxiliary Verbs: In Japanese, auxiliary verbs, for example “です”(-desu) / “ます”(-masu), are sometimes used at the end of a sentence instead of auxiliary verbs “だ”(-da) / “である”(-dearu) in order to represent more polite or softer nuances. However, the main meanings do not differ even if any of these auxiliary verbs are used. Therefore, we ignore the difference of these auxiliary verbs in the corpus sentences.

d) List of Customized Reference Translation: Table XIV show the customized reference translation for ISS2 by the propose method and the machine translation.

3) Result of Automatic Evaluation: The results of evaluation for ISS2 are shown in Table XIV. Underlined characters mean that match between translation results and reference translations considering by BLEU.

TABLE VIII
EVALUATION RESULTS OF ISS1 BY BLEU.

Translation System	Score
Proposed System	0.0544
Machine Translation	0.0881

TABLE IX
EVALUATION RESULTS OF ISS2 BY BLEU.

Translation System	Score
Proposed System	0.1518
Machine Translation	0.0248

D. Subjective Evaluation

In subjective evaluation, we use two viewpoints (adequacy and fluency) and evaluate the results of our translation system

TABLE X
EVALUATION RESULTS OF ISS1 BY SUBJECTIVE EVALUATION

	Improved	Worsened
Adequacy	7	13
Fluency	1	12

TABLE XI
EVALUATION RESULTS OF ISS2 BY SUBJECTIVE EVALUATION

	Improved	Worsened
Adequacy	24	5
Fluency	0	7

TABLE XII
CORRECTION RATE OF THE SYSTEM IN TERMS OF ADEQUACY

	Sentences	Correct points
Total	25	39
System correction	19	24
(Full correction)	(12)	(-)
Correction rate	0.76	0.61
(Full correction)	(0.48)	(-)

by comparing it with machine translation. The results of subjective evaluation for ISS1 is shown in Table X.

The "improved" column in Table X indicates that our system is able to correct mistranslations of Google Translate. Our system, however, sometimes fails to add modifiers into the translated sentence as shown in the "worsened" column in Table X. In addition, our system just replaces words with other words without considering the connection between them. Thus, from the viewpoint of fluency, our system is worse than machine translation.

The results of subjective evaluation for ISS2 is shown in Table XI, and the correction rate of the system in terms of adequacy is shown in Table XII. In Table XII, the "Sentences" column shows the results from a viewpoint of sentences, the "Correct points" column shows the results from the viewpoint of mistranslated points of words, phrases, and idioms that sentences have (one sentence may have two or more correct points), the "Total" row shows the total number of sentences or correct points, "System correction" row shows how many sentences or correct points the system corrected, and the "Correction rate" row shows the correction rate of sentences or correct points that is calculated by the value of the "System correction" row divided by the value of the "Total" row. "Full correction", which appears in "System Correction" row and "Correction rate" row, shows the number of sentences or correction rate of sentences in which the system corrected all the mistranslated points. We investigated the reasons the system mistranslated in each case, and the results are shown in Table XIII.

E. Discussion

The "improved" column in Table XI indicates that our system is able to correct many mistranslations of Google Translation. As shown in Table XI, improvements surpass degradations. Thus, our system is able to translate sentences more accurately especially when machine translation mistranslated. As shown in Table XII, machine translation mistranslated 39 points of words, phrases, or idioms in this experiment. Of these, our system successfully corrected 24 points (correction rate: 0.61). Out of the total 25 sentences, our system successfully corrected 19 sentences (correction rate: 0.76), and fully corrected 12 sentences (correction rate: 0.48).

TABLE XIII
REASONS WHY THE SYSTEM IS INCORRECT

Reason	Incorrect points
Using unnatural nuance	3
Mismatching text because of differences of tense or part of speech	4
Mismatching text because of synonyms	1
Mismatching text because of mistranslated phrases or idioms	4
Mismatching text because of non-existent meanings that machine translation made	4
Could not select correct meanings when the webmaster created the webpage	2

As shown in Table XIII, most of the reasons the system was incorrect are mismatching of text. This means that the system failed to find mistranslated words, phrase, or idioms in various causes. This indicates that the accuracy can be improved if we can match texts more correctly.

VI. Conclusion

In this paper, we proposed a new method for supporting creation of multilingual web pages that creates natural sentences by analyzing sentence structures and what each word means, and we developed a system to create translated sentences using this method. Experimental results showed that our system is able to translate sentences more accurately when machine translation mistranslates. Our system, however, has some points that need improvement:

A. Matching Translated Meanings More Exactly with Translated Fundamental Sentences

When adding modifiers into fundamental translated sentences, our system searches for the positions of modified elements by the modifier to decide the position into which the system adds modifies. Our system, however, uses simple text matching to search for these positions, and these matchings often fail. We will try to solve this problem by using a part-of-speech analyzer.

B. Tense of Words

The meanings contained in the word ID database are the original forms. Thus, the results of our system can only describe present forms. After matching the translated meanings more exactly with the translated fundamental sentences, we will try to correct the tense of each sentence by referring to a dictionary of tense or by some other method.

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TABLE XIV
THE TRANSLATION RESULTS AND REFERENCE TRANSLATION FOR ISS2.

Sentence Number	Translation Result of Proposed Method	Reference Translation for Proposed Method	Translation Result of Machine Translation	Reference Translation for Machine Translation
2-1	川は、その土手を台風 後 の あふれ るしまし た。	その 川は、その土手を台 風 の 後 に あふれた。	川は台風の後に、その 銀行 を オーバーフロー しました。	その 川は台風の後に、 その 土手 を あふれ出 し ました。
2-2	ありがとう、私はおなかが いっぱい の です。	ありがとう、でももう 私 はおなかがいっぱいです。	ありがとう、私は 完全 です。	ありがとう、でももう 私 は おなかがいっぱい です。
2-3	選択はちょうど良い です。	その 選択は 私に ちょうど 良いです。	選択は 右の 私 のため で す。	その 選択は私 にちょうど 良い です。
2-4	トムは、哀れみの 一滴 を 持っていません。	トムは哀れみの 心 を 少し も 持っていません。	トムは同情の ドロップ を 持っていません。	トムは同情の 心 を 少しも 持っていません。
2-5	品物は、多くの異なる色 で来 る。	その 品物は、多くの異な る色 が手に入 る。	品物は、多くの異なる 色 で来 る。	その 品物は、多くの異 なる色 が手に入 る。
2-6	彼はコップを 排出。	彼はコップを 一息で飲み 干した。	彼は、一 口で彼のガラス を排出する。	彼は、コップを 一 息で 飲み干した。
2-7	彼はミス を実現。	彼はミス に気付いた。	彼はミス を実現。	彼はミス に気付いた。
2-8	彼は大金 になり ます。	彼は大金 を稼ぎ ます。	彼は 山になり ます。	彼は 大金を稼ぎ ます。
2-9	医者を連れてくる。	医者を連れてくる。	医者を 得 る。	医者を 連れてく る。
2-10	天気予報 が求めている。	天気予報 では雨だ。	予 想 は雨 のために呼び 出しま す。	天気 予 報で は雨 で す。
2-11	私はくぎを壁にハン マーで打つ。	私はくぎを壁にハン マーで打つ。	私は壁にくぎを ハン マー。	私は壁にくぎを 打ち込 む。
2-12	トムは 完璧に権利である。	トムは まったく正しい。	トムは 死んだ権利である。	トムは まったく正しい。
2-13	今日は憂鬱な い 気分。	今日は憂鬱な気分。	今日は 青い 気分。	今日は 憂鬱な 気分。
2-14	私の妻 がい た。	私の妻 は舞踏会に行き まし た。	私の妻は、ボール に行 きました。	私の妻は、舞踏会 に行き ました。
2-15	彼は機転の利くです。	彼は機転の利く人です。	彼は 明る いです。	彼は 頭がい いです。
2-16	彼はおじぎ を取 る。	彼はおじぎ でこたえ る。	彼は 弓を取 る。	彼は お辞儀でこたえ る。
2-17	収納 箱があります。	ひと 箱 分のお茶 があり ます。	お茶の 胸 があります。	ひと箱分の お茶がありま す。
2-18	この 細かいお金はあり ますか？	細かいお金はあります か？	この変更 はありますか？	小銭 はありますか？
2-19	おんどり ズ 早朝に鳴く。	おんどりは早朝に鳴く。	午前中にルースターズのカラス。	雄鶏は早朝に鳴く。
2-20	私は 私の 足うおのめが ある。	私は足 に うおのめが ある。	私は 徒歩で、トウモロ コシを持ってい る。	私は 足に、うおのめがあ る。
2-21	彼女はトウモロコシの 穂 を食べた。	彼女はトウモロコシの 実 を食べた。	彼女は、トウモロコシの 耳 を食べた。	彼女は、トウモロコシの 実 を食べた。
2-22	イースターで断食する 一部の人々。	一部の人々はイースター のときに断食する。	イースター で の 速い 一部 の人々。	一部の人々 は イースター の ときに断食する。
2-23	私は硬めのマットレスで 眠る。	私は硬めのマットレスで 眠る。	私はマットレスの 会社 で 寝る。	私は かたい マットレスの 上 で寝る。
2-24	我々は食べる こと 動物を 狩る。	我々は食べる ために 動物 を狩る。	我々は食べ てゲーム を 狩る。	我々は食べ るために獲物 を狩る。
2-25	私はナンバーワンを探 していま す。	自分がいい思いを す る。	私はナンバーワンを探 していま す。	自分がいい思いを す る。

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