Designing Protocols for Collaborative Translation

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Abstract. In this paper, we present a protocol for collaborative translation, where two non-bilingual people who use different languages collaborate to perform the task of translation using machine translation (MT) services. Members in one real life example of intercultural collaboration try to share information more effectively by modifying unnatural machine translated sentences manually and improving their fluency. However, there are two problems with this method: One is that poor quality of translation can induce misinterpretations, and the other is that phrases in the machine translated sentence that a person cannot make sense of remain unmodified. The proposed protocol is designed to solve these problems. More concretely, one person, who handles the source language and knows the original sentence (source language side), evaluates the adequacy between the original sentence and the translation of the sentence modified to be fluent by the other person, who handles the target language (target language side). In addition, by determining whether the meaning of the machine translated sentence is understandable, it is ensured that the two non-bilingual people do above tasks properly. As a result, this protocol 1) improves MT quality; and 2) terminates successfully only when the translation result becomes adequate and fluent. The experiment results show that when the protocol terminates successfully, the quality of the translation increases to about 83 percent in Japanese-English translation and 91 percent in Japanese-Chinese translation.

1 Introduction

Internationalization and the spread of the Internet are increasing our chances of seeing and hearing many languages. As a result, the number of multilingual groups where the native languages of the members differ is increasing. In the past, communication in such groups typically took place in one language, which was in many cases English. However, members who are required to communicate in a non-native language frequently find communication difficult [Takano 93, Aiken 94, Kim 02], thus such collaboration tends to be ineffective [Aiken 02, Tung 02].

Machine translation (MT) is a powerful tool for such groups, because it allows people to communicate in their native language. Actually, many groups use MT in their activities.

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MT is useful for realizing some level of communication, because participants can pick up the general meaning even if some words are badly translated [Nomura 03]. However, most MT systems make many translation errors. More precisely, many of the machine translated sentences are generally neither adequate nor fluent. In intercultural and multilingual collaboration based on MT, translation errors have caused mutual misconceptions [Ogden 03]. Moreover, it is difficult to identify translation errors because of the asymmetric nature of MT [Yamashita 06].

Similar kinds of problems are caused in real fields of intercultural collaboration. Members of one NPO group try to share information by modifying unnatural machine translated sentences manually and improving their fluency. However, there are two problems in this method: One is that poor quality of translation can induce misinterpretations, and the other is that phrases in the machine translated sentence that a person cannot make sense of remain unmodified. These problems cause mutual misinterpretation in such collaboration.

In this paper we present the protocol of collaborative translation, where two non-bilingual people who use different languages collaborate to perform the task of translation with an MT system. In the past, only bilingual people could determine whether a translated sentence has the same meaning as a corresponding source sentence. However, the protocol presented in this paper does not assume the presence of bilingual people, and is designed to solve two above-mentioned problems. As a result, the collaborative translation protocol 1) improves MT quality; and 2) terminates successfully only when the translation result becomes adequate and fluent.

The key idea of this protocol is to clarify the task of one person, who handles the source language (source language side) and of another person, who handles the target language (target language side). The target language side modifies the machine translated sentence to improve its fluency. The source language side evaluates the adequacy between the back-translation of the modified sentence and the source sentence. In addition, by determining whether the meaning of the machine translated sentence is understandable, it is ensured that two non-bilingual people do the above tasks properly.

The phenomenon which is observed in this protocol is similar to "coordinated attack problem [Halpern 90]" which is often cited in regards to the problems in the distributed environment such as multi-agent systems. We will show that although it has been proven that common knowledge cannot be attained in such an environment, this kind of problem is solved in collaborative translation protocol by adopting one heuristic.

This protocol ensures that it will most likely output good translations when terminating successfully. However, even if the protocol terminates successfully, the translation results may not be perfect because of human factors, characteristics of MTs, and interlinguistic characteristics. We evaluated the success rate and the reliability of the collaborative translation protocol in an experiment described in chapter 4.

2 Human-Assisted Machine Translation

2.1 Practice in the Field of Intercultural Collaboration

In many real fields of intercultural collaboration, MT is used as a tool for communication and information sharing. We will use internationally active NPO group in Japan as an example of a group working with MTs. The NPO has participants in Japan, South Korea, Austria, and Kenya. The group have a variety of native languages such as Japanese, Korean, German and English.

English is frequently used as a common language for communication in a multilingual community where native languages of community members differ. However, it is often the case in such community that there are people who are not proficient in English. The problem is that using English or a non-native language in communication tends to make it difficult for such people to share the information with others [Takano 93, Aiken 94, Kim 02]. In order to foster information sharing and invigorate intergroup discussion, the group mentioned above developed their own web BBS system using MT. In this system, each person edits an article in his or her native language. The article is translated via this system to three languages, and it enables other people to read contents of the article in their own native language. However, the quality of MT is often imperfect. This can make it difficult to share information among the members of the group. To overcome the problem with MT quality, this system enables people to correct errors of machine translated sentences manually. The illustration of this web BBS system is shown in Figure 1. In this figure, posting a Japanese article is taken as an example. Machine translated sentences can be modified to be natural expressions, which make intragroup information sharing easier.

In addition, the fluency as well as the quality of machine translated sentences can be improved by guessing the meaning of the translated sentences from

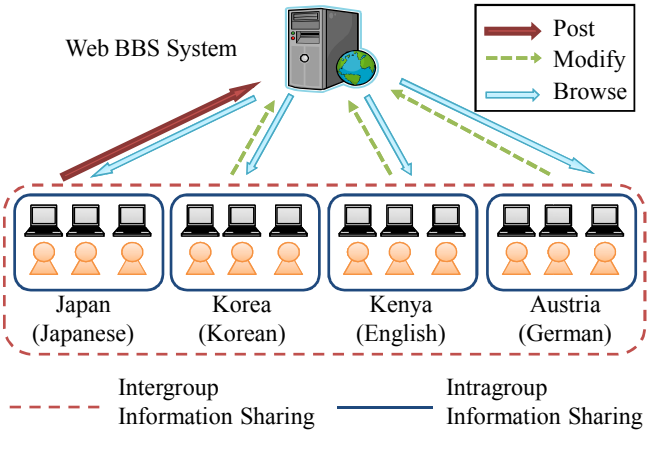

Fig. 1. Illustration of the web BBS system of the NPO group

the context of the text and the background knowledge in the community when modifying it.

Example 1: Improvement of translation quality by modifying machine translated sentence

The Japanese sentence All children who looked at the picture were surprised was translated into English as Everyone was surprised at the children who saw the picture. This English sentence has a different meaning from the original Japanese sentence. However, a native English speaker guessed the true meaning from the context and based on the background of his or her community and modified the English sentence as Children were surprised to look at the picture. This modified English sentence has the same meaning as the original Japanese sentence.

2.2 Problems in Modifying Machine Translation

Wordy and unnatural machine translated sentences can be expressed naturally by modifying them. This leads to making the meaning of the translated sentences clearer and intragroup information sharing easier. From this point of view, human-assisted machine translation is an useful method for real fields of intercultural collaboration. However, there are two main problems in the naive implementation of human-assisted machine translation. The problems are described below.

Example 2: Misinterpretation of the meaning of a machine translated sentence

The Japanese sentence He needed 1 week to cure a cold was translated into English as He was necessary to correct a cold for 1 week. Since there were diction and grammar errors in this English sentence, this sentence was modified to be a natural expression by the native English speaker. However, he or she modified this English sentence as He should recover from a cold within 1 week. This modified English sentence differs in meaning from the original Japanese sentence.

A person who modifies a machine translated sentence can never understand the original meaning of the sentence. Therefore, he or she might misinterpret the meaning. Due to this, the modified sentence might differ in meaning from the original sentence.

Example 3: Incomprehension of the meaning of a machine translated sentence

The Japanese sentence His belly is sticking out was translated into English as A stomach has gone out to him. A native English speaker cannot understand the meaning of this machine translated English sentence. Therefore, this sentence remained unmodified.

It is almost impossible to modify phrases of a machine translated sentence that he or she cannot make sense of. Such phrases tend to remain unmodified. As a result, information about such phrases cannot be shared throughout the domain.

Human-assisted machine translation has following problems:

- It cannot be determined that a modified machine translation has the same meaning as a corresponding original sentence
- Phrases in the machine translated sentence that a person cannot make sense of remained unmodified

It is true that human-assisted machine translation is helpful for information sharing in real fields of intercultural collaboration. However, the prevention of misconception and accurate information sharing cannot be realized until these two problems are solved.

3 Collaborative Translation

3.1 Definition

Participants in a collaborative translation task are two non-bilingual people: one person who handles the source language (source language side), and one person who handles the target language (target language side). Only an MT system performs the task of translation. While the original document can not be revised, the source language side can submit alternatives to the original sentences to the MT system to create reference material.

The source language side and the target language side play different roles. The target language side cannot determine whether a machine translated sentence has the same meaning as the original sentence. However, he or she can determine whether the machine translated sentence is fluent. Therefore, he or she can modify the non-fluent sentences to be more fluent. We assume that the sentences modified by a person are always fluent. Like the target language side, the source language side cannot determine whether the machine translated sentence has the same meaning as the original sentence. However, given the machine translation of a sentence modified by the target language side, the source language side can determine whether the back-translation of the modified sentence has the same meaning as the original sentence. By thinking of this, he or she determines whether a machine translated sentence has the same meaning as the original sentence.

The above definitions are illustrated in Figure 2.

3.2 Protocol

In order to work together efficiently, it is essential to establish shared knowledge or common ground on the subject [Clark 81, Clark 86, Isaacs 87, Clark 91, Krauss 64]. The process of establishing common ground consists of the presentation phase to

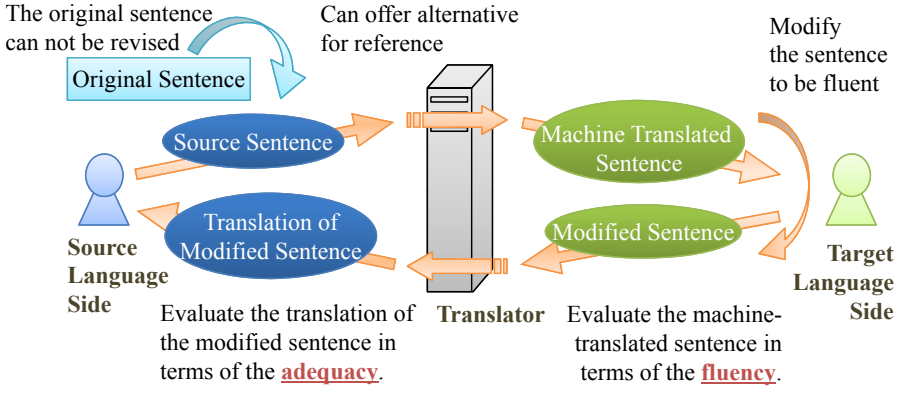

Fig. 2. The basic concept of collaborative translation

present information to the addressees and the acceptance phase to confirm that addressees have received the information correctly [Clark 91]. In collaborative translation, the presentation phase is the transmission of a machine translated sentence to the target language side. The acceptance phase is all processes following the presentation phase. The protocols must be designed to ensure that the correctness of the translation result can be confirmed in the acceptance phase.

Figure 3 shows the formal statement of the basic protocol, which is the minimal protocol to perform collaborative translation. The detail of this protocol is described below.

This protocol starts by sending the machine translated sentence of the original sentence to the target language side (1. Transmission of Source Sentence). Since the source language side plays a role of determining whether the translation of the sentence which is modified by the target language side has the same meaning as the original sentence, he or she waits until the target language side finishes modifying the machine translated sentence to be fluent. In a practical application, since we suppose that the protocol is executed on each sentence of a document in parallel, a person will work at another sentence when he or she waits the processing of an earlier sentence. The target language side plays a role in evaluating the fluency of the machine translated sentence. However, as mentioned in the section 2.2, he or she cannot modify the machine translated sentence if he or she cannot understand its meaning. Therefore, he or she determines that its meaning is understandable before modifying (2. Readability Determination of Translation). If not understandable, the source language side is required to paraphrase the original sentence to make another version of the machine translation. Generally speaking, MTs have a characteristic which tends to output different expressions with a little change of the source sentence. The target language side keeps requesting the source language side to paraphrase the original sentence until the meaning of the machine translated sentence becomes understandable. Only after its meaning is understandable, the target language side modifies it to be fluent (3. Modification of Translation). After the

Let s be a source sentence.
Let c, a, and f be boolean functions. For any sentence x, $c(x)$ indicates that the content of x is understandable, $a(x, s)$ indicates that x means a source sentence s adequately, and $f(x)$ indicates that x is fluent.
Let m and t be functions. For any sentence x, $m(x)$ indicates a human modified sentence of x, and $t(x)$ indicates a machine translated sentence x. For instance, $m(t(s))$ indicates a human modified version of a machine translation of the source.
Let p be the number of modifications made by the source language side, the maximum value permitted is P. Let q be the number of modifications made by the target language side, the maximum value permitted is Q.

1) [Source Language Side: Transmission of Source Sentence]
   Let $p := 0$
   Transmit s to the target language side
      Goto 2)
2) [Target Language Side: Readability Determination of Translation]
   Let $t(s)$ be a machine translated s
   If not $c(t(s))$
      Request the source language side to modify s
      Goto 6)
   Else If $c(t(s))$
      Let $q := 0$
      Goto 3)
3) [Target Language Side: Modification of Translation]
   Let $q := q + 1$
   If $q \geq Q$
      Terminate protocol with label *Unsuccessful*
   Else If $q < Q$
      Let $m(t(s))$ be a human modified sentence of $t(s)$ to be $f(m(t(s)))$
      Transmit $m(t(s))$ to the source language side
      Goto 4)
4) [Source Language Side: Readability Determination of Back-Translation]
   Let $t(m(t(s)))$ be a machine translated $m(t(s))$
   If not $c(t(m(t(s))))$
      Request the target language side to modify $m(t(s))$
      Goto 3)
   Else If $c(t(m(t(s))))$
      Goto 5)
5) [Source Language Side: Adequacy Determination of Back-Translation]
   If $a(t(m(t(s))))$
      Terminate protocol with label *Successful*
   Else If not $a(t(m(t(s))), s)$
      Goto 6)
6) [Source Language Side: Modification of Source Sentence]
   Let $p := p + 1$
   If $p \geq P$
      Terminate protocol with label *Unsuccessful*
   Else If $p < P$
      Let s be a human modified source sentence
      Goto 2)

Fig. 3. The formal statement of collaborative translation protocol

modification of the target language side comes finishes, the source language side starts to evaluate the adequacy of the modified sentence. Since the source language side is also monolingual, the modified sentence is translated into the source language to enable him or her to understand its semantics. In the same way as in the case of the target language side, the source language side determines if the meaning of the translation is understandable (4. Readability Determination of Back-Translation). If understandable, he or she determines that the translation of the modified sentence has the same meaning as the original sentence. (5. Adequacy Determination of Back-Translation). If these sentences have the same meaning, it is recognized that the modified machine translation is not only fluent, but also has the same meaning as the original sentence. Consequently, the protocol can terminate successfully. If these sentences do not have the same meaning, it can be seen that the interpretation of the machine translated sentence by the target language side is likely to differ from the meaning of the original sentence. Therefore, the source language side paraphrases the original sentence again and presents the different expression of the machine translated sentence to the target language side (6. Modification of Source Sentence).

As mentioned above, since an MT intervenes in the communication channel between the source language side and the target language side, there is a possibility that the target language side can interpret information differently from the original meaning. Accordingly, the source language side needs to confirm that the interpretation of the target language side is the same as the intention of the source language side. The confirmation can be made by receiving the translated version of the interpretation of the target language side. However, since the target language side cannot know whether his or her interpretation is transmitted to the source language side properly, he or she needs to confirm this. Even if these processes of confirmation are repeated again and again, they cannot inambiguously confirm whether they have common interpretation. This phenomenon is similar to "coordinated attack problem [Halpern 90]", which is often referred as the problems in the distributed environment such as multi-agent systems. In addition, it has been proven that common knowledge cannot be attained in such an environment [Halpern 90]. In this protocol, one heuristic is adopted that the machine translated sentence has the same meaning as the original meaning if the back-translation has the same meaning as the original sentence. By using this heuristic, common interpretation between the source language side and the target language side can be attained in this protocol.

In order to guarantee that the protocol always terminates, the maximum numbers P and Q of modification of the source language side and the target language side are defined. When translation quality is not improved by repetitive processings of the protocol, the improvement cannot be attained in this protocol, so the protocol will be aborted at a proper stage. Besides, the number of paraphrases that a human can conceive has limitations. In a past intercultural collaboration experiment [Nomura 03], it is reported that the average number of modifications of an original sentence to improve the MT quality (called self-initiated repair in [Nomura 03]) by the most enthusiastic user was eight times. However, this is

viewed as a rare case, so it is reasonable to regard the limitation to even an enthusiastic user as four or five times. There can be two different policies to set the limits; "you must make an effort up to the maximum number of modification since translation quality is likely to be improved," and "you do not have to make an effort over the maximum number since it is a waste of time." From the results of intercultural collaboration experiment, it is reasonable to set the maximum numbers P and Q to three according to the policy of the former, or to five according to the latter.

3.3 Effectiveness

Figure 4 shows that the problem of the target language side's misinterpretation such as example 2 was solved by applying the collaborative translation protocol. The source language side is a native Japanese speaker, and the target language side is a native English speaker. In the first turn, the target language side modified the machine translated sentence with his or her misinterpretation. However, the source language side could determine that the back-translation of the modified sentence did not have the same meaning as the original sentence. This showed that the target language side may misinterpret the meaning of the translated sentence. The source language side modified the source sentence, and

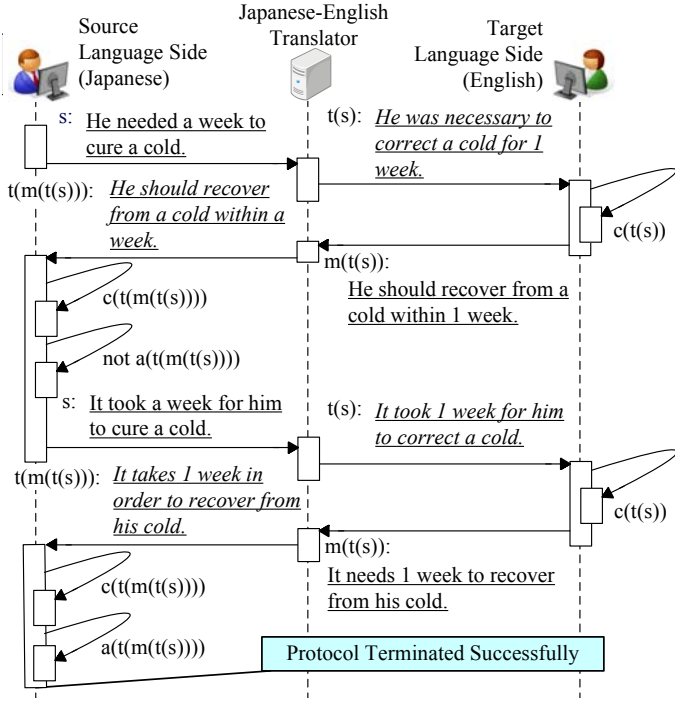

Fig. 4. The problem of Example 2 is solved by collaborative translation protocol

the target language side received its machine translated sentence which was expressed differently from the previous one. In the second turn, the target language side modified it with his or her interpretation which was different from one in his or her first turn. The source language side determined that the back-translation had the same meaning as the original sentence. To sum up, it was recognized that the translated sentence had the same meaning as the original sentence. The target language side's misinterpretation can be detected and corrected by applying the protocol.

Figure 5 shows that the problem such as example 3 was solved in scenario in which the target language side cannot modify the machine translated sentence due to its bad quality. In the first turn, the target language side could not understand the meaning of the machine translated sentence. Therefore, the protocol requested the source language side to modify the source sentence. In the second turn, the target language side received the machine translated sentence again which was expressed differently from the previous one. The target language side could modify it because its meaning was understandable. The source language side determined that the back-translation had the same meaning as the original sentence. Therefore, it was recognized that the translated sentence had the same meaning as the original sentence. The protocol can continue without stopping its processes even if the content of a machine translated sentence is not understandable.

These examples show that the protocol had a tendency to solve two problems of human-assisted machine translation. However, the MT quality tends to cause some errors because of the multi-linguistic characteristics such as word polysemy

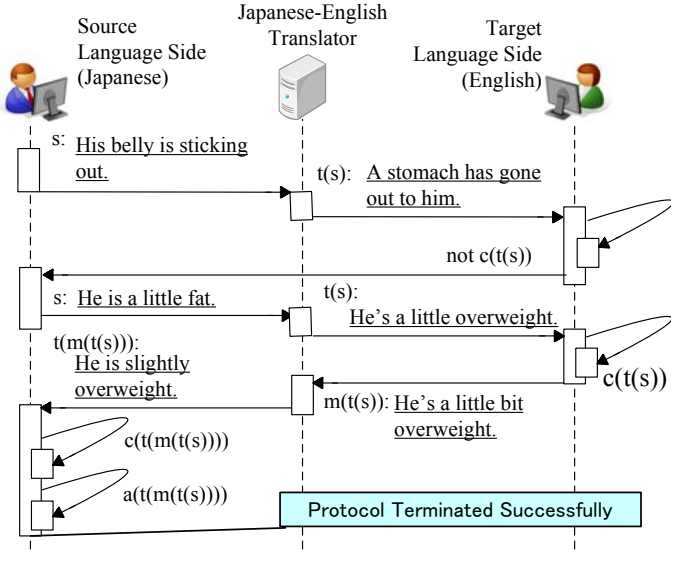

Fig. 5. The problem of Example 3 is solved by collaborative translation protocol

and the ambiguity of syntax analysis. In addition, there are human factors such as difficulties in consistent judgment and different criteria about assessment of translation adequacy. Because of these factors, although the protocol terminates successfully, the translation result could have a different meaning from the source sentence. Therefore, we will confirm the effectiveness of the protocol experimentally.

4 Evaluation

4.1 Setting

We evaluated the collaborative translation protocol in an experiment. Web services provided by Language Grid Project [Ishida 06] were used as modules of the MT system. This project is operated at Kyoto University and its basic software modules have been developed at the National Institute of Information and Communications Technology (NICT).

We used an MT test set provided by NTT Communication Science Laboratories[1]. This set consists of 3,718 Japanese sentences with English translations. In this experiment, 100 randomly selected sentences containing no proper nouns were used as the test set. Japanese-English and Japanese-Chinese translations were conducted and three pairs of participants were made in each language pair to minimize the human effects. The values P and Q, which are defined as the maximum numbers of modifications made by the source language side and the target language side, were set to three.

Besides, we evaluated the effectiveness of the method using back-translation, which is frequently used to improve the quality of machine translated sentences in many fields of intercultural collaboration. Back-translation is the process of translating a document that has already been translated into a foreign language back into the original language. By comparing the back-translated text to the source text, we can roughly figure out the quality of the MT without understanding the target language. We would like to show that the collaborative translation protocol is superior to this conventional method of improving MT quality. In the back-translation experiment, the maximum number of modification of a source sentence was also set to three and if a person could not determine that a back-translated sentence had the same meaning as the corresponding original sentence within the maximum modification limit, we viewed that the back-translation method terminated unsuccessfully.

The results of the collaborative translation, back-translation and the pure MT were scored by bilingual readers on a scale of 5 (All, Most, Much, Little, and None) in terms of translation adequacy[2]. Ratings were conducted by three people and the median was used as the final evaluated value. Since it is postulated that manually modified sentences are always fluent, the fluency of the translated sentences were not evaluated in this experiment.

[1] http://www.kecl.ntt.co.jp/mtg/resources/index.php
[2] http://projects.ldc.upenn.edu/TIDES/Translation/TransAssess02.pdf

In addition, we measured the average time required for collaborative translation and back-translation method and compared them to demonstrate that the time required for collaborative translation was tolerable.

4.2 Results

Success Rate. The rates in Japanese-English translation in which each protocol could terminate successfully were 67 percent for back-translation, and 70 percent for collaborative translation. On the other hand, the success rate in Japanese-Chinese translation was 78 percent for back-translation, and 62 percent for collaborative translation. Correlation between success rates of collaborative translation and of back-translation method were not observed, and those rates are in the same range.

Translation Adequacy. Figure 6 shows a graph of evaluated values of adequacy for pure MT, back-translation and collaborative translation in Japanese-English translation, and figure 7 shows Japanese-Chinese translation. Blue line with triangle marks in each graph indicates the percentage of translation that scored "All" when the protocol terminated successfully and red line with square marks indicates the percentage of translations scored "All" to all results used in the experiment (that is, including sentences where the protocol terminated but also unsuccessfully). In terms of pure MT, these percentages are the same. When the collaborative translation protocol terminated successfully, 83 percent of Japanese-English translation and 91 percent of Japanese-Chinese translation

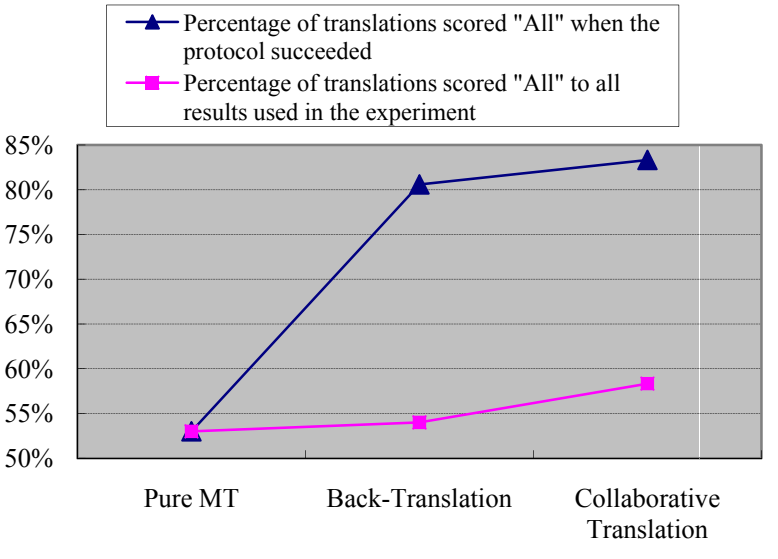

Fig. 6. Results of collaborative translation, back-translation, and pure MT in Japanese-English translation

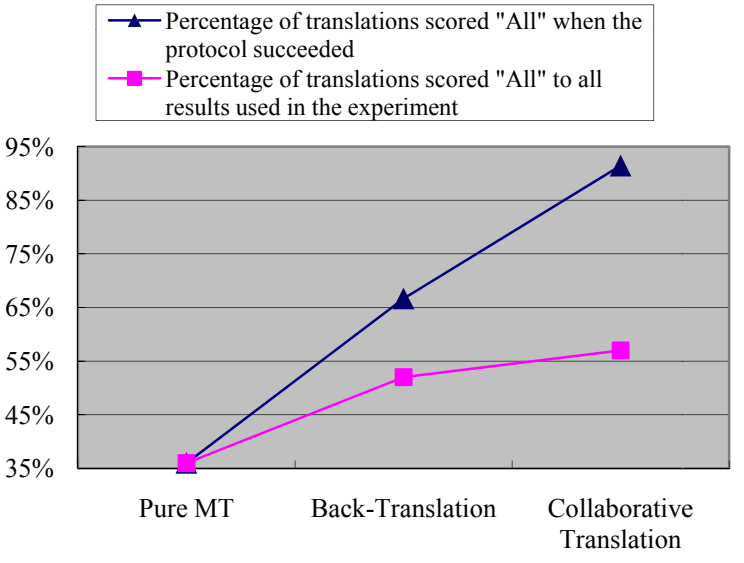

Fig. 7. Results of collaborative translation, back-translation, and pure MT in Japanese-English translation

were scored "All". This result shows that the translation quality is likely to be high if the collaborative translation protocol terminates successfully. As mentioned above, there is a possibility that the adequacy of the translated sentences could be low even if the collaborative translation protocol terminates successfully, but the possibility is very low. Besides, when comparing the results of collaborative translation with the results of back-translation, collaborative translation is superior to back-translation method in terms of translation adequacy in both Japanese-English and Japanese-Chinese translation.

Table 1 shows changes in the evaluated value of the adequacy of the collaborative translation from the value of pure MT in Japanese-English translation, and table 2 shows changes in Japanese-Chinese translation. Since this experiment was conducted with three pairs, 300 result sentences of collaborative translation

Table 1. Results of collaborative translation, back-translation, and pure MT in Japanese-English translation

		Collaborative Translation					
		5	4	3	2	1	Failure
Machine Translation	5	117	10	0	2	3	27
	4	21	5	0	0	0	22
	3	15	5	4	0	0	18
	2	11	1	2	0	0	16
	1	11	1	1	0	1	7

Table 2. Results of collaborative translation, back-translation, and pure MT in Japanese-English translation

		Collaborative Translation					
		5	4	3	2	1	Failure
Machine Translation	5	84	2	1	0	0	21
	4	30	6	0	0	0	18
	3	39	1	1	0	0	22
	2	16	2	1	2	0	51
	1	2	0	0	0	0	1

were available. 5 percent of the Japanese-English collaborative translation and 1 percent of the Japanese-Chinese collaborative translation got a lower evaluated value in adequacy against the results of pure MT, but this shows that most of the results of collaborative translation are higher than or equal to corresponding results of MT in terms of translation quality. In other words, there is very little possibility that collaborative translation degrades the MT quality, it is more likely to improve the MT quality.

Required Time. Average working time per sentence to modify a source sentence in the back-translation method is 40.2 seconds in Japanese-English translation and 29.1 seconds in Japanese-Chinese translation. In collaborative translation, the average working time for the source language side is 48.1 seconds in Japanese-English translation and 56.2 seconds in Japanese-Chinese translation. The time for the target language side is 30.4 seconds in Japanese-English translation and 42.9 seconds in Japanese-Chinese translation. As mentioned in section 3.2, since it is supposed that in a practical application multiple protocols for each original sentence are executed in parallel, the real required time of collaborative translation is not the sum of working times of the source language side and target language side but the maximum. That is, average required time for collaborative translation per a sentence which is used in this experiment is around one minute.

Since collaborative translation needs more human work than pure MT and back-translation method, the working time required is longer. However, we showed that the required time for collaborative translation is not considerably different from the time needed for the back-translation method. Besides, experimental results show that translation adequacy can be improved further by collaborative translation, and the translation results excel especially in fluency because the machine translated sentences are modified manually. Therefore, we can conclude that collaborative translation is more useful in the field of intercultural collaboration using MT.

5 Conclusion

Nowadays, many communities use MT in their activities. In one real field of intercultural collaboration, members try to enhance intergroup and intragroup

information sharing by modifying low-quality machine translation manually. However, there are two problems in the naive implementation: One is that poor quality of translation could induce misinterpretation, and the other is that phrases in the machine translated sentence that a person cannot make sense of remain unmodified. Our main research contribution is that we introduced the protocol in collaborative translation. This protocol solves the above two problems and, in addition, this protocol 1) improves MT quality; and 2) terminates successfully only when a translation result becomes adequate and fluent. We made it clear that the target language side can modify the machine translated sentences to be fluent, and the source language side can evaluate the translation quality by determining whether the back-translation of the modified sentence has the same meaning as the original sentence. Only 53 percent of Japanese-English translation and 36 percent of Japanese-Chinese translation were perfect translations in pure MT. However, when the collaborative translation protocol terminated successfully, 83 percent of Japanese-English translation and 91 percent of Japanese-Chinese translation were perfect. This revealed experimentally that collaborative translation is much more likely to result in a good translation.

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