Statistical Machine Translation with Rule based Machine Translation

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ABSTRACT

We have evaluated the two-stage machine translation (MT) system. The first stage is a state-of-the-art trial rule-based machine translation system. The second stage is a normal statistical machine translation system. For Japanese-English machine translation, first, we used a Japanese-English rule-based MT, and we obtained "ENGLISH" sentences from Japanese sentences. Second, we used a standard statistical machine translation. This means that we translated "ENGLISH" to English machine translation. This method has an advantages that it produces grammatically correct sentences.

From the results of experiments in the JE task, we obtained a BLEU score of 0.1996 using our proposed method. In contrast, we obtained a BLEU score of 0.1436 using a standard method. And for the EJ task, we obtained a BLEU score of 0.2775 using our proposed method. In contrast, we obtained a BLEU score of 0.0831 using a standard method.

This means that our proposed method was effective for the JE and EJ task. However, there is a problem. The BLEU score was not so effective to measure the translation quality.

Categories and Subject Descriptors

I.2.7 [**Natural Language Processing**]: Machine translation

General Terms

Languages

Keywords

SMT Rule-Based MT Hybrid System

1. INTRODUCTION

Many machine translation systems have been studied for long time. The first generation was a rule-based translation method, which was developed over the course of many years. This method had translation rules that were written by hand. Thus, if the input sentence completely matched the rule, the output sentence had the best quality. However, many expressions are used for natural language, this technology had very small coverage. In addition, the main problem are that the cost to write rules was too high and that maintaining the rules was hard.

Recently a statistical machine translation method is very popular now. This method is based on the statistics and easy to build if parallel corpus are existed. There are many versions of statistical machine translation models available. An early model of statistical machine translation was based on IBM $1 \sim 5$[1]. This model is based on individual words, and thus a "null word" model is needed. However, this "null word" model sometimes has very serious problems, especially in decoding. Thus, recent statistical machine translation systems usually use phrase based models. This phrase based statistical machine translation model has translation model and language model. The phrase table is a translation model for phrase-based SMT and consists of Japanese language phrases and corresponding English language phrases and these probabilities. And word N-gram model is used as a language model.

However some problems arise with phrase-based statistical machine translation. One problem is as follows. Normally, an N-gram model is used as a language model. However, this model consists of local language information and does not have grammatical information.

Our system has a two-stage machine translation system. The first stage consists of Japanese-English rule based machine translation. In this stage, we obtained "ENGLISH" sentences from Japanese sentences. We aim to achieve "ENGLISH" sentences that are generally grammatically correct. However, these "ENGLISH" sentences have low levels of naturalness because they were obtained using rule-based machine translation. In the second stage, we used a normal statistical machine translation system. This stage involves "ENGLISH" to English machine translation. With this stage, we aim to revise the outputs of the first stage improve the naturalness and fluency.

We used a state-of-the-art trial rule based machine translation system for the first stage. We used general statistical machine translation tools for the second stage, such as "Giza++"[5], "moses" [7], and "training-phrase-model.perl" [14]. We used NTCIR-7 and NTCIR-8 data. It means we used 3,186,284 sentences. Also, the score was not optimized, and our method was still very promising. We used these data and these tools and participated in JE and EJ at NTCIR-9.

From the results of experiments, we obtained a BLEU score of

0.1996 in the JE task using our proposed method. In contrast, we obtained a BLEU score of 0.1436 in the JE task using a standard method (moses). And we obtained a BLEU score of 0.2775 in the EJ task using our proposed method. In contrast, we obtained a BLEU score of 0.0831 in the EJ task using a standard method (moses). This means that our proposed method was effective for all task. On the other side, our system was the 28th place in 36 system for BLEU score in JE task. And our system was the 7th place in 19 system for average adequacy score in JE task. It means that our system is better for human evaluation. And it means that the BLEU score is not reliable. Same trend have obtained for EJ task.

For the future study, we will try to improve the performance of RBMT system. So, we will continue to develop the method and try again in the future.

2. RELATED WORKS

Our system has a two-stage machine translation system. The first stage is a state-of-the-art trial rule based machine translation system, and the second stage is a normal statistical machine translation system. This idea was based on paper[3],[4],[5]. Similar studies were on paper[16],[17],[18], [15] [19] and [20]. [16] and [17] was Fresh-English translation and used SYSTRAN. [15] was Chineses-English translation for patent task and used SYSTRAN. [18] [19] [20] was Japanese-English translation for patent task.

3. CONCEPTS OF OUR STATISTICAL MACHINE TRANSLATLION SYSTEM

We describe our system by dividing it into two processes, training and decoding. These processes are assumed to be Japanese-English translation.

3.1 Training

The training process is as follows.

1. Parallel Corpus

   We prepare a Japanese-English parallel corpus.

2. Rule-based Machine Translation

   We used a Japanese-English rule-based machine translation. Thus, we obtain "ENGLISH" sentences from Japanese sentences. These "ENGLISH" sentences are pairs of English sentences.

3. "ENGLISH"-English phrase table

   We make an "ENGLISH"-English phrase table using training-phrase-model.perl[14].

4. English N-gram model

   We make an N-gram model from English sentences using SRILM [6].

Fig. 1 shows the flow chart of the training process.

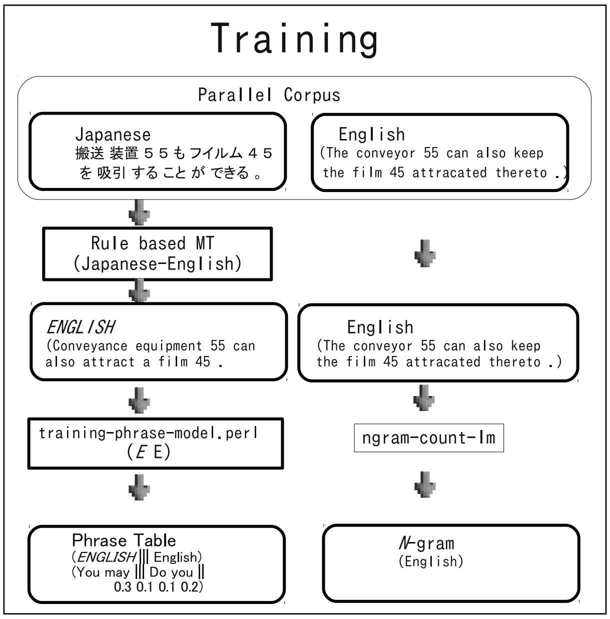

Figure 1: Flowchart of Training

3.2 Decoding

The decoding process is as follows.

1. Test Corpus

   We prepare the Japanese test sentences.

2. Rule-based Machine Translation

   We used a Japanese-English rule-based machine translation. Thus, we obtain "ENGLISH" test sentences.

3. Statistical Machine Translation System

   Using phrase table in Section 3.1, N-gram model in Section 3.1, and moses[7], we decode the "ENGLISH" sentences. This involves "ENGLISH"-English translation. In this way, we obtain English sentences.

Fig.2 shows the flow chart of the decoding process.

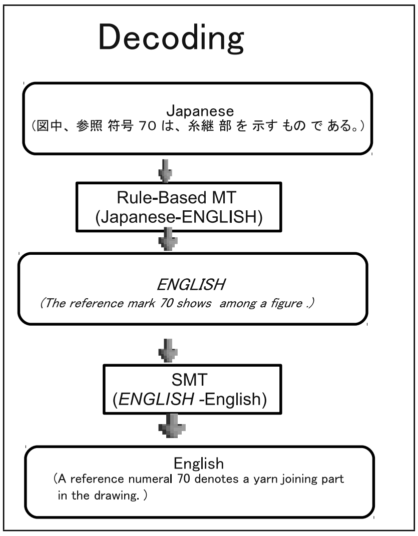

Figure 2: Flowchart of Decoding

4. EXPERIMENTS WITH OUR MACHINE TRANSLATION

4.1 Training Data

We used the English punctuation procedure, which means that we changed "," and "." to " , ", and " . ". Also, we handled the numbers, which means that we changed "100" to "1 0 0". And, we did not handle English case forms. We used NTCIR-7 and NTCIR-8 data. It means we used 3,186,284 sentences.

4.2 First Stage

We used a state-of-the-art trial rule based machine translation system for the first stage.

4.3 "ENGLISH"-"English" Phrase Tables

For the second stage, we made an ENGLISH-English phrase table. To make this table, we used "train-phrase-model.perl[14]" in "training-release-1.3.tgz". We set parameters to default values.

Table 1 lists examples of phrase tables for the second stage of our MT. This phrase table represents an "ENGLISH" "English" phrase table. As seen in this table, some English phrases are natural, although some of them are unnatural.

Table 1: Examples of phrase-tables

equipment , and |||device , where |||
0.416667 0.0170766 0.00200401 0.000436905 2.718 12 2495
equipment , and |||device , whereby the delivery and |||
1 0.123056 0.000400802 1.47153e-09 2.718 1 2495
equipment , and |||device , whereby |||
0.111111 0.100007 0.000801603 0.000675213 2.718 18 2495
from the |||form a |||
0.00136 0.00356 4.86e-05 0.00013 2.718 10236 287812
of each |||with each |||
0.0228983 0.0221287 0.00318399 0.00279683 2.718 6114 43970
of the crank web |||of a crank web |||
0.75 0.0975717 0.75 0.0590791 2.718 4 4

4.4 5-gram Language Model

We calculated the 5-gram model using ngram-count in the Stanford Research Institute Language Model (SRILM) toolkit [6]. And We did not smooth parameters, it means we set the smoothing parameter as "-cdiscount 0".

4.5 Decoder

We used "Moses[7]" as a decoder. In Japanese to English translation, the position of the verb is sometimes significantly changed from its original position. Thus, we set the "distortion weight (weight-d)" to "0.2" and "distortion-limit" to "-1" for standard statistical machine translation. However, our system has 2 stage machine translation and the output of first stage is "ENGLISH". In this case, the position of word did not move so widely. So, we set the "distortion-limit" to "-6" for second stage statistical machine translation for our system.

Table 2 indicates the other parameters. Also, we did not optimize these parameters nor use a reordering model.

Table 2: Parameters of moses.ini

ttable-limit	80	0			
weight-d	0.2				
weight-l	1.0				
weight-t	0.5	0.0	0.5	0.1	0.0
weight-w	-1				
distortion-limit	(-1 or 6)				

5. RESULTS OF OUR MACHINE TRANSLATION

5.1 Examples of Outputs

Table 6 shows examples of outputs. For terms of "Input" in Table 6 shows input Japanese or English sentences. For terms of "Proposed" in Table 6 shows outputs of proposed method. For terms of "Baseline" in Table 6 shows outputs of moses with no parameter tuning. For terms of "RBMT" in Table 6 shows outputs of a-state-of-the-art rule based machine translation, and its means outputs of the first stage. For terms of "REFERENCE" in Table 6 shows reference sentences (correct sentence).

5.2 Automatic Evaluation Results

Table 3 summarizes automatic evaluation results for the JE and EJ tasks. In this table, "Proposed" indicates our proposed system. "Baseline" indicates normal statistical machine translation (moses). "Rule based MT" indicates state-of-the-art rule based machine translation. "()" means the order of entry systems. For example, Our system was the 28th place in 36 system for BLEU score in JE task. As seen in these results, our method was so effective.

5.3 Human Evaluation Results

Table 4 summarizes human evaluation results of our machine translation evaluation for the JE and EJ tasks. In this table, "Proposed" indicates our proposed system. "adequacy" indicates the average adequacy . "acceptability" indicates the average acceptability. "()" means the order of all entry systems. For example, Our system was the 7th place in 19 system for the average adequacy in JE task.

As seen in these results, our method was so effective. And the

Table 3: Results of Automatic Evaluation

	Task	BLEU	NIST	REIBES
Proposed (RBMT+SMT)	JE	0.1996 (28/36)	6.1112 (32/36)	0.6932 (9/36)
Rule based MT (A state-of-the-art)	JE	0.209 (26/36)	6.2831 (30/36)	0.6972 (8/36)
Baseline (SMT:moses)	JE	0.1436 (36/36)	4.926 (36/36)	0.6607 (20/36)
Proposed (RBMT+SMT)	EJ	0.2775 (21/32)	7.3284 (21/32)	0.7479 (4/32)
Rule based MT (A state-of-the-art)	EJ	0.2475 (25/32)	7.1413 (24/32)	0.6782 (23/32)
Baseline (SMT:moses)	EJ	0.0831 (32/32)	3.7711 (32/32)	0.5902 (32/32)

Table 4: Results of Human Evaluation

	task	adequacy	acceptability pairwise comparison score	(tie)
Proposed (RBMT+SMT)	JE	2.73 (7/19)	0.4604 (8/14)	0.3312 (9/14)
Proposed (RBMT+SMT)	EJ	2.6 (9/17)	0.4318 (8/11)	0.2992 (5/11)

BLUE sore was worse compared to other systems. Howver results of human evaluation was good compared to other systems.

6. DISCUSSION

With our system, we aim to reduce the number of ungrammatical sentences. Thus, we analyze the outputs according to these factors. However, the patent sentences are too long and too strange sentences compared normal sentences, it was impossible to analyze these results for detail, and could not determine what was wrong. However, by comparing the output of moses and the output of our system, we found that our system produced more grammatically correct sentences.

7. CONCLUSION

We have developed a two-stage machine translation system. The first stage is a state-of-the-art trial rule based machine translation system. The second stage is a statistical machine translation system. Our goal with this system was to obtain fewer ungrammatical sentences. The results that we obtained in this experiments were so good. In future experiments, we will try these data and these techniques, which we expect will enable our system to perform better.

8. APPENDIX: EXPERIMENTS WITH PARAMETER TUNING

We found many errors and mistakes with these experiments. So we tried these experiments again with same conditions. Also, we use reordering models and optimize these parameters using MERT. Table5 shows the results of these experiments. As can be seen this table, proposed method was so effective. And results of automatic evaluation score were very high. For example, the BLEU score of proposed method was 0.3598 in JE task and 0.3911 for EJ task. These values are the best score in NTCIR-9.

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Table 5: Appendix: Results with Parameter Optimization

	Task	Parameter Tuning	BLEU[8]	NIST[8]	METEOR[9]	TER [10]	WER [10]	RIBES [12]	IMPACT [13]
Proposed (RBMT+SMT)	JE	○	0.3598	8.1769	0.6676	0.5387	0.6436	0.7412	0.5654
Proposed (RBMT+SMT)	JE	×	0.2697	7.1982	0.6049	0.5666	0.6566	0.7240	0.5197
Rule based MT (A state-of-the-art)	JE	×	0.2761	6.8759	0.6099	0.6172	0.7048	0.7114	0.5064
Baseline (SMT:moses)	JE	○	0.2886	7.1503	0.6567	0.6684	0.8307	0.6334	0.4527
Baseline (SMT:moses)	JE	×	0.2120	6.9635	0.5741	0.6431	07852	0.6727	0.4078
Proposed (RBMT+SMT)	EJ	○	0.3911	8.3941		0.4991	0.6184	0.6709	0.5753
Proposed (RBMT+SMT)	EJ	×	0.3076	7.6219		0.5441	0.6492	0.6562	0.5326
Rule based MT (A state-of-the-art)	EJ	×	0.1998	5.4690		0.7274	0.8075	0.5632	0.4393
Baseline (SMT:moses)	EJ	○	0.2408	6.4319		0.5441	0.6492	0.6563	0.4743
Baseline (SMT:moses)	EJ	×	0.2531	7.1181		0.5968	0.7377	0.5532	0.4394

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Table 6: Outputs

		J E
2	Input	図４に非磁性層を流れる電流に対する電気抵抗を縦軸にとってグラフに示している。
	Proposed	The electric resistance to the current flowing in FIG . 4 via a non-magnetic layer is shown in the graph on the vertical axis .
	Baseline	FIG . 4 is a graph showing the electric current flowing through the resistance nonmagnetic layer vertical axis .
	RBMT	The electrical resistance to the current which flows into Fig. 4 through a nonmagnetic layer is shown in the graph for the vertical axis.
	REFERENCE	FIG . 4 is a graph showing an electric resistance to an electric current flowing in the nonmagnetic layer with the axis of ordinates representing the electric resistance .
3	Input	図６は、階段波の波高値を０：±１：±√ ２の５値で、且つ、階段波の波形立が上り時間を遅くした場合のものである。
	Proposed	FIG . 6 shows that obtained when five values of 0 : 1 : & plusmn ; 2 , and 波形立 of a staircase waveform up the crest value of a staircase waveform , and the time delayed .
	Baseline	In step 5 0 , . + -.1 / 2 of the peak value of this waveform is delayed , and when the staircase waveform of FIG . 6 , is provided .
	RBMT	Fig. 6 shows the thing at the time of being five values of 0:± 1:± root2, and 波形立 of a stairs wave going up the wave high price of a stairs wave, and making time late.
	REFERENCE	In FIG . 6 , the peak values of the staircase wave are set to five values , 0 , 1 , and 2 , and the wave is raised in delayed timings .
4	Input	また、サーモメータエンコーダ１１は、入力信号ＩＮ０が「１６」（１０進数）の場合に例外処理を行い、剰余コードＣ０に「４」を出力し、マルチプルコードＣ１ｍｕｌｔｉｐｌｅに「１２」を出力する。
	Proposed	Further , the thermometer film encoder 1 1 conducts an exceptional process , when the input signal IN0 is " 1 6 " (decimal number) , it outputs " 4 " to the excessive code C0 and outputs " 1 2 " to multiple code C1 .
	Baseline	he remainder is " 0 " , " 1 6 " and " 4 " in decimal number) , the output of the thermometer 1 2 ｍｕｌｔｉｐｌｅ exception code (C1 code) encoder 1 0 1 is subjected to the multiple outputs the input signal IN .
	RBMT	Moreover, the thermometer encoder 11 performs exception handling, when input signal IN0 is "16" (decimal number), it outputs "4" to the surplus code C0, and outputs "12" to multiple code C1multiple.
	REFERENCE	Also , when input signal IN0 is 1 6 (decimal number) , thermometer encoder 1 1 performs exceptional treatment , outputs 4 to remainder code C0 , and outputs 1 2 to multiple code C1 multiple .
14	Input	そして、コネクタ１８ａを基板１２に固定するときには、コネクタ１８ａの樹脂爪３０を、基板１２の爪係合孔３２の上に位置させ（図３も参照）、その後樹脂爪３０を爪係合孔３２内に挿入する
	Proposed	When the connector 1 8 a is fixed to the substrate 1 2 , resin claws 3 0 of the connector 1 8 a is positioned on the pawl engaging hole 3 2 of the substrate 1 2 (see FIG . 3) , and the resin claws 3 0 is inserted into the pawl engaging hole 3 2 .
	Baseline	The connector 2 3 is inserted into the connector 3 0 , whereupon the resin substrate 3 8 is placed on the resin substrate 1 2 2 of a pawl member 1 2 0 is fixed at the pawl engaging holes 1 3 a (see also FIG . 3) of the pawl engaging holes 1 8 .
	RBMT	And when the connector 18a is fixed to the substrate 12, the resin nail 30 of the connector 18a is located on the nail engaging-of-clutch hole 32 of the substrate 12 (also see Fig. 3), and the resin nail 30 is inserted into the nail engaging-of-clutch hole 32 after that.
	REFERENCE	When the connector 1 8 a is fixed to the board 1 2 , the resin claw 3 0 of the connector 1 8 a is positioned above the claw engagement hole 3 2 of the board 1 2 (also refer to FIG . 3) , and the resin claw 3 0 is thereafter inserted in the claw engagement hole 3 2 .
		E J
1	Input	As shown in FIG. 4, the valve overlap amount decreases as the valve working angle of the intake valve 30 decreases.
	Proposed	図 ４ に 示す ように 、 バルブ オーバラップ 量 は 、 吸気 弁 ３ ０ の 弁 の 角度 が 減少 し て いる 。
	Baseline	図 ４ に 示す ように 、 バルブ オーバーラップ 量 が 減少 し 、 吸気 弁 ３ の 作用 角 が 減少 し て いる 。
	RBMT	図 ４ に 示さ れる ように 、 バルブ ・ オーバーラップ 量 は 、 吸い込み 弁 ３ ０ 減少 の バルブ を 動かす 角度 につれて 減少 する 。
	REFERENCE	同 図 ４ に 示す ように 、 吸気 バルブ ３ ０ の バルブ 作動 角 が 小さい とき ほど 、 バルブ オーバーラップ 量 は 小さい
2	Input	Thereby, the retention mechanism 8 can be easily detached from the motherboard 2.
	Proposed	これ に より 、 保持 機構 8 は 、 マザー ボード 2 から 容易 に 分離 する こと が できる 。
	Baseline	これ に より 、 保持 機構 は 、 マザー ボード ２ 8 に対して 着脱 自在 と さ れ て いる 。
	RBMT	その ため に 、 保持 メカニズム 8 は 、 容易 に マザー ボード 2 から 分離 する こと が できる 。
	REFERENCE	それ に より 、 リ テンション メカニズム 8 を マザー ボード 2 から 容易 に 取り外す こと が 可能 と なる 。
4	Input	FIG. 26 is a partially enlarged perspective view showing guides 250 of the disc array storage 200.
	Proposed	図 ２ ６ は 、 ディスク アレイ 記憶 装置 ２ ０ ０ の ガイド 部 ２ ５ ０ を 部分 的 に 拡大 し た 斜視 図 で ある 。
	Baseline	図 ２ ６ は 、 ガイド ２ ５ の ディスク アレイ 装置 ２ ０ の 一部 拡大 斜視 図 で ある 。
	RBMT	図 ２ ６ は 、 ディスク ・ アレイ 記憶 装置 ２ ０ ０ の ガイド ２ ５ ０ を 示す 、 部分 的 に 拡大 し た 透視 図 で ある 。
	REFERENCE	ここ で 、 図 ２ ６ は 、 ディスク アレイ 装置 ２ ０ ０ の ガイド ２ ５ ０ を 説明 する ため の 部分 拡大 斜視 図 で ある 。
19	Input	When the sheathed wire is press-fitted into the slot portion 22 of each press-contacting piece portion 23 of the terminal 12 from the upper side, the insulating sheath of the sheathed wire is cut by the blade 21 of the slot portion 22, so that the internal conductor of the sheathed wire contacts the press-contacting piece portion 23.
	Proposed	被覆 電線 を 、 上側 から 端子 １ ２ の 各 圧 接 片 ２ ３ の スロット ２ ２ に 圧入 する 際 、 被覆 電線 の 絶縁 被覆 は スロット 部 ２ ２ の ブレード ２ １ で 切断 さ れ 、 被覆 電線 の 内部 導 電 体 は 、 圧 接 片 ２ ３ に 当 接 する 。
	Baseline	また 、 圧 接 端子 １ の 各 圧 接 刃 ２ １ の 開口 部 ２ ２ に 接触 し て 被覆 電線 の 被覆 電線 の 被覆 部 を 切断 し 、 絶縁 被覆 電線 を 圧入 する 溝部 ２ ２ の 片 ２ ３ ２ の 上面 から 内部 導体 片 ２ ３ で ある 。
	RBMT	鞘 に 納め られ た ワイヤー が 上部 の 側 から の ターミナル １ ２ の 各 圧迫 と 接触 する 部分 部分 ２ ３ の スロット 部分 ２ ２ に 圧迫 入れ られる 場合 、 鞘 に 納め られ た ワイヤー の 絶縁 する さや は スロット 部分 ２ ２ の 葉 ２ １ に よって カット さ れる 。 その 結果 、 鞘 に 納め られ た ワイヤー の 内部 伝導 体 は 圧迫 と 接触 する 部分 部分 ２ ３ と 接触 する 。
	REFERENCE	そして 、 端子 １ ２ の 上方 から 圧 接 片 ２ ３ の スロット ２ ２ に 被覆 電線 が 圧入 さ れる と 、 被覆 電線 の 絶縁 被覆 が スロット ２ ２ の 刃 部 ２ １ により 切 裂 さ れ て 被覆 電線 の 内部 の 導体 が 圧 接 片 ２ ３ に 接触 する 。

“Input” : input sentence.
“Proposed” : output of proposed method with parameter optimizing.
“Baseline” : output of moses with no parameter tuning.
“RBMT” : output of rule based machine trainslation.
“REFERENCE” : reference (correct) sentence .