

Japanese to Ryukyuan Language Translation System with Speech Output and Its Application to Education

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Abstract

A speech translation system is a typical subject of natural language processing and speech processing. However, until now, there is a few WWW demonstration sites of the speech translation, especially no for education. In this paper, we report our demonstration system of translation from Japanese to Ryukyuan language with speech output and its application to education of university level.

1. Introduction

Natural language processing and speech processing are fundamental techniques for multimedia communication using characters and speech. A speech translation system is a typical subject of both techniques. However, until now, there is a few WWW demonstration sites of the speech translation, especially no for education. In this paper, we report our demonstration system of translation from Japanese to Ryukyuan language with speech output and its application to education of university level. Ryukyuan is minor language spoken in southern most part of Japan, Okinawa and is the only one sister language of Japanese. Therefore, our system is not only compact and easy to learn, but also useful for language education of native Ryukyuan students.

Language processing subsystem of this translation system involves of an electronic Okinawan dictionary block and a phoneme transformation block. The transformation block is constructed by using an expert system's programming language. If the inputted word is not entry of the dictionary, the transformation block generates a quasi-Ryukyuan word, which sounds like Ryukyuan. Speech synthesis subsystem is based on the Cepstrum method. The source signal of the synthesis filter is switched according to voiced/unvoiced information. Because the system is constructed as a web server, it can be used from anywhere. In a classroom, a professor can demonstrate and explain about principle of the translation system. Students can also test the system and listen to the resulting Ryukyuan speech.

Many students say in their questionnaires that the subjects are difficult but easy to learn because of the real demonstration and their own experiments. We plan to make this class to be interactive multimedia contents with movie and provide them to other universities via a gigabit network.

2. Japanese to Ryukyuan Language Translation System with Speech Output

The Japanese to Ryukyuan Language Translation System consists of a language processing subsystem and a speech synthesis subsystem. Language processing part performs translation from the Japanese standard language to the Ryukyuan. The speech synthesis subsystem outputs spoken Ryukyuan. Language processing subsystem of this translation system involves of an electronic Okinawan dictionary block, phoneme transformation block and stem transformation block. Figure1 illustrates the flow of language processing subsystem. The phoneme transformation block and the stem transformation block are made up of OPS/R2, which is an expert system's programming language.

2.1. Electronic Okinawan dictionary

Electronic Okinawan dictionary[1] is based on Okinawan dictionary[2], which can be looked up a Japanese word by Ryukyuan and Ryukyuan word by Japanese. This dictionary is composed of efficient trie structure. To increase the efficiency of the searching tree, each node needs to include some value to teach the way to branch. The tree based on this thought is called trie.

Branch node, which decides the way to branch on the trie, adopts characters consisting of keys (entry word in dictionary). A leaf is called information node, which is a complete information record. The information node includes some information connected to keys (meaning and explanation of entry word in dictionary).

The Japanese to Ryukyuan part of the dictionary is used in this system.

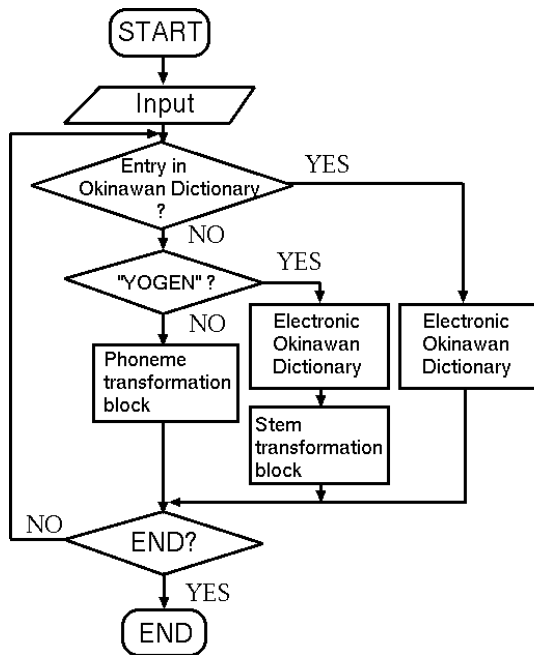


Figure1. Language processing subsystem

2.2. Phoneme transformation block

If the input word is not entry of the dictionary, and it is not "YOGEN", which is a word with inflectional endings and can be used as a predicate, the word is transformed in this phoneme transformation block. This block generates a quasi-Ryukyuan word, which sounds like Ryukyuan. A phonemic transformation from Japanese to Ryukyuan is illustrated in Table1. We arranged 30 rules for phoneme transformation paying attention to the number of mora. These rules do not consider "YOGEN". Therefore, "YOGEN" is not transformed correctly in this block. Table1 illustrates rules of phoneme transformation used in this system.

Table1. phoneme transformation rules

<p>Transform one mora word to two morae word</p> <p>One mora word:</p> <p>(1) An ending of a word /a/ to /aa/ /i/ to /ii/ /u/ to /uu/ /e/ to /ii/ /o/ to /uu/</p> <p>(2) From /hi/ or /he/ to /hwi/ (3) From /ki/ to /ci/ (4) From /gi/ to /zi/ (5) From /cu/ to /ci/ From /zu/ to /zi/ From /su/ to /si/</p> <p>Transform one mora word to one mora</p> <p>(6) More than three morae, a ending /mi/ of a word to /n/</p>
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- More than two morae:
- (7) From /hi/ or /he/ to /hwi/
 - (8) From /ki/ to /ci/
 - (9) From /gi/ to /zi/
 - (10) From /cu/ to /ci/
 From /zu/ to /zi/
 From /su/ to /si/

Transform two morae word to two morae word

- More than two morae:
- (11) An ending /mono/ of a word to /mun/
 - (12) Form /ari/ to /ai/
 - (13) From /uri/ or /ori/ to /ui/
 - (14) From /ai/ or /ae/ to /ee/
 - (15) From /ao/ to /oo/
 - (16) From /awa/ to /aa/
 - (17) From /ui/ or /ue/ to /ii/
 - (18) From /hai/ or /hae/ to /hwee/
 - (19) From /kura/ to /qkwa/
 - (20) From /kure/ to /qkwi/
 - (21) From /gura/ to /ngwa/
 - (22) From /gure/ to /ngwi/

Transform two morae word to one mora word

- More than two morae:
- (23) A beginning /mi?a/ or /mu?a/ of a word to /n?a/
 /mi?e/ or /mu?e/ to /n?e/

Transform consonant to consonant

- More than two morae:
- (24) A beginning /r/ of a word to /d/
 - (25) Expect beginning /rj/ of a word to /j/
 - (26) From /kj/ or /cj/ to /c/
 - (27) From /gj/ or /zj/ to /z/
 - (28) From /sj/ to /s/

Transform vowel to vowel

- (29) From /e/ to /i/
- (30) From /o/ to /u/

2.3. Stem transformation block

The end of the stem of the "YOGEN" of Ryukyuan is changed in some patterns. It is known that the transformation rules of Ryukyuan verb are classified into 14 forms. And also, that of adjective are classified into 2 forms.

This stem transformation block is constructed by using OPS/R2, which is an expert system's programming language. We used the grammatical rules of stem transformation written in the Okinawan dictionary. However, there are some words for which the system could not decide the rules only by checking these patterns. These grammatical rules are not enough to adopt for this system. Therefore, we made some new rules using Electronic Okinawan dictionary for these words.

We arranged 43 rules to transfer the end of stem. We did not consider irregular verbs. Therefore, the irregular verbs cannot be transformed correctly by this block.

Table2. Example of stem transformation rules

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1. Verb

An ending of a word:

More than one mora

- (1) From /zuN/ to /zi/
From /cuN/ to /ci/
From /buN/ to /bi/
- (2) From /nuN/ to /mi/
- (3) From /sjuN/ to /s/
- (4) From /zuN/ to /g/
- (5) From /buN/ to /b/
- (6) From /nuN/ to /m/
- (7) From /cuN/ to /k/
- (8) From /sijuN/ to /c/
- (9) From /zuN/ to /z/
- (10) From /buN/ to /d/
From /nuN/ to /d/
- (11) From /cuN/ to /c/

More than two morae

- (12) Remove /uN/
- (13) From /juN/ to /i/
- (14) From /juN/ to /r/
- (15) From /NzuN/ to /Nd/
- (16) From /k_cuN/ to /k_t/
- (17) From /juN/ to /t/
- (18) From /NzuN/ to /Nt/
- (19) From /k_cuN/ to /k_Qc/

Three morae

- (20) From /tacuN/ to /tat/
- (21) From /m_cuN/ to /m_t/
- (22) From /?ucuN/ to /?ut/
- (23) From /cijuN/ to /cic/
From /nijuN/ to /nic/
From /'ijuN/ to /'ic/
- (24) From /ijuN/ to /iQt/

All word

(These rules are not case such as an ending of a word)

- (25) From /tacuN/ to /taQc/
- (26) From /m_cuN/ to /m_Qc/
- (27) From /?ucuN/ to /?uQc/

More than four morae

- (28) From /tacuN/ to /tat/
From /dacuN/ to /dat/
- (29) From /imucuN/ to /imut/
- (30) From /u?ucuN/ to /u?ut/
- (31) From /tacuN/ to /taQc/
From /dacuN/ to /daQc/
- (32) From /imucuN/ to /imuQc/
- (33) From /u?ucuN/ to /u?uQc/

More than five morae

- (34) From /aarijuN/ to /aari/
From /rarijuN/ to /rari/
From /karijuN/ to /kari/
From /aarijuN/ to /sari/
From /marijuN/ to /mari/
From /marijuN/ to /maQt/
- (35) From /aarijuN/ to /aaQt/
From /rarijuN/ to /raQt/
From /karijuN/ to /kaQt/
From /sarijuN/ to /saQt/
From /marijuN/ to /saQt/
From /marijuN/ to /maQt/
- (36) From /kuNzuN/ to /kuNc/

2. Adjective

An ending of word:

More than two morae

- (1) From /aN/ to /aj/
- (2) From /aN/ to /ai/
- (3) From /aN/ to /ar/
- (4) From /aN/ to /at/
- (5) From /jaN/ to /iku/
- (6) From /saN/ to /ku/
- (7) From /sjaN/ to /sii/

2.4. Speech Synthesis block

We constructed the speech synthesis block using Ryukyu Dialect Speech Synthesis system (RDSS)[3] based on the Cepstrum technique for pitch analysis. We adopt Log Magnitude Approximation (LMA)[4] filter proposed by Imai as the synthesis filter in which Cepstrum coefficients are used. The LMA filter is controlled by the Cepstrum parameters, which are used as vocal tract parameters, and driven by pitch impulse series for voiced sounds or by white noise for unvoiced sounds. Cepstrum coefficients are renewed at each frame for unvoiced sounds and at every time for voiced sounds whenever pitch pulse occurs. Figure2 shows overall of this speech synthesis block.

The parameters for the speech synthesis are the Cepstrum coefficients, pitch period and voiced/unvoiced distinction.

3. Evaluation of translation performance

We performed an evaluation test of the language processing block, which is the most important part of this system. We used 47 sentences for the test, which are selected by random sampling. Twenty-three input sentences are chosen from “The Beautiful Okinawan Dialect”[5] and twenty-four sentences from “Okinawan Proverb Dictionary”[6]. We decided correct or not for each word, comparing the result of the translation with the source sentences.

The result of the translation from standard Japanese to Ryukyuan dialect may be multiple. Some Ryukyuan postpositional particle fuses with a noun. Currently, we do not consider the fusion of these words. So, noun and postpositional particle are translated independently. We decided correct or not using the following three rules.

- (1) It is correct when a translated sentence conforms completely to the sample sentence, comparing the result with the test sentences word by word.
- (2) When the translated word is different from the test word, it is checked using Okinawan dictionary. If the translated word is found in the dictionary, we decide the word is correct.

(3) Noun and postpositional particle are independently decided correct or not.

The correct rate is calculated as the number of correct words divided by a total number of words. The correct rate of translation is 40.5%, which is low at this moment.

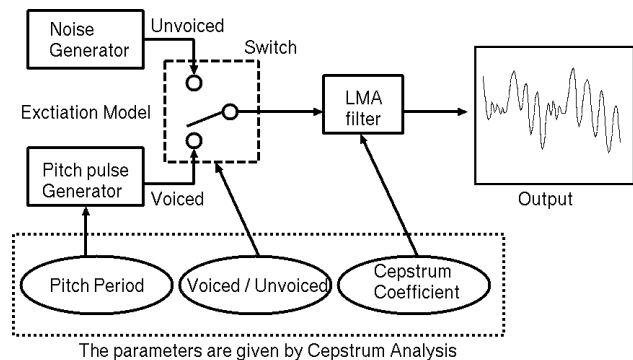


Figure2. Overall of speech synthesis block

4. Application of Japanese to Ryukyuan translation system with speech output to education

Japanese to Ryukyuan translation system with speech output is used for demonstration in classrooms of Ryukyuan University, in "Natural Language Processing" which is a specialist subject of the Information Engineering and "Outline of High-tech Information Engineering" which is the common liberal arts.

In the "Natural Language Processing" class, first, the electronic Okinawan dictionary, which is the subsystem of Japanese to Ryukyuan translation system with output, is introduced as a concrete example of a trie structure. Students are given homework to test this dictionary system after they learned the principle of the trie. Because this system is provided on WWW[7], students can use this system from their own home and it is possible to finish the homework.

In "Outline of High-tech Information Engineering" class, the speech processing is discussed three times. Demonstrations are performed in every class by using a computer. For discussion of the speech synthesis, the speech synthesis subsystem of the Japanese to Ryukyuan translation with speech output system is used for demonstration. After the students learned procedure of the speech synthesis in the lecture, they watch directly the procedure of speech production by using the demonstration system. They can also perform the experiments of speech synthesis at their homes because this speech synthesis system is provided as a Web system.

The application to education of the Japanese to Ryukyuan translation with speech output was evaluated to be very effective by the students, especially by those of

the class "Outline of High-tech Information Engineering". According to the result of questionnaires of the students, the demonstration system makes the students easy to understand the difficult theme of the class. As the future work, we need to provide a speech analysis system and a speech recognition system on Web in order to make it easy for students themselves to perform the demonstration. On the other hand, the effectiveness of the system for education is not so high in the "Natural language Processing". This is thought because the demonstration system does not adopt effective graphical user interface (GUI). For the future work, we need to develop a demonstration system using effective GUI, which makes students easy to understand the translation processing.

5. Conclusion

We have illustrated and reported the Japanese to Ryukyuan translation system with speech output and its application to education of university level. This system inputs Japanese sentence and translates it to Ryukyuan dialect and outputs its speech. The system used to support the language education of Ryukyuan dialect. We got some effective results using the real demonstration in some classes.

As the future work, we plan to improve this system to be easier to study Ryukyuan language, considering its operation, i.e. voice input, using image processing to assist visual aids, etc. And also, we will provide this education system to other universities via a giga-bit network.

Acknowledgement

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