A Stochastic Model for Spoken Language Understanding

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Abstract

In this paper, we propose a new stochastic model for sentence speech understanding using dictionary and thesaurus. The proposed model searches the dictionary for the same word with input text. If it is not in the dictionary, the proposed model search the high level words in the high level word dictionary based on the thesaurus. We compare the probability of sentence understanding model with threshold probability, and we'll get the sentence understanding rate. We evaluated the performance of the sentence speech understanding system by applying twenty questions game. As the experiment results, we got sentence speech understanding accuracy of 79.8%. In this case probability (\( \alpha \)) of high level word is 0.9 and threshold probability (\( \beta \)) is 0.38.

1. Introduction

The promise of a powerful computing device to help people in productivity as well as in recreation can only be realized with proper human-machine communication. Automatic recognition and understanding of spoken language is the first and probably the most important step toward natural human-machine interaction [1]. Speech understanding, whether done by people or by computers, demands great funds of knowledge [2]. In spoken language understanding, in addition to difficulties intrinsic to natural language processing, both recognizer and user errors must be handled. Nevertheless, for a lot of applications using a human-machine speech based interface, not all semantic contents of the utterance are relevant to the communication [3].

Given the goal of extracting from the input utterance just the information needed to complete the query, two opposite kinds of approaches are possible: statistical and knowledge-based. Both of them have advantages and disadvantages. Statistical approaches [4] need a lot of labeled data (only supervised learning is considered here), but require very little a-priori information and extract all the information necessary to fulfill the task form data. They are easily adapted to new domains and tend to be robust with respect to spontaneous speech phenomena and to recognizer error.

On the other hand, knowledge-based approaches [6] do not need data collection and labeling, but require a lot of expert’s work to put the necessary knowledge into the system. Since the knowledge is hand-coded, care must be taken to keep it consistent and error-free [3]. In this paper, we propose an understanding model to understand sentences from stochastic model using dictionary and thesaurus. We compare probability using understanding model with critical value as a result of experiment. Conforming performance of proposed probability model, we realized sentence understanding system and applied to twenty questions game. We compare probability using understanding model with critical value as a result of experiment. Conforming performance of proposed probability model, we realized sentence understanding system and applied to twenty questions game. We made a twenty questions game for animals. Computer gets the probability by searching animal dictionary in twenty questions game of animal. If probability is over critical value, computer decides to be correlation with that animal. When we add dictionary and thesaurus, this system can be applied to other fields.

2. Sentence Understanding System

Sentence understanding system understands input sentence and speech. The understanding system is made up of restricted dictionary, upper words dictionary and thesaurus. The understanding system read out the restricted dictionary for same word with input sentence. If it is not in the restricted dictionary, understanding system read out upper level words in the high level word dictionary based on the thesaurus. Sentence understanding system bring information in selected a category. A user asks understanding system a question using any sentence or text. If a question have a relation a category Yes, relation isn't No.

Dictionary and thesaurus can apply to any field of understanding process. A user asks using speech in content of category that computer decides to idea category of computer. Structure of sentence understanding system is presented in figure 1. Computer is selected a category that computer brings selected information of dictionary. A user asks any sentence related twenty questions game.
System compare dictionary with a user question then output A. There is no exist searching dictionary that upper information bring thesaurus. Probability B output upper dictionary with sentence. Output A adds B after understanding and judgment, decide Yes or No.

Figure 1: Proposed method of sentence understanding

2.1. Dictionary
Sentence understanding system need dictionary that computer understand sentence using large dictionary, restricted dictionary, upper dictionary and lower dictionary etc. Example dictionary explains structure dictionary of twenty question game.

This paper is made up of general animal dictionary and upper animal dictionary. General animal dictionary refer to Yahoo animal dictionary. The animal dictionary presents 510 animals that is shown figure 2.

Figure 2: Animal dictionary

Animal dictionary arrange the Korean alphabet order. 510 kinds of animal select general 5 persons not heard animal name. The dictionary is made up of 50000 words that one animal explain average 100 words. Upper dictionary explains 510 kind of animal to upper word. Thesaurus is made up of animal of upper word. Upper word explain upper dictionary. For example, thesaurus is tiger, chordates, mammalia, carnivore and felidae that upper words dictionary is chordates, mammalia, carnivore and felidae. The upper words dictionary is same context meaning dictionary. It refers to not existing information to animal dictionary. It is shown figure 3.

Figure 3: An example of the upper words dictionary

2.2. Thesaurus
Thesaurus relates upper word or lower word not existing dictionary. Generally thesaurus use searching information.
A kind of thesaurus is whole thesaurus and restricted thesaurus. Thesaurus uses restricted thesaurus or part thesaurus, because whole thesaurus is difficult to explain all object. Sentence speech understanding system gain probability using probability model that probability model use dictionary and thesaurus. Example thesaurus is shown figure 4.

Animal thesaurus displays text and an upper word of general animal dictionary. First word in thesaurus describe same animal name in dictionary. Thesaurus describes information to 510 kinds of animal. Upper word is ordered chordates, mammalian and bovidae that highest word order lower. Maximum upper word of one animal is 4. Animal thesaurus composes tree type that describes upper word information.

Figure 4: An example of the thesaurus
2.3. Probability Model

Probability model needs parts of understanding to previous judgment. This model needs process of understanding and judgment. Sentence understanding measures reference to probability threshold. 

\[ 0 < \alpha < 1, \ 0 < \beta < 1 \ (\alpha : \text{probability search upper dictionary}, \ \beta : \text{threshold}) \]

(1) \( S = (W_1, W_2, ..., W_n) \) \((S : \text{sentence}, W : \text{syllables})\)

(2) If \( W_i \supseteq P_o \), \( w_i = W_i - P_o \) \((P_o : \text{postposition}, w : \text{word})\). If \( D \supseteq w_j \) probability of \( w_{D_k} \) is \( \Pr(w_{D_k}) \). \( W_i = (w_1, w_2, ..., w_n) \), \( \Pr(w_{D_k}) \) : word probability include dictionary; include word number of article \( \sum \frac{1}{n} \) \( D : \text{dictionary} \)

(3) If \( TD_1 \supseteq w_i \) and \( w_i \subset D \), probability of \( w_{D_i} \) is \( \alpha \Pr(w_{D_i}) \) \((TD_1 : \text{upper dictionary of first word,} \ \Pr(w_{D_i}) : \text{word probability include first upper dictionary of word})\)

(4) If \( TD_2 \supseteq w_i \) and \( w_i \subset D \) and \( w_i \subset TD_1 \) probability of \( w_{D_2} \) is \( \alpha^2 \Pr(w_{D_2}) \) \((TD_2 : \text{upper dictionary of second word,} \ \Pr(w_{D_i}) : \text{word probability include second dictionary of word)})\)

(5) If \( TD_m \supseteq w_i \), \( w_i \subset D \) and \( w_i \subset TD_{m-1} \) probability of \( w_{D_m} \) is \( \alpha^m \Pr(w_{D_m}) \) \((m : \text{a number of upper words,} \ \Pr(w_{D_m}) : \text{word probability include } m \text{ th dictionary of word})\)

(6) \( \Pr(S) = \sum_{j=0}^{m} \alpha^j \Pr(W_{D_j}) \) \( \Pr(S) : \text{probability of a sentence} \ j \ \text{is step in upper word of thesaurus} \)

(7) Threshold probability of sentence judgment 

\[ \text{If } \Pr(S) \geq \beta \text{ is Yes, else No.} \]

3. Experimental Results

Experiments of this paper consist of three types. First experiment word and sentence experiment recognition rate. The first experiment measure word recognition rate and sentence recognition rate using speech recognition twenty questions game. The second \( \alpha \) and \( \beta \) decide to experiment that sentence speech understanding probability use optimum values. The last experiment is given second experiment \( \alpha \) and \( \beta \) that judgment rate of twenty questions game measure is optimum.

3.1 Speech Recognition for Twenty Questions

Speech recognition twenty questions system can recognize whole 956 kinds of sentence. Hereby speech recognizer is made up of speaker independent variable vocabulary speech recognizer of CV(Consonant + Vowel), VCCV and VC unit HMM (Hidden Markov Model). Speech recognition twenty questions game is displayed figure 5.

First User select list open model to recognition loading memory eoejoel that we see candidate sentence list. If user start punch button, computer select word of animal. If user utter sentence, first of all eoejoel segmentation after first eoejoel the number of syllable is abstracted. Computer compares the abstracted number register with eoejoel candidate of register syllables abstraction table. This picture result of utterance /팔팔올림픽때 마스코트로 지정된 동물 입니까/.

Recognized results of eoejoel write editor box about eoejoel /팔팔올림픽때, 마스코트로 지정된 동물 입니까/ that result of sentence speech understanding judgment shows answer.

Figure 5: Speech recognition of twenty questions game system

Twenty question of experiment using vocabulary independent speech recognition system and eoejoel extraction algorithm experiment performance evaluation of sentence recognition. A experiment process consist of 10 talkers, any 100 sentence and Table 1 is displayed on first eoejoel recognition rate, all eoejoel recognition rate and recognition of sentence unit. We use 1000 sentence evaluation in experiment of probability model using judgment threshold \( \beta \) and upper probability \( \beta \). It is experiment that \( \beta \) is 0 to 0.5 per 0.02 and \( \alpha \) hanged 0.5 to 1 per 0.05. Experiment process is hereby we search \( \alpha \) and \( \beta \) of optimum
probability. Experiment process find out distribution of true and false about 510 kinds of animals. We use true sentence 1087, false sentence 4013 about 5100 kinds of question. We experiment upper probability (\(\alpha\)) 0.5 to 1 per 0.05 and threshold probability (\(\beta\)) 0.02 to 0.52 per 0.02. Generally twenty questions using excrement consist of "Yes" more "No" that "No" answer is more 3.7 times. Hereby probability distribution of true value shows true sentence 1098, whole sentence 5100.

Table 1: Sentence unit recognition performance of twenty questions game

<table>
<thead>
<tr>
<th>Speakers</th>
<th>First recognition rates (%)</th>
<th>All eojols (%)</th>
<th>Recognition of sentence unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaker1</td>
<td>87</td>
<td>91.64</td>
<td>87</td>
</tr>
<tr>
<td>Speaker2</td>
<td>86</td>
<td>89.10</td>
<td>85</td>
</tr>
<tr>
<td>Speaker3</td>
<td>88</td>
<td>90.48</td>
<td>88</td>
</tr>
<tr>
<td>Speaker4</td>
<td>87</td>
<td>89.33</td>
<td>86</td>
</tr>
<tr>
<td>Speaker5</td>
<td>92</td>
<td>96.30</td>
<td>92</td>
</tr>
<tr>
<td>Speaker6</td>
<td>84</td>
<td>85.90</td>
<td>93</td>
</tr>
<tr>
<td>Speaker7</td>
<td>88</td>
<td>91.02</td>
<td>88</td>
</tr>
<tr>
<td>average</td>
<td>87.42</td>
<td>90.15</td>
<td>87</td>
</tr>
</tbody>
</table>

If \(\alpha\) is 0.75 and \(\beta\) is 0.17, system judge 424 true sentences and 663 false sentences. Hereby whole sentence 4013 show probability distribution of each upper word. Sentence judgment results of 5100 sentence about \(\alpha\) (0.9).

Each upper word correct judgment, true->true, false->false, best probability 4090/5100 between 0.38 with 0.40.Hereby we decide less error each back or forth on is 0.38, is 0.9.

3.2 Sentence Understanding of Twenty Questions

Sentence understanding experiment uses previously decided probability. We implement sentence understanding judgment about usually using 200 sentence that sentence relate questions game. It is a correct judge, when the input sentence is true, the answer is "Yes" and the input sentence is false, the answer is "No". On the contrary case is false. On the contrary case is false. In this case, true -> false, false -> true are incorrect judgment. A result of sentence understanding judgment is shown in table 2.

Table 2: Result of sentence understanding

<table>
<thead>
<tr>
<th>The number of sentence</th>
<th>True- &gt;true</th>
<th>True- &gt;false</th>
<th>False-&gt; false</th>
<th>False- &gt;true</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19359</td>
<td>7091</td>
<td>64066</td>
<td>13484</td>
</tr>
</tbody>
</table>

Sentence understanding judgment shows total 102000 result values of judgment. An accuracy of judgment is 79.8% that it is 81425/102000.

4. Conclusions

We have researched into the field of sentence speech understanding. A understand or judgment model is proposed probability model. We implemented twenty questions game for evaluation of proposed probability model.

Twenty questions game have the use of sentence speech model understanding. A user solves the answer that computer think animal. This system understands for input sentence using animal dictionary, upper dictionary, and thesaurus. In this case optimum probability (\(\alpha\)) of upper level word is 0.9, and threshold probability (\(\beta\)) is 0.38. As the experiments results, we got sentence speech understanding accuracy of 79.8%. We will improve expansion of dictionary and improved understanding model for more accuracy.

5. Acknowledgement

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6. References