Emotion Judgment Method from an Utterance Sentence

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Abstract. Authors focus on the emotion of such common sense and attempt to establish a method to judge the user's emotions based on utterances. A speaker's utterance sentence includes a linguistic proposition and a linguistic modality. The linguistic modality is an important factor to represent emotions for an utterance sentence. Therefore, in this paper, a method is proposed which judges speaker's emotions from the linguistic proposition and modality included in the utterance sentence. The proposed method uses knowledge base and an Association Mechanism. As a result, the accuracy of the proposed emotion judgment method processing the linguistic modality is improved approximately 30% compared with an existing method.

Keywords: Emotion, Common Sense, Concept Base, Degree of Association.

1 Introduction

Authors are conducting research aiming to develop new interfaces that follow the mechanism of human communication, focusing on human common sense. Humans, in such communication, are able to appropriately interpret ambiguous information that they receive and carry on a smooth conversation. Common sense is knowledge (ability) that only man has. The person can express, and act feeling neither sense of incompatibility nor unnatural by using common sense. Moreover, when the sense of incompatibility and unnatural are felt, the person can appropriately interpret them.

Especially, authors focus on the emotion of such common sense and attempt to establish a method to judge the user's emotion based on the utterance. For example, using this system can output not an utterance cultivating sadness as "You are no good at anything" when a user say "Because I failed in work, it has been scolded by the superior" but a consoling utterance as "The odds are in your favor". Thus, using this system can select an appropriate expression if the content that the system tries to provide the user contains expressions that are unpleasant or remind the user of unhappy events.

Such system and method have already been developed. The developed method[1,2] judges user's emotions, categorized into 10 types, from a sentence

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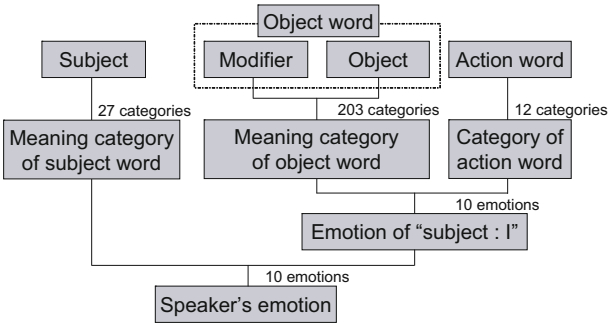


Fig. 1. Outline of the existing Emotion Judgment System

of the user utterance, based on the four components of the sentence: "subject", "modifier", "object word", and "action word".

However, the user utterance sentence is not always consisting of the four components. For example, the subject is often omitted in the conversation. Moreover, the intention and emotions change depending on ending of words of a sentence in Japanese. Therefore, in this paper, a method is proposed which judges speaker's emotions from the linguistic proposition and modality included in the utterance sentence. The proposed method uses knowledge base and an Association Mechanism.

2 The Existing Emotion Judgment System

The components of the utterance sentences to be used to judge speaker's emotion were limited to four ("subjects", "modifiers", "objects" and "action words")[1,2]. Figure 1 shows outline of the existing Emotion Judgment method.

A "subject" was categorized into 3 attributes: liking (likes and dislikes), familiarity (closeness) and sociality (good and evil). These 3 attributes have 3 values. In short, "subject" is categorized into 27 categories. The categorization is processed using the knowledge base based on thesaurus[3].

A "modifier" was an adjective or "adjectival verb" that modifier the "object" which follows the modifier. "Modifiers" may be omitted, as they were not always necessary in textual expression. The direct modification and dependent modification types were further divided into different groups having similar meaning according to the adjectives describing the modifiers, and they were registered in the knowledge base for emotion judgment.

An "object" was a noun that denotes the object of the subject's action, behavior, or state. Objects were also classified according to their meanings using the 203 sense words that the Sense Judgment System[4,5] can judge. These 203 sense words share the common meaning categories with the modifiers discussed earlier. In addition, "modifiers" and "objects" collectively were referred to as "object words". In short, the 203 sense words were used to categorize the meanings of the object words.

An "action word" was a verb, adjective, or "adjectival verb" that describes the subject's action, behavior, or state. An action word converted the feature related to the sense and perception that associated with an object word. Features expressed in terms of senses and perceptions could be roughly divided into positive and negative expressions. Likewise, emotions could also be categorized into two groups, positive and negative. Therefore, four types of effect could be found in the action words.

A sentential actor's ("subject") emotion was judged based on the "object words", and "action words". With respect to the emotions that were generated, those associated with a total of 406 pairs of the meaning categories of object words (203 categories) and action words (2 categories of "succession" and "opposite") were manually defined and registered in the system's Emotion Judgment Knowledge Base. Therefore, speaker's emotion is judged by combination of attributes values (27 categories) of sentential actor ("subject") and judged emotions of sentential actor. 270 rules which are combination of 27 categories (attributes values) of sentential actor and 10 emotions are registered in the knowledge base.

Some knowledge related to the "generation of emotion", the "action words", and the "modifiers" of the "object words" were registered in the Emotion Judgment Knowledge Base. Based on this, the system associated words and expanded its knowledge within the range of common sense, making it possible to handle many expressions. The word association was realized by using the huge Concept Base[6,7] that was automatically built from multiple digital dictionaries, and a method to calculate the Degree of Association[8] that evaluates the relationship between words. Hereafter, this Concept Base and the calculation method are called the "Association Mechanism".

3 Elemental Technique

3.1 Concept Base

The Concept Base is a large-scale database that is constructed both manually and automatically using words from multiple electronic dictionaries as concepts and independent words in the explanations under the entry words as concept attributes. In the present research, a Concept Base containing approximately 90,000 concepts was used, in which auto-refining processing was carried out after the base had been manually constructed. In this processing, attributes considered inappropriate from the standpoint of human sensibility were deleted and necessary attributes were added.

In the Concept Base, Concept A is expressed by Attributes a_i indicating the features and meaning of the concept in relation to a Weight w_i denoting how important an Attribute a_i is in expressing the meaning of Concept A. Assuming that the number of attributes of Concept A is N, Concept A is expressed as indicated below. Here, the Attributes a_i are called Primary Attributes.

$$A = \{(a_1, w_1), (a_2, w_2), \cdots, (a_N, w_N)\}$$

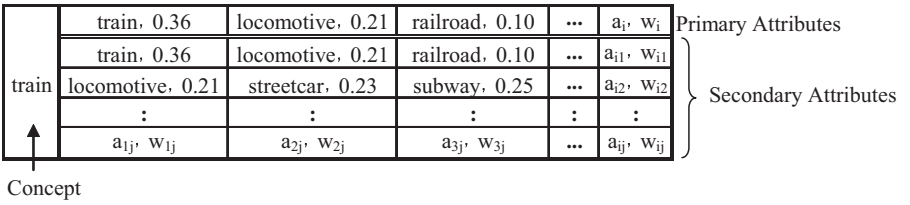


Fig. 2. Example of the Concept "train" expanded as far as Secondary Attributes

Because Primary Attributes a_i of Concept A are taken as the concepts defined in the Concept Base, attributes can be similarly elucidated from a_i. The Attributes a_{ij} of a_i are called Secondary Attributes of Concept A. Figure 2 shows the elements of the Concept "train" expanded as far as Secondary Attributes.

3.2 Degree of Association Algorithm

Each concept is defined as a set of attributes and each attribute is also a concept as described in section 3.1. Each concept is defined by an infinite chain of attributes (concepts). In this paper, a method to derive the Degree of Association between concepts using up to Secondary Attributes is used.

The Degree of Match between Two Sets of Primary Attributes: DM
The relation is higher if two concepts have more of the same attributes since a concept has related concepts as the attributes. When two concepts are defined as the following equations using Primary Attributes a_i, b_j and their weights u_i, v_j,

$$A = \{(a_i, u_i)|i = 1 \cdots L\} \qquad B = \{(b_j, v_j)|j = 1 \cdots M\}$$

the degree of match(DM) between concept A and B is defined as the following equation.

$$DM(A, B) = \frac{\frac{s}{L} + \frac{s}{M}}{2}$$

Where, s is the number of same attributes ($a_i = b_j$) between concept A and B. In this definition, the weights of the attributes are ignored.

The degree of match between concepts A and B using the weights of attributes is defined by the following equations.

$$DMW(A, B) = \frac{\frac{s_A}{n_A} + \frac{s_B}{n_B}}{2} \tag{1}$$

Where,

$$s_A = \sum_{a_i = b_j} u_i \qquad s_B = \sum_{a_i = b_j} v_j$$

$$n_A = \sum_{i=1}^{L} u_i \qquad n_B = \sum_{j=1}^{M} v_j$$

The equation 1 represents the mean value of s_A/n_A (which is the rate of the same attributes in concept A) and s_B/n_B.

The Degree of Association between Concepts Using the Weights of Attributes: DA

The Degree of Association between concept A and B using the weights of attributes is derived by the following algorithm.

(1) Assuming the number of attributes of concept A is less than or equal to the number of attributes of concept $B(L \leq M)$, fix the order of attributes of concept A.

$$A = ((a_1, u_1), (a_2, u_2), \cdots, (a_L, u_L))$$

(2) Make the matrix of the degree of match using the weights of attributes.

$$M_{DMW(A,B)} = \left[\begin{array}{c|cccc} & b_1 & b_2 & \cdots & b_M \\ \hline a_1 & dw_{11} & dw_{12} & \cdots & dw_{1M} \\ a_2 & dw_{21} & dw_{22} & \cdots & dw_{2M} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_L & dw_{L1} & dw_{L2} & \cdots & dw_{LM} \end{array}\right]$$

Where, each element of this matrix is the degree of match between two corresponding attributes using the weights of their attributes,

$$dw_{ij} = DMW(a_i, b_j)$$

(3) Reorder each attribute of concept B so that the sum of the degree of match between corresponding attributes using the weights becomes maximum.

$$B_x = ((b_{x1}, v_{x1}), (b_{x2}, v_{x2}), \cdots, (b_{xL}, v_{xL}))$$

Where, $\{b_{xj} | j = L+1, \cdots, M\}$ are ignored.

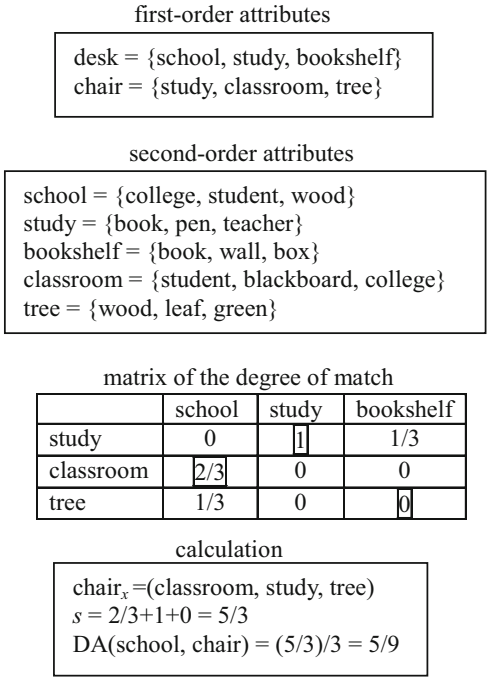
(4) The Degree of Association between concept A and B using the weights of attributes is derived by the following equations.

$$DA(A, B) = \frac{\frac{s_A}{n_A} + \frac{s_B}{n_B}}{2}$$

$$s_A = \sum_{i=1}^{L} u_i DMW(a_i, b_{xi})$$

$$s_B = \sum_{i=1}^{L} v_{xi} DMW(a_i, b_{xi})$$

$$n_A = \sum_{i=1}^{L} u_i \qquad n_B = \sum_{j=1}^{M} v_j$$



	school	study	bookshelf
study	0	1	1/3
classroom	2/3	0	0
tree	1/3	0	0

Fig. 3. An Example of calculating the Degree of Association

Figure 3 shows an example of the Degree of Association ignoring the weights.

To understand the contents of a document, we use the Concept Base, which expresses the semantic characteristics of a word with a word and a weight, and also the method of calculating the Degree of Association, which numerically calculates the semantic relationship between words.

3.3 Sense Judgment System[4,5]

The knowledge base for the sense and perception judgments has a structure like a thesaurus, and it contains sense and perception words that are associated with typical nouns, which have been entered manually. In cases when an unknown word not registered in the Sense Knowledge Base needs to be processed, the system calculates the Degree of Association with those known words registered in the knowledge base for the sense and perception judgments and chooses the one with the highest Degree of Association for processing. This lets the system obtain the rough corresponding sense and perception. In addition, the system refers to the attributes registered in the Concept Base to find the sense and perception particular to that word. Due to its structure, these attributes in the Concept Base contain some inappropriate words as senses and perceptions to be associated, and thus the system is carefully designed so that the correct sense and perception is selected using the Degree of Association.

4 Proposed Emotion Judgment Method

A speaker's utterance sentence includes a linguistic proposition and a linguistic modality. The linguistic proposition represents objective meaning contents of a sentence. The linguistic modality represents mind attitude of speaker. For example, a sentence "I get a cold." is just information. Such sentences including only the linguistic proposition were processed by the existing Emotion Judgment System. However, a sentence "I managed to get a cold." represents emotion "sadness" for speaker. In this way, the linguistic modality is an important factor to represent emotions for an utterance sentence.

Then, in this paper, an proposed emotion judgment method processes the linguistic modality in an utterance sentence. A humanlike emotion judgment is achieved by the linguistic proposition process and the linguistic modality process.

4.1 Classification of Linguistic Modality

The linguistic modality representing mind attitude is important for conveying emotions with conversation. In this paper, major five kinds of the linguistic modality: "Approach", "Expression", "Question", "Declarative" and "Exclamation" are used for classification of the linguistic modality. Moreover, four kinds of mark: "!", "?", "..." and "no mark" are used for subcategorization of the classification. In addition, the use of such signs assumes recognition by the voice recognition technology.

These classifications are achieved by using the knowledge base. The knowledge base is manually constructed based on Japanese grammar books. In addition, 503 words are registered in the knowledge base.

4.2 Redefined Emotion

Many psychologists, philosophers, etc., have studied human emotions[9,10,11]. However, these researchers have had different interpretations of emotion and devised different models for emotion, as emotions have no substance and are quite ambiguous. Therefore, in the existing Emotion Judgment System, emotion has been defined as "something one feels instantaneously when an action takes place" and has defined the following ten emotions to judge: "joy", "sadness", "anger", "ease", "fear", "disappointment", "shame", "regret", "sense of guilt", and "no emotion".

In this paper, the following six emotions to judge are redefined: "joy", "sadness", "fear", "anger", "hate", "surprise" and "no emotion". These emotions can be judged from face expressions that are common in all culture[12]. The facial recognition and the language processing can cooperate in the future by sharing emotions that can be judged from the face expression and the language.

4.3 Method of Emotion Judgment

Figure 4 shows an outline of the proposed emotion judgment method.

The existing Emotion Judgment System judges speaker's emotions from only linguistic proposition. In addition, the existing Emotion Judgment System is

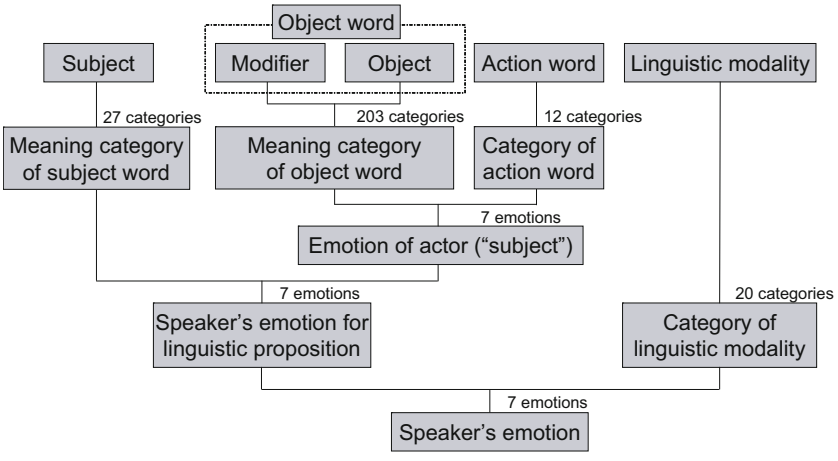


Fig. 4. Outline of proposed Emotion Judgment System

arranged to output seven kinds of emotion. Moreover, the proposed emotion judgment method judges the category of the linguistic modality from the linguistic modality. Then, the speaker's emotions are judged from combination of both such results. 140 rules which are combination of 7 emotions and 20 categories (combination of 5 categories and 4 subsategories for the linguistic modality) are registered in the knowledge base.

5 Performance Evaluation of the Proposed Emotion Judgment Method

5.1 Evaluation Data

In this paper, the purpose is to judge speaker's emotions from an utterance sentence in daily conversation. Then, dialogues of a movie that were natural conversation were used for an evaluation. 200 sentences about which two people were talking were evaluated.

The movie was shown to 20 test subjects, and they were asked to judge an emotion of utterer. As a result of the experiment, the difference was caused in the answer. Then, suitable emotions for the correct answer were defined by using the following expressions.

$$E_{n+1} > E_n \times (1 - 0.5^n)$$

Where, E_n is nth emotion. In short, E_n when the abovementioned expression consists is the correct answer (the suitable emotion).

5.2 Evaluation of Human Judgment

An accuracy rate of human judgments was evaluated based on the abovementioned the correct answer (the suitable emotions). 20 test subjects' judgments were evaluated. As a result, the accuracy rate of human judgments was 79.2% on the average. From this, it was reaffirmed that human cannot perfectly judge others' emotions. In this paper, the proposed emotion judgment method aims at this human's accuracy rate.

5.3 Evaluation of the Emotion Judgment Method

Table 1 shows the results of the proposed emotion judgment method and the existing Emotion Judgment System. As a result, the accuracy of the proposed emotion judgment method processing the linguistic modality was improved 29.5% compared with the existing method. An accuracy rate of the existing Emotion Judgment System processing only the linguistic modality was reported to be 85%. The reported result has the difference of 73% compared with this paper's result. This fact shows that the possibility of the linguistic modality to be included in an utterance sentence for natural conversation is high. Moreover, these results show that the proposed emotion judgment method processing the linguistic modality is very effective for an utterance sentence in conversation. In addition, the proposed emotion judgment method is able to come closer to human's judgment in 52.4%.

Table 1. Results of human judgment, proposed method and existing method

	Human judgment	Proposed method	Existing method
Accuracy rate	79.2%	41.5%	12.0%

6 Conclusions

Authors focused on the emotion of common sense and attempt to establish a method to judge the user's emotions based on utterances. A speaker's utterance sentence includes a linguistic proposition and a linguistic modality. The linguistic modality is an important factor to represent emotions for an utterance sentence. Therefore, in this paper, the method was proposed which judged speaker's emotions from the linguistic proposition and modality included in the utterance sentence. The proposed method used knowledge base and an Association Mechanism.

As a result, the accuracy of the proposed emotion judgment method processing the linguistic modality was improved approximately 30% compared with the existing method. In short, the proposed emotion judgment method processing the linguistic modality was very effective for an utterance sentence in conversation. In addition, the proposed emotion judgment method was able to come closer to human's judgment in 52.4%.

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