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Recognizing and regulating e-learners' emotions based on interactive Chinese texts in e-learning systems

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ABSTRACT

Emotional illiteracy exists in current e-learning environment, which will decay learning enthusiasm and productivity, and now gets more attentions in recent researches. Inspired by affective computing and active listening strategy, in this paper, a research and application framework of recognizing emotion based on textual interaction is presented first. Second, an emotion category model for e-learners is defined. Third, many Chinese metaphors are abstracted from the corpus according to the sentence semantics and syntax. Fourth, as the strategy of active learning, topic detection is used to detect the first turn in dialogs and recognize the type of emotion in the turn, which is different from the traditional emotion recognition approaches that try to classify every turn into an emotion category. Fifth, compared with Support Vector Machines (SVM), Naive Bayes, LogitBoost, Bagging, MultiClass Classifier, RBFnetwork, J48 algorithms and their corresponding cost-sensitive approaches, Random Forest and its corresponding cost-sensitive approaches achieve better results in our initial experiment of classifying the e-learners' emotions. Finally, a case-based reasoning for emotion regulation instance recommendation is proposed to guide the listener to regulate the negative emotion of a speaker, in which a weighted sum method of Chinese sentence similarity computation is adopted. The experimental result shows that the ratio of effective cases is 68%.

1. Introduction

An e-learning system, including real-time class subsystem [56] and intelligent personalized learning recommender subsystem [27] is an open and networked platform full of multimedia and digitalized learning resources, which is a second classroom for continuing education and inquiring about knowledge. However, paying attention to e-learners' cognition rather than their sentiment is dominated due to the space and time separation between students and teachers. 1-to-*N* teaching mode is the dominating mode in the classic educational scenarios, such as real-time class and online question–answering, in which teachers are very easy to be distracted from teaching if they concentrate more on each e-learner's emotional state. Thus, a teacher must limit his/her desire to follow the e-learners' emotions. As a result, the lack of affective interaction between students and teachers seriously affects the learning process, causes learner emotional illiteracy, and decays their learning enthusiasm.

In many recent works, psychologists and neurologists pointed out the important role of the motivation and affectivity in cognitive activities, such as learning. Psychologists and pedagogues pointed out the way that the emotions affect learning. Researchers of computer science in education field had studied techniques of artificial intelligence in order to make the educational systems more customized for the affective states of students [18].

Affective computing is proposed by Picard in 1994, and her work introduces affective computing techniques into the intelligent education environment, such as detecting learners' frustration and correcting their emotion [35,21]. According to Picard's definition [35], an affective (computational) system must have the capacities to recognize, express, and possess emotions. Inspired by Picard's work, many education-related affective researches [4,1] were carried out. To solve the problem of lack of affective interaction, researches have involved four kinds of major techniques, human–machine interaction, emotion category, emotion recognition method, and emotion regulation means.

In the field of human–machine interaction, Rodrigo et al. [39] built a software agent to study the affective states exhibited by students, and emphasized on the affective states and transitions between affective states. Huang et al. [14] analyzed the emotion model for designing learning companion agent. Chao et al. [5] built an affective interface with an animated agent to achieve the

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human–machine interaction function of affective feedback in intelligent tutoring systems. All these works focused on making machine understand one side emotion and pay little attention to understand the emotions of the two interacted parties (such as teacher–student or student–student in an e-learning environment).

There are many emotion categories [35] in the field of affective computing. Besides the four most common types, *fear*, *anger*, *sadness* and *joy*, which are accepted widely, Plutchik's [36], Izard's [17], and Paul Ekman's [9] are the three popular emotion categories, but more researches on e-learner oriented emotion category need to be done due to its application-specific feature.

In the field of emotion recognition, on the one hand currently many researches focused on recognizing e-learners' emotional states from various biological signals [2,55]. For example, D'Mello et al. [7] adopted various biological signals, such as facial expression, heart beating, and body temperature, to determine the feelings of students; Heraz and Frasson [13] analyzed brainwaves to classify emotional states. On the other hand, some researchers noticed the importance of text-based affective computing. Liu [24] adopted natural language processing technology to determine the attitude of a speaker or a writer with respect to some topic. From the viewpoint of methods for text oriented sentiment classification, most existing works [15,20,24,26,28,25,3,37,42,54,50,57,10] employed machine-learning techniques, like Decision Tree, Naive Bayesian models and Support Vector Machines (SVM), to perform sentiment classification. For example, Sriram and Yuan [42] adopted a customized decision tree algorithm to identify six emotion types (*anger*, *disgust*, *fear*, *joy*, *sadness*, and *surprise*) in text. Liu et al. [25] focused on the sentiment analysis on movie rating and reviews in a mobile application environment by using SVM, and believed that SVM is a state-of-the-art method. Wang et al. [50] applied SVM and Multinomial Naive Bayes to emotion identification on Twitter and evaluated many features, such as word-net lexicon, POS, and bags of words. Gokulakrishnan et al. [10] adopted six classifiers, including Complement Naive Bayes, SVM, J48, and Random Forest to recognize twitters' emotions. Khan et al. [20] carried out a task of comparison among some popular classification methods, such as SVM, Naive Bayesian Classifier, Maximum Entropy, Decision Tree, and Neural Network. In addition, Zhao et al. [57] combined the methods of conditional random field with the characteristics "contextual dependency" and "label redundancy" in sentence sentiment classification. These methods generally perform well on topic-related and chapter/document-level sentiment classification, but all existing works do not perform well on the dialog-like interactive Chinese texts, while the interactive texts characterize with not only the richness of short sentences and phrases, but also interactivity and non-linguistic symbols.

In the field of emotion regulation means, many researches adopted a software agent to "talk" or play music and cartoons in order to regulate students' negative emotions [39,21,4]. For example, D'Mello and Art [6] built an affective autotutor to help students Learn by talking with cognitively and emotionally intelligent computers that talk back. Iovane et al. [16] proposed a model to represent and manage affective/emotional feedback in order to form a methodology through the steps that lead us to the identification and quantification of the emotional state of a learner.

In general, we have found that the existing researches paid little attention in applying the affective computing technology to help the two interacted parties (such as teacher–student or student–student) understand their emotion in the interactive Chinese text-based applications. In e-learning systems, there are some typical teaching scenarios: online question–answering scenario, real-time Internet classroom, and group discussion in a special forum, among which it is difficult to understand each other's emotions over the Internet without face-to-face communication. If every e-learner is equipped with detecting devices, the large quantity of cameras and wearable devices may cause high cost and inconvenience to the users. With recent achievements in natural language processing and psychology, it is believed that lots of interactive textual data exist in the e-learning systems which can help us understand the e-learners' emotions. We can imagine that, during group discussion, other students could know a student's interest and emotion after he/she typed a sentence parsed and analyzed by affective computing techniques. This is the goal of this paper.

For achieving this goal, in e-learning systems, the first thing is to enhance the mutual perceiving and understanding of the e-learners' emotions, and to guide the teacher/e-learner' friends to adjust the e-learner' negative emotion through interactive textual messages, but conventional affective computing applications are focused on making machine affective/emotional. Second, the interpersonal and intrapersonal emotions state that the e-learner related emotions, such as *anxiety*, *anger* and *frustration*, sympathy, should be introduced. Third, the basis of recognition in our research is the interactive text in e-learning systems, while conventional researches are based on facial expression, gesture, bio-information, and images. Therefore, the interactive Chinese text-based emotion classification methods should be studied to detect and recognize the e-learners' emotions. Finally, a text-based emotion regulation method should be designed. Conventional approaches lack emotion regulation strategies for his/her teacher/friends to help the e-learner, who is in a negative emotional state.

Aiming at the above mentioned issues, we propose an e-learner affective category model acquired by questionnaires and previous models [17,36]. Based on the model, we present a research and application framework on recognizing the e-learners' emotions from interactive Chinese texts. Furthermore, we exhibit some initial experiment results to illustrate how our method works, and propose the case-based reasoning for emotion regulation instance recommendation to emulate the active listening strategy.

The rest of this paper is organized as follows. Section 2 introduces related works such as basic concepts, emotion categories, computational models of emotion, and emotion regulation rules. A research and application framework is shown in Section 3. Following which, the e-learners' emotion category, model, affective word base, affective computing rules, and syntax features are introduced in Sections 4 and 5, respectively. Methods of classifying the e-learners' emotions and its experiment are described in Section 6, while the case-based reasoning for emotion regulation instance recommendation is presented in Section 7. This paper is concluded and the future work is showed in Section 8.

Note:

- Two words, "speaker and listener", used in the following sections, should be distinguished from their original meanings. In this paper, a speaker is a person who sends textual messages, while a listener is a person who receives the message sent by the speaker. We would like using "speaker and listener" rather than "sender and receiver", because a receiver receives a textual message from a sender without detecting and regulating emotion.
- We focus on Chinese texts due to two reasons: (1) only Chinese is chosen, other languages are still not on our schedule because this will distract us from the focus of our research and (2) multinational and cultural background of e-learners will not be considered in this paper, although many researchers believe that culture has influence on emotion.

2. Related works

Affective computing is a branch of artificial intelligence that deals with the design of systems and devices that can recognize, interpret, and process human emotions. It is an interdisciplinary