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Affective experience modeling based on interactive synergetic dependence in big data

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HIGHLIGHTS

- Propose affective experience modeling for emotional status with interactive big data.
- Construct affective experience distribution with cooperative synergetic dependence.
- Analyze consistency between inner emotional status and external facial expressions.

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ABSTRACT

Affective computing is important in human–computer interaction. Especially in interactive cloud computing within big data, affective modeling and analysis have extremely high complexity and uncertainty for emotional status as well as decreased computational accuracy. In this paper, an approach for affective experience evaluation in an interactive environment is presented to help enhance the significance of those findings. Based on a person-independent approach and the cooperative interaction as core factors, facial expression features and states as affective indicators are applied to do synergetic dependence evaluation and to construct a participant's affective experience distribution map in interactive Big Data space. The resultant model from this methodology is potentially capable of analyzing the consistency between a participant's inner emotional status and external facial expressions regardless of hidden emotions within interactive computing. Experiments are conducted to evaluate the rationality of the affective experience modeling approach outlined in this paper. The satisfactory results on real-time camera demonstrate an availability and validity comparable to the best results achieved through the facial expressions only from reality big data. It is suggested that the person-independent model with cooperative interaction and synergetic dependence evaluation has the characteristics to construct a participant's affective experience distribution, and can accurately perform real-time analysis of affective experience consistency according to interactive big data. The affective experience distribution is considered as the most individual intelligent method for both an analysis model and affective computing, based on which we can further comprehend affective facial expression recognition and synthesis in interactive cloud computing.

1. Introduction to affective experience

With the rapid development of intelligent big data and affective computing, humans are accustomed to solving problems with Human–Computer Interaction (HCI) [1,2]. It is important to understand and master human internal affective experience, because it can improve the rationality and collaboration of HCI and achieve a vivid and seamless interaction [3].

With the help of machine vision and pattern recognition, researchers have achieved many meaningful results in affective computing. Picard [4] presented typical affective computing applications to optimize the HCI, including an emotional mirror, assistance to autism patients, user feedback, emotional learning, virtual emotion, selective forwarding based on the user's preference, expression animation agent, emotion toys, and learning when to interrupt. Coincidentally, Whitehill [5] showed the practical applications for fast-forwarding to the interested part. It is important to highlight that learning when to interrupt is a problem to be solved in proactive computing [6], and the goal of research is to reduce the poor experience and interference generated by the intelligent

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agent's proactive behavior or action to participants according to affective computing [7]. In the beginning of this century, for example, European Union countries proposed a plan of health care services using the technology of proactive computing and affective computing [8,9].

It is clear that analysis of inner affective states for the intelligent agent can help to improve the quality of HCI and the level of services [10]. In specific environments, it is possible to improve the ability of interactive models and reduce the impact of intelligent decision with hidden emotions if the computational model could determine the consistency between participant's inner emotions and outer facial expressions.

There has been wide interest to do research on affective computing with facial expression analysis [11,12], but an intelligent agent cannot analyze precise inner affective status based solely on facial expressions within the HCI [13]. That is the research challenge of affective computing and HCI [14]. Tractinsky [15] argues that the emotional system is highly sensitive to individual, cultural and contextual differences, while other human sub-systems are relatively invariant [16,17]. Norman [18] considers that research to understand the affective system is limited. For example, Picard and Klein [19] illustrate the different interaction patterns between the medical staff and patients; Larsen et al. [20,21] analyze negative and positive characteristics of complex emotions; and Kahneman [22] argues the differences between experienced emotions and learned emotions.

In spite of the challenges, there are still promising approaches to the design of affective computing: (i) in applying a small set of basic emotions [23], such as happiness, sadness, anger, fear, disgust, and surprise [24]; (ii) in detecting the existence of a selected affective state in real situations [25], such as drivers' stress [26]; (iii) and in identifying affective facial expressions in dimensional space [27,28], such as 3D space and parameter space. We point out that some research has proposed the *Computers Are Social Actors* (CASA) approach [29,30] to improve the theory of affective computing by focusing on the study of emotional interactions. For example, Ward and Marsden [31] theorize that intentional communicative affect is both easier to recognize and more important than reactive affect in HCI. There is also evidence of affective expressions being part of social behavior with relation to physiological and brain processes [32,33]. Much of affective research argues that a participant's affective expressions (such as facial expression) can call cooperative affective reactions in terms of facial muscle activity and affective experience [34,35], which is to say, affective experience can be synergetic dependent. Based on Picard's CASA approach and definition of *Social Display Rule* (SDR), we introduce Haken's Synergetic theory [36] to construct a novel affective analysis model in this paper.

From a computational point of view, we need more realistic objective and subjective approaches to modeling and analyzing human's inner affective statues. However, considering the complexity of affective computing, we have studied the inner mechanism between the external facial expression and the internal affective experience based on real-time analysis of facial expressions, and achieved meaningful results. In this paper, one solution to the problems is proposed and described as: (i) design a person-independent model for each participant to detect their facial expression and complete the cluster analysis of the facial features, (ii) construct facial expression nets and complete the predicting inference for the facial expression state for each participant in one person-independent model, (iii) apply the collaborative and interactive mechanisms among person-independent models to design and achieve the computational affective model with objective evidence of facial feature clusters and subjective evidence of predictive facial expression states on the basis of evidence theory.

From the point of view of cognitive intelligence, the interactive environment and person-independent models for affective analysis are proposed. Since participants are constrained by interactive norms, it enhances the operability and reliability of analysis. A person-independent model is responsible for one participant in the interactive environment, and it can improve the analytical skills through models' cooperative interactions and iterative transmission for the evaluations of affective evidences. With cooperative interactions, a person-independent model can improve the algorithm convergence faster and give an optimal universal distribution of affective experiences.

In order to facilitate the study, we focused on the affective experience. Usually, we consider emotion as long-term effects while mood as short-term effects. External stimuli can cause a human's inner emotional feelings to change, and will affect how emotions are displayed by the facial expression to present the feedback of the stimulus. Thus, affective experience is defined as: human's psychological and physiological responses and feedback caused by interactive environment conditions and also by the stimulus from the participant [37].

In a broad sense, affective experience can be explained as some inner spiritual experience from outer stimuli that can be expressed by body-language. We describe the following scenario for a better understanding: the interactive environment is a counseling room with a comfortable chair and melodic music. In this case, an intelligent agent is applied to assist the counselor's treatment by acquisition of facial features, voice intonation, reflective actions, heart rate, respiration, blood pressure, muscle tension and other observed indicators, and further analysis of internal links between emotions and the indicators. Since the computational model can determine a participant's emotions such as distressed, interested, and pleasure, it can report whether the client is interested in the current content of the conversation and help the counselor to adjust strategy and conversation content in order to avoid the client's negative emotional feelings. The principle task for the analysis model is to determine the consistency between the participant's inner emotions and outer stimuli according to facial expressions, and then to assist the counselor.

As mentioned above, we define affective indicators as **facial expression features** and **facial expression states**. Facial expression features are facial features, including the most direct external manifestation, and its measurement can be related to facial feature clusters by their similar distances to the cluster center. Facial expression states are the analysis results after the model's predicting inference. It can be explained that the nature of the predicting inference is facial expression the most likely to be presented in the next moment according to current inner affective experience. A human's affective experience stays in the same period of expression state changes. In other words, facial expression states can reflect the duration time of affective experience and contain the time effect when analyzing the affective experience.

Our contribution, as well as the aim of this paper, is to present a mathematical framework of the affective experience distribution model with Synergetic Dependence to simplify the complexity of the emotion formalization, and to improve the precision of the affective computing. This paper studies how to analyze internal affective experience through external facial expression, on which basis affective computing can be improved and perfected. Although some affective computing research has already been carried out, our work broadens this research field, and the facial expression evidences are utilized to improve analysis and availability through the designed model. Facial expression analysis is used mainly to provide affective evidences, and we present an innovative model of real-time affective experience analysis. Based on the proposed person-independent approach and their cooperative interaction, affective features and states with interactive big data are applied to do synergetic dependence evaluation and to construct a participant's affective experience distribution map in