Proposal for Primitives Representing Brain Function of Facial Expression Recognition

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Abstract: Facial expression of humanlike pedagogical agent plays important role to affect the learners' motivation to interact with it. Uncanny Valley (UV) effect is notorious in the agent design in that extraordinary humanlike agents affect observers negatively to feel eerie. In this study, to uniformly describe the conceptual brain function model which provides the explanation for the mechanism of UV effect, we propose the qualitative description with "basic function" and "representation primitives." Basic functions are hypothesized to be intrinsic functions of brain functions with a consequence of which can represent arbitrary brain functions. Representation primitive is a semantic description that is defined in correspondence with a basic function.

Keywords: Uncanny Valley, Pedagogical Agent, Brain Function, Qualitative Description

1. Introduction

The emotional states of a learner is greatly affected by nonverbal information, such as facial expression of a human teacher (Mashiko et al. 2012) or an embodied pedagogical agent (Hayashi et al. 2013). On the other hand, "the uncanny valley" effect (Mori 1970) is issued in such attempt of humanlike design. Its facial movement is getting more humanlike and more, which increased the probability that the agent is perceived negative. In previous studies, eye width (Seyama and Negayama, 2007), skin texture and balance of facial components (eyes, nose and mouth) (MacDorman et al. 2009) are investigated to effect on eerie feeling in psychological experiments, while few model-based method are adopted to clarify primitive mechanism generating the negative feeling. In order to provide the criteria for avoiding implementation for eerie facial expression, we must understand a mechanism that generates such feeling. Therefore, we provides the conceptual framework to explain the neuro-functional mechanism underlying the relationship between the stimuli (e.g. smiling humanlike agent) and the feeling.

2. What should be modeled to understand the neural basis of emotion?

Previous studies of uncanny valley are common in hypothesizing that eerie feeling are related to the mismatch between expectation to be a human and perception not to be a human (Shimada et al. 2007). The explicit explanation should be given as the framework: "Prediction error" (Saygin et al. 2012). The framework can be applied to the facial expression of humanlike agent. Therefore, we hypothesized that facial expression of humanlike agent can be perceived eerie because agent's facial muscle does not move as like as human does. In other words, agent's facial movement is not match to human expectation of facial movement, which generates error signal.

Our proposed neuro-functional model represents the qualitative process in human recognition of facial movements (Tawatsuji et al. 2016). When human perceives facial movements, initial movement information is transmitted to the cerebellum, where in the meantime generates a prediction of how the facial components will move, based on the internal model. Herein, perception and this prediction can be processed in parallel. In the cases of seeing real humanlike agents, the prediction and perception differ enough to generate alert signals. This processing must play a key role in error detection to facial expressions of humanlike agents. In this paper, we propose a comprehensive description for qualitative representation for brain function.

3. Qualitative Representations of Brain Intrinsic Functions

A brain function can be considered as a series of intrinsic functions and each intrinsic function is subserved by a brain region or a system of some brain regions. According to Mizoguchi's work, the functions of artifacts or of biological organisms can be classified into intrinsic functions or accidental functions. Whether a biological function is intrinsic depends on the goal of the whole system where the organism belongs (Mizoguchi et al. 09). Let us call these hypothetical intrinsic functions of brain *basic functions*, and regard the brain function to be achieved by the determined sequence of these basic functions. In addition, the contents that the basic functions mean are named *representation primitives*. Table 1 shows the pairs of basic functions and representation primitives for our previous model.

Table 1: Representation primitives in recognition of facial movements.

No.	Basic function	Representation Primitives
1	Extractor	To extract a remarkable pattern from the input information
2	Associator	To associate a corresponding emotional episode with the input
3	Intensity-investor	To determine emotional intensity toward the input
4	Analyzer	To extract the visual edges of input
5	Categorizer	To accommodate a stimuli with the learned category
6	Response-generator	To generate a response based on emotional valence
7	Comparer	To compare the visual contour to the expected contour
8	Predictor	To make a prediction of a contour based on internal model

4. Conclusion

In this research, we propose a representation primitives to provide the explanation for how brain function generates error signal to facial expression of a humanlike agent. Some caveats and work should be considered. For every basic function, the triplet – the attribution of input set and output set, and its relationship – must be stipulated. The other work is to verify a length of processing time for each basic function based on neurological knowledges.

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