A Computational Personality-Based and Event-Driven Emotions Model in PAD Space

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Abstract. In this paper, we propose a new computational model of personality-based and event-driven mixed emotions called the PAEM (Personality Associated Emotion Model). The model delineates mixed emotions based on personality traits and updates dynamic emotional states by calculating the relative intensity of mixed emotions triggered by given events. The PAEM produces associated emotions by taking into account the personality traits of subjects, which have a significant influence on decision making processes.

Keywords: PAD space, mixed emotions, personality-associated emotion model.

1 Introduction

In the past decade, a remarkable change has occurred in the influence of affective neuroscience, combined with the psychological study of personality, emotion, and mood. As most of the computational models of emotion and personality are based on a general emotion model of influence on agent behavior, the relationship between personality and emotions in existing models is left open to debate. Since personality traits play an important role in emotion appraisal, a new generic emotion and personality model called the Personality-Associated Emotion Model (PAEM) is proposed in this paper. The PAEM, calculating the relative intensity of mixed emotions, is designed to implement the deduction of mixed emotions and provide a coherent dynamic emotional state.

2 Computational Models of Emotion and Personality

2.1 OCC Model and Five Factor Model

The OCC model, proposed by Ortony, Clore & Collins [1] is a psychological model based cognitive approach. It describes a hierarchy that contains three branches, namely consequences of events, actions of agents, and aspects of objects. The consequences of events are the focus in this paper.

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The Five Factor Model [2], the most widely accepted model of personality, is a purely descriptive model of personality. The five dimensional factors are Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. A quantitative measurable personality can be expressed as a vector in which there are five personality traits (OCEAN), each of them has a value between -1 and 1. Let us denote P_i as a vector representing i^{th} person's personality traits, we have

$$P_i=[p_o\ p_c\ p_e\ p_a\ p_n\ ],\quad -1 \leqslant p_o, p_c, p_e, p_a, p_n \leqslant 1$$

2.2 The Pleasure-Arousal-Dominance Space

The PAD space is a bounded 3D space containing values ranged from -1 to 1 in each axis. The axes are Mehrabian's pleasure (P), arousal (A) and dominance (D) traits [3].

Emotions in PAD Space. Let us denote E_i as i^{th} emotion type. Each E_i of 22 emotion types in the OCC model can be projected on the PAD space.

$$E_i(\ e_p,\ e_a,\ e_d\ ),\ i=1,\ 2,\ \ldots,\ 22,\ -1 \leqslant e_p,\ e_a,\ e_d \leqslant 1$$

Personality in PAD Space. PAD space is a mood space which projects emotions on different mood states. In fact, it is possible to find out the relationship between the personality trait and the PAD space by translating $P_i(p_o,\ p_c,\ p_e,\ p_a,\ p_n)$ into a corresponding PAD space mood state point $M_i(e_p,\ e_a,\ e_d)$ via the following mapping [3].

$$e_p=0.21*p_e+0.59*p_a+0.19*p_n \tag{1}$$

$$e_a=0.15*p_o+0.30*p_a-0.57*p_n \tag{2}$$

$$e_d=0.25*p_o+0.17*p_c+0.60*p_e-0.32*p_a \tag{3}$$

Fig. 1 shows the 22 types of emotions as circular red points and a personality point as a square blue point projected on the PAD space.

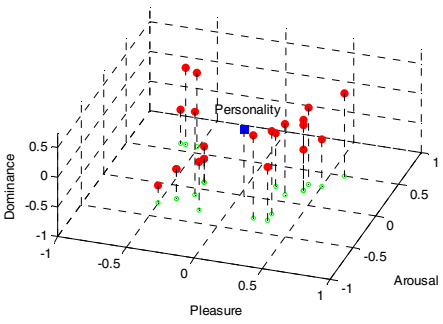


Fig. 1. Scattered emotions and personality point in 3-dimension space

3 Personality-Associated Emotion Model(PAEM)

Although many emotion models have been proposed and used in various applications, few have identified a specific link between emotions and individual personality traits. There are some models which resemble our work like Silas [4] for believable agents that model life-like synthetic characters including emotions and personality. Patrick Gebhard [5] proposed a layered model of affect that integrates three major affective characteristics: emotions, moods and personality. However, our work differs from all other work by trying to provide a dynamic emotion model for processing mixed emotions which are formed based on a subject's personality and events that have occurred.

3.1 Personality-Based Mixed Emotions

The proposed personality-based mixed emotions model is inspired by the concept of the "ecological niche". In general, emotions are generated together in a common environment, one emotion is triggered and other emotions may accompany it [6], while some other emotions may be triggered in sequence or simultaneously in the same niche environment. We take account of the concurrently triggered emotions and define $E_{mixed,}$ as a set of mixed emotions E_i.

$$\mathrm{E_{mixed}} = \bigcup_{i=1}^{22} \alpha_i \, E_i \tag{4}$$

Where, α_i is correlative intensity of emotion E_i. $\mathrm{E_{mixed}}$ may vary between individual subjects even to the same trigger event.

3.2 Dynamical Mixed Emotions in PAEM

This model, the PAEM, showing the relationship of emotions and personality traits in PAD space, is based on two basic common sense assumptions.

Assumption 1. The intensity of the effect that personality traits have on an emotion varies according to their distance in the PAD space. The nearer they are, the more influence the personality traits have on the emotion. That is to say, the subject's emotions are more susceptible to his/her personality traits and more easily triggered by outside events.

Assumption 2. An outside event could trigger a main emotion. The neighboring emotions to the emotion triggered are likely jointly triggered. The probability of the emotion being triggered and its intensity along the time axis can be expressed based on the subject's personality trait point and the distances between the neighboring emotion and the main emotion in the PAD space.

Based on the assumptions above, the mixed emotions in the PAEM are composed of a triggered emotion and emotions associated with the triggered emotion at the same time. The intensity of each emotion decays along the time; however, it is hard to accurately define the intensity of an emotion in a single formula due to diverse personal cognition

and experiences. So, the mixed emotions distribution and probability of being triggered and the intensity decay function are incorporated into the PAEM to reveal the dynamic mixed emotions.

The Emotions Space. An arbitrary point *u(x, y, z)* in the PAD space is defined as an emotion point. Once an emotion is triggered by an event, the intensity of the emotion will decay as time passes. The intensity decay function is defined in this paper as:

$$y(t)=c-e^{\lambda t} \tag{5}$$

Where *c* is constant parameter and λ is adjust parameter for different emotion. When emotion is triggered, it will be released as energy in an active field and the energy [7] will have an impact on other emotions through energy transfer. Both the triggered event and the personality trait will have an effect on the transferred energy.

The Subject's Personality Effect on His/Her Emotions. As stated in Assumption 1, a subject's personality point denoted as P_j, a blue point in the PAD space in Fig. 1 has its relatively steady effect on his/her emotions E_i. The effect of the personality traits on emotions can be expressed in formula (6).

$$I\left(P_j, E_i\right)=\frac{\varpi_1}{\left|p_j-u_i\right|^2} \tag{6}$$

where, ϖ_1 is the influence factor of P_j on E_i.

The Triggered Emotion's Effect on Other Emotions. Let us denote E_0 as the triggered emotion, E_i as one of other emotions in the PAD space which may be jointly triggered, $u_0(x, y, z)$ as the point of the emotion E_0 and $u_i(x, y, z)$ as the point of the emotion E_i in the PAD space, ϖ_2 as the influence factor of E_0 on E_i and $y(t)$ as the emotion decay function, the effect of the triggered emotion E_0 on E_i can be expressed in formula (7). Where, $y_e(t)$ is an event related decay function. It is suggested that there are a number of decay functions corresponding to a number of different types of events.

$$I\left(E_0, E_i\right)=\frac{\varpi_2 \cdot y_e(t)}{\left|u_0-u_i\right|^2} \tag{7}$$

To sum up, when an event occurs, the total relative intensity of emotion E_i affected can be calculated in formula (8).

$$\eta\left(u_i, t\right)=I\left(P_j, E_i\right)+I\left(E_o, E_i\right) \tag{8}$$

As the mixed emotions can be explained as an emotions set, with a set of relative intensity values ranging from 0 to 1, they can be expressed by using $\eta(\mu_i)$ to substitute α_i in formula (4) and taking time into consideration, then we have

$$E_{mixed}(t) = \bigcup_{i=1}^{22} \alpha_i E_i = \bigcup_{i}^{22} \eta(u_i, t) E_i \tag{9}$$

If we set a threshold for the intensity of an emotion and collect only a number of emotions, then we have

$$E_{mixed}(t) = \bigcup_{i}^{k(t)} \eta(u_i, t) E_i \tag{10}$$

where, *k(t)*, the number of emotion types collected varies along time *t*.

4 Implementation of the PAEM

4.1 The Mechanism of the PAEM

The PAEM is the proposed human dynamic emotion model when an event or events occur. As stated above, a subject's personality is a critical factor in the manifestation of his/her emotions. It defines a subject's basic emotional state, which is described by a set of 22 weighted emotions with each weight value ranging from 0 to 1 to indicate the intensity of its associated emotion. At the same time, an outside event or events will trigger a main emotion intensively and other associated secondary concurrently emotions around the main triggered emotion. Therefore, a mixture emotion is the union of non-zero weighted emotions. Both the subject's personality traits and the emotion being triggered concurrently trigger other associated emotions.

4.2 Implementation of Event-Driven Emotions in the PAEM

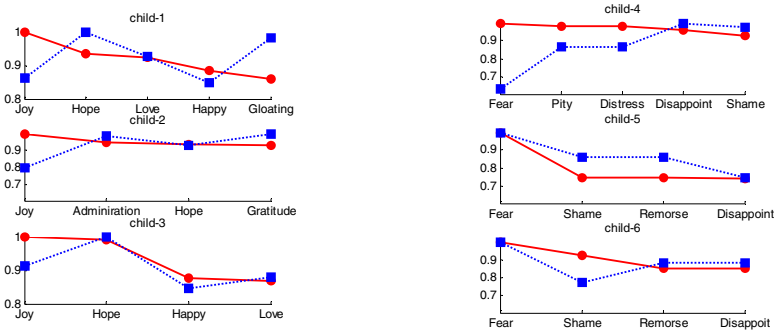
To evaluate the PAEM, implementation was conducted on two groups of children at age 7. Their personality traits were evaluated by giving them well-designed questions and making long-term observations of their activities. With the result that their personality traits projected in PAD space is P_1 (-0.347,-0.482,-0.381), P_2 (0.21, 0.677, -0.63), P_3 (-0.121, 0.17, -0.331), P_4 (-0.366,-0.491,-0.362), P_5 (0.209, 0.662, -0.621), P_6 (-0.101, 0.181, -0.332).

Three children as a group were put in an experiment environment in which a teacher gives each of them an apple. At that moment, all of them were quite happy and joyous at having an apple.

In the PAEM, the effect of each child's personality traits P_i on 22 emotions using formulae (6) and the effect of the main triggered emotion, "*Joy*", using formulae (7), can be calculated. In this experiment, the mixed emotions are calculated using formulae (10) and formed by selecting emotions with higher intensity values exceeds the specified threshold among 22 emotions.

According to the PAEM, when children are given an apple, all of their event-driven main emotions are the same emotion, which is "*Joy*". The selected accompanying emotions that concurrently appear are "*Hope*", "*Love*", "*Happy*", "*Gloating*" for child-1; "*Admiration*", "*Hope*", "*Gratitude*" for child-2; *and* "*Hope*", "*Happy*", "Love" for child-3 as shown in the left of Fig. 2.

The other experiments are conducted on another group of three children to test the triggered emotion "*Fear*" for negative personality traits. Similarly, the mixed emotions are calculated using formulae (10) for child-4, child-5 and child-6 are shown in the right of Fig 2.



Triggered emotion: *Joy* Triggered emotion: *Fear*

Fig. 2. Comparing first and updated mixed emotions of each child

The mixed emotions vary as time passes due to the emotion decay function. Fig. 2 shows the mixed emotions at the very first moment as a solid red line segment and the updated mixed emotions after a certain interval time as a dotted blue line segment. Taking child-4's "*Fear*" mixed emotions as an example, at the very first moment, the mixture emotions were *Fear*→*Pity*→*Distress*→*Disappointment*→*Shame* (indicated by red circles), and were updated to *Disappointment*→*Shame* →Pity→Distress→Fear (indicated by blue squares) after the interval. Which shows the mixed emotions and its distribution and dominance vary as time passes.

Table 1 shows the different triggered emotions by using the OCC model and the PAEM. As can be seen there is only triggered emotion in the OCC model. In contrast, there are accompanying emotions apart from the main triggered emotion in the PAEM.

Table 1. Comparisons of the resulting-Emotion in OCC Model and PAEM

Children	OCC model	PAEM
child-1	Joy	Joy+Hope +Love+Happy-for
child-2	Joy	Joy+Admiration +Hope +Gratitude
child-3	Joy	Joy+Hope + Happy-for + Love
child-4	Fear	Fear+Pity+Distress+Disappointment
child-5	Fear	Fear+Shame+Remorse+Disappointment
child-6	Fear	Fear+Shame+Remore+Disappointment

5 Conclusion and Future Work

In this paper, we have described a computational emotions model, PAEM, which is based on personality traits and driven by events occurring in an environment. We conclude that PAEM can model more complex emotions that resemble dynamic human emotions more reliably. Furthermore, PAEM can be applied in intelligent agents with personality, robots with emotions, and cyber individuals [8].

There is still much work to be done. One area of work is a better understanding of the effect of pre-existing memories on generating event-driven emotion of different emotion decay functions, and how these other factors can be incorporated into the computational emotion model. More elaborate experimentation is needed in order to justify our assumptions, and to verify and revise our proposed model.

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