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OpenPsi: A novel computational affective model and its application in video games

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A B S T R A C T

This paper introduces OpenPsi, a computational model for emotion generation and function by formalizing part of Dörner's PSI theory, which is an extensive psychological model of human brains, including knowledge representation, perception and bounded rationality. We also borrowed some technical ideas from MicroPsi, one of the concrete implementations of PSI theory by Joscha Bach. The proposed emotional model is then applied to control a virtual robot living in a game world inspired by Minecraft. Simulation experiments have been performed and evaluated for three different scenarios. The emergent emotions fit quite well with these circumstances. The dynamics of this affective model are also analyzed using Lewis's dynamic theory of emotions. Evidences of phase transitions suggested by Lewis are observed in simulations, including trigger, self-amplification and self-stabilization phases. These experiment results show that the proposed model is a quite promising approach of modeling both emotion emergence and dynamics.

1. Introduction

Computer games have become one of the most popular entertainment medium around the world. So what makes a successful video game? The answer is immersion. An immersive experience is produced when the game world is so well crafted that the player lose themselves in the game experience (Li et al., 2010). As noted by Nicole Lazzaro, emotions are the key to great experiences (Lazzaro, 2008).

Hence, more elaborate model of emotions is required for creating more realistic characters in video games. Actually, the accurate modeling of the emotional state of any agent, and changes to that emotional state, has long been the subject of extensive research (Blewitt and Ayesh, 2008, 2009). A large number of researchers have studied automatic emotion recognition (Fasel and Luettin, 2003; Fragopanagos and Taylor, 2005; Hanjalic and Xu, 2005; Picard, 2003) and computational modeling of casual factors of emotion for human–computer (Bickmore and Picard, 2005; Hudlicka, 2003; Kasap, 2011; Paiva, 2000). However, only a small part of affective computing community is explicitly concerned with modeling the effects of emotions, such as formal modeling of cognitive appraisal theory (Broekens et al., 2008; Marsella and Gratch, 2009; Meyer, 2006), affective influences on cognition (Canamero, 2002; Gadanho, 2003; Hudlicka, 2005; Marsella and Gratch, 2009; Velásquez, 1998), interacting emotional states in agent reasoning (Coddington and Luck, 2003; Meyer, 2006; Steunebrink et al., 2008), and models of emergent emotions, that is emerging from the interaction between a simple adaptive agent and its environment (Canamero, 2002; Lahnstein, 2005; Velásquez, 1998).

In this paper, we firstly introduce a computational affective model called OpenPsi. It is inspired by PSI theory, which is proposed and described informally by German psychologist Dietrich Dörner (Dörner and Hille, 1995; Dörner, 2003; Dörner and Starker, 2004; Dörner et al., 2006). The emotional model is then applied to control a virtual robot living in a game world inspired by Minecraft (http://www.minecraft.net/). Simulations are performed for three distinctive scenarios. Finally, the experimental results are carefully analyzed using one of the contemporary dynamic theories of emotions proposed by Lewis (Lewis, 2000, 2005).

Dörner's PSI theory covers a wide range fields of intelligence, including knowledge representation, perception and bounded rationality (Dörner and Hille, 1995; Dörner, 2003; Dörner and

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Starker, 2004; Dörner et al., 2006). However, we mainly focus on its affective model, which is quite different from other emotional models like OCC (Ortony et al., 1990). Emotion in PSI theory is not considered as an isolated component. Rather, it emerges from the interaction between the agent and the environment where the agent lives. The agent controlled by the PSI model is considered as an autonomous machine driven by internal motives that are related to urges, which stand for physiological, cognitive or social demands. Then emotions, in PSI model, are derived from the dynamics of the whole system, where the processes of perception, cognition and action selection interact with each other.

Lewis, similar with Dörner, possesses a non-linear, dynamic view of emotional activations (Lewis, 2000, 2005). He suggests that emotions should be considered as phenomenon, which emerge from the dynamics of the whole system. He argues that emotion–appraisals may be conceived as phase transitions including trigger phase, self-amplification phase and self-stabilization phase. Once triggered, recurrent interactions between microscopic processes of emotion appraisal induce a rapid self-amplification effect on the activity of the interaction of the appraisal–emotion constituents of the system. Positive feedback loop between perceptual, emotional and attentional processes are firstly lured by the self-amplifying phase, but then inhibited or constrained by negative feedback effects as the amplification grows. When negative feedback overtakes the system dynamics, the appraisal process enters self-stabilization phase, where change decreases and continuity increases.

The experimental results show that OpenPsi proposed in this paper is a quite promising approach of emotion modeling. The emergent emotions fit quite well with different circumstances; and the phase transitions suggested by Lewis could be observed in the simulations.

In Section 2, the emotional model within PSI theory is explained in detail. In Section 3, dynamic theories of emotional models are discussed. In Section 4, our computational affective model inspired by the PSI theory is described in detail. Section 5 covers three simulation results of OpenPsi. Section 6 concludes the paper with a discussion and future work.

Fig. 1. The PSI agent and the island, adopted from Dörner (2003).

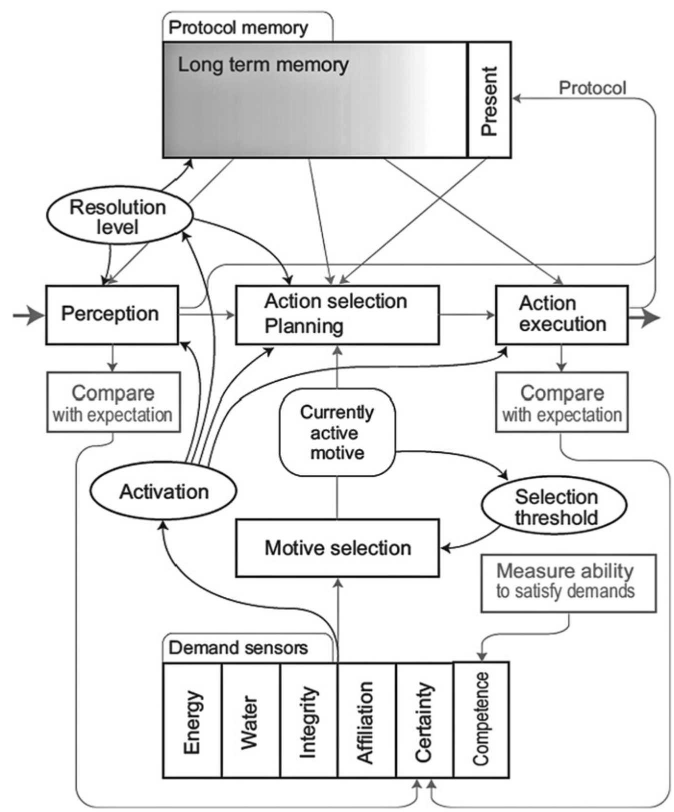

Fig. 2. PSI architecture, adopted from Bach et al. (2006).

2. The emotional model of PSI theory

The most distinctive feature of the PSI theory is its perspective on the autonomous choice and regulation of behaviors. It suggests that each goal-directed action has its source in a motive that is connected to an urge, which stands for a physiological, cognitive or social demand (Bach, 2009). In order to verify the ability of the PSI model, Dörner also implemented virtual agents controlled by PSI living within a complex simulated game world (Fig. 1). These PSI agents are little virtual steam vehicles, which depend on fuel and water for their survival.

A PSI agent does not need any executive structure that controls its behavior, instead it is driven by demands. Some of the demands are related to external resources, like water and energy, or its integrity. There are also abstract cognitive demands, such as certainty and competence, while the affiliation demand is an example of social urge, which can only be fulfilled by other agents. Moreover, there is a threshold for each demand. A deviation from the threshold set for a need will signal as an urge, which then give rise to an intention or a motive. There may be multiple motives at any given time but only one "ruling motive" dominates the system. This active motive is selected based on the strength of the urge and the estimated chance of realization. After selecting a motive intention, actions of the agent are produced accordingly.

PSI agents are based on something like a "sense–think–act" cycle, but perception, planning and action do not occur in strict succession. Rather, they are working as parallel processes and are strongly interrelated. All actions of agents happen due to motivational impulses, which are derived from a set of predefined dynamic demands. Perception, memory retrieval and action control strategies are influenced by modulator parameters, which make up a setting that can be interpreted as an emotional configuration (Fig. 2).

Dörner has suggested four modulators:

- *Activation* is the preparedness of perception and reaction. It helps the agent balance between rapid, intensive activity and reflective, cognitive activity. Fast behavior comes along with