A Flexible Scheme to Model the Cognitive Influence on Emotions in Autonomous Agents

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ABSTRACT

Autonomous agents (AAs) are designed to embody the natural intelligence by incorporating cognitive mechanisms that are applied to evaluate stimuli from an emotional perspective. Computational models of emotions (CMEs) implement mechanisms of human information processing in order to provide AAs for a capability to assign emotional values to perceived stimuli and implement emotion-driven behaviors. However, a major challenge in the design of CMEs is how cognitive information is projected from the architecture of AAs. This article presents a cognitive model for CMEs based on appraisal theory aimed at modeling AAs’ interactions between cognitive and affective processes. The proposed scheme explains the influence of AAs’ cognition on emotions by fuzzy membership functions associated to appraisal dimensions. The computational simulation is designed in the context of an integrative framework to facilitate the development of CMEs, which are capable of interacting with cognitive components of AAs. This article presents a case study and experiment that demonstrate the functionality of the proposed models.

KEYWORDS
Cognitive Model of the Brain, Emotion Process, Fuzzy Logic, Software Agent

INTRODUCTION

Autonomous Agents (AAs) are software and robot entities that act on behalf of users or other programs with certain degree of independence and autonomy. In doing so, AAs make use of knowledge about the environment and representations of desires and goals (Franklin & Graesser, 1997; Wang, 2010; Wang, Zatarain, & Valipour, 2017). This type of intelligent system has been crucial for the advance of fields such as software engineering (SE), human-computer interaction (HCI), and artificial intelligence (AI). In these fields, AAs have been designed to carry out tasks that require the imitation of human cognitive functions, including decision making, planning, and reasoning (Ligeza, 1995; Maes, 1995; Sun, 2009). Giving AAs such cognitive functions allow them to carry out more complex tasks by minimizing human intervention. That is why research in these fields (e.g., AI, HCI, and SE) focuses on improving problem solving, reasoning, and communication skills of AAs. Particularly, the research

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community in the AI field has devoted efforts to create human-like systems for communication and reasoning as well as to reproduce in computer environments the associated brain processes (Ligeza, 1995). In the HCI field some interfaces and mechanisms that improve the interaction of these systems with other agents (computational or human agents) have also been developed (Martínez-Miranda & Aldea, 2005; Perlovsky & Kuvich, 2013).

Evidence shows that emotions influence cognitive functions (Ayesh, Arevalillo-Herráez, & Ferri, 2016; Hurtubise, 1995; Phelps, 2006). The emotional significance of perceived stimuli influences the normal operation of brain processes such as attention, perception, and decision making. According to fields such as psychology and neuroscience, emotions result from the interaction of several cognitive and affective processes, including memory, perception, motivations, and attention (Frijda, 2005; Goldie, 2002; LeDoux, 2000; Smith & Lane, 2016). Emotions are psychophysiological reactions that represent ways of adapting to perceived stimuli from an important object, person, place, event, or memory. Psychologically, emotions alter attention, trigger certain behaviors, and activate relevant associative networks in memory (Wang, 2012). According to Breazeal (1998) and Wang (2010), emotions are necessary to establish long-term memories. In addition, emotions play a key role in learning, from simple reinforcement learning to complex and conscious planning.

A key objective of artificial intelligence is the development of software systems capable of doing complex tasks that produce intelligent responses (Perlovsky & Kuvich, 2013), systems that act and reason like humans. In this context, the literature reports an increasing interest in the development of AAs with abilities to evaluate and respond to emotional stimuli (Cañamero, 1997; Dias, Mascarenhas, & Paiva, 2014; Gebhard, 2005; Rodríguez, Ramos, & Wang, 2011; Wang et al., 2012; Wang, Wang, Patel, & Patel, 2006). Recent works have proposed the incorporation of affective processing in AAs by designing Computational Models of emotions (CMEs), which are software systems designed to synthesize the mechanisms of the human emotion process (Rodríguez, Ramos, & Ramos, 2014; Rodríguez & Ramos, 2015). These CMEs are designed to be included in cognitive agent architectures to provide AAs with mechanisms for the processing of affective information, generation of synthetic emotions, and generation of emotional behaviors. Ortony, Clore, & Collins (1990) propose that CMEs provide AAs with the capacity for affective processing; they synthesize operations and architectures of some components that represent aspects of the human emotional process. In general, CMEs include mechanisms for the evaluation of stimuli, generation of emotions, and generation of emotional responses, providing this type of intelligent systems with the ability to recognize emotions of humans and other virtual agents. For example, Alma is a CME designed to provide virtual humans with emotions, mood and personality, facilitating the generation of emotions by evaluating the stimuli coming from agents’ verbal and non-verbal expressions such as wording, length of phrases, and facial expressions (Gebhard, 2005; Gebhard, Kipp, Klesen, & Rist, 2003).

Despite of the importance of the relationship between cognitive and affective processes in humans, such interaction is not usually considered in the design of cognitive agent architectures (Rodríguez, Gutiérrez-Garcia, & Ramos, 2016) (Figure 1 shows an example of the types of components included in a representative cognitive agent architecture). Moreover, although the literature reports a variety of CMEs, most of them do not take into account the influence on the emotion evaluation process of human key aspects such as personality, culture, past experiences, social context, and physical context, among others, which are processes that may be implemented in cognitive agent architectures and which influence human emotions (Gebhard, 2005; Martínez-Miranda & Aldea, 2005; Wang, 2007; Wang et al., 2006). In this context, although findings in psychology and neuroscience indicate that (1) the evaluation of emotional stimuli is influenced by the results of various cognitive functions and that (2) elicited emotions modulate cognitive processes (e.g., attention, perception, and decision-making), there are several challenges to be addressed in the modeling of this extensive interaction between mechanisms associated with cognitive and emotional functions in cognitive agent architectures (Wang, 2007, 2011).
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