Expert Systems With Applications 43 (2016) 131–141

Contents lists available at ScienceDirect

Expert Systems With Applications

journal homepage: www.elsevier.com/locate/eswa

Programming an expressive autonomous agent

Shikha Jain*, Krishna Asawa

Department of Computer Science, Jaypee Institute of Information Technology, Noida, India

ARTICLE INFO

Keywords:
Autonomous agent
Agent programming language
Emotion engine
Emotion modeling
2APL

ABSTRACT

Emotions are the integral part of human cognitive processes. To make an artificial agent more human-like, agent programming languages should be able to model the emotion based artificial agent. To address the need of incorporation of emotions in agent programming languages, recently, extension of 2APL with emotions is proposed by the researchers. However, they were unable to program complex emotion dynamics, due to integration complexities associated with advanced emotive models. They have modified 2APL by designing E-rules, coping rules, and an interface-Affect Engine. The Affect Engine establishes a link between the modified 2APL and a rather simpler emotion model, ALMA. Here, we propose the programming constructs for integrating an advanced yet rule based emotion model, EMIA, in line with the 2APL. The fusion of both has been carried out by redefining the syntax, semantics and deliberation cycle of the 2APL. These redefinitions lead to the required transformation in the dialect cycle; from the *sense-interpret-act* to *percept–appraisal-elicitation-act*. The proposed novel programming constructs and pragmatics enable flexible and adaptive emotional behavioral modeling for an expressive autonomous agent with domain independent emotion elicitation, emotion regulation and emotion transition processes. The simulation results show high believability in the emotions expressed by the agent while responding to the real life scenarios.

1. Introduction

"Does computer too require understanding and expressing the emotions?" The question raised by several researchers across the world. Some of them say that emotion is a hindrance in rational decision making though others say that without emotions, one cannot make a decision. Consequently, it turns into a topic of level headed discussion.

On examining our regular life's behavioral patterns expressed by individuals, we all concur upon the statement that emotion influences different cognitive processes like perception, learning, memory recall, attention, motivation, decision making, etc. It was observed in one of the research conducted by Ortony, Clore, and Collins (OCC) (1998) that a person feeling sad interprets the world adversely though a person feeling happy deciphers the same situation in a positive way and consequently, it is inferred that emotions influence our perception and analysis of the surrounding world. In another research conducted in neuroscience (Damasio, 1994), it has been demonstrated that if a person cannot feel emotions in view of some anatomical defect in the brain, then the person confronts difficulty in making even primitive decisions like what is important for him and what is not. Damasio, also conducted experiments to observe the response of patients with damage in prefrontal cortex. In one of his experiment, he had shown emotional stimuli in form of visual imagery and observed such patients failed to show anticipatory responses. Similarly, in his gambling experiment such patients were not able to differentiate between bad decks and good decks. These experiments conclude that emotionally impaired people cannot differentiate between good and bad decisions and hence, emotion is imperative in making decisions as well.

In today's smart technology dominant computing world, the virtual characters centric interactive applications e.g. e-tutoring, e-counseling, e-shopping, video games etc. demand that the role playing characters should act more like human. Hence, to make a virtual character more realistic, more credible, to make one vibe more agreeable and to make more human like decisions, it should able to recognize, comprehend and express emotions while interacting with a user. Further, if an agent would have power of expressing emotions, could significantly differ in showing their actions as well. For instance, if an agent is asked to find a travelling path between two places, the autonomous agent only searches for the path within all possibilities. On the off chance, intelligent agent uses the shortest path algorithm based on some heuristics to know the best path, whereas an agent equipped with emotions, in addition to the shortest path algorithm, would also analyze risk with respect to self-well-being.

* Corresponding author. A-10, Sector 62, Noida, UP, India- 201005. Tel.: +91 9810493714.

E-mail addresses: shi_81@rediffmail.com (S. Jain), krishna.asawa@jiit.ac.in (K. Asawa).

http://dx.doi.org/10.1016/j.eswa.2015.08.037

Several agent programming languages (Bordini, Wooldridge, & Hübner, 2007; Dastani, 2008; Giacomo, Lesperance, & Levesque, 2000; Hindriks, de Boer, van der Hoek, & Meyer, 1999; Pokahr, Braubach, & Lamersdorf, 2005; Rao, 1996; Shoham, 1993; Thomas, 1993; Winikoff, 2005) and agent cognitive architectures (Anderson, 1983; Helie & Sun, 2010; Laird, Rosenbloom, & Newell, 1987) have been developed to model an intelligent agent in a simulated environment. While agent cognitive architecture provides the templates to the developers to model agent's behavioral instances, the agent programming languages provide the dedicated programming constructs to create an agent's profile and its behavior. However, they are inadequate in modeling human like decisions and actions.

This requirement forces the researchers to start working towards designing emotive cognitive architectures (El-Nasr, Yen, & Ioerger, 2000; Gebhard, 2005; Gratch & Marsella, 2004; Jain & Asawa, 2015a). These architectures are similar as they are based on different psychological theories of emotions. They use appraisal variables to judge the externally occurred event and generate the emotion. Also, they use one or other kind of memories to store and process the data. But, the approaches vary in terms of representation, methods used, formulas for computation of values, features incorporated, etc. However, a limited research (Dastani, Floor, & Meyer, 2014; Steunebrink, Dastani, & Meyer, 2012) has been carried out in the field of incorporating emotions in agent programming language. In the work reported by Dastani et al. (2014), an affect interface is designed to integrate two independent frameworks; 2APL-An agent programming language and the ALMA-emotion engine. The emotion dynamics modeled by ALMA is simple. Moreover, in the work, procedure call rules (PC-rules) designed are more of domain dependent and are used for behavior coping. Since emotion regulation is not supported by ALMA, so instead of emotion regulation, template based behavior coping is incorporated in 2APL itself.

So, this paper presents the agent programming constructs for emotions triggering mechanism supported by emotive architecture EMIA in line with 2APL. EMIA seems to be compatible for integration with 2APL programming constructs as both are rule based designs (details are discussed in Section 2). EMIA is a domain independent rule based computational model of emotion. It is loosely based upon OCC (Ortony, Clore & Collins, 1998), Scherer (1994), and Roseman, Jose, and Spindel (1990) cognitive theories of emotions. The highlighted features of the model are belief-set, event-set, action-set, goal-set, emotion elicitation, emotion transition and emotion regulation (including decay). 2APL is a rule based agent programming language which provides programming constructs to create and handle behavior of an intelligent agent. The beauty of the language lies in the three types of practical reasoning rules and six actions along with agent's belief-base and goal-base. The objective of this research study is to design programming constructs for integrating an advanced yet rule based emotion model EMIA, in line with the 2APL (called it as E-2APL). To exhibit the emotional behavior of an intelligent agent, the basic *sense-interpret-act* cycle of 2APL is restructured as *percept (while considering self)-appraisal (w.r.t self-well-being)-elicitation-act* cycle. The deliberation cycle to 2APL is restructured to incorporate event perception, event appraisal, and emotion elicitation / transition and emotion regulation process. The scope of the paper is limited to the design of semantics for an agent, and focus is on the effective implementation of emotive–cognitive agent related concepts and abstractions; nevertheless, same can be extended for multi-agent system as well.

The structure of the article is as follows. In Section 2, we present the existing related work. Section 3 discusses the features and functioning of the 2APL and why only 2APL has been chosen to restructure. Section 4 discusses the emotion modeling supported by emotive architecture- EMIA in brief. In Section 5, new programming syntax and semantics are suggested. The deliberation cycle of the new modeling is shown in Section 6. Section 7 shows the effects of emotions on plan and belief-base. Simulation of the agent behavior is presented in Section 8. Finally, the paper is concluded in Section 9 with a brief discussion of practical application, limitation and future scope of the proposed work.

2. Related work

A few researchers proposed the incorporation of emotions in agent programming language. In 2012, Steunebrink et al. (2012) proposed the logical structuring of definition of emotions given in OCC model. The logical structuring is done using dynamic doxastic logic and KARO framework, which is an extension of dynamic doxastic logic. But, no further formal formulation presented by them. In 2014, Dastani et al. (2014) proposed the integration of an emotion model, ALMA, in the existing agent programming language 2APL. To connect these two frameworks, an interface, Affect Engine, is designed which is responsible to communicate emotion related data from 2APL to ALMA compatible mode and vice versa. ALMA (Gebhard, 2005), is a layered model of affect, basically models conversational agent. It uses XML based modeling language to implement the concept of short- term emotions, medium-term moods and long-term personality profiles by using OCC model, pleasure-arousal-dominance (PAD) model of mood and five personality dimensions (OCEAN) model respectively. It defines the rules for event appraisal and elicited the emotions accordingly. OCEAN model is mapped over PAD mood space to determine the current mood of the agent. The push–pull mechanism is used to adjust the mood of the agent.

In the 2APL-ALMA integrated model, the agent's personality and appraisal data is stored in an XML file. Emotion-base is designed to store the appraisal data. Further, E-rules are designed. On occurrence of an event, the appraisal input is generated using E-rules while referring the XML file. This data is passed on to the ALMA via Affect –Engine. ALMA uses the emotion elicitation rules to elicit an emotion and map it over PAD space to determine the current mood. This information is sent back to 2APL as coping data. Now 2APL applies PC-rules and use the coping data to generate a plan.

Since, 2APL is a rule based language, the researchers confronted difficulty in integrating it with the advanced emotion models which could support complex emotion dynamics. The integrated emotion model ALMA, tags the event as either good or bad. However, in actual, events should be evaluated with respect to the goal. Only two polarity description is not sufficient to judge an event. Moreover, ALMA does not support emotion regulation and it is taken care by 2APL separately by defining template strategies for coping. Moreover, corresponding to one coping data, a large number of domain's dependent PC-rules are designed.

In this paper, we propose a different approach for integrating an emotion model, EMIA, within 2APL (E-2APL). The following features are incorporated into 2APL to extend it towards programming an expressive autonomous agent.

1. The basic sense-interpret-act cycle of a rational intelligent agent is transformed to percept-appraisal (with respect to self-well-being)-elicit-act cycle.
2. Agent configuration is modified to reflect the current emotion state of the agent.
3. The event is evaluated with respect to the goal(s) of an agent, the resource available to handle the situation, and the capabilities of the agent.
4. In E-2APL, all the features and rules are embedded in 2APL itself, which makes it adaptable.
5. Event-Base is modified to store the event in terms of goalImp, expectedEventResult, resource available and suddenness which make remaining processing domain independent.
6. An additional database, emo-base is added to store the values of appraisal variables of an event and current emotion of the agent.