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Creativity evaluation in a cognitive architecture

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Abstract
Evaluation is a key factor of creativity: for this reason it should be integrated into a cognitive architecture of a *creative* artificial agent. The approach illustrated in this paper uses the Psi model, and describes the framework for introducing internal and external evaluations, and how they influence demands and motivation of the artificial agent. Internal evaluation mechanisms drive the creative process, and influence competence of the creative agent. External evaluation acts through certainty, and requires interaction with human users that express both opinions and some subjective quantitative evaluations on the final artwork. The system uses natural language processing techniques in order to infer the satisfaction and the emotional impact of the final product obtained by the creative agent.

Introduction

Cognitive architectures (CA) are inspired by functional mechanisms of human brain, and the various models proposed (Goertzel, Lian, Arel, de Garis, & Chen, 2010) try to define the necessary modules to emulate the complex interactions among perception, memory, learning, planning, and action execution.

It is a great open challenge to be able to integrate in such architectures all the aspects relating to language, emotions, abstract thought, creativity and so on. Probably the main difficulties are due to the management of the internal representation of the external world, and the ability to efficiently update these models through the interaction with the outside world. In this context it is necessary that the new models of neuro-biological mechanisms of the human mind to be able to explain even the highest level of cognitive functions (Heilman, Nadeau, & Beversdorf, 2003), and

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vice versa, i.e., to update and modify the cognitive architectures according to the biological constraints considered as indispensable.

For example, new models of learning and classification such as deep learning (Bengio, Courville, & Vincent, 2013) in the future could solve some of these difficulties, and their use in cognitive architectures could contribute at reducing the gap between the low-level models and high-level ones. The cognitive architectures inspired by biology should give greater weight to interactions with outside world, and they should define how the modules that handle internal representations can be influenced by them.

For various reasons, creativity, among the many high-level cognitive functions, could be the one that allows to investigate new solutions or improvements. Creativity is a component of human intelligence that cannot ignore external influence, given that its mechanisms of association, analogy, and composition depend strongly on some evaluation processes (Boden, 1998).

In the past decades, artificial intelligence has focused attention mainly on learning, knowledge management, and action planning, but it has often ignored the dynamic interactions with the outside world (especially social interactions). The artificial creativity in this sense may represent a more complete testbed to stimulate the development of cognitive architectures. Artificial creativity heavily introduces both internal and external evaluations, and it focuses on the creation of an outcome or a process with a certain degree of innovation and invention, and capable of arousing emotions.

It is difficult to give a definition of creativity, as well as for intelligence, but it is easier to focus on the final product of the creative process. Recently, an attempt was made to formalise the artificial creativity (or computational creativity) (Colton, Pease, & Charnley, 2011), to define methodologies and to establish metrics of creativity (Galanter, 2012). How an embodied artificial agent able to interact with humans and the environment might produce a creative processes or creative acts trough a given cognitive architecture? Jordanous (Jordanous, 2012) indicates 14 key components to take into account in order to deal with creativity, and some of them could be partially considered in various components of a CA: *dealing with uncertainty; intention and emotional involvement; generation of results; domain competence; originality; social interaction and communication; variety, divergence and experimentation; value; evaluation*. Other factors are more difficult to manage, requiring more investigation and better definition for real implementation:*active involvement and persistence, general intellectual ability, progression and development, spontaneity and subconscious processing, independence and freedom, (abstract) thinking*. Various cognitive architectures have some mechanisms of self-evaluation that can enable the comparison of expected results with the one obtained. However, it is necessary to capture external evaluation (e.g. feedbacks from users) in order to introduce creativity modules which can truly affect the creative process. In the self-evaluation, pre-configured (or innate) mechanisms could certainly assure results consistent with a given goal (e.g. to make a portrait), and an aesthetic sense (Romero, Machado, Carballal, & Correia, 2012) to get an acceptable result (also emotionally). The social (external) evaluation must necessarily act on the agent's motivation, affective system, and goals. In this paper we show how it can be integrated into the Psi cognitive architecture.

The paper is structured as follows: section 'Introduction' describes how to introduce a creative process in the PSI cognitive architecture; section 'Creative productions in a cognitive architecture' deals with computation of demands/urges and motivation, and finally an example of human evaluation is reported in section 'Human evaluation by conversation'.

Creative productions in a cognitive architecture

An effective way to build an artificial intelligent agent that can interact with humans is to endow it with a cognitive architecture: perceptions, actions are managed (at least at high level) in a manner similar to what happens in the human brain. This allows social interactions based on shared mechanisms and shared real world understandings (Infantino, Lodato, Lopes, & Vella, 2008). But human cognitive processes are determined by a complex information processing systems, and they are influenced, for example, by emotional (Chella & Infantino, 2004; Infantino & Rizzo, 2013) and motivational regulatory sub-systems (Breazeal, 1998).

Artificial creativity is one of the biggest challenges in cognitive architectures because it involves several cognitive capabilities and representation levels. Human creativity is mainly perceived as a high level cognitive process (Boden, 2009), however it is also based on low-level mechanisms that manage perceptions and representations (Bach, 2009) that are not considered in this discussion. At high level, a system, in order to be considered creative (and not a simple creativity support tool) should take a certain responsibility and autonomy during its creative processes (Colton & Wiggins, 2012).

In a previous work (Augello, Infantino, Pilato, Rizzo, & Vella, 2013a) we have introduced a creative process on a cognitive architecture supporting the execution of digital portraits. During the learning phase the system creates a collection of styles (i.e. the sequences of operations that modify an image) by using a genetic algorithm. Then, it chooses the execution plan of the artwork through the influence of perceived emotions on the subject to be portrayed. The production—evaluation cycle during the production phase is integrated in a PSI cognitive model (Bartl & Dörner, 1998) as shown in Fig. 1. Moreover, in order to improve the final results of the artificial painter, we have investigated the relationships between colours, palettes and emotions, trying to find out their reciprocal influences (Augello et al., 2013a). This approach (Augello et al., 2013a, Augello, Infantino, Pilato, Rizzo, & Vella, 2013b; Infantino, Pilato, Rizzo, & Vella, 2013b) was based on a multilayered mechanism, implemented as an associative memory based on Self Organizing Maps (SOMs) (Kohonen et al., 2001), and it is capable to properly mix elements belonging to different domains in order to emulate some sort of combinatorial creativity (Augello, Infantino, Pilato, Rizzo, & Vella, 2014a) introduced by Boden (2009).