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RESEARCH ARTICLE

Introducing a creative process on a cognitive architecture

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Abstract
In this paper we present a system that implements a creative behavior on a cognitive architecture. It is aimed at creating digital art images from snapshots of a human subject, simulating a simple creative process. Such a process starts from a Training Phase that creates a set of image filter sequences. This phase is oriented to approximate some painting styles obtained from famous images and portraits of the past. The learned filter sequences are then used during the Production Phase. During this subsequent phase, the ''artificial artist'' interacts with the subject trying to ''catch'' the human emotions that drive the creation of the portrait. The artist processes feedbacks from the user according to the cognitive model Psi and its implementation of the motivations. These motivations influence further modifications of the applied filter sequences achieving an evolution of the artificial artist.

1. Introduction

The aim of this work is to combine an approach based on cognitive architectures (Goertzel et al., 2010; Langley et al., 2009) with some mechanisms of computational creativity (Boden, 2009; Colton et al., 2009). The main purpose therefore is not to propose a theoretical model, but to have an implementation model that could be exploited as a testbed and which may, however, be extended, modified, and improved. The proposed model is designed to be implemented on a humanoid Nao platform.[1] Given the proposed models of creativity in the literature, we have identified some features that are likely to produce a *digital* painter using a robot, that is able to develop his artificial visual perception, and originating a *creative act* based on its experience and expertise, also through interaction with the human (both in the stage of learning that final evaluation). The first phase of the research project aims at developing a cognitive software infrastructure that provides creative skills mainly from visual perception. In a second phase, we plan to introduce the physicalness of the humanoid adding

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[1] http://www.aldebaran-robotics.com.

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other sensory information such as auditory and tactile, to achieve perhaps the use of a real brush and a canvas.

The presented work is placed in an intermediate position with respect to Non-Photorealistic Rendering (NPR) (Collomosse and Hall, 2003; Collomosse and Hall, 2006; Litwinowicz, 1997) and an automated painter (Colton, 2012, for example; McCorduck, 1991). Fig. 1 illustrates the overall diagram of the system that is split in two parts with different tasks. A set of predefined filters are developed in a Training Phase that uses a genetic algorithm. To each filter we have associated a symbol so that a sequence of symbols represent a set of elaborations. The ordered set of symbols is stored in a string representing the image processing steps in a specific order. Each filter sequence is a sample of the space of the possible processing filters and is produced according to the definition of exploratory creativity described by Boden (2009). Some strings drive effects that produce a similar appearance and purposeful intentions. To a set of strings of this kind we associate the name *Style*. During the Production Phase the humanoid creates a portrait of a subject using a snapshot and a set of image filters obtained from some predefined painting styles. The use or choice of the painting style in portrait processing is driven by motivations (or Urges in the figure) of the system. We found that these *Urges* can be implemented using the cognitive model Psi (Bartl and Dörner, 1998) that also take into account concepts related to Certainty and Competence. The agent that has enough competence to go beyond the common ground is much more creative than the others.

The paper is structured as follows: after a brief introduction to the cognitive architectures the paper introduces the one used in the experimentation focusing on the motivation aspects that are important for creativity. The system is described in the section ''Humanoid portraitist'' stressing the cognitive aspects, while the implementation details are left to the next section. The last sections are dedicated to some experiments and comments, and to conclusions and future works.

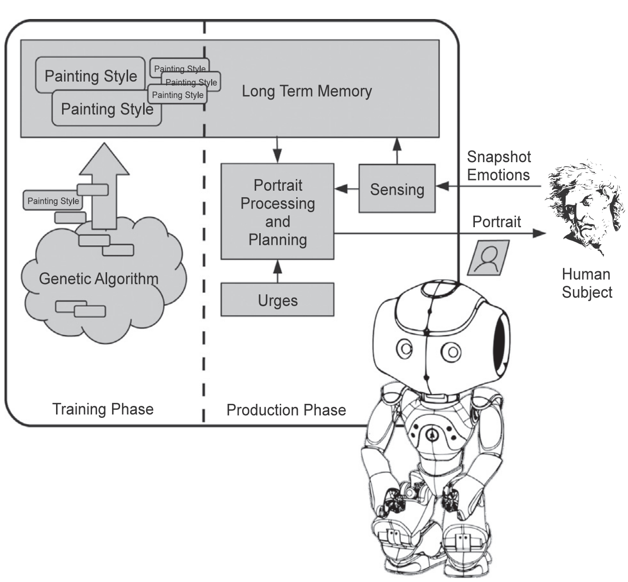

Fig. 1 The overall diagram of the proposed system.

2. Cognitive architectures

Cognitive architectures allow software to deal with problems that require contributions from both cognitive science and robotics, in order to achieve social behaviors typical of the human being. Several cognitive models of the human mind can find common ground and experimental validation using humanoid agents. To achieve an advanced human-robot interaction, many researchers have developed cognitive systems that consider sensory, motor and learning aspects in a unified manner. Dynamic and adaptive knowledge also needs to be incorporated, using internal representations that are able to take into account variable contexts, complex actions, goals that may change over time and capabilities that can extend or enrich themselves through observation and learning. Cognitive architectures represent the infrastructure of an intelligent system that manages, through appropriate knowledge representation, the process of perception, the processes of recognition, categorization, reasoning, planning and decision-making (Langley et al., 2009). In order to make the cognitive architecture capable of generating behaviors similar to humans — and especially in the case of creativity — it is important to consider the role of emotions. Reasoning and planning may be influenced by emotional processes and their representations in a similar way to what happens in humans. Ideally, this aspect can be implemented through a suitable representation of emotional states that, in addition to influencing behavior, also helps to detect and recognize human emotions. This position agrees with the hypothesis that human creativity only makes sense when placed in the context of rich social interactions (Csikszentmihalyi, 1988; Sawyer, 2008, 1999).

In a wider perspective, the mental capabilities (Vernon et al., 2007) of artificial computational agents can be introduced directly into a cognitive architecture or emerge from the interaction of its components. The approaches presented in the literature are different and range from cognitive testing of theoretical models of the human mind, to robotic architectures based on perceptual-motor components and purely reactive behaviors (Goertzel et al., 2010; Langley et al., 2009). Currently, cognitive architectures have had little impact on real-world applications and a limited influence in robotics. The aim and long-term goal is the detailed definition of the Artificial General Intelligence (AGI) (Goertzel and Pennachin, 2007), i.e. the construction of artificial systems that have a skill level equal to humans in generic scenarios.

All cognitive architectures presented in literature do not explicitly provide mechanisms to achieve creativity, partly because only recently research is addressing important and closely related cognitive aspects such as emotions, intentions, awareness, and consciousness. This attention to creative and other high level cognitive functions is reported in Samsonovich (2012).

More interesting for the purposes of our work is the Psi model (Bartl and Dörner, 1998; Bach et al., 2006) and its architecture that involves explicitly the concepts of emotion and motivation in cognitive processes. MicroPsi (Bach et al., 2006) is an integrative architecture based on the Psi model which has been tested on some practical control applications. It has also been used on simulated artificial