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Research article

Automatic reward system for virtual creatures, emergent processes of emotions and physiological motivation

Jonathan-Hernando Rosales[a], Myrna S. Zamarripa[a], Félix Ramos[a,*], Marco Ramos[b]

[a] Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Department of Computer Science, Av. del Bosque 1145, Col. El Bajio, P.C. 45019, Zapopan, Mexico

[b] Autonomous University of Estado de México, Department of Computer Science, Cerro de Coatepec S/N, Col. Ciudad Universitaria, P.C. 50130, Toluca, Mexico

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ABSTRACT

Emotional and motivational evaluations are part of the development of rewards within living beings. Particularly, during the perception of stimuli in the environment, these evaluations collaborate with one another to generate reward values automatically, without the need to involve rational processes. In this paper we propose a conceptual model of automatic reward for virtual creatures inspired by neuroscientific evidence, contemplating the processes of emotions and motivations, as well as the generation and recovery of automatic reward values. According to the evidence, the reward process is divided into two processes: liking, which is oriented toward interpreting information inputs and generating reward values, and wanting, focused on the recovery of the stored reward values and the generation of objectives in the environment. The reward process is implemented as a concurrent and parallel naturally distributed system, allowing virtual creatures to adapt to their environment and generate more credible behaviors. The results of liking and wanting are shown in this article through a case study, in which the performance of both processes is observed when the creature interacts with the environment.

Introduction

Emotional and motivational systems are usually studied separately, as they are apparently processes with independent objectives. Emotions help us to know our internal state, and their purpose is to skew our decisions and actions in the environment. The same can be said of social interactions, inasmuch as emotional behaviors toward others can express our internal state. Meanwhile, motivation is the explanation of why organism's start and maintain certain actions in the search of goals. This is based on detecting internal deficiencies in the organism's, and seeking their satisfaction (Hull, 1950). Motivational theories based on an organism's needs have a biological basis, but are likewise adopted by the social sciences (Bernard, Mills, Swenson, & Walsh, 2005).

In psychology in particular, affect is identified as a basic process that generates emotions (Gendron & Barrett, 2009; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012; Russell, 2003, 2009). Also, affect is part of motivation, given Maslow's proposal (Maslow, 1943), where it is the second level of classification. From this point, a relationship can be seen between motivation and emotions. After the affect level, in Maslow's pyramid, the first level is focused on survival and is called physiological motivations. These motivations are physical needs generated by the organism, such as thirst, hunger, temperature, and others. Focusing on affect and physiological motivation, within neuroscientific research, we find that they share brain structures involving a secondary process known as a reward.

There are different types of rewards, which correspond to stimuli, actions, or behaviors. However, the rewards generated by processes of affect and physiological needs are aimed at evaluation of stimuli perceived in the environment. In this article, the evaluation stimulus is termed automatic reward. Automatic reward determines how pleasant a stimulus is when a user interacts with it. This process helps discriminate rewarding stimuli perceived in the environment from pleasure, displeasure, or physiological needs that these stimuli satisfy.

The contributions of this article are the collaboration between affect and physiological needs to generate the resulting subprocesses of reward, and the way an automatic reward process implemented in virtual creatures helps generate more credible behaviors. First affect, physiological motivation, and reward are described. Subsequently, some state-of-the-art cognitive architectures incorporating processes emotions and motivation are observed. Next, evidence is collected and reviewed, various reward models proposed are compared and the brain structures involved in this process are described. In addition, a case study of

* Corresponding author.
E-mail addresses: jrosales@gdl.cinvestav.mx (J.-H. Rosales), mszamarripa@gdl.cinvestav.mx (M.S. Zamarripa), framos@gdl.cinvestav.mx (F. Ramos), maramosc@uaemex.mx (M. Ramos).

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implementation is presented and the results are observed. Finally, the results and some conclusions of this work are discussed.

Affect - the first stage of emotion and motivational value

In modern psychology, affect refers to an internal mental representation product of the perception or interaction with stimuli in the environment (Barrett & Bliss-Moreau, 2009). It is considered a psychological primitive generated automatically and cannot be interpreted (Wundt, 1998). It is also seen as a cornerstone for the development of various psychological phenomena, such as emotion, attitude, decision making, prediction, motivation, and personality, among others (Barrett & Bliss-Moreau, 2009).

Psychological constructivist theories study affect as the premise for the generation of emotions (Lindquist et al., 2012; Russell, 2003). Moreover, in neuroscience, there is evidence of emotional nuclei within the brain involved in the evaluation of stimuli and the expression of emotional behaviors (Barrett & Bliss-Moreau, 2009). The human being has the most highly developed affective nuclei of all animals (Barrett & Bliss-Moreau, 2009), which is why our affective processing is so complex.

Considering that affect is a positive (pleasant) or negative (painful) evaluation of a particular stimulus in the environment (Barrett & Bliss-Moreau, 2009), it is possible to skew our decisions based on the affective value (pleasant/painful) of those stimuli with which we interact (Barrett & Bliss-Moreau, 2009).

Physiological motivation - a necessity of the system and a goal in the environment

Human beings first need is to satisfy the physiological motivations that keep them alive. These motivations arise from the body's internal homeostatic processes. According to Cannon (1932), homeostasis is the process that keeps bodies in balance. To present a variation in their states (outside the ranges established through experience) regulatory mechanisms are activated, giving rise to what are termed physiological needs. Some physiological needs of the human being are hunger, thirst, temperature, and sex, among others. Stimuli that satisfy these needs will have greater relevance as goals in the environment (Berridge, 2004).

There are brain structures that receive information about the organism's needs (Richard, Castro, DiFeliceantonio, Robinson, & Berridge, 2013). These structures identify physiological needs and require a connection with other systems to guide actions in search of what the body needs to satisfy these needs (Dickinson & Balleine, 1994; Kalivas & Volkow, 2007).

Reward - a wanting and liking process of stimuli within the system

Reward is the evaluation process that determines how gratifying an action, an episode, or a stimulus perceived in the environment has been (Camara, Rodriguez-Fornells, Ye, & Münte, 2009). Gratification-oriented stimuli, at the same time, help us to predict possible rewards in different actions from previously stored memories. Therefore, it could be said that reward consists of two subprocesses.

- Liking, which establishes how pleasant it is to interact with a given stimulus, situation, or action, whereas the affective and motivational information is provided by such a stimulus (Berridge, 1996; Berridge, Robinson, & Aldridge, 2009).
- Wanting, which establishes whether or not a stimulus may be considered a goal in the environment on the basis of stored affective and motivational information, and the individual's current needs (Berridge, 2007; Dickinson & Balleine, 2010).

These subprocesses can work concurrently, although for the wanting process to work, prior information is required, provided by liking. Liking must have been activated at least once before wanting. The systems of affect and physiological motivation are the first information inputs within the system of rewards. However, neuroscientific studies have shown that there are other systems involved, such as the cognitive assessment system, which is a product of reasoning and also provides input for the system, because it requires individuals to be aware of their involvement in the environment and provide a subjective assessment of each stimulus. This input is not automatic and requires several cognitive processes for processing, so it is not considered in this work, since it does not help in the generation of automatic reward assessments of perceived stimuli.

Cognitive architectures

Cognitive architectures are systems based on biological evidence seeking to endow agents with the abilities of the human being. The principle is to model the senses of perception and cognitive abilities, such as motor skills, emotions, and memory, among others. Cognitive architectures are used primarily to recognize the environment and solve problems the way to humans do (Profanter, 2012). Different cognitive architectures have been designed considering systems of motivation and/or emotion.

- **iCub** is being implemented in a robot with the visual, vestibular, auditory, and optical capabilities of a three-year-old (Vernon, Metta, & Sandini, 2007). This work considers the motivations for the selection of the robot's actions based on homeostatic principles. These motivations are intrinsic and based on learned experiences. iCub contains an affective state, which skews the selection of the robot's actions and is the only component oriented to emotions. This affective state is produced directly from the perceptions that iCub has of the environment (Vernon, von Hofsten, & Fadiga, 2010). The main disadvantage of this system is the absence of affective values. This absence precludes the system from generating affective attachment to perceived stimuli, similar to what can be observed in three-year-old children as an attachment to certain persons or objects. Although it has the ability to generate needs from homeostatic principles, and to determine whether a stimulus satisfies a given need, the incorporation of affective values would help it to decide among stimuli that satisfy the same need.
- **Soar** has implemented humanoids that receive instructions in natural language and perform specific tasks (Laird, Lehman, & Rosenbloom, 2006). It proposes an emotional system based on three parameters: emotion, feeling, and mood. These parameters work together for the generation of emotional behaviors and internal moods. However, the emotional system of Soar has not been implemented; only part of its general model has (Laird, 2012). The absence of a system of emotions precludes the humanoid from expressing its internal state through behaviors. Furthermore, the fact of not having emotional or motivational evaluations precludes the humanoid from generating automatic reward values for the stimuli perceived in its environment. These absences could generate behaviors that are unnatural or not credible in humanoids equipped with Soar architecture.
- **Kismet** (Breazeal, 2003; Breazeal & Scassellati, 2000) is another cognitive architecture implemented in a robot that expresses different types of human emotions. It has both stimulus and emotion systems. The stimulus system regulates social, stimulation, and fatigue needs. These stimuli affect the system of emotions that are generated, including anger, disgust, fear, joy, sadness, surprise, boredom, interest, and calm. However, this architecture does not consider physiological motivations since the robot does not have a complete body, so it is only focused on social interaction-based motivations for the generation of emotional expressions. It is able to generate emotional behaviors but has no other cognitive processes

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