Interaction between Task Oriented and Affective Information Processing in Cognitive Robotics

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Abstract. There is an increasing interest in endowing robots with emotions. Robot control however is still often very task oriented. We present a cognitive architecture that allows the combination of and interaction between task representations and affective information processing. Our model is validated by comparing simulation results with empirical data from experimental psychology.

Keywords: Affective, Cognitive Architecture, Cognitive Robotics, Stimulus Response Compatibility, Psychology.

1 Introduction

An uplifting beep tone in moments of despair, a pair of artificial eyebrows showing an expression of genuine concern or a sudden decision to 'forget the rules' and 'save the girl' are common in Hollywood blockbuster movies that feature robots, but are currently not that realistic in everyday robot life. Typically, research in robot control focuses on the successful execution of tasks, such as grasping cups or playing the drums. The main goal of such research is to optimize task execution and to achieve reliable action control [1]. Increasingly, roboticists are also concerned with the social acceptance [2] of robots. A lot of effort is being put in the appearance of robots and their capability to display expressions that we may recognize as emotional. One may wonder, however, to what extent emotions (or affective information in general) may contribute to actual decision making [3].

In traditional machine learning approaches, such as reinforcement learning, affective information is usually treated as additional information that co-defines the desirability of a state (i.e., as a ‘reward’) or action alternative (i.e., as part of its ‘value’ or ‘utility’). By weighting action alternatives with this information, some can turn out to be more desirable than others, which can aid the process of decision making (e.g., [4]). In psychological literature, however, there is also evidence that affective information can influence how people respond to stimuli, by producing so-called compatibility effects. Empirical findings suggest, for example, that affective stimuli can automatically activate action tendencies related to approach and avoidance (e.g., Chen and Bargh [5]). The ability to respond quickly to affective stimuli clearly has advantages for survival, for humans and possibly for robots too.

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In an empirical study by Beckers, De Houwer and Eelen [6], participants had to classify positive and negative words according to their grammatical category (noun or verb) by performing one of two actions (moving a response key up or down). Crucially, one of the responses systematically resulted in a mild but unpleasant electroshock. Word valence, even though irrelevant for the grammatical judgment task, influenced response times. The 'negative' response (resulting in an electroshock) was performed faster in response to negative words than to positive words. In contrast, the 'positive' response (associated with the absence of a shock) was performed faster in response to positive words than to negative words. This shows that actions are selected or executed more quickly when their effects are compatible with the affective valence of a stimulus than when they are incompatible.

In this paper we show how this experiment can be simulated in our computational HiTEC cognitive architecture [7] and thereby make it accessible for robot control. The general HiTEC architecture is described in section two. In section three we present the simulation results and finally, in section four, we discuss our findings and their implications for cognitive robotics.

2 HiTEC

2.1 Theory of Event Coding

The HiTEC cognitive architecture is based on the Theory of Event Coding (TEC), which was formulated by Hommel, Müsseler, Aschersleben and Prinz [8] to account for various types of interaction between perception and action, including stimulus-response compatibility effects. Most notably, they proposed a level of common representations, where stimulus features and action features are coded by means of the same representational structures: 'feature codes'. Feature codes refer to distal features of objects and events in the environment, such as distance, size and location, but on a remote, descriptive level, as opposed to the proximal features that are registered by the senses. Second, stimulus perception and action planning are considered to be similar processes, as they both involve activating feature codes. Third, action features refer to the perceptual consequences of a motor action; when an action is executed, its perceptual effects are encoded by feature codes. Following the Ideomotor Theory of William James [9], actions can be planned voluntarily by intending their perceptual effects.

2.2 HiTEC's Structure and Representations

HiTEC is implemented as a connectionist network model that uses the basic building blocks of parallel distributed processing (PDP) [10]. In HiTEC, the elementary units are codes that may be connected and are contained within maps. Codes within the same map compete for activation by means of lateral inhibitory connections. As illustrated in Figure 1, maps are organized into three main systems: the sensory system, the motor system and the common coding system. Each system will now be discussed in more detail.