Chapter VI
Robotic Emotions:
Navigation with Feeling

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ABSTRACT

The hypothesis that artificial emotion-like mechanisms can improve the adaptive performance of robots and intelligent systems has gained considerable support in recent years. To test this hypothesis, a mobile robot navigation system has been developed that employs affect and emotion as adaptation mechanisms. The robot’s emotions can arise from hard-coded interpretations of local stimuli, as well as from learned associations stored in global maps. They are expressed as modulations of planning and control parameters, and also as location-specific biases to path-planning. Our focus is on affective mechanisms that have practical utility rather than aesthetic appeal, so we present an extensive quantitative analysis of the system’s performance in a range of experimental situations.

INTRODUCTION

Despite decades of optimism, the robotics and artificial intelligence communities have thus far been unable to synthesize adaptive capabilities comparable to those possessed by humans or even simple animals. Affect and emotion are increasingly viewed as a potentially vital facilitators of adaptive behavior (Arkin, 2005), possibly to the extent of being prerequisites for general intelligence (Minsky, 1986; Damasio, 1994). However, affect has been conspicuously absent from many traditional AI frameworks and autonomous robots.

Recent years have seen increased interest in the development of robots and intelligent systems that possess emotion-inspired software mechanisms. Much of this research focuses on the application
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of affect to social robotics (e.g. Breazeal, 2004; Broekens, 2007; Hollinger et al., 2006). In this domain, the natural human tendency towards anthropomorphism can be exploited by portraying robotic emotions as facial expressions, body language and/or tone of voice. Affect can also be applied to robotics applications other than human-machine interaction (Arkin, 2005). Nevertheless, many purportedly general-purpose affect models are applied in a social context, where they influence interactions with humans or other robots. Few implementations have been demonstrated that approach the issue from the perspective of an individual robot in a non-social context.

To address the question of whether affect can improve a robot’s performance beyond the social domain, we have developed and implemented a computational model inspired by theories of biological emotion. This model incorporates a range of affective states and processes, including affective stimuli, drives, emotions and moods. It is utilized as an adaption mechanism for a mobile robot planning and control architecture, and it is applied to a range of navigation and exploration tasks. Emotion-like mechanisms enable the robot to adapt its internal parameters to suit the different situations and environments it encounters while performing its duties. To assess the validity of our approach, we present quantitative results that compare the performance of the underlying planning and architecture to one whose parameters are modulated by the affect model.

BACKGROUND

Artificial affect representations can be broadly categorized into symbolic and neurophysiological models (Aylett, 2006). Symbolic models are typically favored by large-scale general-purpose AI frameworks, and emphasize cognitive roles of affect such as goal prioritization and memory management. They are often based on cognitive appraisal theories of emotion such as that proposed by Ortony et al. (1988). These types of models often have limited applicability in the robotics domain, where symbolic objects are not simply assumed to exist; they must be derived from real-world sensor data.

Thus, robotic implementations are typically more heavily inspired by neurobiological theories of emotion such as that proposed by Damasio (1999). Affect and emotions may be employed as internal ‘sensors’, or as discrete states that drive action selection. One of the main functions of this type of affect representation is to motivate a robot to respond quickly to certain events without waiting for its slower cognitive processes to ponder the situation. Affect is thus regarded as a potential replacement for deliberative processing in robotic controllers. Interactions between affect and deliberative processing have received little attention in the robotics domain, because they are often viewed as competitors for the same role.

One robotic affect model that has inspired various implementations is Valásquez’s Cathexis architecture (Valásquez, 1997), which models Ekman’s six basic emotions (anger, fear, happiness, sadness, disgust and surprise) (Ortony and Turner, 1990) as ‘proto-specialist’ agents (Minsky, 1986) executing in parallel. Emotions are one of several inputs that control behavior activation. A similar approach is adopted by Breazeal (2003) for the robotic head Kismet. In Kismet’s model, stimuli are tagged with three dimensions of affective information (valence, arousal and stance), and their associated emotional responses compete for activation in a winner-takes-all manner. In addition to driving certain cognitive processes, emotions are portrayed as variations in the robot’s facial expression, gaze direction and tone of voice.

Arkin’s TAME architecture (Arkin, 2005) models a broader set of affective states and processes (traits, attitudes, moods and emotions) for behavior-based robotic systems. Each category of affect is represented by multiple dimensions of intensity values. Traits are based on the Five-Factor Model of Personality (McCrae and Costa,