Time-Varying Affective Response for Humanoid Robots*

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Abstract. This paper describes the design of a complex time-varying affective architecture. It is an expansion of the TAME architecture (traits, attitudes, moods, and emotions) as applied to humanoid robotics. It particular it is intended to promote effective human-robot interaction by conveying the robot’s affective state to the user in an easy-to-interpret manner.

Keywords: Humanoids, emotions, affective phenomena, robot architectures.

1 Introduction

Based on our considerable experience implementing affective phenomena in robotic systems (see [1] for a summary), we are now considering the application of sophisticated cognitive models of human Traits, Attitudes, Moods, and Emotions (TAME). These affective states are embedded into a novel architecture and designed to influence the perception of a user regarding the robot’s internal state and the human-robot relationship itself. Recent work by Arkin et al in non-verbal communication [2] and emotional state for the AIBO [3] addressed powerful yet less complex means for accomplishing these tasks. Introducing time-varying affective states that range over multiple time scales spanning from an agent’s lifetime to mere seconds with direction towards specific objects or the world in general provides the power to generate heretofore unobtained richness of affective expression. This paper describes the cognitive underpinnings of this work in the context of humanoid robots and presents the directions being taken in this recently initiated project to implement it upon a small humanoid robot.

2 Related Work

Although most work on humanoids focuses on the physical aspects (e.g., perfecting walking gaits, sensors or appearance), there are some who add affect into the mix. For example, humanoid Waseda Eye No. 4 Refined [4] combines emotions, moods, and personality. The overall goal of the system is to achieve smooth and effective communication for a humanoid robot. Although many elements of this system are not

* This research is funded under a grant from Samsung Electronics.
psychologically or biologically founded, it provides a few interesting mechanisms, such as modeling personality’s influence on emotion via a variety of coefficient matrices and using internal-clock activation component in moods.

Fukuda et al. [5] also include the notions of emotions and moods in their Character Robot Face; emotions are represented as semantic networks, and the combination of currently active emotions is deemed as mood. Two other humanoid robotic head robots, Kismet [6] and MEXI [7] have emotion and drive systems. Kismet is modeled after an infant, and is capable of proto-social responses, including emotional expressions, which are based on its affective state. In MEXI, the Emotion Engine is composed of a set of basic emotions (positive that it strives to achieve and negative it tries to avoid) and homeostatic drives. Space prevents a more complete description of other related projects.

3 Cognitive Basis of TAME

The TAME affective architecture has been initially tested on the entertainment robot dog Aibo [8], but its application to a humanoid robot is fairly straightforward in principle. In fact, using the framework for a humanoid will provide a number of advantages. The synergistic combination of affective phenomena focuses on long-term, and sometimes subtle, effect on robotic behavior, which fits well with one of the main goals for creating human-like robots - making the communication between them more natural, commonplace and prolonged, where machines act as partners rather than bystanders. The second advantage of applying TAME to humanoids is their expressive potential, exhibited not only in facial and bodily expressions (e.g., a smile, a shoulder shrug, a handshake), but also in a variety of tasks they could perform for which human-like personalities are readily applicable. The framework itself takes inspiration from a large number of theories and findings from Personality, Emotion, Mood and Attitude areas of Psychology, which are adapted to enhance robotic behavior.

3.1 Overview

The Affective Module, the core of TAME, is subdivided into Dispositions and Affective State. Dispositions include personality Traits and affective Attitudes, and represent a propensity to behave in a certain way; they are more or less persistent, long-lasting, and either slowly changing (attitudes) or permanent (traits) throughout robot’s “life”. Affective State consists of Emotions and Moods, more fleeting and transient affects, manifesting as either high-intensity, short duration peaks (emotions) or slow smooth undulations (moods). Table 1 summarizes differences in duration and temporal changes of these four components.

Another direction along which these components differ is object specificity: emotions and attitudes appear and change in response to particular stimuli (such as fear in the presence of an attacker or dislike towards an unfriendly person), whereas traits and moods are diffuse and not object-specific – they manifest regardless of presence or absence of objects. Although they all can be categorized differently and each have a distinct function and purpose, we cannot regard these phenomena as independent, as they strongly influence each other and interweave to create a greater illusion of life.