Body Language of Humanoid Robots for Mood Expression (Doctoral Consortium)

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ABSTRACT

Bodily expression of affect is crucial to human robot interaction. Bodily emotion expression concerns explicit body actions that typically interrupt ongoing functional behaviors. Instead, we design bodily mood expression by integrating affective cues with functional behaviors without interrupting them. We propose a parameterized behavior model with specific parameters that control pose and motion dynamics of the behavior. Modulating those parameters results in different behavior appearance through which the robot mood is expressed. We applied the model to behaviors of the NAO robot, and conducted a user study to identify principles to be used for parameter modulation, experiments that evaluated whether the mood can be recognized by participants with or without a context, and experiments that address the effect of the mood expression on participants in human-robot interaction in a laboratory setting and a real life setting. Results showed that our approach for bodily mood expression of a humanoid robot is effective.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics – *Commercial robots and applications*. H.1.2 [**Models and Principles**]: User/Machine Systems – *Human factors*. H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Evaluation/methodology*.

Keywords

Mood Expression, Nonverbal/Behavioral Cues, Body Language, Social Robotics, Human Robot Interaction (HRI).

1. INTRODUCTION

The expression of affect is an important ability of social robots for participating in affective human-robot interaction (HRI) [1]. Among the modalities of affect expression, bodily expression is a nonverbal channel that facilitates human understanding of a robot's behavior, rationale, and motives, and increases the perception of a robot as trustworthy, reliable, and life-like [2]. Bodily expression is in particular important for humanoid robots that lack facial features such as NAO, ASIMO, and QRIO.

One of the challenges is to express robot affect by bodily expressions at an arbitrary time, even while executing a task. To this end, we are developing body language for humanoid robots to express mood, i.e., we design behavioral cues and integrate them with functional behaviors required by the task. Mood is a relatively long-lasting and stable affective state. Integrating mood into the body language of a robot not only provides the robot with an alternative but also a more stable channel for communicating affective information than explicit emotion expressions.

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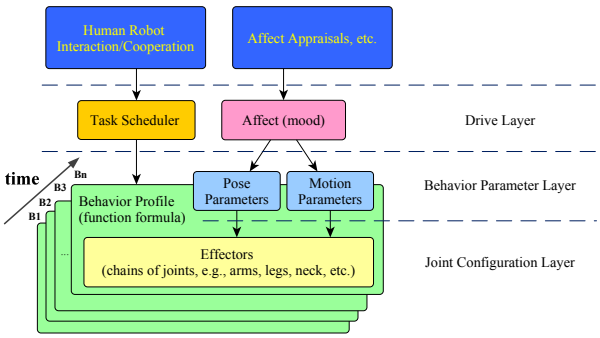

Figure 1. **General Parameterized Behavior Model.**

Our main research questions are 1) *which* behavior parameters have the potential to express mood when modulated, and *how* should these parameters be modulated to express a specific mood; 2) *whether* people, while interacting with a robot, can recognize mood from robot behaviors that are modulated to express positive or negative mood; and 3) *what* the effects of robot mood on someone who is interacting with that robot are. For example, it is well known that mood can be transferred between persons, and thus, it is useful to gain insights into the possible transfer and effects of mood from a robot to an individual.

2. APPROACH

To enable a robot to express mood, even during task execution, we have developed a model for integrating mood expression with functional behaviors (e.g., task behaviors, communicative gestures, and walking). In this model (Figure 1), a particular functional behavior is parameterized, and by varying these parameters, the "style" or "appearance" of the behavior is modified, without modifying the function of that behavior.

The set of parameters are generic and can be used to modulate a broad range of behaviors (we have applied the model to more than 40 behaviors of the NAO robot). Parameters such as the speed and the amplitude of a movement can be applied to arbitrary behaviors. A parameter may also be associated with a particular body part of the robot (e.g., head, hand palm, finger). To express mood while performing a specific behavior, one only needs to specify which parameters should be varied and what extent the variation is.

3. EXPERIMENTS

We first applied our mood expression model to two typical behaviors in HRI, waving and pointing, and defined parameters for them. We conducted a user study [3] to address whether our model can be used to express mood, and to figure out how the parameters should be modulated. Participants were asked to modulate the behaviors to match given valence levels by adjusting the parameters. Results show that participants create different parameter settings corresponding to different valence levels. We also found that the spatial extent parameters (hand-height and amplitude), the head vertical position, and the temporal parameter (motion-speed) are the most important parameters [4]. They are "global" features that shape the overall quality of behaviors. Moreover, multiple parameters were found to be interrelated. These parameters should be modulated in combination to provide particular affective cues. The video clips of the resulting design can be found on our website[1].

To evaluate the parameter settings resulting from [3], we conducted a recognition experiment [5] in a laboratory setting without a context under three conditions: modulating all parameters, only important parameters, and only unimportant parameters. The results show that valence and arousal can be well recognized as long as the important parameters are modulated. Modulating only the unimportant parameters might be useful to express weak moods. We also found that speed parameters, repetition, and head-up-down correlate with arousal.

We first integrated our mood expression with the gestures used in an imitation game [6], in which a human player imitates the gestures performed by the robot in a laboratory environment. A video clip of the gestures used in the experiment and gestures modulated by a continuously changed mood is available on our website[2]. We not only confirmed that people can recognize robot mood from the body language, even when they were not primed to pay attention to the expression, but also observed an effect that we interpreted as "mood contagion" effect [7]. We also found that participants' self-reports of their own mood match the mood of the robot in the easy task condition, and the robot mood had an effect on game performance.

Second, we investigated mood expression in a real-life scenario, in which the robot gave a lecture and interacted with audiences using quiz questions in a university classroom [8]. Our mood expression model was applied to 41 coverbal gestures. The robot gave the same lecture to two groups of audiences in either a positive or a negative mood condition. We observed the differences of participants' own valence and arousal between conditions, which suggests that the mood expression can be used to shape the interaction affectively. The audiences' ratings of the lecturing quality and gesture quality of the robot are higher in the positive condition, which suggests mood expression of a robotic teacher is important for the rating of the robot's teaching quality. Additional materials including videos are available on our website[3].

4. FUTURE WORK

Our future research is aimed at two goals. First, we believe that there is still room for improving our mood expression model. For example, our model succeeds to display positive-valence high-arousal and negative-valence low-arousal moods, but it is not easy to display negative-valence high-arousal and positive-valence low-arousal moods like anger displayed in the pointing behavior in [5], due to the fact that some parameters correlate with both valence and arousal. Another topic is the quantification of the expressed mood by modulating each parameter. This is necessary for expressions that aim to present a mood on continuous scales like valence and arousal. Although our work on the importance of the parameters [4], [5] provide some insight into the effects of different parameters on the displayed mood, the quantification is still challenging due to the demand of large data about human perception of the expressed mood for a full factorial analysis of the effect of each parameter. A third topic related to improving the model concerns the balance between behavior expressiveness and behavior naturalness. Expressive behaviors often require some exaggeration. However, in certain contexts exaggerated behaviors may be perceived as unnatural. For example, in a game setting [6] exaggerated behaviors were more acceptable than in a lecture setting [8]. A model can be built to classify contexts and then adapt the bounds of the parameter modulation.

Second, we would like to explore the application of our mood expression model in other contexts, e.g., robotic theater or storytelling robots. In these contexts, a robot should perform a monologue in a tone that fits the mood of the texts and perform coverbal gestures that fit the mood. This line of work will require more research on automatic affect detection from texts [9] and automatic selection of co-verbal gestures [10].

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