Published at the 1rst Workshop on Emotion and Computing at KI 2006, 29th Annual Conference on Artificial Intelligence, June, 14-19, 2006, Bremen, Germany

Generation of Facial Emotional Expressions Based on Psychological Theory

Amandine Grizard and Christine Lisetti

Affective Social Computing Group,
Eurecom Institute,
2229 route des crêtes, Sophia Antipolis
{grizard,lisetti}@eurecom.fr

Abstract. Facial expressions are an important aspect in affective social computing. They express internal states of robots during social interactions. In this paper we present the use of Scherer's psychological theory to express facial emotions. This theory has the advantage of linking cognitive and emotional processes. We have implemented a part of this theory on a robot: iCat. We present results by comparing several representations of the same emotions.

1 Introduction

We present in this paper the use of Scherer's psychological theory to express emotional facial expressions. This work forms a part of development of an affective-cognitive architecture to create socially intelligent robot. In the following, we focus on the way which robots express emotions. We explain Scherer's theory and emotional predictions. Then we introduce iCat (a robot created by Philips), how we use it to test emotional theory, and discuss the results of user studies.

2 Application of psychological theory on robot

2.1 Scherer's theory description

Scherer defines emotional behavior as a dynamic process rather than a steady state. This process, called "The Component Process Model of Emotion", is grounded on a multi-level and multi-component approach.

In [1], Leventhal and Scherer present a hierarchical processing system where emotional process is organized at three levels: the sensory-motor level where organism has its primary emotional responses with for example reflexes, the schematic level based on learning history of individual and abstract representation of stimulus responses, and the conceptual level where individuals reason about environment and emotional responses. These three levels are linked to appraisal objectives or components: relevance of the event for an individual and how it can be affect him (relevance), consequences of the event on individual's

goals (implications), how an individual can cope with this event (coping potential) and if the event respects individual's social norms (normative significance) [2]. These components are used in emotional predictions in a chronological order: from relevance component to normative significance component. For each component, Scherer defines intensities of emotional responses that vary in function of the expressed emotions. Emotional responses depend on individuals and how they evaluate events that occur. In this paper we are interested in the facial expression emotional responses and how they are represented by Action Units (AUs), as defined by Ekman [3]. The final emotional response is the result of the sequence of intermediate emotional responses, corresponding to each of the four components.

2.2 iCat robot

Fig. 1. iCat robot

Fig. 2. iCat facial expressions

iCat is a robotic research platform developed by Philips. It is focused on human-robot interaction with speech and facial emotional feedback [4]. We will interest in iCat's social aspect and its abilities to express basic emotions such as sadness, anger, happiness or fear (figure 1 and 2). We implemented Scherer's psychological theory to express facial emotions in term of Action Units which represents a muscle or a set of muscles. AUs are used to describe facial activity with FACS (Facial Action Coding System). They have been defined for human and iCat has not a human appearance: we can express some Action Units on iCat but not others. It can move its neck, eyes, eyebrows, lids and lips but for the three last, iCat lacks some degrees of freedom. For example it is impossible for iCat to move bottom lids, to retract lips or to raise all eyebrows. For each AU necessary to emotional responses, we have to adapt them in terms of iCat possibilities: some AU remain unchanged (AU2: outer brow raise), others are extrapolated (AU4: brow lowered is expressed as AU2) or even ignored (AU17: chin raising), as shown in Table 1.

3 Believability, Exaggeration, and Recognition User Studies

In this study, we compare, on iCat robotic platform, different ways of expressing the following emotions: happiness, disgust, sadness, anger and fear.

Action Units	FACS Name	Neutral Example	Medium Example	Very High Example
POSSIBLE ACTION UNITS				
AU2	Outer Brow raise			
AU12	Lip Corner Puller			
AU15	Lip Corner Depressor			
EXTRAPOLATED ACTION UNITS				
AU4	Brow Lowered			
AU26	Jaw Drop			
AU41	Lid Droop			

Table 1. Possible and Extrapolated Action Units

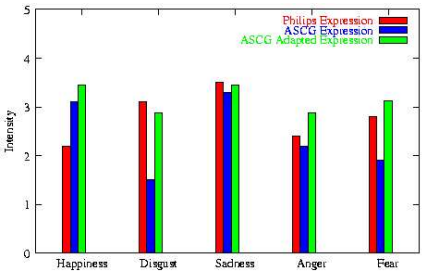

Fig. 3. Emotions believability

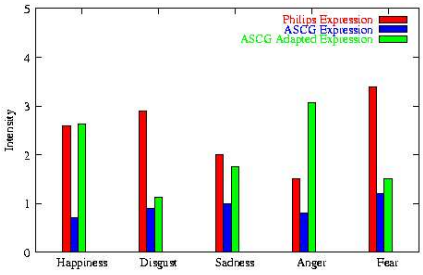

Fig. 4. Emotions exaggeration

The first experiment involved eleven persons, four women and seven men, between twenty and thirty years old. They had to compare emotional expressions created by Philips and by our research group with a questionnaire evaluating the believability and the exaggeration of each emotional expressions. Philips research has used principles of animation defined by Disney to animate characters [5]. Our group has implemented Scherer's emotional responses. We can observe that Philips' expressions are more believable in general (figure 3) but more exaggerated (figure 4) than our expressions (ASCG expression). The believability of emotional expressions created by Philips is due to their exaggeration. Indeed, emotional responses defined in Scherer's theory are for humans and not for robots. Because of these results, we adapted Scherer's theory on iCat in a second implementation using all possibilities provided by this platform: head and neck movements, lights in paws and ears. For this we have conducted a second user studies in which fifteen participants have to recognize the expressed emotions (table 2). In general, participants recognized happiness, anger, fear and indifference better than others expressions. Disgust expression is confused with contempt expression. Pride is recognized as pride with 38% and as fear with 31%. Some expressions such as contempt, pride indifference and shame are very difficult to represent because they use gaze expression and iCat is unable to do this.

The third experiment involved fifteen persons, three women and twelve men. They had to evaluate the believability and the exaggeration of ours new expressions (ASCG Adapted Expression). We can observe that the results have increased with these new emotional facial modelisation.

Showed \ Recognized	Happ.	Disg.	Cont.	Sadn.	Prid.	Fear	Ange.	Indi.	Sham.	None
Happiness	**75%**	13%	0%	0%	0%	0%	0%	0%	6%	6%
Disgust	0%	**25%**	56%	0%	6%	0%	0%	6%	0%	6%
Contempt	6%	0%	**19%**	0%	63%	6%	0%	0%	0%	6%
Sadness	0%	19%	0%	**56%**	0%	0%	0%	0%	25%	0%
Pride	13%	0%	0%	0%	**38%**	31%	0%	6%	0%	13%
Fear	0%	0%	0%	0%	0%	**69%**	0%	6%	13%	13%
Anger	0%	0%	6%	0%	0%	0%	**88%**	0%	0%	6%
Indifference	0%	0%	0%	6%	19%	0%	0%	**63%**	13%	0%
Shame	0%	0%	0%	31%	0%	0%	6%	19%	**31%**	13%

Table 2. Emotional recognition rate for iCat

4 Conclusion and future works

In this paper we propose to represent emotional facial expression with Scherer's emotional predictions. We use it because of the link between cognitive and emotional processes and this approach permits us to develop an emotional-cognitive architecture.

We implemented emotional expressions on iCat by combining Scherer's prediction and principles of animation defined by Disney. The results showed that our representation is believable.

For more believability, we will generate different but similar expressions for same emotions. Indeed, when a human smiles, the way of express his smile is always different with little variations. Furthermore we will develop an application of interaction between human and iCat.

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