A Layered Dynamic Emotion Representation for the Creation of Complex Facial Expressions

Emmanuel Tanguy, Philip Willis, and Joanna Bryson

Department of Computer Science
University of Bath
Bath BA2 7AY, United Kingdom
{E.A.R.Tanguy Or P.J.Willis Or J.J.Bryson}@bath.ac.uk
http://www.cs.bath.ac.uk/∼{cspeart Or pjw Or jjb}

Abstract. This paper describes the Dynamic Emotional Representation (DER): a series of modules for representing and combining the many different types and time-courses of internal state which underly complex, human-like emotional responses. This system may be used either to provides a useful real-time, dynamic mechanism for animating emotional characters, or to underly the personality and action-selection of autonomous virtual agents. The system has been implemented and tested in a virtual reality animation tool where it expresses different moods and personalities as well as real-time emotional responses. Preliminary results are presented.

1 Introduction

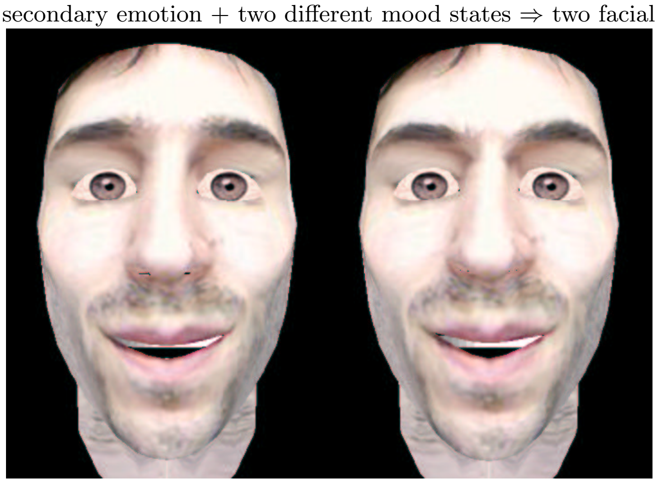
Emotions are an important part of human expression. They are expressed through behaviours: body motions, facial expression, speech inflection, word choice and so on. If we wish to make virtual agents (VAs) communicate well with humans, they need to express these emotional cues [3]. Emotional VAs have been classified into two categories: communication-driven and simulation-driven [2]. Communication-driven agents display emotional expression without any true emotion representation within the character. Simulation-driven agents use modelling techniques to both represent and generate emotions. The problem with the first view is that it provides no mechanism to keep consistency within the displayed emotions, making them less believable and the agent less comprehensible. The problem with the simulation of emotion within a character is the complexity of the emotion generation, which should be based on assessment of the environment and cognitive processes [1].

The work in this paper provides for a third, middle way. We present a system, the Dynamic Emotion Representation (DER) which develops a rich, real-time representations of emotions, but encapsulates this without their automatic generation. This representation will give the consistency needed for communication-driven VAs. For simulation-driven agents, this representation can also be integrated with emotion synthesis. Under either approach, the state in the representation can be used to influence behaviour through action-selection mechanisms.

The DER is based on a two-layer architecture inspired by CogAff architecture [6] and Thayer's theory of mood [7]. DER contributes a real-time representation of dynamic emotions which incorporates multiple durations for internal state. Brief emotional stimuli are integrated into more persistent emotional structures in a way that is influenced by long-term mood and personality variables.

The DER's layered representation allows us to create complex facial expressions. *Complex* here means expressions that present more than one emotion or conflicting emotional state. For example, looking at the Figure 1, which one of these two smiling characters would you trust more?

Fig. 1. One secondary emotion + two different mood states ⇒ two facial expressions.



Our research also addresses the issue of the VA personality. In the DER, a VA personality will be represented by a set of values that influences how the emotions vary over time and how they are affected by external emotional stimuli.

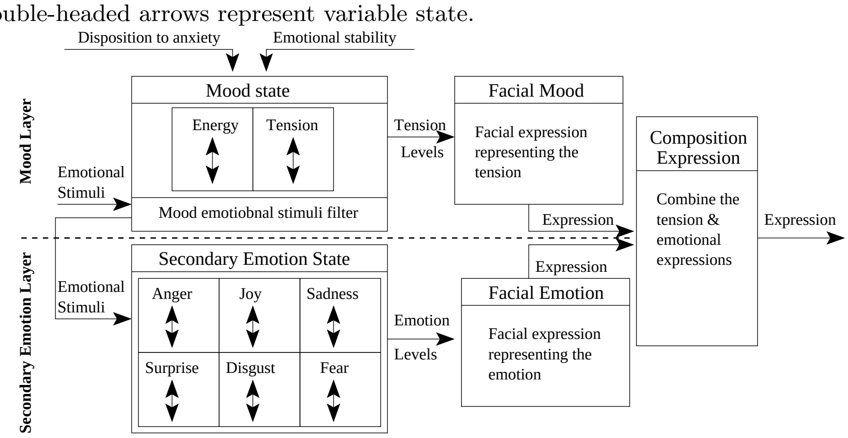
2 Layered Dynamic Emotion Representation

The DER architecture is inspired by Sloman theory of emotions which describes a three layers architecture, CogAff [6]. In Sloman's model each layer generates a type of emotions. In the same way, in our architecture each one of the two layers represents a type of emotion: Secondary Emotions and Moods.

The Secondary Emotional state is described by six variables (see Fig. 2) which are related to the Six Universal Facial Expressions. Typically, this type of emotion will last for less than a minutes to few minutes [5]. An emotion's intensity increases quickly when this emotion is stimulated and decays slowly afterwards. If an emotion is consecutively stimulated the effect of these stimuli is cumulative [5]. This layer requires external Emotional Stimuli (E.S.) to be sorted into categories corresponding to the Secondary Emotions. An emotion is stimulated when a corresponding E.S. occurs but only if the intensity of this emotion is currently the highest. Otherwise, higher intensities of opposing emotions, such as Anger for Happiness, have their normal decay accelerated.

The mood state is described by two variables: Energy and Tension [7] (see Fig. 2). These two variables vary slowly due to the persistence of moods for hours or days. External E.S. are separated into two groups; positive and negative that respectively decreases and increases the Tension level. The Energy level should vary over time but it is fixed in the current implementation and equal to the external parameter *Disposition to anxiety*. The Energy level determines how much negative E.S. influences the Tension. The external parameter *Emotion stability* determines how much the Tension is influenced by any E.S. A particular set of values for these two parameters determines the emotional personality of the VA. To simulate the influence of the mood on the Secondary Emotions, the intensity of E.S. is modified by the mood state before the E.S. enter in the Secondary Emotions layer.

Fig. 2. Diagram of the current DER system implementation. Arrows indicate the flow of information or influence, boxes indicate processing modules and representations. Double-headed arrows represent variable state.



3 From Emotion states to Facial Expressions

To animate the facial mesh we use an implementation of the Waters' abstract muscle model [4].

To express the Secondary Emotion state, the emotion with the highest intensity is selected and the facial expression corresponding to the selected emotion is displayed. To communicate the intensity of the emotion, the muscle contractions of the facial expression are proportional to this intensity. The facial expression of the higher emotion intensity is also influenced by the facial expressions of the other secondary emotions.

In the mood layer, the same system is used to create a facial expression that communicates the Tension intensity of the character (see Fig. 3). The final facial expression is created by selecting the highest muscle contraction from the facial expressions of Secondary Emotions and mood.

4 Preliminary results

The results can be analysed in two ways: statically and dynamically.

Statically, the system enables an animators to create complex facial expressions. In Fig. 1, the differences between the two VAs are small but play a crucial role in the expressiveness of a person. In fact, these differences are due to different levels of tension. An animator could give a certain expression to a character by firstly describing its overall emotional state (mood), and then by applying a shorter but highly expressive emotion. By decomposing the creation of emotions through these two stages we facilitate the animator's need to create complex emotional expressions. There is a parallel with real actors, when they rehearse to assimilate the state of mind and the personality of the character, before they play the scene.

Dynamically, the personality parameters enable the creation of characters that react differently to the same emotional stimuli (see Fig. 3).

(a) Different Tension Levels (b) Different Anger Intensities

Fig. 3. Different facial expression due to different personalities: 3(a) shows the output of the Facial Mood module: the agent on the right is more *tense* than the left one. 3(b) (the output of the Facial Emotion module) shows that this tension also affects secondary emotion accumulation — in this case, anger in the same two agents.

An important problem with the results presented here is the small perceptive differences between each picture. This is partially due to a loss of quality in the pictures, but also to the fact that the DER is best appreciated running in real time. These are only snapshots of dynamic expressions.

The number and type of Secondary Emotions we chose to represent is disputable because there is no consensus on this matter in psychology. However, the DER architecture itself does not constrain what Secondary Emotions developers may employ in their models, others can easily be added.

Given a functional view of emotion [1], we may expect that the separation of emotions by types and durations to have significant impact on decision-making or action selection. The different durations and decay attributes of emotions and moods might reflect their impact on an autonomous agent's intelligence. Artificial life models incorporating the DER could be used to explore many interesting theoretical issues about the evolution of these characteristics and their role in both individual and social behaviour.

5 Conclusion

We have presented the Dynamic Emotional Representation. By introducing two layers of emotional representation, we have created a good platform for building characters which display personality and mood as well as (and at the same time as) transient emotion. We have demonstrated this system as a real-time animation tool suitable either for directed animation or as a VR platform for an intelligent virtual agent.

Acknowledgement

All three authors wish to acknowledge that the first author (Tanguy) was solely responsible for the coding of DER and most of its design. This work is funded by a studentship from the Department of Computer Science, University of Bath.

References

[1] Cañamero, D. (1998). Issues in the design of emotional agents. In *In Emotional and Intelligent: The Tangled Knot of Cognition*, pages 49–54, Papers from the 1998 AAAI Fall Symposium. Menlo Park. AAAI Press.

[2] Gratch, J., Rickel, J., Andre, E., Badler, N., Cassell, J., and Petajan, E. (2002). Creating interactive virtual humans: Some assembly required. *IEEE Intelligent systems*, 17(4):54–63.

[3] Johnson, C. G. and Jones, G. J. F. (1999). Effecting affective communication in virtual environments. In Ballin, D., editor, *Proceedings of the second workshop on intellingent virtual agents*, pages 135–138, University of Salford.

[4] Parke, F. I. and Waters, K. (1996). *Computer Facial Animation*. A K Peters Ltd.

[5] Picard, R. W. (1997). *Affective Computing*. The MIT Press, Cambridge, Massachusetts, London, England.

[6] Sloman, A. (2001). Beyond shallow models of emotions. *Cognitive Processing*, 2(1):177–198.

[7] Thayer, R. E. (1996). *The origin of everyday moods*. Oxford University Press.