Emotion-based Synthetic Characters in Games [1]

Xiangyang Huang Yan Peng
College of Information Engineering, Capital Normal University, Beijing 100037, China
huangxiangyang@sina.com

Abstract

An Emotion-based Synthetic Character (ESC) is proposed to enhance game entertainment and to highly personalize human-machine communication in games. The model of the ESC integrates emotional system with attention, intention and facial expression system. Forgetting characteristic of human is also simulated to make the ESC be equal to player characters. Fuzzy representation is used to capture the inherent uncertainty of emotion and cognition. As a result, an experiment implements the model.

1. Introduction

The game industry evolves so fast; the quality of commercial computer games is directly related to their entertainment value.

Historically, Nonplayer Characters (NPCs) are generally given direct access to the game data, free to extract whatever they need; logically they may know everything and never forget whatever known. But it is unfair to Player Characters. Nonplayer characters themselves may explore the same world as well as Player Characters while obtaining knowledge and achieving their goals.

Synthetic Characters have a virtual body and they are subject to the constraints of their environment. Many game players, and even developers, would consider synthetic characters the "proper" way of dealing with AI nonplayer characters [1].

Actually simulating Synthetic Characters enables developers to add biologically plausible errors to the interaction with the environment. Including such biologically plausible details allows the Synthetic Characters to behave more realistically.

To most AI developers, such research in biologically plausible emotion systems sounds extremely promising. In many ways, artificial emotions represent an ideal complement to classical AI. Therein reside our interests from a game developer's perspective: emotions are a key factor in realism and believability. With emotions, all nonplayer character behaviors would seem more realistic and generally increase the immersiveness of the game environment. Each of these features increases entertainment value.

Recently, neurological evidence has indicated, contrary to what most people believe, that emotions are essential and that they serve a substantial function in human intelligence. Arguments are made based on neurological evidence that not having "enough" emotion can bring disaster into our behavior and actions.

Here we will assume that our model of emotional control is merely an artificial simulation of existing neurological models of emotions in biological systems.

2. Related works

A model is proposed for customizing automatically non-player characters according to the player's temperament and players can enjoy characters with personalities that reflect human behavior [2]. In some experiments, the NPC can change its facial expression according to its emotion like the human to attract game players [3]. Karim Sehaba explains an emotion model for Synthetic Characters with Personality [4].

Cathexis [5], a computational model of emotions, is presented, which addresses a number of issues and limitations of models proposed before including the need for models of different kinds of affective phenomena, such as emotions and moods, the need to consider different systems for emotion activation, and the need for flexible way of modeling the influences of emotion on the motivations and behavior of agents. Another model, which is an extension of the Cathexis model, was built to integrate perception, attention, motivation, emotion, behavior, and motor into specific circuits.

Hannon [6] improved the control mechanism of several of their cognitive-based agent models by using

[1] This work is partially supported by NSF Grant #60773130

978-0-7695-3304-9/08 $25.00 © 2008 IEEE
DOI 10.1109/ICNC.2008.167

an emotion-based approach. In their models, they use attention agent and arousal agent. In Malfaz' system[7], when there is not any active emotion, the dominant drive will decide the goal of the robot, and therefore it will determine which behaviour will become active in order to reach the goal. Similarly, in a mobile robot model [8], Expectations could trigger emotions that will in turn trigger actions that have no environmental inputs.

We have attempted to introduce emotions to our learning autonomous NPCs (LANPCs) [9] and proposed a new model based on some work on synthetic agents and characters.

3. The model

There is agreement in that emotion includes an expressive or motor component. Some of the aspects involved in this expressive component include central nervous system efferent activity, prototypical facial expressions, body posture, head and eye movements, vocal expression, and muscle action potentials. Finally, most researchers would agree that once an emotion is generated, it registers in consciousness [5].

It is hypothesized that stimuli are processed under two different perspectives, perceptual layer and cognitive layer; and the assessment of a stimulus is sent to cognitive layer from perceptual layer [10].

Our current model is depicted in Fig.1. In response to an external stimulus, the emotion component and the memory component both extract a reduced set of essential features. In the emotion component, there are two direct maps. One is between stimulus and desirability and another is between emotions and moods. On the other hand, in the memory component, the stimulus is temporarily stored.

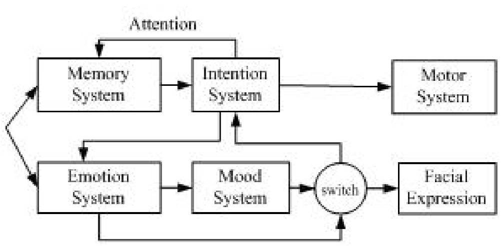

Figure 1. **The model of emotion-based synthetic characters**

Ebbinghaus discovered that people forget 90\% of what they learn in a class within thirty days, which has been confirmed by those who followed him [11]. We simulate this characteristic of human through assigning fuzzy values to what the memory component stored, and the fuzzy values decay with time elapsing(see equation 1), where $\alpha \in [0,1]$ denotes the fuzzy value and b>0 denotes forgetting rate).

$$\alpha = ae^{(-bt)} + c \quad (1)$$

When the fuzzy values become below a certain threshold, the contents relating to those fuzzy values will be deleted, as though a synthetic character totally forgot them. If the intention component decides to pay attention to the stimulus, it sends a signal to the memory component. As a result, the memory component creates a cognitive image which is rich enough to allow a fairly good reconstruction of the original stimulus and the original stimulus is reserved much long time.

Emotion or mood can produce facial expressions with a very low threshold, i.e. generating facial expressions is reactive (we ignore other reactive behaviors). Once an emotion or mood is selected by the intention component with its intensity above a certain threshold which is not the same value as generating expressions, then the intention component sends a signal to the memory component and later selects a proper motor. Sometimes the intention component can generate an emotion to either replace or inhibit the current emotion, for example, a policeman searching a robber can generate an intension or an expectation to inhibit his fear.

4. Modeling emotions

The following subsections describe how to implement the model.

4.1. Basic emotions

The expression of basic emotions has been used in many different ways. In this thesis, the term basic is used to emphasize how evolution has played a significant role in forming the unique and common characteristics that emotions exhibit, as well as their current function [12]. However, as a first step towards addressing the complexity, the model deals with the following basic emotions: Happiness, Anger, Fear and Sadness. Expectation is also included in the model in order to simulate the comparisons of external events with goals.

Ekman has maintained that emotions can be very brief, typically just a couple of seconds and at most minutes [12], i.e. once an emotion is generated, it does not remain active forever. After some period of time, unless there is some sort of sustaining activity, it disappears. In our model, we assume that emotions only last a few time cycles.

Evidence suggests that emotions dynamically interact in important ways which should be considered in a comprehensive model of emotions. The computational model presented in Cathexis provides models for different kinds of affective phenomena including basic and mixed emotions. In our model, the mixture of emotions will be filtered to get one emotion according to their priority and intensity. Fear and Expectation have a high priority; Happiness, Anger and Sadness have a low one. All emotions are represented as linguistic variables, each of which consists of three memberships, describing the intensity as low, medium, or high. The emotion with the highest intensity and the highest priority will be chosen. This type of interaction is consistent with real life emotional systems, in which high arousals will tend to inhibit other emotions.

4.2. Moods

A layered approach is introduced for modeling emotions and moods in this thesis. Unlike other models [5], temperaments are not modeled, but they can act on the model through changing the activation threshold. The changes in moods are generally triggered by the emotions of synthetic characters. The moods correspond directly to the emotions in our model, and they are Dread, Hatred, Sorrow and Joy, respectively corresponding to those emotions: Fear, Anger, Sadness and Happiness or Expectation.

The moods interaction is similar to the emotions, however, there is no consideration about reaction to the emotions.

As Ekman suggests [13], moods last much longer than emotions, thus their intensities will decay more slowly. In our model, we provide with a built-in decay function, like in Cathexis, which controls the duration of the moods once they have become active. The moods also seem to lower the threshold for arousing the intention component.

4.3. Emotion recognition

The current psychological and neurophysiological evidence indicates that emotions are so closely associated with cognition that it is nearly impossible to isolate the two aspects within a complex biological system.

Many theorists have dedicated much of their time to find the answers to emotion generation or activation, including cognitive and noncognitive elicitors of emotion [5][14].

All emotions can be triggered from memory through the intention component, and we also assume that the intention component maybe produces anger or sadness emotion according to data synthetic character collected in a statistical fashion and experiences synthetic character possessed when assessment of a stimulus is sent to the intention component. It is possible that fear and happiness with low intensity can be replaced by anger and sadness through intention component process. The intention component can also bring on enough expectation to inhibit other emotions. When an expectation is satisfied, then happiness is released.

When fear is triggered from external stimulus, it can be cognized by level of opposition, level of distance, level of enemy's number and level of enemy's power. In the same way, happiness can be cognized by level of item's value or level of friendship and level of time-span.

Fuzzy form of knowledge representation is very intuitive, and comes surprisingly close to modeling human thoughts. Using a model closer to linguistic definitions can simplify the design of systems, enabling humans (not only experts) to add knowledge to the system [1].

Each emotion can be recognized by a fuzzy finite-state machine (FFSA) (see Fig.2). The fuzzy finite-state machine itself may be unfolded into a set of fuzzy rules defined over the states and the input/output alphabet.

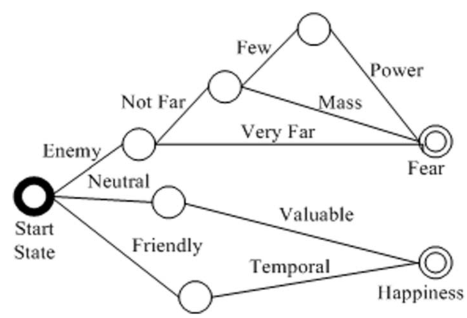

Figure 2. **Emotion recognition by fuzzy finite-state machine**

Here, each input is a linguistic variable associated with three fuzzy variables over a base variable. The three fuzzy variables of a linguistic variable, in fact, consist of what the base variable is normalized to three degrees, such as Allegiance [1] defined as a collection of membership functions (enemy, neutral and friendly) defined over a single base variable (love). If these three fuzzy variables of a linguistic variable don't intersect with each other (defined as linguistic variable fluents(LVFs) [9]), then will greatly simplify computation.

4.4. Interaction with intention

Evidence suggests that the emotion experience has powerful influences on memory process, goal generation, action selection, further generation of emotions, reasoning style, and learning, among other things.

After being activated, the emotion component can generate what are termed desirability vector [15]. A desirability vector represents a basic kind of assessment of a stimulus. As soon as receiving a desirability vector, the intention component pays attention to the stimulus and selects a proper behavior. We assume that only one desirability vector can be selected to execute at a given time, thus there exist competition not only between desirability vectors produced by internal and external stimulus but also between the being executed and the waiting, according to their priority and intensity. On the other hand, the mood component can generate what we call "feeling factor", instead of desirability vector. The feeling factor can have an influence on decision making. For example, a synthetic character needs some money; though a certain place has some and the synthetic character has ever visited the place, the synthetic character only has a fuzzy memory about that due to the time elapsing; perhaps the synthetic character make a try to look for the place when he has a good mood. Moods are modeled with nested states (see Fig.3), and the transitions between these moods are determined by changes in the emotions. When the current mood decays below a certain threshold, the moods model will go to state non-mood. By giving a random input to state non-mood, we can simulate mood instability.

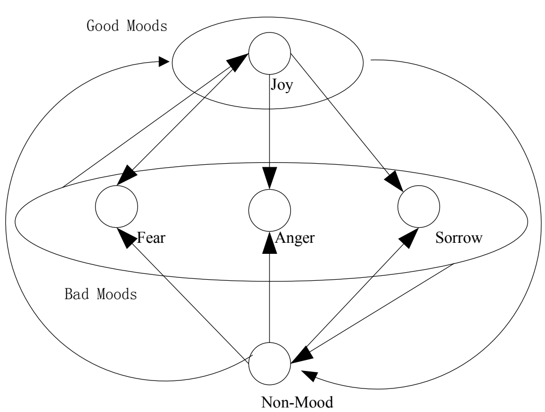

Figure 3. **Mood transitions represented by nested states**

4.5. Facial expression and motor

Several researchers agree that emotions and moods include an expressive or motor component. Frijda suggested changes in action readiness or action tendencies are major [16]. Certainly, the expression of emotion is one of the most important aspects in game. In the model, we mainly focus on facial expressions and assume that generating facial expressions is reactive. Some key facial expressions, which correspond directly to emotions and moods, are predefined. While there exists more than one mood at same time, blended morphing technique can be used to produce facial expressions according to the following formula.

$$v = v_0 + \sum_{i=1}^{k} (v_i - v_0) b_i \,. \tag{2}$$

$$n = n_0 + \sum_{i=1}^{k} (n_i - n_0) b_i \,. \tag{3}$$

where v is the target coordinates of each vertex; v_0 is the initial coordinates of each vertex in the person's face with no expression; v_i represent vertex coordinates of the face under different moods; and b_i are blending factors determining the percentage of the differences to blend different moods. n, n_0 and n_i represent normals of vertices.

It is assumed that motor is selected by intention component but moods implicitly influence it, for example, when a synthetic character is joyful, it walks trippingly.

5. Experimentation

In Fig.4, an ESC is fighting with a monster in a game demo [9]. The last three facial expressions are shown at the top right corner of the game window, which are blend moods, fear emotion and sadness emotion. How to happen? The ESC was trying to find the monster with blended moods(joy 0.4, hatred 0.2, and dread 0.1. see the top left corner of the window); suddenly they met by chance the ESC felt fear at sight of the huge and dreadful monster; and the ESC cried with sad voice when it was hit by the monster's magic during fight.

Figure 4. **A moment in game demo (the last three facial expressions are shown at the top right corner of the game window)**

6. Conclusions

In this paper, we presented a new model for modeling Synthetic Characters in games. Based on synthetic agents, we integrate emotional systems with attention, intention and expression system to enhance the entertainment. We also simulate forgetting characteristic of human to make nonplayer characters be closer to player characters or real player. We describe cognitive appraisal of emotions using fuzzy representation and influence moods operate on decision making due to forgetting. In the model we assume emotions directly change facial expressions without intention involving in.

The model discussed here is a simple prototype of an emotional system including few emotions and moods. There is no consideration about internal stimulus, such as hunger, sexual lust ... It is merely a step towards building emotional NPCs.

7. References

[1] A. J. Champandard, AI Game Development: Synthetic Creatures with Learning and Reactive Behaviors, New Riders Publishing, Indianapolis, 2003.

[2] H. Gomez-Gauchia, and F. Peinado, Automatic customization of non-player characters using players temperament, Technologies for Interactive Digital Storytelling and Entertainment, Third International Conference, TIDSE 2006, Proceedings (Lecture Notes in Computer Science Vol. 4326), p 241-52, 2006.

[3] C. Kozasa, H. Fukutake, et al, Facial animation using emotional model. Proceedings, Computer Graphics, Imaging and Visualisation Techniques and Applications, p 428-433, 2006.

[4] Karim Sehaba, Nicolas Sabouret, and Vincent Corruble, An Emotional Model for Synthetic Characters with Personality, the second International Conference on Affective Computing and Intelligent Interaction (ACII2007), Lisbon, Portugal, pp 749-750, 2007.

[5] J. Velasquez, Cathexis, A Computational Model for the Generation of Emotions and their Influence in the Behavior of Autonomous Agents, Master's thesis, MIT.1996.

[6] C. J. Hannon, Emotion-based Control Mechanisms for Agent Systems, International Conference on Information Systems and Engineering, 2003.

[7] Charles J. Hannon, Emotion-based Control Mechanisms for Agent Systems.International Conference on Information Systems and Engineering, 2003.

[8] M. S. El-Nasr, and M. Skubic, A fuzzy emotional agent for decision-making in a mobile robot, Proceedings of the 1998 Int. Conf. On Fuzzy Systems (FUZZ-IEEE'98), Anchorage, Alaska, May 1998.

[9] X. Y. Huang, Y. X. Yin, G. P. Zeng, and X. Y. Tu, A Cognitive Model for Learning Autonomous Nonplayer Characters, Sixth International Conference on Intelligent Systems Design and Applications(ISDA 2006) , Jinan, Shangdong, China, p 1195-1199, 2006.

[10] L. Custodio, R. Ventura, and F. C. Pinto, artificial emotions and emotion based control systems[a], Proc ETFA'99, Barcelona: IEEE Publication, 1415-1420,1999.

[11] Hermann Ebbinghaus, Memory: A Contribution to Experimental Psychology, Translated by A. R. Henry & C. E. Bussenius(1913) Originally published in New York by Teachers College, Columbia University.

[12] P. Ekman, An argument for basic emotions. Cognition and Emotion, 6, 169-200, 1992.

[13] P. Ekman, R. J. Davidson, The Nature of Emotion. Oxford University Press, Oxford, 1994.

[14] I. J. Roseman, P. E. Jose, and M. S. Spindel, Appraisals of Emotion-Eliciting Events: Testing a Theory of Discrete Emotion, Journal of Personality and Social Psychology 59(5):899-915, 1990.

[15] J. D. Velsquez, From affect programs to higher cognitive emotions: An emotion-based control approach. In Workshop on Emotion-based Agents Ar- chitectures, EBAA-99, 1999.

[16] N. Frijda, The Emotions, Cambridge, U: Cambridge University Press, 1986.