Affective Computation Based NPC Behaviors Modeling

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Abstract

In AI (Artificial Intelligence) game, authentic behaviors of NPC (Non-Player Character) are great challenges to NPC intelligence. Emotions help to enhance the quality and intelligence of behaviors, contribute to increase entertainment value of game. In this paper, we describe several common emotional behaviors of NPC and construct a simple emotion-behavior model for emotion transition. The model was simulated in our developing project.

1. Introduction

Forty years ago, Nobel Prize winner, Herb Simon pointed out "thinking will take place in intimate association with emotions and feelings and will serve a multiplicity of motives at the same time", and he emphasized that the general theory of thinking and problem solving must concern the impact of emotion (1967) [1]. It is provable nowadays that emotion is an inseparable part of intelligence. Especially, emotion is indispensable in process of sensing, learning, decision making, reasoning, planning, and creating etc. Artificial Intelligence (AI) experts have found that some explosively combinatorial problems, such as the game of GO, may trap computers into endless searching process. But these problems are easy for human because human reason and make decision with sensation, intuition and emotion. By preferring the behaviors that give human better survival opportunity, and the habits nurtured in growing process of individual, emotions save a lot of thinking for people – they shortens the time-consuming searching process of rationalization. Emotions serve to survival itself through triggering those reacting behaviors propitious to survival of human. For example, fear stimulates body to excrete hormone for combat; surprise wakens the sensory organs and compels the brain to pay more attention to surrounding situation; anger drives people to destroy obstacles toward destination; sorrow encourages people to find comfort, and so on.

In AI game, authentic behaviors of Non-Player Character (NPC) are great challenges to NPC intelligence. Failing to accomplish a task without common sense, for instance, running into a wall, may be considered as a bug in the game. On the other hand, when NPC is fully functional, the problem is how to increase the levels of authenticity. Emotions help remarkably with this by enhancing the quality and intelligence of behaviors. Further more, emotions will bring many interesting features to game such as:

Personalizing: Emotions endow "personality" to NPCs and enrich their expression approach. This will increase the unpredictability and emergent states of NPCs so that player will give more expectation to them.

Multiplicity of Storylines: By providing NPCs with emotions, their interactions with humans are greatly improved. The storylines will become more zigzag and more impressive to enhance the entertainment and attraction of game.

Immersing: With emotions, NPC behaviors would seem more realistic and amiable so as to increase the immersion of the game environment.

Each of these features will contribute to increase entertainment value of game [2]. For game style training system, they will help to improve learning effect.

Traditionally, emotions of NPC are described and realized by Finite State Machine (FSM). But in general, FSM is advantageous to deal with a handful of emotion states but when the amount of emotion states increases, the complexity of FSM goes up exponentially. At the same time, FSM is fit for discrete emotions instead of continuous ones.

In our work we attempted to build a simple emotion behavior model easy to be understand and realized in game development. The rest of this paper is organized as follows. First, we review related emotion classification theory that we will cite later. Second we explore several common emotions and the corresponding behaviors of NPC. Third, we construct a simple emotional behavior transition model that scales emotion with Mehrabian's Pleasure/Arouse/Dominance (PAD) representation [3]. Fourth we describe the model simulation in our

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developing project "Game Style Training System for Mine Disaster Rescue".

2. A Glance of emotion classification

In 1962, Tomkins put forward eight basic emotions: scare, anger, distress, happiness, disgust, surprise, concern and shame [4]. In 1980, Plutchik proposed eight different basic emotions: scare, anger, sadness, happiness, disgust, surprise, tolerance and anticipation [5]. In 1988, Ortony、Clore and Collin summarized twenty-two basic emotions and four of them are most universal: fear, anger, sorrow and happiness. The two coming to heel are disgust and surprise [6]. In 1992, Paul Ekman brought forth six basic emotions: scare, anger, sadness, happiness, disgust and surprise [7]. The six basic emotions are widely accepted.

Some scholars were not interesting in classification of basic emotions and they preferred to explore the problem of continuous emotion dimension [8]. In 1980-1997, Mehrabian detailed the theoretical rationale and experimental foundations for the PAD Emotional State Model [3]. The Model consists of three nearly independent dimensions that are used to describe and measure emotional states: pleasure / displeasure, arousal/ non-arousal, and dominance /submissiveness. "Pleasure/displeasure" distinguishes the positive-negative affective quality of emotional states; "Arousal/non-arousal" refers to a combination of physical activity and mental alertness; "Dominance/submissiveness" is defined in terms of control versus lack of control. Specific terms describing emotions can be visualized as points in a three-dimensional PAD emotion space. Alternatively, when the PAD scale scores are standardized, each emotion term can be described succinctly in terms of its values on the pleasure/ displeasure, arousal/ non-arousal, and dominance/ submissiveness axes. Each dimension can assume values from –100% to +100%, and a PAD valence score is a 3-tuple of these values (e.g. [-.51, .59, .25] might represent anger).

3. NPC emotional behavior model

3.1. Emotional behavior of NPC

Although intelligence is the basic element to create NPC, emotion will greatly enhance the credibility of NPC. To express emotions with special habits makes NPC more distinctive in personalities. A special habit emphasizes the biological moods, allowing player to identify NPCs easily and to hobnob with them.

According to psychologists, sensation is a pattern arousing emotion changes. Sensation arises mainly from external stimulation and is a combination of sustaining external stimulus. The Sensation will cause emotion transition from one to another. For example, the sensation of fear will lock the corresponding feeling of fear and release feelings of anger.

Emotions of NPCs are expressed with various behaviors in the attainment course of their objectives, so we should choose the most expressive emotional actions to enhance the reality of the game, at the same time maintain the simplicity with the minimum number of affective form. For example:

- Be ready to escape with stiff action when frightened.
- Thump wall violently with diminished accuracy when angry.
- Suspend thinking with sluggish action when sad.
- Jump, wave, or dance of happiness.
- Turn away in disgust.
- Raise eyebrow, open eye widely and look around watchfully when surprised.

3.2. Emotion transition model of NPC

First we define $X(x_1, x_2, ..., x_n)$ as emotional state space. Second we define $x(t)$, $y(t)$ as emotional vectors in X. Thereinto $x(t)$ represents current NPC emotional state and $y(t)$ represents disturbing factor viz. external stimulus, y_{NPC} , y_s ,y_p are three branch vectors of $y(t)$ .Here s is scene and p is game player. After t is dispersed, we get $t_1, t_2, ..., t_n$ and following equations.

$$x(t_2) = x(t_1) + y(t_1) \quad (1)$$

$$y(t_n) = y_{NPC}(t_n) + y_s(t_n) + y_p(t_n) \quad (2)$$

$$x(t_{n+1}) = x(t_n) + y(t_n) \quad (3)$$

$x(t)$ is an abstract representation of emotion for convenience of inference. In application, it will be embodied as a vector of PAD valence score.

Now we define the mechanism to deal with emotions:

1)We define three kinds of objects in game: *NPC, player, scene* ;

2) We define one relation in game: *Game(NPC, player, scene)*;

3) At the beginning of the game, we set the initial score values as $NPC(t_0)$, $player(t_0)$, $scene(t_0)$ for each object;

4) We define recursive equations from above equations (1)(2)(3) as following:

$$x_{NPC}(t_{n+1}) = x_{NPC}(t_n) + y(t_n);$$

Here $x_{NPC}(t_n)$ is the emotion valence score of current NPC.

$$y(t_n) = -k*(e(t_n) - e(t_{n-1}));$$

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$$e(t_n) = k_1 * NPC(t_n) + k_2 * player(t_n) + k_3 * scene(t_n);$$

According to classification theory, we get each branch value of NPC(t_n) from the maximum value of corresponding branch values of all NPCs at t_n moment:

$$NPC(t_n)_i = Max(NPC_1(t_n)_i, NPC_2(t_n)_{i,\ldots}, NPC_m(t_n)_i)$$

Here m is the number of NPCs that affect the emotion of current NPC.

$$player(t_n)_i = Max(player_1(t_n)_i, player_2(t_n)_{i,\ldots}, player_m(t_n)_i);$$

$$scene(t_n)_i = Max(scene_1(t_n)_i, scene_2(t_n)_{i,\ldots}, scene_m(t_n)_i)$$

5)For each $NPC_j(t_n)$ that impacts the emotion of current NPC, we can define an equation as:

$$NPC_j(t_{n+1}) = NPC_j(t_n) + O_{NEW}(t_{n+1})$$

Here $O_{NEW}(t_{n+1})$ is the new object that join the scene at t_{n+1} moment and impact the emotion state of NPC_j . The object may be NPC, or player as well as scene entity.

Through recursive approach with above equations, we can calculate the emotion valence score of current NPC from its initial valence and the disturbing valence of surrounding objects interact on it

4. Simulation and evaluation

We simulated above model in the project "Game Style Training System for Mine Disaster Rescue". At the beginning of the game, Rescuing team members (NPCs) assemble at the entrance of disaster mine and the team header assigns tasks for each member, shown as Figure 1.

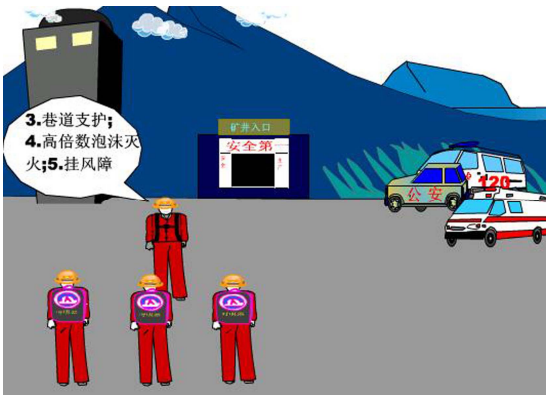

Figure 1. Being ready to enter the mine

After entering the mine laneway, each NPC should cooperate with other NPCs and the avatar of player, to search persons locked into mine disaster, and to bring them to a safe place for medical treatment. The NPC, as well as player, has to face endless dark, landslip, flooding, cave-collapse, gas explosion, toxic gas that threaten their survival at any moment. They perhaps encounter the wounded with splashed blood and broken leg. And they may fall across decomposed body reeking of sickening effluvium. The NPC will be terrified when facing extreme danger, angry when passing by unused safety facility, excited when the wounded are rescued successfully, and so on.

Six kinds of emotions defined by Ekman were simulated in our system. They were fear, anger, sorrow, happiness, disgust and surprise. To simplify the process, we chose one NPC (we assumed other NPCs were outside of view) and six scenes to simulate. With PAD representation, we assigned the NPC's initial emotion valence score as (0.0,0.0,0.0) and endowed each scene a disturbing valence interacting on the NPC. Table 1 shows the disturbing values of six scenes.

Table 1. Disturbing PAD values of scenes

Scene	Disturbing PAD values	*k*
Landslides	(-0.4,0.4,-0.1)	-0.1
Cadaver	(-0.3,-0.3,-0.2)	-0.2
Splashed blood	(-0.2,0.2,-0.1)	-0.1
Gas explosion	(-0.6,0.7,0.2)	0.2
Live person	(0.5,0.4,0.3)	0.3
Unused safety facility	(-0.2, 0.6, 0.2)	0.2

According to the initial values and our emotion transition model, the emotion states of the NPC changed as it wandered in the dark mine laneway and passed by designed scenes. Its emotions were expressed through actions, illustrated as Table 2.

Table 2. Emotional behavior of NPC arising from scenes

Scene	NPC action	Dominant Emotion
Landslip	Look around watchfully	Surprised
Cadaver	Tearful eye and sluggish action	Sad
Splashed blood	Turn away	Disgusted
Gas explosion	Be ready to escape and be stiff	Scared
Live person	Jump, wave, dance	Happy
Unused safety facility	Thump the wall violently	Angry

To show the emotional reaction of NPC in varied scenes, we extracted a frame from the game screen, as Figure 2. In this scene, landslip occurs suddenly nearby so that the NPC is surprised to dodge by the light of nature

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and then to look around warily. At the moment, the NPC raises its eyebrow and open its eye widely.

Figure 2. Surprised NPC facing landslip

In the simulating process, it was easy for us to understand the NPC's emotions because its conventional reactions in specific environment were similar with ours. Despite the prototype NPC was comparatively clumsy, even ludicrous sometimes, several invited players (trainees) said the game was rather interesting and attractive. They recognized the NPC's emotional state. And they said the NPC's reacting behaviors were logical and believable. This means that our model is effective at some degree.

5. Summary

Although intelligence is an essential element for creating functional NPCs, emotions significantly enhance their creditability and affinity. Therefore, emotion seems to be an essential component for game AI. Moreover, endowed with emotions, NPC may create many interesting emergent patterns. NPC will look amiable to player for their conventional behavior with emotional reaction so the game environments become more attractive and immersing.

In our emotional behavior model, the emotion can be discrete or continuous. We combine the theory of basic emotion with that of emotion dimension. We can select some common emotion to compute with continuous emotion dimension representation such as PAD. This makes the model easy to be simulated.

We are dedicating to create a vivid virtual environment for mine disaster rescue training – game style training system. What is the game style training? We would like to consider that game style training should take advantage of those properties which game possesses, such as simulating the real world, to take game approach to instruct player's actions, and to put the policies into game so that players could learn more strategies from game. The game style training may be applied to the rescue of civilians in a simulated large-scale disaster simulation, to decision support for emergency response system, even to immersing learning. We deem for any kind of things, if they worked properly, they'd be tools, not toys. The game style training system is in game model but is not a game. According to current global security state and corresponding policy, this technology is very useful in the future.

Besides NPC emotional behavior model, we are studying to design a model of player personality profiling so that the avatar could simulate the behavior style of the player. In this way the avatar will serve as an emotional mirror or a learning companion [9] of the player (trainee) to help improve his learning effect as well as meliorate his personality.

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