Foundations for Modelling Emotions in Game Characters: Modelling Emotion Effects on Cognition

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Abstract

Affective gaming has received much attention lately, as the gaming community recognizes the importance of emotion in the development of engaging games. Affect plays a key role in the user experience, both in entertainment and in 'serious' games. Current focus in affective gaming is primarily on the sensing and recognition of the players' emotions, and on tailoring the game responses to these emotions. A significant effort is also being devoted to generating 'affective behaviors' in the game characters, and in player avatars, to enhance their realism and believability. Less emphasis is placed on modeling emotions, both their generation and their effects, in the game characters, and in user models representing the players. This paper accompanies a tutorial presented at ACII2009, whose objective was to provide theoretical foundations for modeling emotions in game characters, as well as practical hands-on guidelines to help game developers construct functional models of emotion. While the tutorial covered models of both emotion generation and emotion effects, this paper focuses on modeling emotion effects on cognition.

1. Introduction

Affective gaming has received much attention lately, as the gaming community recognizes the importance of affect in the development of more engaging games [1,2,3]. Affect plays a key role in the user experience, both in games developed purely for entertainment purposes, and in 'serious' games for education, training, assessment, therapy or rehabilitation. Affective computing has much to contribute to affective gaming. The three core areas of affective computing provide methods and techniques directly relevant to game development: (1) Emotion sensing and recognition by machines; (2) Computational models of emotion; and (3) Expressive manifestations of emotions, and effects on behavior, problem-solving, and decision-making.

Current focus in affective gaming is primarily on the sensing and recognition of the players' emotions, and on tailoring the game responses to these emotions; e.g., minimizing frustration, ensuring appropriate challenge [4,5]. Research is also focused on the development of more accurate affective user models; e.g., by assessing the degree of entrainment via physiological measures, such as heart rate [6]. Significant effort is also being devoted to generating 'affective behaviors' in game characters, and in player avatars, to enhance their realism and believability [1]. Less emphasis is placed on modeling emotions, both their generation and their effects, in the game characters and in user models representing the players. (For a more extensive discussion of affective gaming see Hudlicka [7].)

This paper summarizes a minitutorial presented at ACII2009, whose aim was to provide an introduction to affective modeling, and to highlight its relevance to affective gaming. The tutorial provided an overview of models of emotion generation, and emotion effects on cognition. Due to space limitations, this paper focuses on models of emotion effects on cognition only. A more thorough coverage of affective models in game characters can be found in related papers [7,8], covering models of emotion generation, and emotion effects on cognition, expression and behavior.

2. Why Model Emotion Effects on Cognition in Game Characters?

The fact that believable and engaging non-playing characters (NPCs) require affective expressions appropriate for their context is self-evident. It follows that it is also necessary to dynamically generate emotions within the NPCs, in the context of the ongoing gameplay, and the user-NPC interactions. Both of these aspects of emotion modeling are addressed by affective computing, and a number of emotion generation models have been developed that are applicable to NPC emotion modeling [e.g.,9,10], most of them based on the OCC model of emotions [11]. Techniques also exist to map emotions onto their expressive manifestations and action choices, and for rendering the expressive manifestations of emotions in game characters (e.g. [12,13]).

Less self-evident is the need for the NPCs to also model emotion effects on cognition. At first glance modeling the 'invisible' effects of emotions on cognitive processes may seem like an 'overkill' for an applied context such as games. It may seem that a simple direct mapping of an emotion onto its expressive manifestations, and behavioral choices, is adequate. However, much as introducing emotion as the mediating

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variable between stimuli and responses allows for more flexible mapping between the environment and the agent's behavior, so does the explicit representation of cognitive processes as intervening variables between emotions and their expressive and behavioral manifestations. Modeling affective biases on cognition also provides an efficient means of generating appropriate behaviors in more complex environments, and a means of generating the type of affective variability that makes NPCs more believable.

Furthermore, it is also important to model emotion effects on cognition in a theoretically and empirically grounded manner. By this we mean that the models should use an established theory of emotions (e.g., discrete, dimensional, componential), and that the mappings among the emotion and their effects on cognition should be consistent with empirical data. We revisit these issues in section 4, and illustrate them with concrete examples, following a brief summary of relevant emotion research in psychology.

3. What Are Emotions?

When searching for a definition of emotions, it is interesting to note that most definitions involve descriptions of characteristics (e.g., fast, undifferentiated processing), or roles and functions (e.g., coordinating mechanisms to manage goals in uncertain environments, hardwired responses to critical stimuli, communicative mechanisms to facilitate social interaction). The fact that emotions are so often described in terms of their characteristics, rather than their essential nature, underscores our lack of understanding of these complex phenomena. Nevertheless, many emotion researchers in psychology do agree on a high-level definition of emotions, as "evaluative judgments of the environment, self and other social agents, in light of the agent's goals and beliefs", and the associated coordination and execution of adaptive responses.

A key aspect of emotions is their multi-modal nature. Emotions in biological agents are manifested across four distinct, but interacting, modalities. The most familiar is the behavioral / expressive modality, and its expressive, action-oriented characteristics; e.g., facial expressions, speech, gestures, posture, behavioral choices. Closely related is the somatic/physiological modality - the neurophysiological substrate making behavior (and cognition) possible (e.g., heart rate, neuroendocrine effects). The cognitive/interpretive modality is most directly associated with the evaluation-based definition provided above, and emphasized in the current cognitive appraisal theories of emotion generation (see [7,8]). The most problematic, from a modeling perspective, is the experiential / subjective modality: the conscious, inherently idiosyncratic, experience of emotions within the individual. While the current emphasis in emotion modeling is on the cognitive modality and appraisal, and the behavioral modality (manifesting emotions in agents), the physiological and the experiential modalities also play critical roles [14].

The term 'emotion' can often be used rather loosely, to denote a wide variety of affective factors, each with different implications for sensing and recognition, modeling and expression. Emotions proper represent short states (lasting seconds to minutes), reflecting a particular evaluative assessment of the state of self or the world, and associated behavioral tendencies and cognitive biases. Emotions can be further differentiated into basic and complex, based on their cognitive complexity, universality of triggering stimuli and behavioral manifestations, and the degree to which an explicit representation of the agent's 'self' and social norms are required (e.g., [15,16]). 'Basic' emotions typically include fear, anger, joy, sadness, disgust, and surprise. 'Complex' emotions such as guilt, pride, and shame have a larger cognitive component and associated idiosyncracies, in both their triggering elicitors and their behavioral manifestations, which makes their recognition, modeling and expression more challenging. Moods reflect less-focused and longer lasting states (hours to days to months). Finally, affective personality traits represent more or less permanent tendencies (e.g., extraversion vs. introversion, aggressiveness, positive vs. affective emotionality).

4. Models of Emotion Effects on Cognition

4.1. Theoretical and Empirical Foundations

Theories explaining the mechanisms that mediate the effects of emotions are less well developed than theories of cognitive appraisal. In addition, two distinct classes of processes need to be considered: effects of emotions on the visible, expressive manifestations (e.g., facial expressions, speech, gestures and movements), and the 'internal' effects of emotions on cognitive processes. The empirical data, and the computational methods and tools, are very different for these two types of effects.

4.1.1 Data Requirements

The first step in model development is to specify the mappings from the emotion to its visible expressive and behavioral manifestations, or the effects and biases on cognitive processes. Regarding the former, an extensive base of empirical data is available to develop these mappings, especially for the basic emotions (e.g., joy, sadness, fear, anger, disgust), and for several of the social emotions (e.g., shame, guilt, pride, contempt). Specific behaviors associated with these emotions are well-documented: e.g., fear associated with freezing or fleeing, anger with aggression, sadness with withdrawal, and joy with approach behaviors and openness to experience. For expressive manifestations, extensive data exist for affective facial expressions, as exemplified in the detailed analysis of facial expressions in terms of Ekman and Friesen's FACS system [17]. Although not as well established and extensive, data also exist for other expressive channels, including speech, and, to a lesser extent, gestures and movements.

A key challenge in generating realistic and believable visible manifestations of emotions in NPCs is the coordination among the multiple available channels. This coordination must be implemented in two dimensions. Within a single time frame, expressive manifestations must be coordinated across the different channels available; e.g., in an angry agent, anger must be consistently portrayed in all the visible channels available: facial expression, speech, gestures, movement quality and the choice of action. Expressive manifestations must also be coordinated across temporal intervals, to ensure believability. This means that the magnitude of the expressive behaviors must follow the dynamics of the emotion itself, with realistic ramp-up and decay rates of intensity being reflected in the corresponding changes in the expressive manifestations. For the affective dynamics, the supporting data are not quite as extensive, and are typically not available in the quantitative terms required for modeling, with the major exception of facial expressions, where available data sets include descriptions of the facial musculature dynamics corresponding to changes in intensity.

The situation is quite different when it comes to defining the mappings between an emotion and its effects on cognitive processes. While much data exist regarding effects of the basic emotions on attention, memory, and perceptual and decision biases, these are typically described in qualitative terms, and therefore extensive 'educated guesses' must be made to translate these into computational models. This problem is even more extensive when it comes to defining the affective dynamics: that is, mapping the emotion intensity onto the magnitudes of the effects, and defining the dynamic relationships among these as the emotion episode evolves in time. Little or no data are available regarding the combined effects of multiple emotions.

In addition to this lack of quantitative data, modeling emotion effects on cognition poses an even greater challenge: lack of knowledge regarding the nature of the internal mental constructs that mediate these effects. While data exist regarding affective biases on attention, memory, and some aspects of perception and decision-making, little is known about the mechanisms of these effects, and the nature of the internal mental constructs that presumably play a key role: e.g., goals, beliefs, expectations. This gap in knowledge presents a major challenge for modeling emotion effects on cognition, and for identifying the associated mechanisms.

4.1.2 Methods, Techniques and Tools

The generation of realistic and believable affective expressions is technically challenging, in large part due to the computationally-intensive nature of the rendering and animation tasks necessary to generate believable expressions, in real-time. However, due to the extensive progress in these areas over the past 10 years, including development of dedicated hardware, these issues are being successfully addressed in the gaming and agent research communities. In addition, emerging standards and markup languages facilitate the development of embodied agents and their affective expressive behavior.

Less work has been done in the rather neglected area of modeling emotion effects on cognition. In part this is due to a lack of principled guidelines and standardized approaches for the development of these models, in addition to lack of data and adequately operationalized theories. Without a strong theoretical base it is difficult to develop principled design approaches, which then makes it difficult to develop standardized techniques and tools. We review several relevant theories below.

4.1.3 Theoretical Foundations for Modeling Emotion Effects on Cognition

Three categories of theories postulate mechanisms that mediate emotion effects. Spreading activation models, e.g., Bower's "network theory of affect" [18], were developed to explain the phenomenon of mood-congruent recall. These conceptual models suggest that emotions can be represented as nodes in a network that contains both emotions and cognitive schemas. When an emotion is activated, it co-activates (via spreading activation) schemas with similar affective tone. Component process theories [19] suggest that the domain-independent appraisal dimensions that mediate emotion generation map directly onto specific elements of affective expressions, such as the facial musculature; e.g., novelty correlates with eyebrow raising, pleasantness with raising of lip corners and eye lids [20], and possibly even onto emotion effects on cognition [21]; e.g., an appraisal of high certainty may be linked to heuristic processing whereas an appraisal of low certainty to more analytical processing. Parameter-based models, proposed independently by several researchers (e.g. [22,23,24,25]), suggest that emotions induce patterns of systemic effects on cognitive processing, which cam be captured in terms of global parameters. These models appear consistent with recent neuroscience evidence that emotion effects on cognition may be implemented via neuromodulatory transmitters, acting globally on multiple brain structures [26].

4.2. Examples of Modeling Approaches

The few modeling efforts that focus on modeling emotion effects on cognition typically use the parameter-based approach. Examples of these models include Hudlicka's MAMID [27,28] and Broekens et al. [29]. MAMID models the effects of emotions on high-level decision-making, within a symbolic cognitive-affective architecture. The architecture implements a generic methodology for modeling emotions, traits and other individual differences [22,28]. Within MAMID, an agent's profile is first defined in terms of its current emotions and traits. These are then translated into a set of architecture parameter values, which control the speed and capacities of the distinct architecture modules, where each module corresponds to some high-level psychological function: "Attention", "Situation Assessment", "Goal Management", etc.). Parameters also control processing within the individual modules, and enable an implementation of a number of documented affective biases, such as a threat bias in attention and situation assessment, and self bias in attention, situation assessment and goal selection.

In the system described in Broekens et al. [29], affect is used as a parameter to guide the learning process of an autonomous learning agent. Here, the agent learns a task using reinforcement learning, and an agent-generated affect signal controls the amount of exploration versus exploitation (randomness) that agent uses while making decisions about actions.

Several other recent models of emotion effects use a parameter-based approach that shares similarities with the MAMID methodology described here, that is, the use of processing parameters to encode emotion effects [25,30,31]. The approaches vary in terms of the parameters represented, the functions calculating their values, and the degree of correspondence with psychological processes and empirical data (e.g., in some cases parameters simply model the degree of noise and reduce performance effectiveness, e.g., [25]).

4.3. Examples of Modeling Emotion Effects on Cognition in NPCs

Below we discuss two approaches to modeling emotion effects on cognition in NPC's. First, a parameter-based approach similar to the one used in MAMID (above), and then an approach based on randomized selection of alternatives within an appropriately defined space of possibilities. In each case the aim is to maintain consistency with existing empirical evidence, as much as possible.

4.3.1 Parameter-Based Models

As outlined above, parameter-based models implement emotion effects on cognition in terms of a set of parameters that control, or bias, processing within the components of the NPC architecture. The model must define consistent mappings from the emotions (and affective traits) onto the parameter values, such that changes in the emotion-trait NPC profiles cause significant (and interesting) changes in the agent's behavior, arising from differences in internal processing. For example, a fearful agent will focus on high-threat cues, anticipate dangerous future situations, and, as a result, select more self-protective goals, and possibly overly-aggressive actions, in response to the falsely emphasized threat.

We illustrate the use of this modeling approach in terms of a concrete game example. Consider a game where an NPC gets points for capturing enemies, cooperating with friends, and amassing resources. The NPC faces a situation where his resources are depleted, and he can see an enemy approaching in the distance. A supply source is coming up, and, shortly after this, a friendly figure will suddenly appear.

To make the game interesting and engaging, we would like the NPC's behavior to vary, depending on his current emotion. Specifically, we would like him to exhibit the following variations in behavior. When in a **neutral** mood, he will behave as follows. He will replenish his resources, collect the friend and together they will capture the enemy. He will thus get points in all three categories of awards in this game. When feeling **happy,** he will not replenish his resources (feeling overly confident he has enough), will collect the friend (feeling friendly), and together they will capture the enemy. He will collect points for cooperation and capturing the enemy. When feeling **angry**, he will not replenish his resources (underestimating the risk of running out), he won't ask the friend to cooperate (not feeling friendly). As a result, when he reaches the enemy, he will not have enough resources and will not capture the enemy, thus losing points in all three categories. Finally, when feeling **anxious,** he will miss the supply source (because he is focusing on the enemy in the distance), will mistake the approaching friend for an enemy and kill him (anxiety-induced threat bias in interpretation), and when reaching the enemy, he will not have adequate resources to capture him. Again, losing points in all three categories: no resources, no cooperation, no enemy capture. Note however, the different behaviors in the angry and anxious case, as a result of the different emotions.

These types of behavioral variations add richness to the game, but cannot be easily implemented unless the effects of emotions on cognitive processes are modeled. The types of biases that induced these variations can be implemented in the parameter-based models of emotion effects as follows.

First, the NPC architecture is defined, typically by establishing its constituent modules, where each module corresponds to some high-level cognitive process necessary to implement behavior (e.g., Attention, Situation Assessment, Goal Manager, Action Selection). *Next,* the mental constructs manipulated by these modules are defined, e.g., cues, expectations, goals, and the mappings among these constructs within each module. These mappings are necessarily domain-dependent and represent the NPC's long-term memory, which captures its knowledge and expertise within the game. For this example, the mappings might include ["unknown NPC approaching" -> "friendly NPC"] (for the Situation Assessment module) or ["friend approaching" -> "[ask for help"]) for the Goal Manager module. These mappings may be implemented in terms of some symbolic representational mechanism, ideally one that can handle probabilistic reasoning, such as Bayesian belief nets.

Next, the architecture parameters are defined. These influence the speed and capacity of the distinct modules, as well as the attributes of the mental constructs that determine their processing priority (by influencing their rank in the processing queue associated with each module). Thus, for example, an anxiety-associated threat bias will be implemented by giving preference to high-threat constructs (e.g., enemy), and possibly completely ignoring low threat constructs (e.g., supply station).

Once the NPC architecture and parameters are specified, the relationships between different emotions and traits, and the parameters, are defined. These relationships are based on empirical data and capture the documented biasing effects of emotions on cognition; e.g., threat bias in attention and interpretation associated with anxiety, underestimation of risk associated with anger, and overestimation of success associated with happiness [21,32]. Since existing theories do not specify the exact functions implementing these mappings, the modeler must construct these to match the available qualitative empirical data, and tune the model performance as necessary. Often, weighted linear combinations of the influencing factors are used and the tuning is accomplished by modifying these weights.

This model then enables the NPC architecture to generate the different behaviors outlined above, by manipulating the architecture parameters as a function of the distinct emotions.

4.3.2 Randomized Selection Models

The objective of the randomized selection models is the same as that for the parameter-based models outlined above: to demonstrate significant and interesting differences in behavior as a function of distinct NPC emotions. In randomized selection models, this variability is accomplished by randomly selecting one of several possibilities at each stage of the internal processing. Thus, for example, to model anger-associated effects, an NPC would be biased toward selecting hostile attributions of other NPCs' behavior, and more aggressive and assertive actions. The key requirement here is that the alternative selected must be consistent with the known effects of particular emotions. The modeler must therefore define, for each represented emotion effect or bias, a set of alternatives, from which one is then randomly selected during processing.

Existing empirical base regarding affective biases, and theoretical emotion models, provide the necessary foundations for defining the representational structures, and for guiding the inferencing required in these models.

The empirical data help define the space over which randomized selection will occur. Continuing with the architecture outlined above, where distinct mental constructs are manipulated to simulate cognitive processing (e.g., cues, beliefs, goals), the affective bias data help define the types of additional construct attributes that are subject to affective biases, and thus necessary to allow for a meaningful randomized selection among alternatives. In other words, if anxiety induces a threat-bias on attention, causing threatening cues to be processed faster, then the structures representing cues must include a 'threat level' attribute. Similarly, to model a self-bias in processing, also associated with anxiety, cues and beliefs must be able to represent whether their content regards the self or non-self. To implement anger-linked biases, such as high risk tolerance, impulse to act, and attribution of hostility in others, the following information must be represented: degree of risk associated with goals and actions, degree of danger associated with perceived situations (e.g., low level of resources available), to enable modeling of high-risk tolerance; whether a possible action focuses on external behavior (e.g., move forward and capture enemy) vs. internal behavior (e.g., plan a better route), to enable modeling of the impulse to act; and the nature of motivation (intent) in other game characters (e.g., wishing me good vs. wishing me ill), to capture the hostility attribution bias.

Once the space of possibilities is thus defined, emotion theories provide guidelines for implementing the randomized selection. The dimensional theories are well suited for this approach. These theories define emotion in terms of 2 (arousal and valence) or 3 (arousal, valence, dominance) dimensions [33]. Many emotions can thus be uniquely defined in terms of 2- or 3-tuples within the associated space.

The arousal dimension helps specify the parameters of the algorithm that randomly selects among the available alternatives. The arousal dimension represents the overall level of 'energy' or activity-potential within the NPC. As such, it helps define 'global' qualities of both the behavioral manifestations of an emotion, and the associated cognitive processing. For example, emotions characterized by high arousal, such as anxiety, fear and excitement, are associated with more energetic expressive manifestations, such as more rapid movements, trembling, and louder and more intense speech. In the case of cognitive processing effects, arousal influences the following aspects of cognitive processing: *speed* of the overall processing cycle; *persistence* of a given 'line of thought' (high arousal will involve more rapid 'switching' among alternative interpretations of a situation and possible goals than low arousal); and the *capacity* of processing (high arousal will reduce overall processing capacity, leading to more 'focused' processing, which does not allow for a thorough consideration of other alternatives).

These aspects can be simulated at a high level by adding a "noise" parameter to the NPC's decision-making process that has a persistent goal: when highly aroused, the NPC is "jumpy" and unpredictable in its behavior, but is very active to achieve the goal. For example, an NPC might make more random decisions while executing a shortest path to get to a certain location, simulating "frantically searching for" behavior.

5. Conclusions

We summarized a tutorial on emotion modeling in game characters, focusing on the often-neglected models of emotion effects on cognition. We presented theoretical background and some practical guidelines for developing models of emotion effects on cognition in NPCs. We attempted to demonstrate that an explicit representation of these effects allows for the development of more flexible, believable and engaging game characters, by supporting the generation of a wider variety of behaviors within the game environment. Due to lack of space, many aspects of emotion modeling have been omitted, including emotion generation, affective dynamics (changes in intensity over time), and the integration of the effects of multiple emotions. These are discussed in related papers [7,8].

Explicit focus on emotion in games promises to produce more believable characters and contribute to more engaging games for entertainment, and more effective serious games [2,7]. However, more systematic guidelines are necessary for model development, and tools are needed to facilitate integration of emotion in game design; e.g., Hudlicka's recent suggestion for the development of affective game engines, to support the development of affective games [34]. The aim of this tutorial was to provide a step in the direction of developing practical guidelines for affective modeling in games. Additional information on affective modeling in game characters can be found on a new website established to promote affective gaming: affectivegaming.org.

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