EEP – A lightweight emotional model: Application to RPG video game characters

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***Abstract*— A key factor for the playing experience in modern video games is the behavior of the agents in the game. Recently, several mechanisms have been put forward, with the objective to define synthetic emotional models, so as to make the player believe that the responses of the software agents are motivated, in some way, by emotions. However, there is currently no virtual agent model that satisfies the restrictions imposed by the software development of a commercial video game, namely limited design time and computational complexity but offering flexible mechanisms to define emotional reactions. In this paper, we present the Emotional Elicitation Process (EEP), a lightweight emotional model suitable for use in real-time video game environments. EEP includes: (1) a parametric definition for the character emotional profile, (2) a mechanism to translate events into emotions, (3) a method to update mood state by these emotions, and (4) a mechanism to map mood state into different behavior controllers. We illustrate this model by an example from a commercial role-playing game (RPG) scenario, in which a relatively simple set-up of EEP can produce realistic emotional behaviors consuming few computational resources.**

I. INTRODUCTION

Today's AAA class games (blockbusters video games with a big superproduction budget and high quality technical and detail aspects) require sophisticated character models. Still, while in such games the visual aspects of the virtual characters are usually well polished, their behavior has only recently been considered as important as the visual effects. In the past few years, game development has applied static off-the-shelf solutions that sometimes lead to inflexible and unrealistic behaviors. This can, of course, cause players to become dissatisfied with the game: they want to have the feeling that the characters in the scenario have a purpose and a goal, and are not just roaming around the scene. Different planning and reasoning techniques have been adapted to produce effective (rational) behavior of virtual characters as well as the interactions with them. Still, to achieve real believability of virtual characters in games, they should also be capable of (sometimes) surprising and challenging the player. To this respect, behavior patterns of the virtual character that are perceived by the player as being emotional are of foremost importance. In this paper, we present a model that generates "emotional" reactions of virtual characters in response to events from the game environment, regardless of whether they were originated by the player or not. Our model can be easily configured for a particular video game and integrated with different game engines.

Even though the evaluation of the emotional response of characters in video games is a difficult matter, it is important to select particular criteria to judge whether the character actions are affected by any emotional influence. The carry out the experimental part of this paper, we have decided to apply this model at several scenarios in a widely known video game, NeverWinterNights™[1]. One of this scenarios will be fully explained as a case of study. We will analyze the emotional behavior of the characters in order to evaluate the believability of the characters across a combat. The example is oriented to facilitate the understanding of the model and how it works, as well as to identify the design aspects required to define an emotional behavior in these characters.

The rest of the document is organized as follows: on the section II we analyze the elements of other works applied to the virtual character emotions, in III we introduce the fundamental aspects that we considered important in a cognitive representation of a virtual character, in IV we describe the fundamental aspects of cognitive psychology used in this work, the section V presents the Emotional Elicitation Process (EEP) model with its main components and properties, section VI reports a detailed case of study of this model in a commercial video game by showing the evolution of the emotional process of the characters, and, finally, on section VII, we show the conclusions and future work with EEP.

II. RELATED WORK

The quantitative analysis of the human emotions is a topic widely treated in psychology. There is a variety of ideas applied to projects that try to create a synthetic emotional framework to evaluate and/or simulate the emotional component of humans or agents. Roseman's appraisal theory [1] treats the emotional events as motive accordance or motive non-accordance. This distinction allows the agent to evaluate the goal alignment with the event. Therefore, it provides mechanisms to estimate the emotion produced by this event. The model proposed by Scherer and Ekman [2] makes use of appraisal as an information processing system, and by means of this, the model examines changes in the present emotional status based on five subsystems. Besides, OCC model [3] estimates the emotions as derived from three

[1] http://nwn.bioware.com/

different sources: (1) the consequences, (2) the actions of the agents and (3) the evaluations of the objects.

In general, appraisal theories of emotion usually present a complex architecture with well-founded principles of psychology and robust pillars of cognitive models, such as the EMA model [4], WASABI [5] or Feeling and Reasoning [6]. Even though these models provide a complete mechanism for handling emotional responses, the inclusion of any of these models in the architecture of the video game characters is too complex. The video game scenario needs "coarse-grained" emotional states and simple and efficient transitions. On top of that, the design of multiple characters is an extra effort that requires to consider models somehow easier to calibrate and evaluate.

The model presented on this work deals with the problems of these and others models, for instance, the EMA model does not represent the personality of the characters, instead, it declares the beliefs, desires and intentions of the characters, creating a difficult starting point to represent easily the characters. Besides, in EMA model, there are appraisal and re-appraisal procedures to support the dynamics of the emotions, as well as, the memory of emotions for these procedures, which could be computationally to expensive and difficult to configure on design time for a video game engine. The WASABI model projects the mood in a linear unidimensional variable, it is simpler than our approach, but makes the relations about the mood and the emotions dimmer, requiring to rank the emotional states according to only one criteria, something not fully realistic. The Feeling and Reasoning model works with a decay function that applies to the emotions affecting the mood like in our model, but the personality is only represented by the specifications of the OCC valenced factors such consequences or actions and the decay functions, but does not present and starting point for the current arousal of mood of the character in the initial position.

III. Elements for virtual character emotions

In the context of applied psychology, the appraisal theories usually establish some key points for the computational analysis and/or simulation of emotions, such as, the difference between the appraisal and the inference about the events that a character perceived [4], minimal necessity of certain inferences to distinguish between emotions [7], believability and empathy with the user [6], and some others.

From these studies, and in order to define the environment in which this contribution is developed, we have selected the following aspects as crucial for the creation of a model for a real-time virtual environment (such as a video game). These aspects consider two main objectives: (i) being robust enough to produce coherent and expected emotional responses in certain game situations, (ii) but also with the required simplicity to be applicable with minimal computational overhead:

- (**R1**) Making the distinction between the appraisal of an event and the inference of the consequences of an event [8]. The perception of an event produces some emotions (appraisal) and the reasoning about the perceived event produces other emotions (inference).
- (**R2**) A structured analysis of the emotions produced by the events [3]. We classify the events into three major components: Actions, Consequences and Objects; all the emotions under consideration deal with at least one of these components.
- (**R3**) A definition of the transition between emotional states in a robust and efficient way [9]. We use few parameters to describe and analyze the events and we create a mechanism to identify the current mood and its transitions.
- (**R4**) A taxonomy of the elements within the environment, in order to correctly locate the correspondence between configurations and events. We describe an initial classification of the elements that are necessary and sufficient to evaluate the events. This classification is shared among the character profile configuration and the events.
- (**R5**) A model for defining the initial tendencies of the character facing its environment [10]. The character, at its profile, sets its own personality and, consequently, its initial and central mood towards which, in absence of emotions, the character tends to be.
- (**R6**) An emotional dynamics that represents the raising and lowering of an emotion [5]. The use of some functions to compute the mood adjustment along time and also the attenuation of the past emotions.
- (**R7**) A mechanism of information propagation, which provides the feedback of the emotional state into the control procedures (e.g., any planning module) of the character [11]. The EEP model is a standalone emotional engine that produce, as a returning value, the current mood state. This mood state could be considered within the reasoning model of the character. Besides, it is possible to input into the EEP model some consequences derived for the cognitive procedure of the character generating new events.

IV. Cognitive Psychology Concepts

The design of the model presented in this paper is founded on some well-known psychology techniques and models that, at this section, are briefly presented, in order to clarify the remainder of the document.

A. OCC Model

Ortony et al. developed a computational emotion model, that is often referred to as the OCC model[3], which has established itself as the standard model for emotion synthesis. This model specifies 22 categories for the emotions based on valenced reactions to situations constructed either (i) as being goal-relevant events (they could be acts from an accountable agent, including itself), or (ii) as attractive or unattractive objects. It also offers a structure for the variables, such as likelihood of an event or the familiarity of an object, which determines the intensity of the emotion types.

In this paper, we use the OCC model to analyze the events that a character perceive and to select a set of emotions prompted by each of these events. We use a simplified representation of the original model, according to the characteristics of the objective application domain, but preserving a well-balanced approach between the provision of flexible mechanisms to define emotions and the support to design and configure the model with a reasonable effort.

B. Big Five Personality Traits

The general psychological model of the Big Five Factors [12] introduces different factors useful for the computational representation and manipulation of character personalities. The five factors used by this model are:

- Openness – Appreciation for art, emotion, adventure, unusual ideas, curiosity, and variety of experience
- Conscientiousness – A tendency to show self-discipline, act dutifully, and aim for achievement; planned rather than spontaneous behavior
- Extraversion – Energy, positive emotions, and the tendency to seek stimulation in the company of others
- Agreeableness – A tendency to be compassionate and cooperative rather than suspicious and antagonistic towards others
- Neuroticism – A tendency to experience unpleasant emotions easily, such as anger or anxiety, depression, or vulnerability.

The profile of a character includes a parametrized version of its personality (as temperament representing point) described by the Big Five Factor representation (described as real numbers between $[-1, 1]$). This parametrization will be used as starting point for the mood of the character.

C. Pleasure-Arousal-Dominance Emotional & Temperament Model

The PAD Temperament Model [10] (as well as, the scales and space associated to its framework) were designed specifically to address substrate of connotative and metaphorical meanings which were viewed as being essentially emotion-based. The PAD model presents three orthogonal scales of emotions: *pleasure-displeasure* ($\pm P$ component, representing affective states) as the emotional counterpart of positive-negative evaluations, *arousal-nonarousal* ($\pm A$ component, i.e., mental and/or physical activity) as the correlate of stimulus activity, and *dominance-submissiveness* ($\pm D$ component, as, for example, the control over the situations) as the negative correlate of stimulus potency.

The PAD space can be conceptually and semantically divided in eight different octants according to the different sign of the different components (view Table II). This division is interesting to understand the different representation of the different emotions and moods that a character could experience.

The EEP model, presented on this paper, uses the PAD Model in different aspetcs: (1) the projection of the emotions of the OCC model into the PAD space (as shown at the table I), (2) for the translation of the personality to the default mood (using the Mehrabian transformation [10], see table III) and (3) the representation of the mood in the Mood Vector Space (see section V-D).

Emotion	**P**	**A**	**D**	**Mood Octant**	
ADMIRATION	0.50	0.30	-0.20	+P+A-D	Dependent
ANGER	-0.51	0.59	0.25	-P+A+D	Hostile
DISTRESS	-0.40	-0.20	-0.50	-P-A-D	Bored
GLOATING	0.30	-0.30	-0.10	+P-A-D	Docile
GRATIFICATION	0.60	0.50	0.40	+P+A+D	Exuberant
GRATITUDE	0.40	0.20	-0.30	+P+A-D	Dependent
HAPPYFOR	0.40	0.20	0.20	+P+A+D	Exuberant
HATE	-0.60	0.60	0.30	-P+A+D	Hostile
JOY	0.40	0.20	0.10	+P+A+D	Exuberant
LOVE	0.30	0.10	0.20	+P+A+D	Exuberant
PITY	-0.40	-0.20	-0.50	-P-A-D	Bored
PRIDE	0.40	0.30	0.30	+P+A+D	Exuberant
REMORSE	-0.30	0.10	-0.60	-P+A-D	Anxious
REPROACH	-0.30	-0.10	0.40	-P-A+D	Disdainful
RESENTMENT	-0.20	-0.30	-0.20	-P-A-D	Bored
SHAME	-0.30	0.10	-0.60	-P+A-D	Anxious

TABLE I

PAD EMOTIONAL MAPPING

+P+A+D	Exuberant	**-P-A-D**	Bored	**+P+A-D**	Dependent
-P-A+D	Disdainful	**+P-A+D**	Relaxed	**-P+A-D**	Anxious
+P-A-D	Docile			**-P+A+D**	Hostil

TABLE II

PAD SPACE OCTANTS

$$\begin{aligned}\mathbf{P}leasure &= 0.21 \cdot Extraversion + 0.59 \cdot Agreeableness \\ &\quad +0.19 \cdot Neuroticism \\ \mathbf{A}rousal &= 0.15 \cdot Openness + 0.30 \cdot Agreeableness \\ &\quad +0.57 \cdot Neuroticism \\ \mathbf{D}ominance &= 0.25 \cdot Openness + 0.17 \cdot Conscientiousness \\ &\quad +0.60 \cdot Extraversion - 0.32 \cdot Agreeableness\end{aligned}$$

TABLE III

BIG FIVE TO PAD RULES

V. EMOTIONAL ELICITATION PROCESS

The work presented in this paper is the Emotional Elicitation Process (EEP), which is the engine that processes the events produced in the environment, adapting the current mood of the character to these events. In addition, we establish the mechanisms to combine this engine in the AI controller of a character. Moreover, we describe the inputs and outputs that the model requires. This model is designed to work as a standalone component that requires certain configuration to work, but this model encloses all the procedures to evaluate the emotions and to manage the mood state and dynamics, according to the environment and the character, see Figure 1. The main contributions of this work is the structured analysis of the events, according to the widely admitted OCC model[3] and the use of the PAD model [13] to project, quantify and manipulate numerically the emotions. We introduce a mechanism to compose emotions prompted by an event and its application to update the mood of the character. The character mood is projected into a Mood Vectorial Space, which is modeled as an algebraic space of three dimensions with the enough functions to grant the correct combination, measure and decay of the emotions which affect the mood.

A. Architecture

The EEP is divided in four components:

1) Conceptual Dictionaries (*CD*),
2) Character Profile (*CP*),
3) Emotional Elicitation Process Engine (*EEPE*) and,
4) Mood Vectorial Space (*MVS*).

A standard cycle on the EEP model consists in:

1) The changes in the environment are processed and generate a set of events, each event has: (1) the source of the event (animate or inanimate), (2) the target of the event (animate, inanimate or none), (3) the consequences of this event, (4) the actions that are the cause of these consequences and (5) the objects related to this event.
2) The EEPE decomposes and analyzes the event. Using the configurations recorded at the CP, the engine produce a set of emotions associated to the elements that conform the event,
3) The emotions elicited by the EEPE are translated into scaled vectors described with the PAD components [13],
4) The PAD vectors are composed and added to the current mood represented in the MVS.
5) The MVS provides the mechanisms to find the nearest mood tag from the ones stored at the CP.

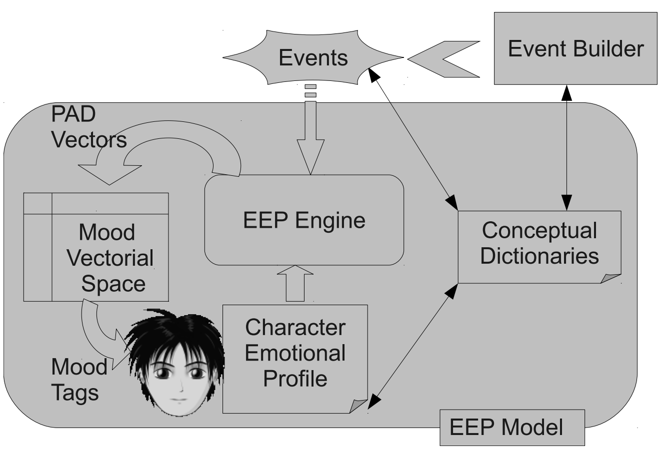

Fig. 1
EEP GENERAL ARCHITECTURE

B. Conceptual Dictionaries

For the correct alignment of the events and character profile, it is necessary a set of repositories that store all the possible elements that could appear in the scenarios in which we want to apply the EEP model. We distinguish between four different dictionaries:

1) Consequences Dictionary ($D^c = \{c_1, c_2, \ldots, c_n\}$): the Consequences are the character's expectations about things that would happen independently of any belief about their possible causes. In our example, the scenario can produce an event that has some of these consequences: {BE-HIT, BE-ATTACKED, ATTACK-ENEMY, BE-KILLED, KILL-ENEMY}
2) Actions Dictionary ($D^a = \{a_1, a_2, \ldots, a_n\}$): the Actions represent what the characters can do with the environment, or a group of some actions that we considered as the equivalent. For instance, in our sample scenario: {ATTACK, DEFEND, FLEE}
3) Objects Dictionary ($D^o = \{o_1, o_2, \ldots, o_n\}$): the Objects are physical or conceptual elements that generate emotions of liking or disliking by its mere presence on the events. For example, in our fantasy scenario we can have these objects: {ORCS, ORCBOSS, HUMANBOSS}
4) Relationships Dictionary ($D^r = \{r_1, r_2, \ldots, r_n\}$): this dictionary links characters btween them and also to group of characters[2] that could appear in the scenario, once a character is involved in an event, its membership to the Relationship Groups is evaluated. For example: {HUMANBOSS, ORCARCHER, @ORCS, @HUMANS}.

C. Character Profile

The character profile is the specification of the character's preferences and emotional behavior. The profile is composed by three different groups of information: (1) the parameters for the elements referred at the events, (2) the personality traits that describe the general mood state of the character, and (3) the association of the mood space points to mood tags, for those which are relevant for the character.

1) Emotional Parameters: The parameters describe the desirability of the consequences, the praiseworthiness of the actions, the appeal associated to the objects and the relationship with other characters in the scene. These values are selected from the point of view of the character, for example, the BE-HARMED consequence must be evaluated as the desirability of been harmed, it will be applied even for the evaluation of the consequences, appealing and praise of third persons, as suggested by [3], about the general assumption of external alignment of our own scale of values applied to other persons. All of the emotional parameters must be in one of the Conceptual Dictionaries since any of these elements could appear in an event.

The relationship among characters is slightly different. These relationships can be declared for groups and for individuals, the individual relationship qualification overrides any group value. The group relationships are averaged to evaluate the relationship of the character with another character who belongs to one or more groups.

2) Personality Traits: The personality description is based on the Big Five Factors, as shown in the section IV-B. In our example, it could be said that the human archer is a cautious, extrovert and friendly so could represent his personality as: *Openness*: 0.4, *Conscientiousness*: -0.1, *Extraversion* : 0.4, *Agreebleness*: 0.5 and *Neuroticism*: -0.1 according to the definition and semantic of the parameters.

[2]We represent the groups with @.

3) Mood Space Points: As we will see, the combination of the emotions, prompted by the events, will move the current mood of the character across the MVS giving a unique position on a given time. Among all the possible points in the MVS we select a set of them as reference points of the possible emotional states of the character. We assign to these reference points some labels (Mood Tags) to use them as a response for the EEP engine. The MVS describes a mechanism to compute the distance between any given point at the MVS and the reference points, with the objective to identify the closest reference point in the set. This reference point will provide the Mood Tag, which we will use to describe the current mood of the character.

In our example, as a guideline, we use the PAD octants to allocate three different labels that represent different mood stated for the characters[3], which will be used to conduct different behavior controlers:

NORMAL	$(0.2, -0.1, 0.3)$	AFRAID	$(-0.4, 0.6, -0.5)$
	ANGRY	$(-0.2, 0.8, 0.8)$	

D. Mood Vector Space

We model the Mood Vector Space as a bounded $\mathcal{M} \subset \mathbb{R}^3 \mid \mathcal{M} = [-1, 1]^3$ (more detailed at [14]) space that corresponds to the 3 orthogonal axis created by the PAD components proposed by [13]. The representation of emotions as vectors enables the translations of the current mood across the MVS.

The MVS is defined as $MVS = (\mathcal{M}, \oplus, \odot, \| \cdot \|, A)$ where $\oplus, \odot, \| \cdot \|$ are functions to handle the emotional vectors in the bounded space (to compose and translate, or to scale the vectors), and A is a family of functions to attenuate the current mood M_i, driving it back along the time to its initial state M_0.

To satisfy the restrictions of this bounded space, we define $MVS = (\mathcal{M}, \oplus, \odot, \| \cdot \|, A)$ as a *Attenuated Mood Space*, where $(\mathcal{M}, \oplus, \odot, \| \cdot \|)$ is Topological Mood Space (a type of Hilbert space) and A is a family of functions indexed by $\mathcal{M}$ denoted as $A = \{a_M\} : M \in \mathcal{M}\} = \{a_M\}_{M \in \mathcal{M}}$, for, which $\forall M \in \mathcal{M}$ it is possible to define an infinite sequence: $\langle M_n : n \in \mathbb{N} \quad M_n \in \mathcal{M} \rangle_M$ such as $\lim_{n \to \infty} M_n = M$.

Briefly, the MVS is a three dimensional space for temperament and mood representation, these space is build with different objectives:

- to compose emotions and add them to the current mood. It could be see as a translation (composition) across the 3D bounded space,
- to apply a function to represent the decay of the emotions along the time to lead character's mood to the default state (derived from the personality traits),
- and, to define a distance measure to the different Mood Space Points to assign the closest Mood Tag for the current mood to one of them.

E. EEP Engine

The EEP Engine evaluates the events perceived by the character, according to its Character Profile. As we could see on the Algorithm 1, the emotional elicitation process (EEP) is decomposed as follows:

Algorithm 1: EEP Engine Algorithm

```
Initialization: begin
    Let CP =< D, P, A, R, M*, B > the Character Profile, for a
    given Mood Space M. Where D, P, A, R are the Emotional
    Parameters, M_i* ∈ M* the different reference points with their
    corresponding mood labels l_i = label(M_i*), and B the Big Five
    personality description.
    M_0 = B5toPAD(B), initial mood state
end
//For each event, ε, that the EEP receive
Evaluation of (ε =< γ, α, ω, src, tgt >) where γ is the set
consequences of the event, α is the set actions that trigger the event
and ω is the set of objects view in the event, and src and tgt are the
source and target of the event.
begin
    E_{α_i} = scale(pad(action(α_i, P, R)), P, R), emotions of i
    actions
    E_{γ_j} = scale(pad(conseq(γ_j, D, R)), D, R), emotions of j
    consequences
    E_{α_i−γ_j} = scale(pad(attr(E_{α_i}, E_{γ_j}), R), emotions of
    attribution
    E_{ω_k} = scale(pad(object(ω_k, A)), A), emotions prompted by
    the k objects
    E_Σ = E_{α_i} ⊕ E_{γ_j} ⊕ E_{α_i−γ_j} ⊕ E_{ω_k}
    M_i = M_{i−1} ⊕ E_Σ
    return label(argmin_{M_j* ∈ M*} || M_j*, M_i ||) label of the closest
    reference point.
end
//In absence of events
Attenuation of the M_i along the time
begin
    M_{i+1} = a_{M_0}(M_i), apply the attenuation function of the MVS
    which tends to move the current mood M_i to M_0
    return label(argmin_{M_j* ∈ M*} || M_j*, M_i ||) label of the closest
    reference point.
end
```

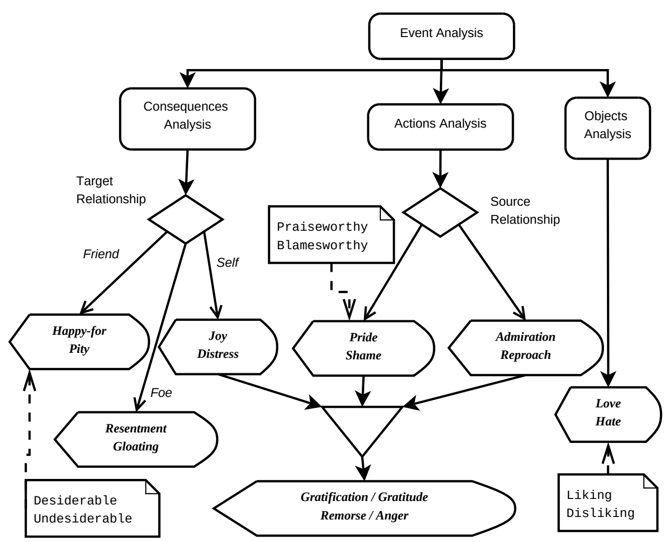

Fig. 2
EEP ENGINE EVENT ANALYSIS

1) After receiving the initial configuration of the charac-

[3]Denoted in the format of a PAD vector (P, A, D) with $P, A, D \in [-1, 1]$

ter, we initialize the current mood to its initial state M_0 applying translation function $B5toPAD(B) = M_0$, where $B \in [-1,1]^5$ (Big Five Personality Traits) and $M_0 \in \mathcal{M}$, where $\mathcal{M}$ is the MVS (equivalent to $[-1,1]^3$). We implement $B5toPAD(B)$ using to the rules proposed by [10].
2) Obtaining the emotions elicited by the event. See the Section V-E.1 for the detailed definition of the evaluation of the events, adapted from the solution proposed by [3]. Briefly the event is analyzed as follows:
   a) Evaluation of the Actions producing the Attribution emotions $E_\alpha \in \mathcal{M}$.
   b) Evaluation of the Consequences enclosing the Fortune-of-Others emotions and the Well-Being emotions, $E_\gamma \in \mathcal{M}$.
   c) Evaluation of the Compounded Emotions (Attribution+Well-Being), $E_{\alpha-\gamma}$, where $E_\alpha, E_\gamma, E_{\alpha-\gamma} \in \mathcal{M}$.
   d) Evaluation of the Objects creating the Attraction emotions E_ω.
3) Quantification of the emotions prompted by the event, according to the projection of the set of emotion tags, named $\mathcal{E}$, into the PAD space (mood space $\mathcal{M}$) as said by [10]: $\forall e \in \mathcal{E}, pad(e) = M \in \mathcal{M}$
4) Once we get the vectorial representation of the emotions on the MVS, then apply the scalar product of the contextual parameters (such, distance, relationship strength, etc.) to the M_i: $scale(\rho_1, \ldots, \rho_n, M) = \prod_{i\in[1,n]} \rho_i M \in \mathcal{M}$
5) Modification of the mood state, applying the vector that represents the composition of all of the emotions prompted by the event E_Σ to the current mood M_i.
6) The current mood label is returned as the closest reference point to M_{i+1} according to a distance function $\|\cdot\|$.

In absence of events, the current mood M_i tend to move back to the initial mood point derived by the personality M_0. It is made by applying the attenuation function a_{M_0} to the MVS elements.

1) Event Evaluation: Once an event ($\varepsilon =< \gamma, \alpha, \omega >$) is received by the EEP Engine the general sequence of evaluation begins. For all the sequence we classify the relationship among the characters as $< Self, Friend, Foe >$ describing Friend with the relationship quantified by values "> 0" and Foe in the cases of relationships "< 0".

The evaluation sequence is as follows:

1) Evaluate of the emotion produced by the Actions ($\mathcal{A}$) of the event perceived according to a set of emotion tags $\mathcal{E}$ if there are any: $actions(\alpha, p_\alpha, r) \in \mathcal{E}$, where $p_\alpha \in [-1,1]$ is the praiseworthiness of the action $\alpha \in \mathcal{A}$, and $r \in [-1,1]$ is the relationship between the perceiving character and the source of the action, and E_α is the tagged emotion produced by this action extracted from the set of emotion tags $\mathcal{E}$. The evaluation is done as explain at IV
2) Evaluation of the emotions produced by the Consequences ($\mathcal{C}$) of the event perceived: $conseq(\gamma, d_\gamma, r) \in \mathcal{E}$ where $d_\gamma \in \mathcal{C}$ is the desirability of the consequence $\gamma \in [-1,1]$. The consequences generates the emotions depicted at IV
3) When the Actions and Consequences prompt certain emotions in the mood space, the combination of these emotions produces another set of emotions, called Attribution emotions: $attr(E_\alpha, E_\gamma) \in \mathcal{E}$, where $E_\alpha, E_\gamma \in \mathcal{M}$. The combination is explained at the table IV. It takes into account the intensity of the Actions and Consequences Emotions.
4) Evaluation of the emotion produced by the Objects ($\mathcal{O}$) of the event: $object(\omega, a_\omega) \in \mathcal{E}$ where $a_\omega \in [-1,1]$ is the appealing of the object $\omega \in \mathcal{O}$. The evaluations are made according the table IV.

Values of $conseq(\gamma, d_\gamma, r)$		
Target	$d_\gamma > 0$	$d_\gamma < 0$
Self	JOY	DISTRESS
Friend	HAPPY-FOR	PITY
Foe	RESENTMENT	GLOATING

Values of $actions(\alpha, p_\alpha, r)$		
Source	$p_\alpha > 0$	$p_\alpha < 0$
Self	PRIDE	SHAME
Friend	ADMIRATION	REPROACH

Values of $attr(E_\alpha, E_\gamma)$		
	JOY	DISTRESS
PRIDE	GRATIFICATION	
SHAME		REMORSE
ADMIRATION	GRATITUDE	
REPROACH		ANGER

Values of $object(\omega, a_\omega)$	
$a_\omega > 0$	$a_\omega < 0$
LOVE	HATE

TABLE IV
OCC EMOTIONS PRODUCTION

2) PAD Quantification and Projection: According to the PAD projection of emotions described at section IV-C we transform the emotional tags provided by the event evaluation process to obtain a 3D vector that is treated as input to the Mood Vector Space. The different emotions prompted by a specific event are composed according to the restrictions of the MVS to satisfy the constraint of range, also, the application of the different parameters (as desirability, praiseworthiness, relationship strength, proximity, etc.) scales the resulting composed vector.

VI. CASE OF STUDY

To analyze the application of the EEP model in an experimental case we have crafted a set of different scenarios for the game NeverWinterNights, designing for several characters their parameters that rule their emotional behavior:

- Personality traits of the characters: We have desgined a unique personality for each character.
- Emotional parameters (for consequences, actions, objects and relationships): Most of these parameters are the same for all the characters in the scenario, or at least for those in the same group (e.g., orcs and humans).

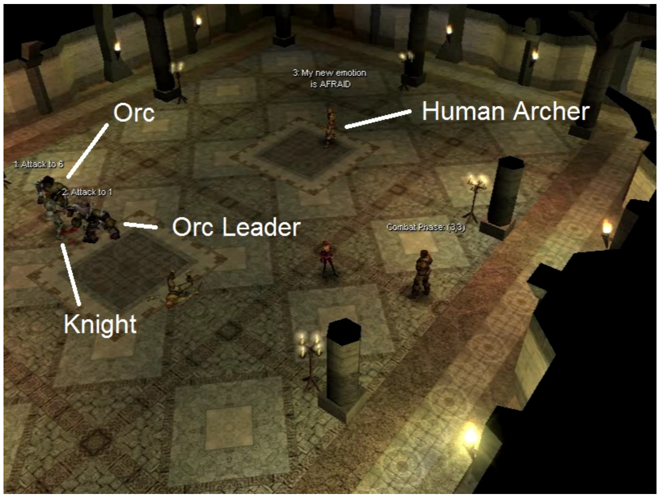

Fig. 3
SCREENSHOT OF THE INSTANT WHEN THE HUMAN ARCHER BECOMES AFRAID

- We have defined three emotional labels for the corresponding Mood Tags NORMAL, ANGRY andAFRAID states.
- For each of these emotional labels we have assigned a specific controler designed with Behavior Trees.

Besides the design of the controllers, the rest of the parameters represent a minimum configuration effort for all the characters designed for these experiments.

We are going to evaluate one of these scenarios to trace the emotional evolution of the characters according to the events occured during a combat in the game. The scenario strats as follows: "*a group of human characters (a fighter, an archer and a knight) are exploring a forbidden temple, when they encounter a gang of raging orcs defending one of the chambers in the temple, this gang is led by an orc chief who charge their warriors upon the human explorers*".

The evolution of the combat has the following main events[4]:

① The two groups are engaged in combat. One of the orcs attacks the knight and the other orc and the orc leader attack the fighter.
② The orc leader receives damages from the fighter.
③ The fighter kills one of the orcs but is slayed by the orc leader.
④ The orc leader joins the other orc in their combat with the knight.
⑤ The knight dies and the the orc warrior and the orc leader attacks the archer.

If we analyze some particular actions we have two interesting emotional responses:

- Orc Leader: Has a short-tempered personality, $BigFive = (-0.5, -0.5, 0.1, 0.3, -0.4) \Rightarrow pad(M_0) = (-0.217, -0.039, 0.035)$ in the disdainful octant according to Table II.
  1) At the instant ①, the orc leader is attacking and damages the fighter. This character has 0.5 praiseworthiness for the attacking action, that deliver the PRIDE emotion as well as a 0.6 desirability of the consequence of hitting and enemy that drives the emotion of JOY.
  2) If one action/consequence pair prompts PRIDE and JOY it also produces GRATIFICATION emotion.
  3) The combination of these emotions, together with some other action from their warriors, put the mood state in $(0.562, 0.555, 0.507)$.
  4) At the instant ②, the orc leader keeps attacking and damaging the fighter but also receives an injury. This character reaches the mood $(0.764, 0.741, 0.667)$.
  5) When reaching this mood state the point in the PAD space is closer to the ANGRY Mood Tag than to the NORMAL Mood Tag, thus the orc is enraged (changing its behavior, see round 2 in the figure 4).

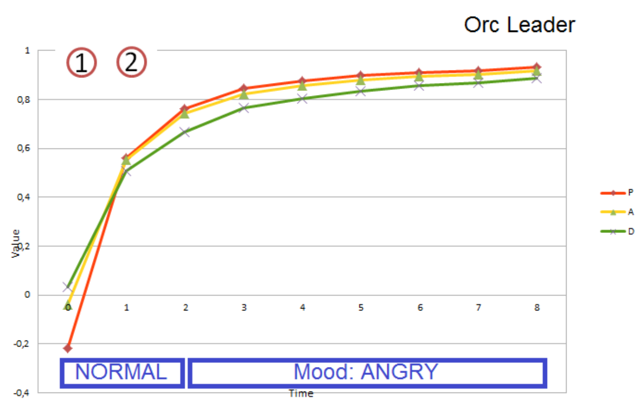

Fig. 4
ORC LEADER MOOD EVOLUTION

- Human Archer: Has a completely different personality, $BigFive = (0.5, -0.1, 0.4, -0.1, 0.4) \Rightarrow pad(M_0) = (0.360, 0.153, 0.163)$ in the exuberant octant according to Table II.
  1) The character reaches the action at the instant ② with a similar mood state $(0.342, 0.164, 0.088)$.
  2) When its fellow fighter dies (instant ③), it has a -0.8 desirability consequence of being killed, being the target a character with a 0.6 friendship relationship. It is represented by a PITY emotion.
  3) In the instant ④, the knight is receiving attacks from multiple enemies, this situation represents a combined set of emotions of PITY for its friend and RESENTMENT for the enemies. Considering that the archer has a 0.8 friendship relationship with the knight, all these emotions drop its mood state to the point $(-0.385, -0.151, -0.670)$ in the PAD space.

[4] The video and the detailed log traces of this particular scenario can be downloaded from http://www.ia.urjc.es/∼luispenya/research/eep/

4) This point in the PAD space has the Mood Space Point with the AFRAID Mood Tag as the closest label. The archer is afraid and tries to defend desperately, or even flee if possible.

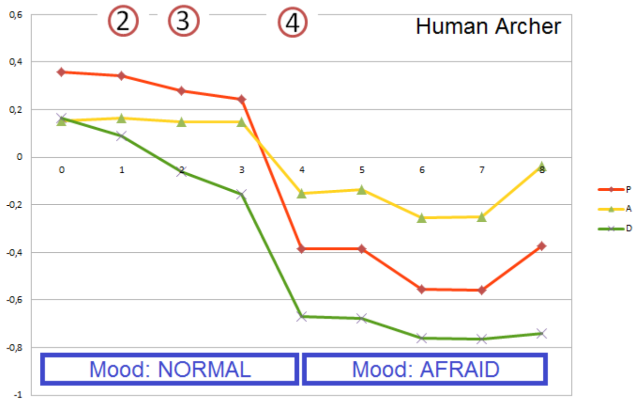

Fig. 5
HUMAN ARCHER MOOD EVOLUTION

A. Evaluation of the Scenario

As we have presented in the introduction, the ultimate objective of an emotional model is to make the players believe that the actions of the characters in the game are motivated by some kind of emotional responses. To carry out this evaluation we have consider the following method, (1) first, the trace of the actions are recorded together with the emotional state of the characters, explained as we have presented above, (2) then, a group of expert users judges if the response of the characters, according to the behavior and the description of the mood transitions are believable and match what they were expecting to happen. For the proposed scenario, 13 out of 15 expert players (86.67%), agreed that the actions of the agents were coherent and significantly better of the one usually happening in the game.

VII. CONCLUSIONS

In this paper we have presented a new model for the simulation of the synthetic emotions in a video game framework. Considering previous models for emotional agents, we have created a lightweight model that can work in parallel with the planning model (in our case to select different controllers designed with behavior trees, each of them associated to the three Mood Tags defined on this scenario). Moreover, it enriches the inputs of the controller with the mood of the character derived from the emotions.

The requirements proposed on the section III are satisfied as follows: **R1** is compliant with the architecture that sets the Event Build outside of the EEP, that derives the constructions of the consequences of events to a higher element that could have more information about the causal relations of the elements on the environment, leaving the appraisal of the events to the emotional model, **R2** is achieved using the OCC model that presents a structured analysis for events with a coherent set of emotions, **R3**, the MVS represents the formalism that provides mathematical robustness to the transitions conducted by the emotions, **R4 & R5** the definition of the Conceptual Dictionaries establishes the articulation point for the events and the analysis of them, through the application of the Character Profile, **R6** is satisfied by the existence of the transitions across the MVS, which are modeled with mathematical functions that achieve the Attenuated MVS restrictions. These functions provide the mechanisms for the dynamic adjustment of the mood with and without emotions along the time, and **R7** is carried out by the mood mapping for the values that the EEP model produces into the rest of the character cognitive mechanism, leaving the embodiment lighter and simpler for the video game designers and programmers.

Finally, the evaluation of the scenario were presented to expert gamers that judged that the behavior and reactions of the characters were improved compared with the original game.

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