

Integration of a semantic and affective model for realistic generation of emotional states in virtual characters

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Abstract

In this paper we proposed a computational model that automatically integrates a knowledge base with an affective model. The knowledge base presented as a semantic model, is used for an accurate definition of the emotional interaction of a virtual character and their environment. The affective model generates emotional states from the emotional output of the knowledge base. Visualization of emotional states is done through facial expressions automatically created using the MPEG-4 standard. In order to test the model, we designed a story that provides the events, preferences, goals, and agent's interaction, used as input for the model. As a result the emotional states obtained as output were totally coherent with the input of the model. Then, the facial expressions representing these states were evaluated by a group of persons from different academic backgrounds, proving that emotional states can be recognized in the face of the virtual character.

1. Introduction

In this work we achieve a straightforward virtual world implementation, with realistic virtual characters capable of manifest their emotional states in an interacting way. Therefore we have developed a computational model that integrates a model of knowledge (used for definition of the characters and their environment) with an affective model (used for the computation of the character's emotional states from personality and emotions values).

The result of the computational model is the emotional state of the character, visualized through their facial expression. Using the MPEG-4 Facial Animation Parameters [1] was possible to obtain realistic facial expressions for the different intensities of the emotional states.

Our research has been inspired by previous works on generation of emotions, emotional states and their facial representation. Niewiadomski and Pelachaud [13] pre-

sented a model of facial behaviour encompassing interpersonal relations for an Embodied Conversational Agent, where a variety of facial expressions (expressed, masked, inhibited, and fake expressions) were used for the first time. Kshirsagar and Magnenat-Thalmann [10] presented a layered approach for modeling personality, moods and emotions. For implementation they used Bayesian Belief Networks with conditional probability values set by intuition. Gebhard [6] proposed a layered model of affect named ALMA which integrates emotions, moods and personality in a the PAD space. Visualization of emotions was done using facial expressions, and visualization of emotional states was done using body gestures. Arellano *et al.* [3] proposed an affective model that determines the emotional state of a character according to the personality traits and the experienced emotions. These emotional states were visualized using facial expressions based on their associated emotions. Facial expressions for intermediate emotions were generated automatically from expressions for universal emotions, using the MPEG-4 standard.

In the area of semantic representation, García-Rojas *et al.* [5] proposed an ontology in order to support the modeling of emotional facial animation in virtual humans using the standard MPEG-4. The structure of the ontology specifies a facial expression defined by an archetypal or intermediate emotion profile that utilizes psychological models of emotions. The ontology allows storing, indexing, and retrieving prerecorded synthetic facial animations that express a given emotion. In [4], García-Rojas *et al.* presented an ontology that lays out the knowledge of previous work on body animation expressions within MPEG-4 framework. In Gutiérrez *et al.* [7] a semantics-based method for organizing the various types of data that constitute a virtual human is presented. Their proposed ontology depends on a two-way process: labeling graphical representations with semantic information and being able to extract semantic information from graphical representations. Lera *et al.* [8] proposed a generic knowledge model which represents the ambient and events that surround a character, his personality and pref-

erences. They also designed an algorithm that permits to obtain the emotions of a character using the elements mentioned before.

The previous work do not contemplate the whole process from eliciting emotions due to events, to the visualization of the emotional response in the face of the character. They propound particular solutions, which are used as the basis to build a new computational model presented in this paper. Our main contribution is the integration of two fields, semantic knowledge and affective computing, to represent any kind of environment with any type of affective virtual character. The implementation of this process gives the possibility to create new events and characters, or select already existent ones, and design new stories with realistic affective outputs. Another novelty is the evaluation of the emotional state in the facial expression of the character. So far the majority of the researchs evaluated facial expressions of emotions, or emotional states associated to facial expressions of emotions. In this work, emotional states due to certain events were directly associated to facial expressions. The paper is organized as follows. First we describe the semantic data model and the ontologies that compose it. Then we briefly explain how its output is used by the affective model to obtain emotional states. Using a test scenario, we show how the whole process is achieved. Finally, the results of the evaluation of the obtained expressions are discussed.

2. Semantic Model

The proposed semantic model represents a knowledge base that depicts the context that surrounds and defines the character. This context representation has been improved by using ontologies, which are the conceptualization of a domain interpretation. In this model, two ontologies have been defined.

The first ontology, *Event Ontology*, describes the environment and the events, with their actions, that surround and change the affective state of the character. This description answers the following questions: **what:** is the action, which contains a verb and the complements; **where:** represents the description of the place where the action occurs; **when:** is a period of time; **who:** represents the persons and animals that execute and/or receive the action. Figure 1 shows this ontology diagram. The **Action** of the event belongs to three categories, which are fuzzy sets, that determines the level of satisfaction of the agent: SATISFACTORY (**S**), INDIFFERENT (**IA**), NOT SATISFACTORY (**NS**). “Who” performs the action also decides the set of produced emotions, e.g. the action of *kiss* a person, or be kissed by a person can generate two different types of emotions: *fear* for being rejected by the loved one, or *happiness* for having being kissed by the loved one, respectively. Thus, emotions induced in compliance to the performer of the action (*byMe*, *onMe*, *byOther*, *onOther*) are shown in Figure 2. In this fig-

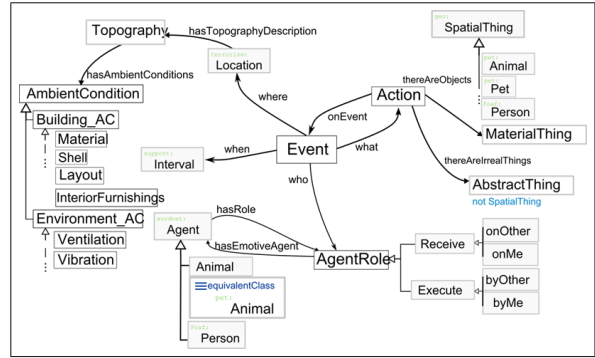


Figure 1. Event Ontology Diagram.

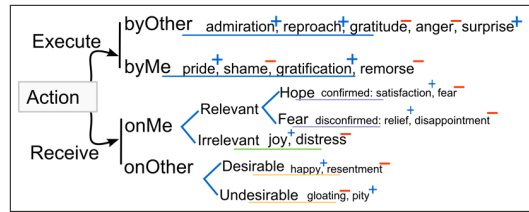


Figure 2. Categorization of Emotions.

ure, emotions with positive signs (+) are elicited by a SATISFACTORY action, emotions with negative signs (-) are elicited by a NEGATIVE action, INDIFFERENT actions do not elicit emotions at all. The list of emotions are the ones considered in the OCC model [2].

The second ontology, *Personality-Emotion Ontology*, defines the goals, preferences, personality, and emotions of the character. All this concepts are explained in Figure 3.

Starting from the top left of the Figure 3, a *Character* has *Goals* and *Preferences*. A *Goal* (Fig. 3:B), is considered as the occurrence of an event with a desirability degree. This degree will be the intensity of the triggered emotions due to the achievement of a goal. *Preferences* (Fig. 3:C) can be divided in two types: *Sporadic*, are based on motivational states (thirsty, hungry, etc.), or *Not Sporadic* which are preferences for other agents (person or animal), actions, material objects, or other things from the environment. All preferences are categorized in a class named *EmotiveScale* (Fig. 3:D) where each item is a fuzzy set, and each preference belongs to various fuzzy sets: STRONGLY-GOOD (SG), GOOD (G), INDIFFERENT (IP), BAD (B), STRONGLYBAD (SB). Each set determines the emotion to be triggered, respectively (Fig. 3:H): *Love*, *Liking*, *No emotions*, *Disliking*, *Hate/Fear*.

To define personality we have used the Five Factor Model (FFM) [11] also known as the OCEAN model: *Openness*, *Conscientiousness*, *Extraversion*, *Agreeableness*, and *Neuroticism* (Fig. 3:E). With this model, any personality can be obtained as a combination of these factors.

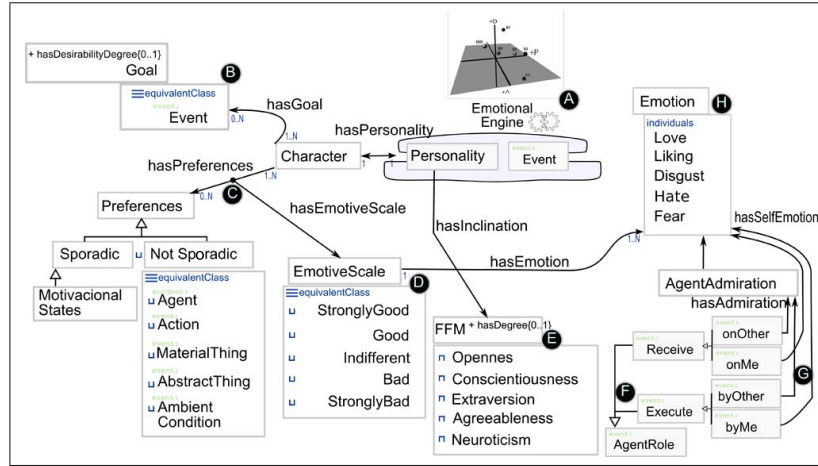


Figure 3. Personality-Emotion Ontology Diagram

The level of appreciation of one agent for another is considered in the class *AgentAdmiration* (Fig. 3:F,G). It can belong to the fuzzy sets: POSITIVE (P), INDIFFERENT (IAg) or NEGATIVE (N). Figure 2 shows the emotions elicited depending on the agent that executes or receives the actions. In this case, positive signs (+) on emotions indicate a positive feeling for the agent that receives (*onOther*) or executes (*byOther*) the action. Negative signs (-) on emotions indicate a negative feeling for the agent that receives (*onOther*) or executes (*byOther*) the action.

As a result of these two ontologies, a set of positive and negative emotions is produced. However, the intensities of these emotions will be enhanced or attenuated depending on the degree of satisfaction of the action, and the preference for an object or agent. This is done through the use of logic rules which are based on fuzzy logic theory. First, we take into consideration the correspondent fuzzy sets for the action (SATISFACTORY(S), INDIFFERENT (IA), NOTSATISFACTORY (NS)), and the fuzzy sets for preferences of an object (STRONGLYGOOD (SG), GOOD (G), INDIFFERENT (IP), BAD (B), STRONGLYBAD (SB)), or for agent admiration (POSITIVE (P), INDIFFERENT (IAg) or NEGATIVE (N)). Then we combine each given action fuzzy set with each given object preference fuzzy set, or agent admiration fuzzy set. This combination by pairs gives as result propositions P_i , which degree of membership μ_{P_i} , is the min of the degrees of membership of action sets and object preferences, or agent admiration. Then, using $\max_{\mu_{P_i}}$ we obtain the final P . Its degree of membership μ gives the exact increment or decrement of emotions. Table 1 indicates the relation between the action and the object preference, and how positive or negative emotions are incremented or decremented by the degree of membership of the final proposition μ . Table 2 indicates the relation between the action and the agent admiration, and how positive or

negative emotions are incremented or decremented by μ .

	SG	G	IP	B	SB
S	$(+\mu^2)Pos$	$(+\mu)Pos$	-	$(-\mu)Pos$	$(-\mu^2)Pos$
IA	-	-	-	-	-
NS	$(+\mu^2)Neg$	$(+\mu)Neg$	-	$(\pm\mu)Neg$	$(\pm\mu^2)Neg$

Table 1. Object - Action relationship

	P	IAg	N
S	$(+\mu)Pos$	-	$(-\mu)Pos$
IA	-	-	-
NS	$(+\mu)Neg$	-	$(\pm\mu)Neg$

Table 2. Agent - Action relationship

Finally, the resultant set of emotions serves as the input for the affective model (Fig. 3:A).

3. Affective Model

The resultant emotions of the knowledge base model are used as input for the affective model, which importance is the capability of mapping personality, emotions and emotional states parameters into the same 3D space, named PAD space. The PAD space, proposed by Mehrabian [12], distributes emotions and emotional states in eight octacts given by the axis of Pleasure, Arousability, and Dominance, as shown in Table 3. It allows to simulate the influence of personality and emotions on emotional states.

ES	Emotions
(E)xuberant (+P,+A,+D)	(B)ored (-P-A-D)
(De)pendent (+P+A-D)	(Di)sdainful (-P-A+D)
(R)elaxed (+P-A+D)	(A)nxious (-P+A-D)
(Do)cile (+P-A-D)	(H)ostile (-P+A+D)

Table 3. Emotional States (ES) in PAD space [6]

Based on the work of Gebhard [6], an emotional state (**ES**), is defined as a point with coordinates in the PAD space, where each axis $P, A, D \in [-1, 1]$. The intensity of the emotional state **ES** is the norm of the vector that goes from the origin of the space to the point that defines it. On the other hand, all elicited emotions in a certain time t , due to an event, are combined in the affective model in an *emotional center* **EC**, which is the center of mass of all these emotions. The *emotional center* is the one that induces the displacement of the emotional state.

Personality traits (FFM model) are used to compute a *default emotional state* **DES**, using a set of equations proposed by Mehrabian [12]. The *default emotional state* is considered the *normal* state of the character according to their personality. Its intensity is calculated as the norm of the vector that goes from the origin of the PAD space. Having the default emotional state **DES**, and the emotional center **EC** of the elicited emotions in time t , the *actual emotional state* **ES**(t), is calculated as the displacement of the **DES** towards the **EC**. This displacement is a fraction of the distance between both points, and it is recomputed as long as there are active emotions of time t , slowing the approachment of the emotional state to the emotional center.

As this is a dynamic model, when the character experiments new emotions, these will be affected by the *actual emotional state*. Then, the emotional state at the instant $t + 1$ will depend on the emotional state experimented at the instant t , **ES**(t), and this will affect the future emotions generating a *new emotional state*. If the emotional center of a set of emotions in time $t + 1$ and the emotional state in time t belong to the same PAD octant, the *new emotional state* will be pushed to the limits of this octant, increasing its intensity.

Finally, when no emotions are felt, or after a period of time, the character tends to return to the default emotional state. This is implemented as a *decay* function that computes the center of mass between **DES** and **ES**(t). The motivation behind this formulation is to obtain a new point in the PAD space that represents the emotional state and responds to the influence of the default emotional state and the actual emotional state. The result is that vector **ES**(t) is moved towards **DES** in the PAD space.

The output of the affective model is a facial expression of the resultant emotional state, generated automatically using the standard MPEG-4. The algorithm used for creation of facial expressions is based on the work of Arellano *et al.* [3], where emotional states were associated with expressions of emotions, classified as universal and intermediate. Facial expressions for intermediate emotions were created as a combination of two universal emotions, or as a categorization of one universal emotion.

4. Scenario - How to use this model

In this section, how to use the model and the obtained results are explained through experimentation. The experiment consisted in using the proposed computational model for simulating a series of events of a normal day of our character, and her emotional response by facial expressions. The idea was to evidence the coherence of the computational model to generate emotional states given characteristics of the character and the event; and also whether subjects are able to associate a facial expression with an emotional state, given the personality of the character and the event that produced that state.

First, a story was defined: *At 7:00 AM, Alice is ready to have breakfast. In the kitchen, she realizes that she ran out of her favorite cereals. Instead she prepares herself a bowl of oats. Later, at the university, she receives an email notifying that her paper for conference XX has been rejected. In the afternoon she meets her best friend, but they argue and got apart. An hour later, he calls her and reconcile themselves. In the evening, she gets home, and finds that her flatmates have cooked an special dinner for all of them.* From this story, 5 relevant events are pointed out: **1. Breakfast oats in her kitchen, 2. Getting email with rejection for conference, 3. Arguing with best friend, 4. Reconciliation with best friend, 5. Dinner with flatmates at home.**

We evaluated the process assigning 2 different personalities to our character, **Personality 1 (P1)** and **Personality 2 (P2)**. Personality affects only at the affective model level, and does not directly influence the generation of emotions in the ontology. Goals, preferences, action categorization, and agent admiration have been defined in 2 different ways for the same set of events, **Configuration 1 (C1)** and **Configuration 2 (C2)**. Thus, we ended up with 4 different situations (with 5 events each), and therefore, 4 different sets of emotional states for each of the 5 events (**P1-C1, P2-C1, P1-C2, P2-C2**). The process followed by the user to set all the concepts of the ontology is explained through an example definition of event **5. Dinner with flatmates at home**.

1. **Event Identification.** The user provides the data for the concepts defined in the *Event ontology* (Fig. 1). In this case, **C1** and **C2** are the same.

Configuration 1 (C1) - Configuration 2 (C2).

- (a) **Where:** Living room at home.
- (b) **When:** 21:00.
- (c) **Who:** Flatmates.
- (d) **What:** Have dinner (Action).

2. **Character Preferences and Goals definition** (Fig. 3:B,C). The user identifies the degree of preference (STRONGLYGOOD (SG), GOOD (G), INDIFFERENT (IP), BAD (B), STRONGLYBAD (SB)) of the agent for the living room, the time of day,

and the admiration (POSITIVE (P), INDIFFERENT (IAg) or NEGATIVE (N)) for the flatmates. In this case, having dinner with flatmates is a goal in **C1**.

Configuration 1 (C1).

- (a) Living room at home: $G (0.7) \cap IP (0.3)$
- (b) 21:00: $G (0.9) \cap IP (0.1)$
- (c) Flatmates: $P (0.8) \cap IAg (0.2)$
- (d) Have dinner with flatmates: Goal: Des(0.7)

Configuration 2 (C2).

- (a) Living room at home: $IP (0.3) \cap B (0.7)$
- (b) 21:00: $B (0.9) \cap IP (0.1)$
- (c) Flatmates: $N (0.8) \cap IAg (0.2)$
- (d) Have dinner with flatmates: Is not a goal

3. **Emotional Categorization of Events** (Fig. 2). The user categorizes the action of the event as SATISFACTORY(S), INDIFFERENT (IA), and NOTSATISFACTORY (NS). This categorization decides if positive or negative emotions are triggered. In **C1** the user decides that having dinner with flatmates is mainly SATISFACTORY for the agent, whereas in **C2** in NOTSATISFACTORY.

Configuration 1 (C1).

- (d) Having Dinner: $S (0.7) \cap IA (0.2) \cap NS (0.1)$.

Configuration 2 (C2).

- (d) Having Dinner: $S (0.1) \cap IA (0.2) \cap NS (0.7)$.

4. **Personality definition** (Fig. 3: E). **P1** defines a very neurotic ($N=0.99$) and very unfriendly ($A=-0.99$) character. **P2** defines a very extroverted ($E=0.99$) and very friendly ($A=0.99$) character. Only two personality traits have been considered for simplification.

4.1. Obtaining emotions

Having all the concepts defined and classified by the user, the model generates the corresponding emotions and their intensities. Three phases are distinguished:

- I. Emotions without intensities are obtained from the complete definition of the events in **C1** and **C2**. Emotions are produced by the preferences, the category of the actions, relation with other agents, and achievement of goals.
- II. Intensities of these emotions are computed. Defuzzification of preferences, actions, and relation with other agents sets, give the values for emotions. Defuzzification is done using the center of gravity method [9]. From steps I and II, the following values for emotions are obtained:

Configuration 1 (C1).

- (a) Living room at home: Liking=0.27
- (b) 21:00: Liking=0.39

(c) Flatmates: Admiration=0.38, Surprise=0.38, Joy=0.38, Satisfaction=0.38

(d) Having Dinner: Joy=0.7, Satisfaction=0.7, Pride=0.25, Gratification=0.25

Configuration 2 (C2).

(a) Living room at home: Disgust=0.27

(b) 21:00: Disgust=0.39

(c) Flatmates: Reproach=0.38, Anger=0.38, Disappointment=0.38, Distress=0.38

(d) Having Dinner: Shame=0.25, Remorse=0.25

- III. Fuzzy logic rules are used to adjust the intensities of the elicited emotions, according to the relation between the action and the agent admiration. Propositions P_i for each configurations **C1** and **C2** are:

Configuration 1 (C1)

$P_1: \min(S (0.7), P (0.8)) \Rightarrow \mu = 0.7$

$P_2: \min(S (0.7), IAg (0.2)) \Rightarrow \mu = 0.2$

$P_3: \min(IA (0.2), P (0.8)) \Rightarrow \mu = 0.2$

$P_4: \min(IA (0.2), IAg (0.2)) \Rightarrow \mu = 0.2$

$P_5: \min(NS (0.1), P (0.8)) \Rightarrow \mu = 0.1$

$P_6: \min(NS (0.1), IAg (0.2)) \Rightarrow \mu = 0.1$

Configuration 2 (C2)

$P_1: \min(S (0.1), N (0.8)) \Rightarrow \mu = 0.1$

$P_2: \min(S (0.7), IAg (0.2)) \Rightarrow \mu = 0.1$

$P_3: \min(IA (0.2), N (0.8)) \Rightarrow \mu = 0.2$

$P_4: \min(IA (0.2), IAg (0.2)) \Rightarrow \mu = 0.2$

$P_5: \min(NS (0.7), N (0.8)) \Rightarrow \mu = 0.7$

$P_6: \min(NS (0.1), IAg (0.2)) \Rightarrow \mu = 0.7$

Then applying max to all the propositions P_i obtained in **C1** and **C2**, the following final propositions P are produced:

Configuration 1 (C1)

$P = \max(P_1, P_2, P_3, P_4, P_5, P_6)$

$P: S (0.7) \cap P (0.8) \Rightarrow \mu = 0.7$

Configuration 2 (C2)

$P = \max(P_1, P_2, P_3, P_4, P_5, P_6)$

$P: S (0.7) \cap N (0.8) \Rightarrow \mu = 0.7$

Using Table 2 can be deduced that positive emotions triggered under configuration **C1** are incremented with a percentage of 0.7 (μ), and negative emotions under configuration **C2** are incremented with a percentage of 0.7 (μ).

The final set of emotions for **C1** and **C2**, are used by the computational affective model together with personalities **P1** and **P2**, to generate emotional states for each situation **P1-C1**, **P2-C1**, **P1-C2**, and **P2-C2**. Results of emotional states, which names are mentioned in Table 3, with their intensities are displayed in Table 4.

	<i>P1-C1</i>	<i>P2-C1</i>	<i>P1-C2</i>	<i>P2-C2</i>
<i>Default ES</i>	Di =0.57	E =0.5	Di =0.57	E =0.5
<i>Ev.1</i>	H =0.35	H =0.3	Di =0.18	E =0.72
<i>Decay</i>	Di =0.42	E =0.38	Di =0.47	E =0.62
<i>Ev.2</i>	B =0.26	A =0.04	H =0.3	E =0.33
<i>Ev.3</i>	B =0.77	B =0.46	Di =0.2	H =0.12
<i>Decay</i>	B =0.62	Do =0.12	Di =0.46	E =0.4
<i>Ev.4</i>	R =0.08	E =0.47	R =0.15	E =0.8
<i>Ev.5</i>	E =0.45	E =0.8	Di =0.11	E =0.15

Table 4. Results of Emotional States

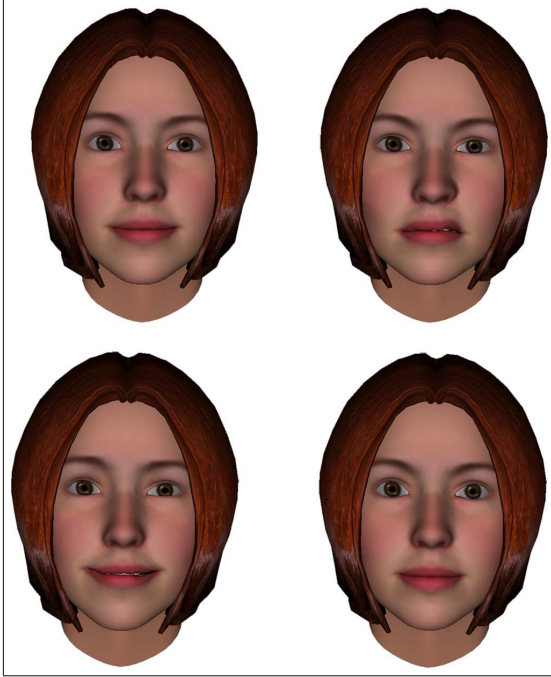


Figure 4. Event 5. Upper row: Exuberant(0.45), Disdainful(0.1). Lower row: Exuberant(0.8), Exuberant(0.15).

Facial expressions for the emotional states of each situation of event 5 (Ev.5), generated using the MPEG-4 standard, are shown in Figure 4.

4.2. Evaluation

The evaluation set consisted on 20 animations, generated using the MPEG-4 standard. Each of them corresponds to the process of changing from the previous emotional state to the actual emotional state produced by one of the five events categorized in **P1-C1** or **P2-C1**, with **P1-C2** or **P2-C2**.

The participants of the experiment were 21 persons (4 women and 17 men) between 20 and 41 years old, all from different academic backgrounds. The procedure was to show them 3 animations per event: the correct one, and two incorrect ones. Events were shown in order of occurrence. First, participants read what was the event, the personality and the emotional state of the character after the occurrence of the event. Then they observed the three animations

twice. After that, they marked in the questionnaire the animation (A1, A2, A3) they considered more appropriate to the situation.

The results of the experiment are shown in table 5. For each event with configuration **C1** or **C2**, and personality **P1** or **P2**, we counted the percentage of persons that correctly associate “situation - emotional state - facial expression”.

	<i>P1-C1</i>	<i>P2-C1</i>	<i>P1-C2</i>	<i>P2-C2</i>
Ev. 1 (%)	72	29	62	95
Ev. 2 (%)	71	52	71	76
Ev. 3 (%)	81	81	48	67
Ev. 4 (%)	76	85	76	85
Ev. 5 (%)	85	29	95	62

Table 5. Results of the evaluation

4.3. Discussion

The aim of this experiment was to demonstrate the coherence of the affective results given a definition of the character and their environment. This coherence had to be manifested through facial expressions of emotional states capable of being recognized by the users. The results are presented in Table 5. For the neurotic and disagreeable personality **P1**, all events with configuration **C1** were correctly recognized in more than 71% of the cases. For the same configuration **C1**, from the events where personality was extroverted and agreeable, **P2**, only two were correctly recognized in more than 80% of the cases. Events 1, 2 and 5 obtained low recognition rates (29%, 52%, 29% respectively). An explanation for this is that people tended to attribute smiling expressions to unpleasant events, due to the agreeable personality of the character in these cases, although correct expressions corresponded to very subtle angry ones. This lack of expressiveness in the virtual face, especially with a extroverted personality, was seen by subjects as an error and lead to wrong interpretation of the expression. Events with configuration **C2** and character with personality **P1** were correctly recognized with a percentage over 62%, except for event 3 where a considerable number of persons chose the very angry face, biased by the neurotic and disagreeable personality. Finally, events with configuration **C2** and character with personality **P2** were correctly recognized with a rate over 62%.

5. Conclusion

In conclusion, a computational model that integrates a knowledge base and an affective model for creation of realistic virtual characters and their environments was proposed. The idea was to provide the user with a tool that allows them to create from scratch, and reusing data already existent, personalized characters with all the static and dynamic elements that could surround and affect them.

Our appraisal model is based on the OCC model, which provides the knowledge to elicit different emotions according to the situation that generates them [2]. The OCC model has established itself as the standard model for emotion synthesis. Nevertheless, it lacks of some features that has been added in our model. On the one hand, the OCC model considers the evaluation of events, objects, and other agents, resulting in information of the emotions affected, their intensities, and how this new emotional state influence the current emotional category of the character. On the other hand, our model makes use of this information and with fuzzy logic and a model of personality, refines the emotional response of the character. The result is a more complete and categorized model. Scalability of this model can be addressed by the addition of new concepts in the ontology model. However, the definition of the world is extensive enough to cover all possible scenarios for a number of different applications. Population of the base knowledge might appear like an arduous work, but the idea is to achieve this task step by step, taking into consideration what usage of the computational model.

The output so far are facial expressions that manifest the emotional state after some event has been produced. Results of the evaluation with users indicated that although recognition of these emotional states is done, some personality traits as extraversion needed more distinct expressions. Also, the association of a situation with an emotional state and a facial expression is not an easy task, but a very subjective one. Subjects can be biased by one of this three parameters, especially by personality as seen in 4 out of 20 situations, which were poorly recognized. As a result, a refinement of the evaluation is needed in order to obtain more accurate results. To this end, a validated emotion measurement tool as the one proposed by Scherer should be used. The model proposed by Scherer [14], considers categories that includes a number of related emotions. Also, a reduction in the number of considered emotions must be performed according to their recognition rate to make the evaluation task simpler.

Possible applications of our computational model are virtual worlds for entertainment or for education. In the educational field, experts can define behavior rules according to the affective definition of the character, and use it as a training tool for people with difficulties expressing or recognizing emotions and emotional states.

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