A COGNITIVE MODEL FOR HUMAN BEHAVIOR SIMULATION IN EBDI VIRTUAL HUMANS

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Abstract: In this paper, we present a new cognitive model based on Psychology for simulating human behavior in realistic virtual humans. To do this, we use the Minnesota Multiphasic Personality Inventory (MMPI), taking into account the personality scales defined in it to endow the virtual humans with a real personality and form a set of fuzzy rules used to obtain the emotional influences that modify virtual humans' affective state according to their personality and the events they perceive from their environment. We also implemented an EBDI-based action selection by using an event calculus definition. This action selection mechanism allows virtual humans to perform actions based on their current emotional state, their beliefs, their desires and their intentions. These actions define virtual humans' behavior for each situation they experience in the environment. As case study, we present an scenario where a male virtual human with a psychopathic personality and a female virtual human with a hysteric personality are interacting in a real way.

1 INTRODUCTION

As human beings, our daily life is influenced at each time by stimuli received from the environment. These stimuli generate emotional influences that change our internal affective states and behavior, which give us the ability to generate an almost immediate emotional response to the different situations experienced in the real world. In Psychology, one of the most studied human characteristics that influences individuals' behavior is Personality. Personality is often defined as a set of psychological traits and mechanisms within the individual, which are organized and relatively stable over time. These psychological traits and mechanisms influence individual's interactions and adaptations to the environment intraphysical, social and physical. Psychological or personality traits are defined as forms of persistent patterns for perceiving, relating and thinking about the environment and oneself. These features distinguish a person from another, and they are reflected in individuals' behavior in a wide range of contexts such as social and personal.

In this paper, we present a behavior model based on Personality that endows virtual humans with the ability to interact and behave in their environment according to their emotional and mood states. In our approach, we use the Minnesota Multiphasic Personality Inventory (MMPI) (Tellegen et al., 2003) (Sellbom et al., 2008). This inventory is one of the most widely used personality test in the field of Psychology. The main objective of applying this test is to identifying with a high degree of reliability and accuracy both the individual's personality profile (personality traits) and the detection of his/her possible psychopathologies (emotional disorders). The 10 personality scales evaluated by the MMPI are: hypochondriasis (*Hs*), depression (*D*), hysteria (*Hy*), psychopathic deviate (*Pd*), masculinity-femininity (*MF*), paranoia (*Pa*), psychasthenia (*Pt*), schizophrenia (*Sc*), hypomania (*Ma*), and finally, social introversion (*Si*). We take into account these scales to form a set of fuzzy rules. This fuzzy set is used to obtain the emotional

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influences that modify virtual humans' affective state according to their personality and the events they perceive from their environment. We also implement an EBDI-based action selection to endow the virtual humans with the ability to behave and perform actions based on their current emotional state, beliefs, desires and intentions. These actions define virtual humans' behavior for each situation they experience in the environment.

The present work is organized in the following way: Next section presents an overview of the most important models of personality and emotion applied to intelligent agents' behavior. In third section we propose a new cognitive model based on Personality to simulate human behavior in virtual humans. Finally, in last section we will give our obtained conclusions from this work.

2 MODELS OF PERSONALITY AND EMOTION APPLIED TO BEHAVIOR OF AGENTS

Traditionally, the OCC model (Ortony et al., 1988) has been considered as the standard model for emotion synthesis and the best categorization of emotions available. In this model emotions are interpreted as reactions (positive or negative) to either consequence of events, or actions of agents, or aspects of objects. The OCC model explains human emotions and tries to predict under certain situations, which emotions can be investigated. Though this model is rather good, it does not explain completely the origin of the emotional processes and does not present how to filter mixed emotions to obtain a coherent emotional state.

On the other hand, most of the proposed personality models are based on trait theories, because the conversion from trait dimensions to an efficient computational model is very easy. These models consist of a set of dimensions, where each dimension represents a set of personality traits. The OCEAN model (Costa and McCrae, 1992) is one of the most widespread. This model groups personality traits in five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. Each dimension represents a set of specific personality traits that correlate together. Although the OCEAN model is widely accepted, it has many criticisms, because it does not exactly indicate how Personality affects the human behavior based on the obtained stimuli and experienced situations.

Searching for a better model of emotion, FLAME (Fuzzy Logic Adaptive Model of Emotions) (El-Nasr et al., 2000) is used to produce emotions and simulate the emotional intelligence process. This model is based on fuzzy rules used to explore the capability of fuzzy logic for modeling the emotional process. These fuzzy rules are used for mapping from events to emotions and from emotions to behaviors. In (Liu and Lu, 2008) is presented a computer model of motivation. This model integrates personality, motivation, emotion, behavior and stimuli together. In spite of the fact that this model shows how motivation and Personality drive a virtual character's emotion, it only gives a primary outline for a motivation model and it is restricted to be tested by a 3D facial animation system. A new framework based on Artificial Intelligence for decision making is introduced in (Iglesias and Luengo, 2007). This framework is used to produce animations of virtual avatars evolving autonomously within a 3D environment. The exposed animations in this framework are not very realistic, because the avatars follow a behavior pattern from the point of view of a human observer.

A model of individual spontaneous reactions for virtual humans is proposed in (García-Rojas et al., 2008). This model was defined by analyzing real people reacting to unexpected events. This model presents a semantic-based methodology to compose reactive animation sequences using inverse kinematics and key frame interpolation animation techniques. Nevertheless, this model was created in a subjective way in according to authors' personal judgment. In addition, the reaction types and animation sequences virtual humans perform are not validated from the point of view of psychology, but the obtained results are satisfactory. A different mechanism to add a dynamic personality and personality trait openness into agents is presented in (Ghasem-Aghaee and Oren, 2007). This work is based on the fact that personality trait openness has implications on cognitive complexity and the decision making ability of agents in problem solving. In this paper also it is implemented a fuzzy agent to show personality descriptors, personality factors, personality style and problem solving success consequently. In addition, it is showed a prototype system to demonstrate how personality trait openness affects agents' problem solving ability. Other computational model of personality with personality change is explained in (Poznanski and Thagard, 2005). This model uses a neural network for simulating personality over time and intends to be used as an application in a Sim-type video game. But, for this work it is necessary to establish a set of psychologically inspired rules to determine which situations change personality and in what ways.

Due to the direct correspondence between emotions and facial expressions (Hong, 2008), many researchers prefer to employ Ekman's six basic emotions (Ekman, 1994) (anger, disgust, fear, happiness, sadness and surprise) for facial expression classification and the OCEAN model, or else the OCC model in combination with the OCEAN model. The mutual dependence between emotions and personality is often represented by Bayesian belief networks (Ball and Breese, 2000) (Kshirsagar and Magnenat-Thalmann, 2002). Another interesting approach that describes emotions, mood, personality and their interdependencies using vector algebra is proposed in (Egges et al., 2004). Many of the revised works, which address the use of personality in the behavior of virtual creatures, make mistakes when assigning random values to the different basic personality traits. The allocation of these values cannot be supported, because the used theoretical framework does not make sense from a psychological point of view, indicating that so far none of the existing work provides an accurate and reliable mechanism for modeling human behavior. In this paper, our approach is more different because we are inspired by psychological studies about human being's personality and we use the obtained results from these studies to endow virtual humans with a realistic personality, which allows them to behave in a more intelligent way in their environment in according to their affective state, beliefs, desires and intentions.

3 COGNITIVE MODEL FOR HUMAN BEHAVIOR SIMULATION

In order to generate a better behavior model for virtual humans, in this work we apply the main ideas expressed by Paul D. MacLean in his model triune brain (MacLean, 1973). Thus, we propose a new model of three interrelated layers to generate behaviors influenced by Personality. A brief view of the operating cycle of our model is the following (see figure 1): the virtual human obtains information and stimuli from its environment through sensors. Thus, based on its personality and its perception, it interprets them to decide whether it has perceived an event that catches its attention. Thus, once an event has been perceived, this is processed unconsciously generating an emotional response and an instinctive reaction that can be of two types: the first one is a reflex reaction (for example when we touch a hot object with the hand our reaction is immediately withdraw it without having previously thought) and the second one is an instinctive reaction of protection (for example, when somebody suddenly throws us an object, our reaction is to avoid the blow that can cause us the object). Immediately in parallel to the generated emotional response and instinctive reaction, the virtual human becomes aware of the perceived event and it searches for an explanation by looking for information from its beliefs and its long and short term memory. Once the virtual human collects the necessary information, it shows a behavior consistent with its personality. In this way and based on its desires and intentions, the virtual human executes actions that it deems the most appropriate to the situation. Finally, the virtual human is capable of evaluating the obtained results from its exhibited behavior and learns about them.

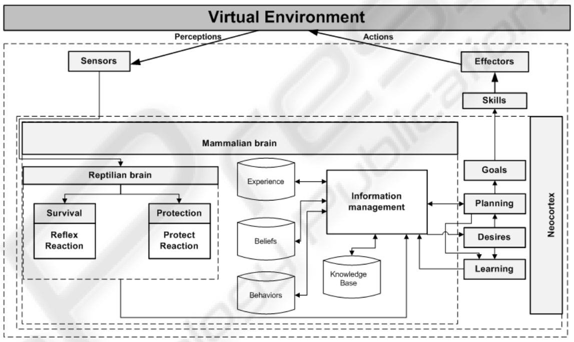

Figure 1: Cognitive model for human behavior simulation in EBDI virtual humans.

3.1 Fuzzy Rules for Generating an Emotional Influence

We use a fuzzy rule-based model composed by a set of if-then rules. This set of rules is used to generate the emotional influence that changes virtual humans' emotional and mood states according to their personality and the events they perceive from the environment. We use fuzzy logic, because the perceived events, the emotional influence (a six-dimensional vector with corresponding values for each of the six basic emotions) and the personality have fuzzy limits. This permits changing virtual humans' emotional and mood states in a more natural manner, generating more realistic behaviors. We use a set of input variables corresponding to each personality scale, for these scales we define five fuzzy sets: *very_low, low, medium, high*, and *very_high*. An event is represented with an input variable, which has seven defined fuzzy sets: *negative_high, negative_medium, negative_low, neutral, positive_low, positive_medium*, and, *positive_high*. The impact of an event over each emotion in the emotional influence vector is described by the following fuzzy sets *negative_very_high, negative_high, negative_medium, negative_low, neg-*

ative_very_low, *neutral*, *positive_very_low*, *positive_low*, *positive_medium*, *positive_high*, and, *positive_very_high*.

In order to obtain the emotional influence vector, we used jFuzzyLogic (Cingolani, 2009), which is a java package that offers a complete fuzzy inference system (FIS). This package implements a fuzzy control language specification according to IEC 1131-7 (IEC 1131, 1997). We defined in this language the input and output variables and the set of fuzzy rules used to obtain the emotional influence. For example, some representative fuzzy rules written in FCL for the Hy (hysteria) personality scale are: *IF Hy IS high AND event IS positive_high THEN anger IS negative_high, disgust IS negative_medium, fear IS negative_low, happiness IS positive_low, sadness IS negative_low, surprise IS positive_low* and *IF Hy IS very_high AND event IS negative_low THEN anger IS positive_medium, disgust IS positive_low, fear IS positive_very_low, happiness IS negative_very_low, sadness IS positive_low, surprise IS negative_very_low*.

As example, figure 2 shows the defined fuzzy sets for the variables Hy (hysteria), event, and anger, respectively.

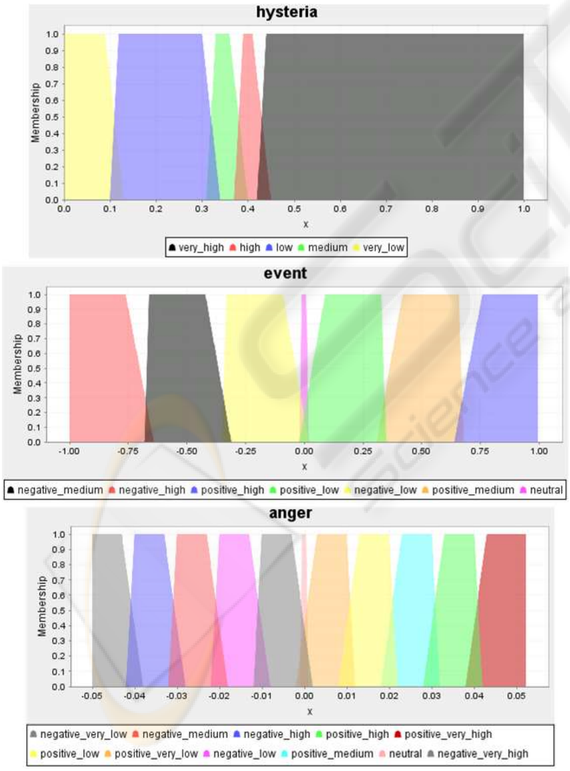

Figure 2: Defined fuzzy sets for the variables Hy (hysteria), event and anger.

3.2 Affective State Update

We propose a process to update virtual humans' emotional and mood state by using the 10 personality scales defined by the MMPI, the six Ekman's basic emotions (anger, disgust, fear, happiness, sadness and surprise) and three basic moods (good, neutral and bad). For this matter, we consider the virtual humans as entities with a constant personality and a dynamic behavior, which is constantly changing over time t. Therefore, the virtual humans' personality p is initialized with a set of constant values at time $t = 0$, and their emotional and mood states, e_t and m_t respectively, are dynamic over time and these are initialized to 0 at time $t = 0$. We formalize these concepts as follows:

$$p^T = [Hs, D, Hy, Pd, MF, Pa, Pt, Sc, Ma, Si], \quad Hs, D, Hy, Pd, MF, Pa, Pt, Sc, Ma, Si \in [0,1] \tag{1}$$

Where *Hs* (hypochondriasis), *D* (depression), *Hy* (hysteria), *Pd* (psychopathic deviate), *MF* (masculinity/femininity), *Pa* (paranoia), *Pt* (psychasthenia), *Sc* (schizophrenia), *Ma* (hypomania), and *Si* (social introversion), are the 10 personality scales defined by the MMPI.

Emotional state e_t represents the intensities of the six Ekman's basic emotions at each time t. These emotions are labeled as: *an* (anger), *di* (disgust), *fe* (fear) *ha* (happiness), *sa* (sadness), and *su* (surprise) in a 6-dimensional vector in the following way:

$$e_t^T = \begin{cases} [an, di, fe, ha, sa, su] & \text{if } t > 0 \\ 0 & \text{if } t = 0 \\ an, di, fe, ha, sa, su \in [-1,1] & \end{cases} \tag{2}$$

In a similar way, the mood state m_t represents the intensities of three basic moods at each time t. These moods are labeled as: *gd* (good), *nl* (neutral) and *bd* (bad) in a 3-dimensional vector:

$$m_t^T = \begin{cases} [gd, nl, bd], gd, nl, bd \in [-1,1] & \text{if } t > 0 \\ 0 & \text{if } t = 0 \end{cases} \tag{3}$$

We also use an emotional history ω_t and a mood history σ_t, which contain the emotional states e_0 until e_t and the mood states m_0 until m_t, respectively. The next step is to update the emotional and mood states. To do this, we use an emotional influence vector a, which is obtained by applying the fuzzy rules defined above. This vector contains a desired change of intensity for each of the six basic emotions. Thus, when a virtual human has assessed the emotional influence, the emotional and mood states are updated in two steps. The first step consists in updating the emotional state. The second step consists of updating the mood state. The emotional state is updated taking into account the last mood as follows:

$$e_{t+1} = e_t + \Psi_e(p, \sigma_t, a) + \Omega_e(p, \omega_t, \sigma_t) \qquad (4)$$

We define a 6×10 *Personality-Emotion Influence Matrix* P_0 (how personality influence emotions). This matrix is defined once and it is multiplied with the vector p to obtain a new vector u. We use this vector to construct a diagonal matrix P (how strong an emotion can be given a personality). Thus, we compute a 6×3 *Mood-Emotion Influence Matrix* T (how moods influence emotions) that is multiplied with the current mood m_t to obtain the mood influence on the final emotional state. Thus, we obtain the following definition for the function Ψ_e:

$$\Psi_e(p, \sigma_t, a) = P \cdot a + T \cdot m_t \qquad (5)$$

Finally, the function for emotion decay Ω_e is defined as a 6-dimensional vector. This vector contains the amount of decrement or increment desired for each of the six basic emotions. In our case, we use 0.03 to increase the intensity of an emotion or -0.03 to decrease its intensity. The mood state is updated by a function that calculates the mood change based on the new emotional state:

$$m_{t+1} = m_t + \Psi_m(p, \omega_{t+1}, \sigma_t, a) + \Omega_m(p, \omega_{t+1}, \sigma_t) \qquad (6)$$

We use a 3×6 *Emotion-Mood Influence Matrix* Q, which defines the relation between emotions and each mood dimension. The influence of vector a on the mood is calculated by $Q \times a$. Similarly to the emotion update, using the personality, we now also define a 3×10 *Personality-Mood Influence Matrix* R (how personality influences each mood dimension). This matrix is also defined once and it is multiplied with the vector p to obtain a new vector v. We use this new vector to construct a diagonal matrix R. So, we give the following definition for the function Ψ_m:

$$\Psi_m(p, \sigma_t, a) = R_0 \cdot Q \cdot a \qquad (7)$$

Finally, the function for emotion decay Ω_m is defined as a 3-dimensional vector. This vector contains the amount of increment or decrement desired for each of the three moods. In our case, the desired values to increase the good mood normally are 0.03 for the good value, 0.1 for the neutral value, and -0.3 for the bad value. The desired values to increase the bad mood are -0.03 for the good value, 0.1 for the neutral value, and 0.3 for the bad value.

3.3 EBDI-based Action Selection

We use an EBDI (Emotion-Belief-Desire-Intention) architecture similar to those presented in (Georgeff et al., 1999) (Jiang et al., 2007) (Pereira et al., 2008), but we add time constraints to choose the actions a virtual human should perform according to external and internal events, and how these change virtual human's affective state considering time. For this matter, we use Event Calculus, which is a temporal formalism that allows reasoning about events and the time when these occur (Kowalski and Sergot, 1986). We selected this formalism by its intuitive definition of events. Next, we present the list of the event calculus predicates used to formalized our approach:

- *Initiates(e(), f, t)*: Fluent f holds, after event e() is perceived at time t.
- *Terminates(e(), f, t)*: Fluent f does not hold, after event e() is perceived at time t.
- *HoldsAt(f, t)*: Fluent f holds at time t.
- *Happens(e(), t)*: Event e() is perceived at time t.
- *InitiallyP(f)*: Fluent f holds from t = 0.

For a detailed definition of the axioms that rule these predicates see (Shanahan, 1999).

A fluent is a variable that can change over time. We use boolean fluents. We consider the following three sets of boolean fluents:

1. A set of emotions, which consists of the six emotions: anger (an), disgust (di), fear (fe), happiness (ha), sadness (sa), and surprise (su);
2. A set of beliefs, which are agents' assumptions about the state of the world and agents possible skills;
3. A set of desires, which are agents' goals.

The above is formalized as follows:

$$E = \{an, di, fe, ha, sa, su\} \qquad (8)$$

$$B = \{b_1, b_2, \cdots, b_i\} \qquad (9)$$

$$D = \{d_1, d_2, \cdots, d_j\} \qquad (10)$$

$$Fluents = E \cup B \cup D \qquad (11)$$

We assume that agents have a set of initial beliefs (IB) and initial desires (ID), which are treated in the following way:

$$IB \subseteq B, \forall f \in IB : InitiallyP(f) \qquad (12)$$

$$ID \subseteq D, \forall f \in ID : InitiallyP(f) \qquad (13)$$

The set of intentions $I = \{intention_1, intention_2, \cdots, intention_n\}$ represents all the possible plans agents select in order to follow a given course of action to achieve a goal, according to agents' emotional state and beliefs.

An intention is defined as follows:

$$intention = \{Happens(e_1(), t_1) \wedge Happens(e_2(), t_2) \wedge \cdots \wedge Happens(e_m(), t_n) \wedge\ t_1 < t_2 < \cdots < t_n\} \quad (14)$$

The events that happen in the virtual humans' environment can be either internal events (IE) and external events (EE); internal events when they refers to actions perform by virtual humans in the achievement of goals; and external events when the virtual human perceives a change in the environment. These are denoted as follows:

$$IE = \{ie_1(), ie_2(), \cdots, ie_r()\} \quad (15)$$

$$EE = \{ee_1(), ee_2(), \cdots, ee_s()\} \quad (16)$$

$$Events = IE \cup EE \quad (17)$$

In addition, we consider that agent's beliefs with respect to the actions it can perform, cannot be accomplished, for example, an agent believes that it can swim in certain conditions, however when it attempts swimming, it realizes that such belief is not truth, and then its beliefs must be updated. This update process is achieved in the following way:

$$\begin{aligned} HoldsAt(b_1,t) \wedge HoldsAt(b_2,t) \\ \wedge \cdots \wedge HoldsAt(b_i,t) \\ \wedge Initiates(e(), d_j, t) \\ \leftarrow Happens(e(),t) \wedge HoldsAt(emotion_1,t) \\ \wedge HoldsAt(emotion_2,t) \\ \wedge \cdots \wedge HoldsAt(emotion_k,t) \end{aligned} \quad (18)$$

$$\begin{aligned} Happens(e_1(), t_1) \wedge Happens(e_2(), t_2) \\ \wedge \cdots \wedge Happens(e_m(), t_n) \\ \wedge t_1 < t_2 < \cdots < t_n \leftarrow HoldsAt(d_j, t) \end{aligned} \quad (19)$$

$$\begin{aligned} Happens(e_1(), t_1) \wedge Happens(e_2(), t_2) \\ \wedge \cdots \wedge Happens(e_m(), t_n) \wedge\ t_1 < t_2 < \cdots < t_n \\ \wedge Terminates(e_H fails(), b_i, t_w) \\ \leftarrow Happens(e_H fails(), t_w) \\ \wedge HoldsAt(emotion_1, t_w) \\ \wedge HoldsAt(emotion_2, t_w) \\ \wedge \cdots \wedge HoldsAt(emotion_k, t_w) \end{aligned} \quad (20)$$

$$Terminates(e_m(), d_j, t_n) \leftarrow Happens(e_m(), t_n) \quad (21)$$

Where, $emotion_k \in E$, $b_i \in B$, $e_m() \in Events$, and $d_j \in D$.

In equation 18, certain emotions hold and an event is perceived at time t; then a certain desire d_j is initiated if a set of beliefs holds at the same time t. The initiation of desire d_j activates a set of possible course of actions in order to achieve d_j, this is expressed in equation 19. Next, if there is failure in the execution of the plan (denoted by $Happens(e_H fails(), t_w)$), then another plan is selected according to the current predominant emotion $emotion_K$ (see equation 20). Now, whenever the last action of any plan is successfully performed, desire d_j is removed from agent's desires, because it was achieved (see equation 21).

4 CASE STUDY

We present as case study a situation where there are two virtual humans, a woman and a man interacting in a virtual environment. Woman has a hysteric personality and man has a psychopathic personality. Figure 3 shows the study case. We assume that the virtual humans have the following beliefs and desires:

- Male virtual human's beliefs: IamASilentWalker and WomanIsDistracted.
- Female virtual human's beliefs: IamCalm and IHaveNothingToDo.

In the male virtual human side, we have the following plan definition:

$$\begin{aligned} HoldsAt(WomanIsDistracted, t) \\ \wedge HoldsAt(IamASilentWalker, t) \\ \wedge Initiates(WalkToWoman(), ScareWoman, t) \\ \leftarrow Happens(WalkToWoman(), t) \\ \wedge HoldsAt(happiness, t) \end{aligned} \quad (22)$$

Once the male virtual human adopts a desire, it computes a plan to release the desire (see figure 3.a, 3.b and 3.c).

$$\begin{aligned} Happens(WalkToWoman, t_1) \\ \wedge Happens(ScreamToWoman, t_2) \wedge t_1 < t_2 \\ \leftarrow HoldsAt(ScareWoman, t) \end{aligned} \quad (23)$$

Now, in the female virtual human side (see figure 3.a, 3.b and 3.c), the behavior is specified as follows:

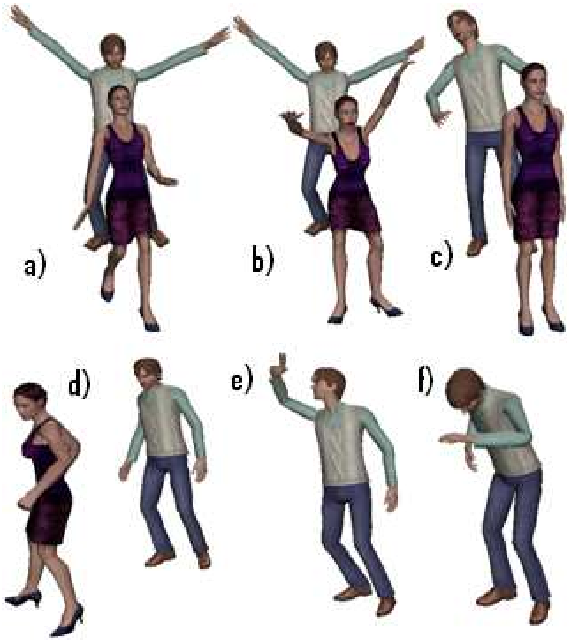

Figure 3: Exposed behavior by virtual humans according to their personality and the events they perceive.

$$\begin{aligned} & HoldsAt(IhaveNothingToDo, t) \\ & \wedge HoldsAt(IamCalm, t) \\ & \wedge Initiates(Wandering(), FeelTheWind, t) \\ & \leftarrow Happens(Wandering(), t) \\ & \wedge HoldsAt(Happiness, t) \end{aligned} \tag{24}$$

Once the male virtual human frustrates female virtual human desires of *feel the wind*, the female creates a new plan and updates some beliefs (see figure 3.d). This is shown next:

$$\begin{aligned} & Happens(Jump(), t_1) \wedge Happens(Scream(), t_2) \\ & \wedge Happens(GetAway(), t_3) \wedge \ t_1 < t_2 < t_3 \\ & \wedge Terminates(MaleScareHer(), IamCalm, t) \\ & \leftarrow Happens(MaleScareHer(), t) \\ & \wedge HoldsAt(Happiness, t) \end{aligned} \tag{25}$$

Then, the male reacts according to the events perceived (see figure 3.d, 3.e and 3.f):

$$\begin{aligned} & Happens(LaughtAtHer(), t_1) \\ & \wedge Happens(SayGoodByeHer(), t_2) \wedge \ t_1 < t_2 < t_3 \\ & \wedge Terminates(GetAway(), WomanIsDistracted, t) \\ & \leftarrow Happens(GetAway(), t) \\ & \wedge HoldsAt(Happiness, t) \end{aligned} \tag{26}$$

This simple scenario showed how simple is to model virtual human behavior based on EBDI by using event calculus.

5 CONCLUSIONS

In this paper, we presented a behavior model for realistic virtual humans. This model is valid from a psychological point of view, because it is supported by studies on Personality and the resources provided by them. With the use and interpretation of MMPI, we implemented a real behavior model for virtual humans, because we do not simulate predefined actions, but we consider all possible reactions for each personality scale defined by MMPI, according to perceived events from the environment. With this, virtual humans are able to behave in different ways to the same perceived events based on their personality and affective state. We also have implemented an EBDI-based intention selection using the Event Calculus formalism. This intention selection mechanism allows virtual humans to perform actions based on their current emotional state, beliefs, desires and intentions. Thus, these intentions are used to define virtual humans' behavior for each situation they experience in the environment according to their personality and the events they perceive.

6 FUTURE WORK

As continuation of our work we are creating and implementing a complete fuzzy model that will be used to update virtual humans' mood and emotional state in a more natural and efficient way. We are working on defining different fuzzy sets and fuzzy rules to update and regulate virtual humans' affective state according to their personality, emotional history and mood history, taking into account the level of intensity of perceived events from their environment. With this new fuzzy model, we will completely replace the matrix model that was described above. Finally, we also are working on applying the principles of Emotional Intelligence Model (Goleman, 1995) to endow virtual humans with an emotional intelligence that allows them to perceive and express emotions, assimilate emotion-related feelings, understand and reason with emotion, and regulate emotions in themselves and other virtual entities. To implement this intelligence, we intent to use the Emotional Competence Framework (Mayer et al., 2000) defined in the Emotional Intelligence Model. With this framework, we will develop virtual humans' personal and social competencies on the basis of the following characteristics: Personal Competencies such as self-consciousness, self-regulation and self-motivation, and Social Competencies such as social awareness and social skills.

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