ALMA – A Layered Model of Affect

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ABSTRACT

In this paper we introduce ALMA – A Layered Model of Affect. It integrates three major affective characteristics: emotions, moods and personality that cover short, medium, and long term affect. The use of this model consists of two phases: In the preparation phase appraisal rules and personality profiles for characters must be specified with the help of AffectML – our XML based affect modeling language. In the runtime phase, the specified appraisal rules are used to compute real-time emotions and moods as results of a subjective appraisal of relevant input. The computed affective characteristics are represented in AffectML and can be processed by sub-sequent modules that control the cognitive processes and physical behavior of embodied conversational characters. ALMA is part of the VirtualHuman project which develops interactive virtual characters that serve as dialog partners with human-like conversational skills. ALMA provides our virtual humans with a personality profile and with real-time emotions and moods. These are used by the multimodal behavior generation module to enrich the lifelike and believable qualities.

Categories and Subject Descriptors

I.2.0 [**General**] (cognitive simulation)
H.1.2 [**User/Machine Systems**]

General Terms

Algorithms, Human Factors, Theory

Keywords

Simulation of Affect, Personality, Mood, Emotion, Embodied Conversational Characters

1. INTRODUCTION

The examination of different software in various application areas reveals that virtual characters and especially embodied conversational characters get more and more used to provide users with a more human-like interface. Popular application areas for virtual characters are virtual training environments [1], portable personal guides [2], interactive fiction [3], storytelling systems [4], as well as e-commerce applications [5], and in interfaces of consumer electronics [6].

At the early stages of employing conversational characters in applications, a common understanding was that characters engage in a face-to-face conversation style with the user. In order to increase the believability of the virtual conversation partner, researchers have begun to address the modeling and emulation of human-like qualities such as personality and affective behavior. Examples of emotional characters include COSMO [7], Émile [8], Peedy [9], and the Greta agent [10]. In these systems emotion modeling has been inspired by the so-called OCC model developed by Ortony, Clore, and Collins [11], although the approaches differ in the granularity of modeling, the mathematical machinery for computing emotions, and in the way of how the model has been implemented on a technical level.

As a next step, systems with multiple characters have also been proposed by others. Earlier approaches, such as Gilbert & George [12], Mr. Bengo [13], Inhibited Market Places [14, 15] and Virtual Human Team Training [16]. However, they do not explicitly model affective states in their characters. In contrast to these approaches, a few research groups have started to address emotion modeling in multi-character scenarios. In the context of a military mission rehearsal application Traum and Rickel [17] address dialog management comprising human-character and character-character dialogs in immersive virtual environments. Prendinger et. al. [18] developed a framework for scripting presentations with multiple affective characters in a web-based environment. Part of their work is the SCREAM system that computes affective states based on the OCC-model but also considers aspects of the social context, i.e. role and status of the characters.

During the last years our group has explored the simulation of conversations among animated agents as a new style to present information to a user. A shift from settings with single presentation agents towards the use of presentation teams bears a number of advantages: They enrich the repertoire of modalities to convey information and they can serve as a rhetorical device to reinforce beliefs.

Following the motivations of other researcher to enhance the believability of our virtual characters, we have started to incorporate personality and affective states to extend a character's conversational and social repertoire. We use affective states to color simulated dialogs and through verbal and non-verbal expression of emotions [19]. Focusing on multi-party conversations (rather than performing physical actions), emotions can be used in the dialog generation processes to inform the selection of dialog strategies and linguistic style strategies as proposed by [20]. They also play an important role in the turn-taking behavior (e.g. a spontaneous barge-in may result from an intensive emotion) and in the realization of concrete dialog moves.

To enhance our underlying model of affect, we focus on the fact that different kinds of affect influence different aspects of behavior in humans. For instance, Davidson points out that „emotions bias action, whereas moods bias cognition"[21]. In comparison, personality can be understood as a general affective framework of individuals that interferes with all other kind of affect, like emotion and mood [22].

In this paper, we introduce a layered model of affect called ALMA, which provides three distinct affect types: emotions as short-term affect, moods as medium-term-affect, and personality as long-term affect. Following our understanding of affect, each temporal characteristic of affect is related to specific tasks, or functions which influence the human behavior. ALMA serves as a testbed to easily adopt psychological results of human behavior analysis for embodied virtual characters.

2. THE VIRTUAL HUMAN PROJECT

The VirtualHuman research project [23] aims at the development of concepts and techniques for human-like conversational characters. This is realized by the combination of state-of-the-art computer graphics technology [24] with multimodal dialog generation, which has been developed in the SmartKom [25] system. In VirtualHuman, the multimode dialog generation is extended by the affect generation module to produce a more human-like behavior.

Figure 1: Screenshot of the VirtualHuman system.

The VirtualHuman system was first presented to the general public at the CeBIT convention 2004. The system provides students a new interactive experience by offering a virtual learning displaying human-like sized characters in a 3d environment (see Figure 1). The idea was to provide the user with a group learning experience where the human student acquires new knowledge together with the virtual student Sven and the virtual teacher Valerie. Her main task is to provide information about the subject of the lesson – the life and death of a star. In addition, Valerie asks questions about the recently conveyed information. Sven should support the human student by giving hints to questions. Both, the human student and Sven compete with each other in answering questions. The more intelligent Sven is defined the faster he gives answers, which makes it more difficult for the human student giving a correct answer in time. Answers are given through a multiple choice field or by spoken input.

At the beginning, a third character that plays the role of a virtual moderator offers to specify the personality profile of the virtual student and the virtual teacher. The personality profile defines their general behavior. Valerie's personality parameters are: severe versus tolerant and dry versus flowery which influence the wording of her explanations and her conversational gestures. Sven's personality parameters are: ambitious versus lazy. They define the amount of time after that Sven gives an answer, but also influence the quality of his answers. During runtime, each dialog contribution – including the spoken or typed input of the human student – is appraised by each character's affect generation module, which then alters the character's affective state. Based on that state, the facial expressions, the wording, idle behavior and gestures of the virtual humans are generated.

3. A LAYERED MODEL OF AFFECT

As pointed out in the introduction emotions successfully help controlling behavior aspects of virtual characters. Using emotions as abstract information for sub-sequent modules that manage the cognitive processes and non-verbal and verbal behavior of embodied conversational characters may not be sufficient. Especially when considering the fact, that emotions – in our understanding – are short-term affect. Behavior aspects that changes over a long period of time can not be successfully controllable by them directly. Finally, this may lead to a less believable behavior, because of unnatural changes.

- Before proposing what other information can be used to facilitate and enhance the mentioned issue, it is essential to know, which behavior aspects should be taken into account:
- Verbal and non-verbal expressions: wording, length of phrases, speech parameters, facial expressions, conversational gestures, special gestures, posture changes, general idle behavior (e.g. eye blink, breathing)
- Cognitive processes: making decisions, motivation, appraisal

When analyzing them according their temporal characteristics, there are short-term behavior aspects, like facial expressions, gestures, or the wording of verbal expression. Also, there are medium-term and long-term aspects, like the process of making decisions, or the motivation of characters. And there are behavior aspects that consist of mixed-term aspects, like a character's idle behavior that includes for example eye blink (short-term) and posture-changes (medium-term). Using different kind of affects, which differ in their temporal characteristics that can be related to behavior aspects, should fulfill the above requirements.

An approach is our layered model of affect, called ALMA that simulates three interacting kind of affect as they occur in human beings:

1. *Emotions* reflect short-term affect, which is usually bound to a specific event, action or object, which is the cause of this emotion. After its elicitation emotions usually decay and disappear of the individual's focus [22].
2. *Moods* reflect medium-term affect, which is generally not related with a concrete event, action or object. Moods are longer lasting stable affective states, which have a great influence on human's cognitive functions [26]. According to [26, S. 24f.] conditions for mood changes can be divided into (a) the onset of a mildly positive or negative event, (b) the offset of an emotion-inducing event, (c) the recollection or imagining of emotional experience, and (d) the inhibition of emotional responding in the presence of an emotion-inducing event.
3. *Personality* reflects long-term affect. Personality reflects individual differences in mental characteristics. A common personality schema is the Big Five model of personality [27]. It specifies the general (affective) behavior by the traits openness, conscientiousness, extraversion, agreeableness and neuroticism.

When using this three affect categories for controlling the above described behavior aspects, it has to be defined how each kind of affect will be computed and how they interact with each other.

Our work based on the EmotionEngine described in [19, 20]. It implements the OCC model of emotions [11] combined with the five factor model of personality [27]. The personality trait information is used to control the computation of emotions' intensities. OCC is a cognitive model of emotions, and is essentially based on the concepts of appraisal and intensity. The individual is said to make a cognitive appraisal of the current state of the world. Emotions are defined as valenced reactions to events of concern to an individual, actions of those s/he consider responsible for such actions, and objects/persons. The intensity of emotions underlies a natural decay, which can be configured by several decay functions. We enhanced the EmotionEngine's underlying model of affect by a model of moods as medium-term affect relying on the mood (or temperament) model proposed by Mehrabian [28]. This model defines mood as "an average of a person's emotional states across a representative variety of life situations. Mood is distinguished from emotions in that it reflects an individual's stable or longer lasting affective state. Mehrabian describes mood with the three traits pleasure (P), arousal (A), and dominance (D). The three traits are nearly independent, and form a three dimensional mood space. The implementation of the PAD mood space uses axes ranges from -1.0 to 1.0 for each dimension. Mood is described with the following classification of each of the three mood space axis: +P and –P for pleasant and unpleasant, +A and –A for aroused and unaroused, and +D and –D for dominant and submissive. With this classification all octants of the PAD mood space are described by Table 1.

Table 1: Mood octants of the PAD space.

+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	**Hostile**

A mood octant stands for a discrete description for a mood, which is defined by three trait values pleasure, arousal, and dominance. For example, a person's discrete mood description is relaxed, if the value of the trait pleasure is positive, the value of the trait arousal is negative, and the value of the trait dominance is positive. We define the strength of a current mood by its distance to the zero point of the PAD mood space (algebraically: the norm of the PAD vector). While using a three dimensional space with maximum absolute values of 1.0, the longest distance in a mood octant is $\sqrt{3}$. To use no numbers for describing strength, we divide the longest distance into three parts and call them: slightly, moderate, and fully. If, for example, the mood of a person has the values: 0.25 pleasure, -0.18 arousal, 0.12 dominance, its discrete mood description is slightly relaxed. A mood represents a point in the PDA space.

When starting medium-term affect computation, it is essential to define an individual default mood for all characters, as a mood start value. A reliable mapping presented in [29] defines a relationship between the big five personality traits and the PAD space. Using this mapping, the EmotionEngine, which uses the big five personality model to define a characters personality, is thereby able to compute a default mood for characters:

Pleasure := 0.21•Extraversion + 0.59•Agreeableness + 0.19•Neuroticism

Arousal := 0.15•Openness + 0.30•Agreeableness - 0.57•Neuroticism

Dominance := 0.25•Openness + 0.17•Conscientiousness + 0.60•Extraversion - 0.32•Agreeableness

Using this mapping a person, whose personality is defined with the following big five personality traits: openness=0.4, conscientiousness=0.8, extraversion=0.6, agreeableness=0.3, and neuroticism=0.4 has the default mood slightly relaxed (pleasure=0.38, arousal=-0.08, dominance=0.50).

A more challenging task is the simulation of human-like mood changes. As mentioned above, [26] has identified four conditions that can change mood in humans. To leave the modeling of mood changes as lean as possible, we take emotions as the mood changing factor. In order to realize this, emotions must be somehow related to a character's mood. While using the PAD space for modeling mood, it is obvious to put emotions in relation to the PDA space too. There are mappings for emotions into the PAD (or comparable) 3 dimensional affect space [29], which can be used for this purpose. However, not for all 24 emotion types provided by the EmotionEngine exist a mapping into the PAD space. Those that lack a mapping we carefully provide the missing pleasure, arousal, and dominance values by exploiting similarities to comparable emotion types. Table 2 shows the mapping we currently rely on.

Our approach to human-like simulation of mood changes relies on a functional approach. We concentrate on how the intensity of emotions influences the change of the current mood and we consider the aspect that a person's mood gets the more intense the more experiences the person make that are supporting this mood. For example, if a person's mood can be described as slightly anxious and several events let the person experience the emotion fear, the person's mood might change to moderate or fully anxious.

Table 2: Mapping of OCC emotions into PAD space.

Emotion	P	A	D	Mood Octant
Admiration	0.5	0.3	-0.2	+P+A-D Dependent
Anger	-0.51	0.59	0.25	-P+A+D Hostile
Disliking	-0.4	0.2	0.1	-P+A+D Hostile
Disappointment	-0.3	0.1	-0.4	-P+A-D Anxious
Distress	-0.4	-0.2	-0.5	-P-A-D Bored
Fear	-0.64	0.60	-0.43	-P+A-D Anxious
FearsConfirmed	-0.5	-0.3	-0.7	-P-A-D Bored
Gloating	0.3	-0.3	-0.1	+P-A-D Docile
Gratification	0.6	0.5	0.4	+P+A+D Exuberant
Gratitude	0.4	0.2	-0.3	+P+A-D Dependent
HappyFor	0.4	0.2	0.2	+P+A+D Exuberant
Hate	-0.6	0.6	0.3	-P+A+D Hostile
Hope	0.2	0.2	-0.1	+P+A-D Dependent
Joy	0.4	0.2	0.1	+P+A+D Exuberant
Liking	0.40	0.16	-0.24	+P+A-D Dependent
Love	0.3	0.1	0.2	+P+A+D Exuberant
Pity	-0.4	-0.2	-0.5	-P-A-D Bored
Pride	0.4	0.3	0.3	+P+A+D Exuberant
Relief	0.2	-0.3	0.4	+P-A+D Relaxed
Remorse	-0.3	0.1	-0.6	-P+A-D Anxious
Reproach	-0.3	-0.1	0.4	-P-A+D Disdainful
Resentment	-0.2	-0.3	-0.2	-P-A-D Bored
Satisfaction	0.3	-0.2	0.4	+P-A+D Relaxed
Shame	-0.3	0.1	-0.6	-P+A-D Anxious

Our simulation of mood changes uses the active emotions generated by the EmotionEngine. Each appraisal of an action, event or object, lets the EmotionEngine generate an active emotion that once generated, is decayed over a certain amount of time (for example, 1 minute). All active emotions are used as input of the *pull and push mood change function*. It first computes the virtual emotion center of all currently active emotions in the PAD space by using the above mapping. The virtual emotion center represents a point in the PAD space and has an intensity that is the average of all active emotions' intensity. Its maximum intensity is 1.0. If no active emotions exist, no virtual emotion center exists and the current mood is not influenced by active emotions. Usually the virtual emotion center jumps from one mood octant to another one in very short time periods, caused by new elicited emotions. Due its erratic behavior, it does not reflect character's mood changes. But it can be used for the simulation of smooth and steadily changes in mood.

The pull and push mood change function works in the following way (see Figure 2): If the current mood position is between the PAD space's zero point and the virtual emotion center, the current mood is attracted towards the virtual emotion center. This is called pull phase. If the current mood is beyond (or at) the virtual emotion center the current mood is pushed away, further into the current mood octant in which the mood is located. This is called push phase. The push phase realizes the concept that a person's mood gets more intense the more experiences the person make that are supporting this mood. The intensity of the virtual emotion center defines how strong the current mood is attracted respectively pushed away.

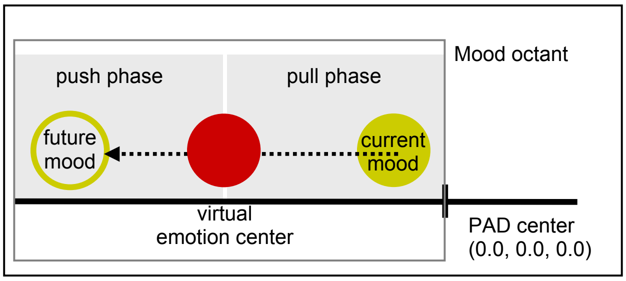


Figure 2: Pull and push mood change function.

For being flexible at mood changes, we define a usual mood change time. This defines the amount of time the pull and push mood change function needs to move a current mood from one mood octant center to another one, presumably that a suitable virtual emotion center exists that long, what is usually not the case. Our character's usual mood change time is 10 minutes.

The virtual emotion center (dark grey ball) and the current mood are located in the PAD space. An observable effect is that the virtual emotion center first attracts the current mood and, when crossing its position, it pushes the current mood further into current mood octant.

```
<AffectComputation>
   <EmotionDecay time="20000" period="500" function="linear"/>
   <EmotionBaseline threshold="0.4"/>
   <MoodReturn time="600000" period="500"/>
   <MoodRelations>
      <EmotionRelation name="Admiration" p="0.5" a="0.3" d="-0.2"/>
      <EmotionRelation name="Anger" p="-0.51" a="0.59" d="0.25"/>
      ...
   <PersonalityRelations>
      <PleasureRelation extra="0.21" agree="0.59" neur="0.19"/>
      <ArousalRelation open="0.15" agree="0.30" neur="-0.57"/>
      <DominanceRelation open="0.25" con="0.17"  extra="0.60"
                  agree="-0.32" neur="0.0"/>
   </PersonalityRelations>
   <RealtimeOutput enable="true" period="500">
      <FileLog enable="false" file="docs/affect.log"/>
   </RealtimeOutput>
</AffectComputation>
```

Figure 3: An example affect computation definition document.

Another aspect of our mood simulation is that the current mood has a tendency to slowly move back to the default mood. Generally, the return time depends how far the current mood is away from the default mood. We take the longest distance of a mood octant (√3) for defining the mood return time. Currently this is 20 minutes.

4. AFFECT COMPUTATION

Before affect can be computed, global *computation parameters* and a *personality profile* for each character must be provided. The computation parameters (see Figure 3) consist of the specification of how emotions and moods are generated (e.g., emotion decay parameters, mapping of personality traits and emotions into the PAD space). The entire affect configuration, input and output data is represented by structures of AffectML, our XML based affect modeling language.

```
<CharacterAffect name="Valerie" monitored="true" docu="Valerie ">
  <Personality open="0.4" con="0.8" extra="0.6" agree="0.3" neur="0.4"/>
  <Appraisal>
    <Basic>
      <GoodEvent desirability="0.7"/>
      …
    </Basic>
    <SelfAct type="Calm">
      <GoodActSelf agency="self" praiseworthiness="0.5"/>
    </SelfAct>
    <DirectAct type="Attack" performer="Sven">
      <BadEvent desirability="-0.5"/>
      <BadActOther agency="other" praiseworthiness="-0.3"/>
    </DirectAct>
    <SelfEmotion emotion="ReproachDisplay">
      <BadEvent desirability="-0.3"/>
    </SelfEmotion>
    …
```

Figure 4: An example character personality specification.

A character's personality profile (see Figure 4) consists of the personality definition and subjective *appraisal rules* defining how a character appraises its environment.

Appraisal rules (see Figure 4) consist of a matching part and an action body. The matching part relates relevant input. The action body can either hold terminal symbols (input for the EmotionEngine) or non-terminals. The appraisal rules are structured in hierarchical appraisal classes, which are related to input types:

- *Basic appraisal rules*. They define how a character appraises events, actions, and objects related to him. For example, an event like "the sun is shining" is appraised as GoodEvent. They serve as symbolic abbreviations for emotion eliciting conditions (EECs), which are needed for the emotion computation based on the EmotionEngine. They correspond to the appraisal tags introduced in [19].

  Rule:<basic appraisal input> :=
  <EEC variables> (see [20, 132-133)

- *Act appraisal rules*. They define how a character appraises its own acts and other characters acts. Subclasses of acts are dialog acts that specify the underlying communicative intent of an utterance, e.g. tease, or congratulate. For other characters acts the performing character had to be specified. In this case, we differentiate between being directly addressed (direct) and being in the position of a listener (indirect). Dialog acts appraisal rules correspond to the dialog act tags introduced in [19].

  Rule: <act input, {self, {direct|indirect}|other}> :=
  {basic appraisal input}+

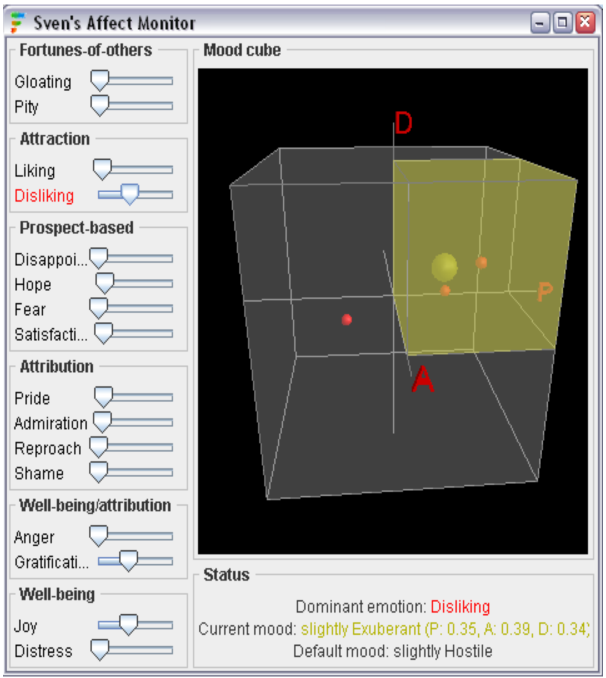
- *Emotion display appraisal rules*. They define how a character appraises its own emotion displays, but also other characters' emotion displays. Emotion displays are visual cues of an experienced emotion, e.g. a blush of shame. The performing character had to be specified. This appraisal class is introduced to enable virtual characters to reflect their own emotional displays.

  Rule: <emotion display input, {self|other}> :=
  {basic appraisal input}+

- *Mood display appraisal rules*. They define how a character appraises its own mood displays, but also other characters' mood displays. Mood displays are visual cues of a specific mood. At this time, we consider specific idle behavior as mood cue, e.g. a nervously looking character over a specific amount of time is considered to be anxious. This appraisal class is introduced to enable virtual characters to reflect their own mood displays. The performing character had to be specified.

  Rule: <mood display input, {self|other}> :=
  {basic appraisal input}+

At runtime, the affect computation periodically (every 500ms) updates the affective profile of all characters. The real-time affect computation first appraises relevant input for all characters (by using each character's own subjective appraisal rules). The output of the appraisal process is a set of emotion eliciting conditions. These are used to update a character's emotions and mood. In parallel, a graphical interface illustrates what's going on in the affective part of a character's "brain".




```
<AffectOutput>
  <CharacterAffect name="Sven">
    <DominantEmotion name=„Disliking" value="0.46"/>
    <Mood       moodword=„Exuberant"       intensity=„slightly"
          p="0.35" a="0.39" d="0.34"/>
    <Personality open="0.3" con="-0.6" extra="0.7"
              agree="0.4" neu="-0.1"/>
  </CharacterAffect>
  …
</AffectOutput>
```

Figure 5: AffectMonitor and corresponding affect output.

Figure 5 shows the AffectMonitor that displays Sven's affective profile and the corresponding AffectML structure at a given time. The left side of the AffectMonitor shows Sven's emotions and their intensities. The right side shows a 3 dimensional PDA mood cube displaying the current mood (the highlighted octant stands for the discrete mood description, whereas the light gray ball reflects the actual mood) and all active emotions (dark gray balls). Below, the affective state, including the current dominant emotion, and the default as well as the current mood, is displayed.

5. AFFECT EXPLOITATION

In the VirtualHuman system, the multimodal dialog generation module and the affect computation module are tightly working together. The latter receives relevant input from the multimodal dialog generation and gives its output directly back to this module. The received input consists of appraisal tag input, dialog act input, emotion and mood input, and the information about the role of the character in the ongoing conversation (e.g. speaker, addressee, or listener). This is passed also to the character player module which is responsible for rendering the character's visual appearance and its speech output.

The following example illustrates the exploitation of affect in the current VirtualHuman scenario. By the characters' personality it is defined that Sven is in a slightly hostile mood and that Valerie is in a slightly relaxed mood. At the beginning of a lesson, Sven's mood causes him to give rare and rude answers. But the encouragement from Valerie makes him slightly exuberant, which results in the fact that Sven produces more and more friendly answers. In general, affect is currently used to:

- *Select the wording and phrasing* for the natural language surface realization. All utterances of the virtual characters are scripted, but according to their current mood. For example, when being relaxed, our characters' utterances are more lengthy and bloomy. When being in a hostile mood, utterances are shorter, more precise and harsh.
- *Select the use of dialog strategies*. Every action of the human student is appraised by the both virtual characters. The elicited emotions than influence the virtual character's mood, which is used as an information for selecting a dialog strategy. For example, if the virtual teacher's mood is relaxed while the human student has given a wrong answer, the virtual teacher gives a more detailed explanation of the asked question. If the virtual teacher's mood is docile or bored explanations are short or not given.
- *Trigger idle gestures*. The character's idle behavior reflects a character's current mood. If, for example, a character's mood is hostile its idle behavior consists of gestures, which reflect this. E.g. expressive head movements, and gaze, crossed arms before chest.
- *Change the characteristics of conversational gestures* and postures. According to a character's mood and to its dominant emotion the type and the characteristics of conversational gestures and postures are altered. For example, while being in relaxed mood, gestures and posture changes will be performed less powerful.
- *Control the facial expressions*. Facial expressions are used to reflect a character's dominant emotion.

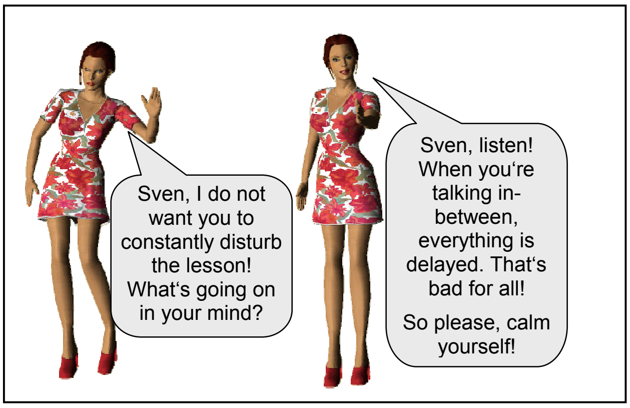


Figure 6: Examples of character behavior.

An impression how affect is used in the VirtualHuman Project to control our character's behavior, gives Figure 6. It shows a snapshot of a lessons situation, in which the virtual teacher Valerie reproves the virtual student Sven for repeatedly disturbing the lesson. This lets Valerie experience the dominant emotion reproach, because of Sven's blameworthy action. The left side shows Valerie is in a hostile mood, the right side shows Valerie in a relaxed mood, both time while reproving Sven. In both cases her gestures, posture and the wording of her utterance reflects her mood and the active emotion. The selection of gestures, posture and wording is managed by the multimodal dialog generation which represents the cognitive functions of our virtual humans.

In general, for defining a characters behavior according to emotions, we rely on the work presented in [19, 20].

6. DISCUSSION AND FUTURE WORK

In this paper we introduced ALMA, a layered model of affect, which provides three distinct affects: emotions as short-term affect, moods as medium-term-affect, and personality as long-term affect. Affect is viewed as result of a cognitive appraisal. This approach extends other approaches by providing an extended set of affective information for controlling the behavior of lifelike characters. It enables virtual character behavior designers to use specific results of psychological human behavior research related to the three affect types provided by ALMA.

In order to do so, an affective character specification for each virtual character had to be provided, containing personality specification and subjective appraisal rules. For this purpose, we introduced a modeling language called AffectML. It allows reusing parts of an existing affective profile in order to use them as templates for defining other characters' affective specifications. Also, AffectML provides both input and output structures as an interface language for external modules.

A version of ALMA is successfully implemented in the VirtualHuman system tightly working together with a multimodal dialog generation component. It uses the generated different kinds of affect to control a characters behavior at the level of cognitive processes and at the level of verbal and non-verbal expressions.

In future evaluation work, which is part of the VirtualHuman project, it had to be verified that using different kinds of affect for controlling behavior really improves the believability and quality of our virtual characters. Besides that, we are aware, that the proposed affect generation by ALMA is a first approach for generating different temporal affects and should be enhanced in several ways. For example, an emotion's intensity is not influenced by the current mood. This reflects the fact that people in a bad mood tend to perceive events negatively, as opposed to positively, when in a good mood.

Also, we want to allow the changes of the appraisal rules during runtime to adapt the affect computation to different situations. In addition, we want to extend the model in order to generate abstract key values for group mood that should serve the underlying system as additional information in order to tailor the systems actions for achieving a specific overall mood.

As a next step, we want to provide AMLA as freely available software toolkit, for making affect computation more accessible to other virtual character behavior designer. We hope that our affective model will contribute to the development of believable virtual human-like characters by introducing the approach of three distinct affect types and by providing a declarative affect modeling language, which provides data structures for affect computation, character affect specification, affect input, and affect output.

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