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Semantic Model for Facial Emotion to improve the human computer interaction in AmI

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Summary. To facilitate the Human Computer Interaction will be needed to create a friendly interface in AmI. Thus, in this work we propose a semantic knowledge model to represent facial emotions of a virtual character. These emotions depend on the personality, preferences, goals of the character and the environment events. The virtual character's emotions are the nonverbal communication interface between the system and the user. Furthermore, we develop an algorithm to deduce the resultant emotion using previous information, and we represent it with a set of activated facial animation parameters.

1.1 Introduction

Ambient Intelligence (AmI) researchers claim for system awareness which is embedded in all types of objects to attend human necessities in a transparent and unobtrusive way. AmI discipline involves Human-Computer Interaction (HCI) field [1], where researchers work in the creation of graphical interfaces, interaction devices, voice synthesizers, movement capture devices, among other fields. AmI researchers try to obtain an interaction more "human-like" although this task is rather difficult due to the complexity of the human communication. The way to communicate the message (linguistic message, non-linguistic conversational signal, emotion, person identification), can take place (facial expression, head movement, tone of voice, etc.), where it take place and the actions of the speech listener [2] are factors that difficult the computational analysis of the human language.

In this work, we propose a knowledge semantic model to represent facial emotions of a virtual character. The virtual character's face "humanizes" the system with the aim of facilitate the feedback communication. Furthermore, we represent personality traits and preferences which clarify their character so that we can emphasize and understand better its message. Our model involves two HCI fields: the context identification through events and the affective feedback among the system and the users. Facial expression will change according to character's personality, preferences, goals, and the events of the environment.

1.2 Related Work

In the field of emotions and personality one work is the one of Egges *et al.* [3] which present a generic personality and emotion simulator where mood can have any number of dimensions. The relationship between emotions, personality, and moods is done using matrices with empirical values that relate these elements according to their influence on each other. Kshirsagar *et al.* [4] presents a layered approach for modeling personality, moods and emotions. They adopt the Five Factor Model (FFM) of personality, and Bayesian Belief Network for the implementation of the model.

In the 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 [6], García-Rojas *et al.* presented an ontology that lays out the knowledge of previous work on body animation expressions within MPEG-4 framework. The animations are classified into a model of emotion and some parameters are presented in order to enhance the face expressivity.

In the area of HCI within AmI discipline, Pantic [2] introduces the importance of identify the emotional state in AmI environments for an affective computing. Also, she proposes a method for automatic recognition of facial expressions though the position of facial points.

1.3 Semantic Data Model

We propose a generic knowledge model which represents elements as the ambient and events that surround a character, his personality and preferences. We also design an algorithm that permits to obtain the emotions of a character using the elements mentioned before. We improve context representation using ontologies because they permit to define new knowledge and easily reuse it. Also the applicability of inference rules allows to improve the outcoming of emotions, adaptability and evolution of the character in front of new events. Finally, ontologies are able to develop an automatic process using artificial intelligence techniques. Ontology repositories, which are external data sets, provide new specific context knowledge for every situation.

The figure 1.1 represents the base-model; the upper layers show the future knowledge modules for adaptation in AmI or other environments. Ontologies define the model requirements such as the personality, actions, emotions, objects, characters, animals, goals, environment, etc. The upper layer is used to access the ontology data. Moreover, this layer will be composed of query engines, an inference engine, and a database manager. AmI Module interprets all events in temporal order and fixes the sequence of credible facial expressions. However, in our case we consider the event as independents facts. The events are classified in three types: indirects, directs, and inferreds. Indirect events are obtained by the context interpretation using external sensors. Direct events are user's orders, i.e. "turn on the TV", there are not any kind of interpretation in that sentence. The inferred events are done by superior entities for specific adaptations as: management of hospital patients, teaching, or security systems. In this work we have focused on inferior architecture's layers: context representation, character's personality and preferences, and an algorithm to obtain character's facial emotions.

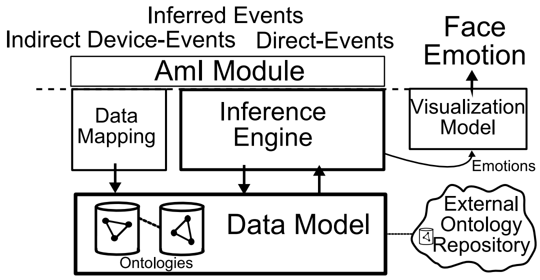

Fig. 1.1. Architecture based on two layers data information and inference engine

1.3.1 Event Ontology: Environment Description

The interaction depends on the context that provides new information, and it affects the user's behaviour. Events trigger the facial reaction. This ontology defines concepts that describe the events presented in generic domain, which cause a change in the affective state of the character. The model is based on action description, more precisely on four questions: *Who* (represents persons and animals present in the action), *Where* (represents the place and its description), *What* (represents the action, contains a verb and the complements), and *When* (is a period of time).

In this ontology, we use concepts that have been already defined on external ontologies, such as: person, animal, pet, material object, location, and time interval. They are obtained from ontologies with a different purpose from ours. Importing external knowledge, more complex structures without reach

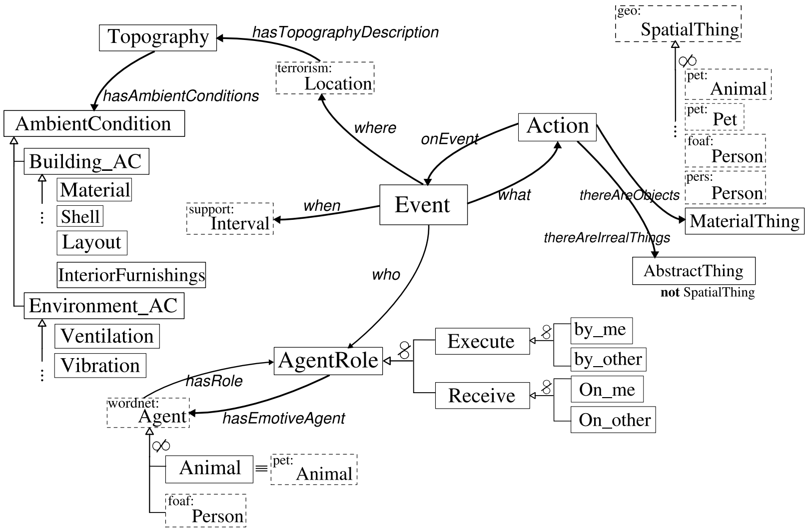

Fig. 1.2. Simplified Event Ontology Diagram

to understand specific domains can be represented. Thus, we save code and time development.

1.3.2 Action Categorization Ontology

Scenarios where several action produce different emotions are plausible. To solve that, we classify them as group of emotions. So that, there are actions emotionally similar although they are not identical. This classification is represented in the action categorization ontology.

Every action has a unique genre. This link represents a "standard" vision of this action. For example, most people think action "to kill a person" has a negative connotation, thus, it belongs to negative genres: *horror*, *war*, or *thriller*. We identify a set of genres such as: *action*, *comedy*, *family*, *history*, *mystery*, *thriller*, among others. The greater the number of genres, the better the quality of interpretation of the emotion categorization. However, this number has an operational threshold that is going to be explained in next section. An perfect solution would be a binary relationship between one genre and one action.

1.3.3 Personality-Emotion Ontology

The core of the ontology is composed by the character, the personality, the emotional categorization, and the emotions. Starting from the top left of the fig. 1.3, a *character* has *goals* and *preferences*. A *goal* is considered as the occurrence of an event with the highest desirability degree, for instance, "keep a

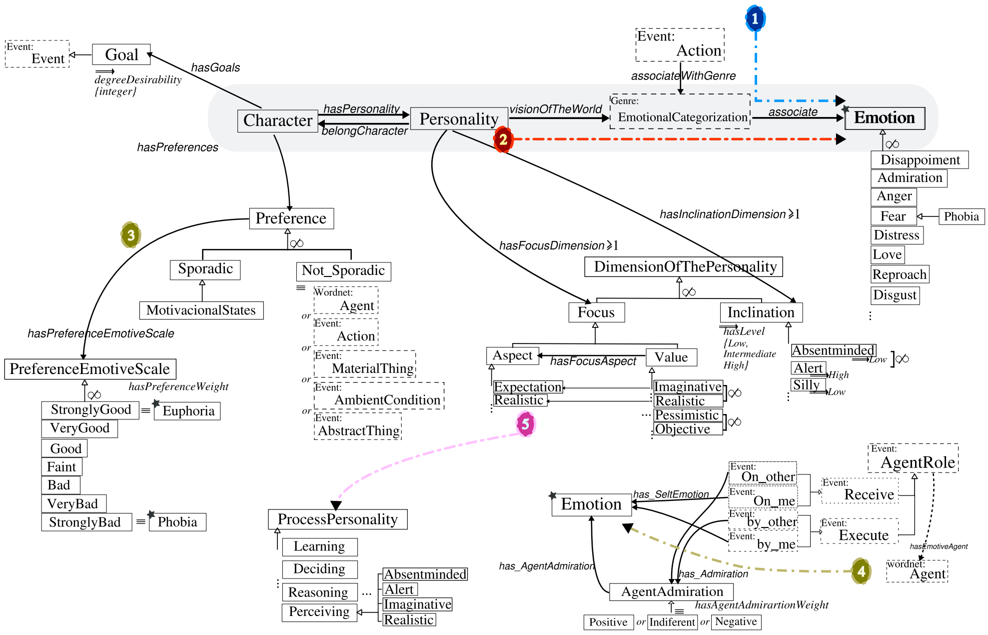

Fig. 1.3. Simplified Personality-Emotion Ontology Diagram

warm temperature at home". *Preferences* can be divided in two types: *sporadic* based on motivational states (thirsty, hungry, etc.), or *not sporadic* which can be: an agent (person or animal), an action, a material object, or preferences from the environment. All preferences are categorized in a class named *PreferenceEmotiveScale*, in concordance with the seven item Likert scale.

In our ontology the scale is given by the following values: *7-StronglyGood*, *6-VeryGood*, *5-Good*, *4-Moderate/Indifferent*, *3-Bad*, *2-VeryBad*, *1-StronglyBad = Phobia*. Therefore, everything that could like, dislike, or make the character feel indifferent, is grouped in this class.

Another aspect of the character is his *personality*. In this ontology the personality model we have used is the one proposed by Rousseau, which main goal is to classify personality traits in a structured way, identifying their impact on the behavior of the character, moods and relationships. The classification is based on the different processes that the agent can perform: perceiving, reasoning, learning, deciding, acting, interacting, revealing, and feeling emotions. Each process is considered in two levels that form the class *DimensionOfThePersonality*: *Focus* and *Inclination*. They are defined as the aspect an agent focuses on while performing the process, and the tendency the agent has to perform the process [7]. In our ontology, *personality* is linked with the classes *Focus* and *Inclination* through the relations *hasFocusDimension* and *hasInclinationDimension*, respectively. Depending on the values that *focus* and *inclination* have assigned, we can derive a process represented by the class

ProcessPersonality. The reason to choose the described model is its completeness and the possibility that it offers to derive other personality models from it, as is the case of the Five Factor Model (FFM) [8].

The personality of the character will determine his *visionOfTheWorld* which can be categorized in genres, grouped in the class *EmotionalCategorization.* The genres we have considered were described in the previous section. The combination of the perception according to the personality and the emotional categorization of an event result in a set of emotions, which are the ones proposed in the OCC model [4], except *happy-for* and *fear-confirmed.*

In our model, the level of appreciation of one agent for another is considered in the class *AgentAdmiration.* It can have three levels, or weights: *Positive*, *Indifferent* or *Negative.* An event can also be considered from the point of view of the agent who performs the actions or from the agent who receives the action. If the agent is the one who performs the action (*me*) the set of possible emotions is: *relief, remorse, pity, pride, satisfaction,* or *shame*; and the emotions for the agent that receives the action (*On_other*) are: *pride, pity, surprise,* or *gloating,* depending on the degree of *admiration* for the other. If the agent is the one who receives the action (*On_me*) the set of possible emotions is: *relief, gratification, pride, shame, surprise,* or *disgust*; and the emotions for the agent that performs the action (*by_other*) are: *disappointment, joy, love, reproach, gratitude, resentment, surprise, disappointment,* or *gloating,* depending on the degree of *admiration* for the other.

1.4 How to use this model to obtain emotions

The inference engine layer contains the algorithm to obtain emotions from the environment and the character. The developed generic guideline to obtain a set of final emotions is not a closed sequence of steps. The process estimates emotions and their intensities during event generation including external factors. Intensity is the weight of each emotion. The set of higher intensity emotions will be the ones we represent. We distinguish three phases:

(I) In the first phase, we call *base emotions* to the ones obtained from actions (figure 1.3 tags: ① ②) and the ones obtained in case there are preferences with extreme intensities of the scale (*stronglygood* and *stronglybad*) (*Preference Extreme Emotive Scale, PEE*; fig. 1.3: ③). Every action has its own cultural interpretation, for example, people culturally associate the action *kissing* to emotions like: happiness and love (fig. 1.3: ①). However, each person has his own interpretation, its different vision of the world due to its education and other external factors. Those persons can associate emotions as shame or reproach to *kiss* action (fig. 1.3: ②). We obtain the base emotion combining both interpretations. Extreme values of the preference scale represent the euphoria or anxiety disorder, suffered by people due to strong and persistent feelings of fear or happiness.

(II) In the second phase, we control intensities of the base emotions, which depend on environment actions. Character preferences about objects, persons, or animals, increase or decrease positive or negative emotions respectively (fig. 1.3: ③).

(III) In the last phase, there are three steps but all of them generate additional emotions with their intensities that add new emotions or increase the intensity of the existent ones. In the first step, the algorithm consider the emotions caused by other people who take part in the action (fig. 1.3: ④, fig. 1.4). In the second step is checked if the event is similar to the goal and if so, new emotions with intensities corresponding to the goal's desirability degree are triggered. In the last step, first order logic rules treat particular cases that depend on specific personality traits or a character role. Rules give flexibility and improve process accuracy.

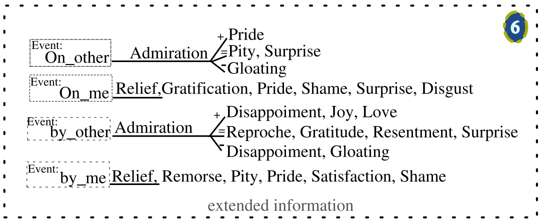

Fig. 1.4. Extending information about person admiration

1.5 Visualization of the Emotional States

We develop an algorithm that works with the facial parameters specified in the MPEG-4 standard, and mixes the universal, also called basic, emotions: *joy*, *happiness*, *sadness*, *anger*, *fear*, *surprise*, to obtain intermediate emotions: *hate*, *disappointment*, *love*, among others. To visualize facial expressions, we have considered each emotion E_i associated with a set of activated facial animation parameters (FAPs), named P_i. Each P_i has a set of values (range of variation) $X_{i,j}$, such as $P_i = \{X_{i,j}\}$, where j is the number of the FAP ($j = \{1, ..., 64\}$). $X_{i,j}$ has the form $[minValue, maxValue]$. For intermediate emotions, the ranges $X_{i,j}$ were generated as a sub-range of a basic emotion, or a combination of two basic emotions, depending on their relation according to the Whissell model [9].

1.6 A case study

We present a group of events that can occur in AmI. We suggest a first event where children are playing with fire. In this case the character has two personalities: one more aggressive and other one more sentimental. In the second event the user is grateful to the system for its support. Finally, in the third event the system set the temperature, illumination, and music of a room.

In the next phase we define three possible genres for each event: *Dangerous Situation*, *Congratulation*, and *Setting Room* respectively. The genre definition depends on each situation. For instance, other event as "House thief" could be a dangerous situation. The character's preferences are: admiration for a group of children with Faint scale (WordNet:Agent); admiration for the user with VeryGood scale (WordNet:Agent) and he "likes" a temperature around 23°C (event:ambientCondition), illumination at 40% (event:ambientCondition) and chill-out music (event:AbstractThing).

According to character's personality, table 1.1 shows personality traits for each genre. Only event *Dangerous Situation* is used with aggressive and sentimental personalities.

Table 1.2 represents the simplified process to obtain emotion. First row contains the triggered event and the first column, the algorithm phases. The two first columns are the same event: children play with fire for both personalities. Our character does not have any extreme preferences (PEE). Afterwards, the algorithm produces a set of emotions belonging to (1∩2), which corresponds to character's personality and action genre (fig. 1.3 tags: ① ②). Following, step 2 increases or decreases intensity emotions caused by character preferences (fig. 1.3: ③). In the fourth event, the character's references about temperature, music, and illumination increase the weight of the emotion according to its scale, in the fourth event. In step 3, we define rule R1 as: *If* $Children \wedge \text{“}causethesituation'' \wedge DangerousSituation \mapsto Reproach(2)$. Rule R1 is triggered in the first and second event; being considered emotions elicited by person admiration (fig. 1.4) and goal's character. Finally, we choose the three emotions with higher intensities to be represented.

1.7 Conclusion and Future Work

Human Computer Interaction is an essential discipline to improve the interaction between AmI system and user. In this work we focus on the facial representation of virtual character for system request feedback. Human Face transmits non-verbal communicative cues and is able to get on with the users. Thus, we presented a knowledge model using ontologies to define facial emotions of virtual agents. These emotions depend on the personality, preferences, and goals of the character and the events that take place in the context.

We dealed with the "emotional" part of the system so that in our model we represent personality traits and preferences about: agents (persons and animals), physic and abstract things (music, perfume, car,...), ambient conditions; goals and the emotions. Also, the environment is represented using events which are described as an answer to four questions: Who, When, What,

Table 1.1. Join Personality-Categorization and Event-Categorization Tables for Aggressive and Sentimental Personality

Traits		**DangerousSit.**	**SettingHouse**	**Traits(P2)**	**DangerousSit.**
Perceiving	Absentminded	Surprise	–	Alert	Anger, Disgust, Gloating
	Imaginative	Sadness, Fear	–	Realistic	Anger
Reasoning	Rational	Hope, Surprise	Joy	Rational	Disappointment, Surprise
	Objective	Sadness	Satisfaction	Pessimistic	Sadness
Learning	Curious	Pity	–	Incurious	–
	Open-minded	–	–	Intolerant	–
Deciding	Insecure	Fear	–	Self-Confident	–
	Thoughtful	Sadness	Pride	Impulsive	Anger,Hate
Acting	Active	Disgust	–	Zealous	Hate
	Diligent	Disappointment	–	Perfectionist	Annoyed, Disappointment
Interacting	Extroverted	Disgust	Joy	Extroverted	Disgust, Reproach, Resentment
	Neutral	–	–	Hostile	Reproach, Resentment
Revealing	Open	–	Gratification	Open	–
	Honest	Disgust, Sadness	–	Honest	Disgust, Reproach
F.Emotions	Sensitive	Sadness	Joy, Liking	Emotionless	Disgust
	Unselfish	–	Joy	Selfish	–

and Where. We have proposed a model so it can be easily adapted to any situation. Furthermore, we developed an algorithm to obtain a final set of emotions and respectively intensities. This set of emotions is represented with our algorithm based on MPG4. We show the right work of the purpose with a case study of an AmI.

To sum up, this idea is under development. We are working on two applications to rapidly characterize the personality and the events. In addition we are centering our efforts working in a model of AI to handle the event history and character's behaviour generation. Additionally, we are researching its applicability in other fields as automatic characters in a virtual worlds, virtual teachings, guide of museum, and computer games.

Acknowledgment

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Table 1.2. Algorithm Sketch applies in three AmI events

	Events					
	Ev1(**P1**): PlayWithFire		Ev1(**P2**): PlayWithFire		Ev4: SettingHouse	
Step	Case	E(+I)	Case	E(+I)	Case	E(+I)
(1) **PEE (1∩2)**	ϕ *Danger.*	– Surprise(2), Sadness(5), Fear(2), Hope, Pity, Disgust(3), Disappointment	ϕ *Danger.*	– Anger(3), Disgust(4), Gloating, Disappointment(2), Surprise, Sadness, Hate(2), Annoyed, Resentment(2), Reproach(3)	ϕ *Sett.*	– Joy(4), Satisfaction, Pride, Gratification, Liking
(2) **Pref.**	–	–	–	–	*AmbientCond.:*	(+1PE) Temperature, (+1PE) Illumination, (+2PE) Music
(3) **Rule**	R1	Reproach(**2**)	R1	Reproach(**2**)	ϕ	–
Agent	⑥	Reproach, Disappointment, Resentment, Surprise	⑥	Reproach, Disappointment, Resentment, Surprise	ϕ	–
Goal	ϕ	–	ϕ	–	ϕ	–
	Final Emotions					
	Sadness(**5**) Disgust(**3**) Surprise(**3**)		Disgust(**4**) Reproach(**6**) Anger(**3**)		Joy(8) Satisfaction(**4**) Liking(**4**)	
						

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