Comparison of recent architectures of emotions

Thi Haï Ha Dang, Sabine Letellier-Zarshenas, Dominique Duhaut

Comparison of recent architectures of emotions

Thi-Hai-Ha Dang
VALORIA – South Brittany University
Francophone Institute for Informatics
Hanoi - Vietnam
dthha@ifi.edu.vn

Sabine Letellier-Zarshenas & Dominique Duhaut
VALORIA – South Brittany University
Vannes - France
letellier,dominique.duhaut@univ-ubs.fr

***Abstract* – In this paper we present a generic computational model to include emotion and personality in the behaviour of a robot. This model is based on a comparison of recent computational models of emotions and classical hybrid architecture for robot computation; it is also merged with psychological works on emotion and personality.**

***Key words* – hybrid architecture, robot programming, emotion, psychology.**

I. INTRODUCTION

Nowadays, an increasingly number of scientists conduct their research to the design of emotions in computational agents (including "softbots" as well as embodied robots) that must perform unanticipated tasks in unpredictable environments. This tendency comes from the rapid development of human-machine applications in our everyday life. Conversational agents, embodied agents, and then robot assistants, robot servants or companion robot become more and more popular. A main demand for this kind of things is having human-characteristics like personality traits and/or emotional behaviour.

Our project EmotiRob [17][18] is also in such approach. We aim at designing a robot companion for impaired children or for children having to undergo lengthy hospital stays. We want to equip the robot with the necessary perception and natural language understanding capacities for it to be capable of building a formal representation of its interlocutor's emotional state. Our project also includes the building of a model of the robot's internal emotional state and of its evolution through time so as to generate reactions that would come as close as possible to natural ones.

Based on these ideas, we looked at research on emotion and personality and how to include them in software architecture. For emotion, things are difficult because a lot of different definitions exist depending on the field of interest. For instance philosophers, psychologists, traders, ethnologists do not describe human emotion in the same way. We then look to some definitions of personality. Based on this we propose a generic architecture to include emotion and personality in robot behaviour.

Section II of this paper will present two studies on personality: one of Rousseau and other of Briggs-Meyes & Meyes. Then, in section III, we take an overview on some interesting models of emotions. We propose, in section IV, a generic computational model based on 8 modules to include emotion and personality in the robot control architecture. Lastly, we will give some words for our future work and conclusions.

II. PERSONALITY

It exists a tight relation between emotions and personality. The way we act everyday depends strongly on our personality. But how can we identify our personality? And what is the real relation between personality and emotion? To answer these questions, many researchers have paid their attention trying modeling personality like works of Cattell 1965, Allport 1966, Briggs-Meyers and Meyers 1981, Phares 1984, Rousseau 1996, etc. In this section, we would like to present two models of personality that draw our attention thanks to their popularity and generality: Rousseau's model and Briggs-Meyers and Meyers' model.

A. Rousseau's model of personality proposed in 1996 [4]

The goal is to set a model that classifies personality traits in a structured way and that identifies their impact on a character's **behavior, moods** and **relationships**.
The classification is based on eight different processes that an agent can perform in a conventional architecture: **perceiving, reasoning, learning, deciding, acting, interacting, revealing and feeling** emotions. Each process is considered at two levels: the natural **inclination** (tendency) that an agent has to perform the process, and the main aspect an agent **focuses** on while performing the process. So, this model of personality contains in total 8*2 dimensions.
Additionally, there is always a relation between personality and behavior. A personality trait is specified in abstract rules that a character can follow when it is time to choose an action to perform in a given context. Such rules specify which types of behaviors an individual would likely perform according to his personality.
On the other hand, the author also takes into account the relation among personality, moods (which seemed to be emotions) and relationships. They tested this model of personality in CyberCafe – an application of the Computer Virtual Theater (Hayes-Roth and Van Gent, 1996).

B. MBTI - Model of Briggs-Meyers and Meyers [15]

The purpose of the Myers-Briggs Type Indicator (MBTI) personality inventory is to make the theory of psychological

978-1-4244-2287-6/08/$25.00 ©2008 IEEE

types described by C. G. Jung understandable and useful in people's lives. The Myers-Briggs Type Indicator [19] is a self-report instrument that helps to identify an individual's strengths and personality preferences; in 1991, MBTI test was used by more than 10000 persons by day in the USA.

The **Personality type** is evaluated in responding four questions: where you focus your **attention**, the way you take in **information**, the way you make **decisions** and how you deal with the **outer world**. The evaluation is described below:

Attitude: Where you focus your attention: Do you prefer to focus on the outer world or on your own inner world? This is called **Extraversion** (E) or **Introversion** (I). People who prefer Extraversion tend to relate easily to the outer world of people and things. People who prefer Introversion tend to relate easily to the inner world of ideas and impressions.

Perception: The way you take in information: Do you prefer to focus on the basic information you take in or do you prefer to interpret and add meaning? This is called **Sensing** (S) or **Intuition** (N). Sensing People tend to be interested in what the five senses show them—what exists in the present. Intuition People tend to use their imagination to see new possibilities and insights—focusing on the future.

Decisions: The way you make decisions: When making decisions, do you prefer to first look at logic and consistency or first look at people and special circumstances? This is called **Thinking** (T) or **Feeling** (F). People who prefer Thinking tend to base decisions on objective analysis and logic. People who prefer Feeling tend to base decisions on values and people-centred concerns.

Structure: How you deal with the outer world: In dealing with the outside world, do you prefer to get things decided or do you prefer to stay open to new information and options? This is called **Judging** (J) or **Perceiving** (P). Judging People tend to like to have things decided; life is likely to be planned and orderly. Perceiving People tend to not want to miss anything; life is likely to be spontaneous and flexible.

After all, when you decide on your preference in each category, you have your own **Personality type**, which can be expressed as a code with four letters. The identification and description of the 16 distinctive personality types results from the interactions among the categories.

For our work, MBTI seems more interesting than the other models because MBTI doesn't define a strict relation between emotions and personality but a flexible one; we can construct a model of emotion and then integrate this MBTI in our model easily. This advantage meets our purpose of proposing a generic model of emotion which incorporates personality.

III. STUDIES ON EMOTIONS

Studies in emotions are divided into two main approaches: one on emotion classification and the other on emotional process. The second draws our attention in these first days of project because we want to have a **computational model** of emotions, which is generic enough to give us a global view on emotion; and then allow us to construct a reasonable **evaluation** of emotions on future EmotiRob experiments. For further information on emotions classification, readers are proposed to read [10], [11], [12] and other works.

A. Models of emotions of psychologists

In this section, we would like to mention some physiologic theories that influence the construction of many recent computational models of emotions: the model of Ortony & al on **event appraisal**, the theory of Lazarus about **appraisal** and **coping**, and finally the theory of Scherer on emotional **processes**.

1) Model OCC proposed in 1988 by Ortony & al. [13]

For Ortony, Clore Collins, emotions are valenced reactions to events, agents or objects. These events, agents or objects are appraised according to an individual's goals, standards and attitudes.

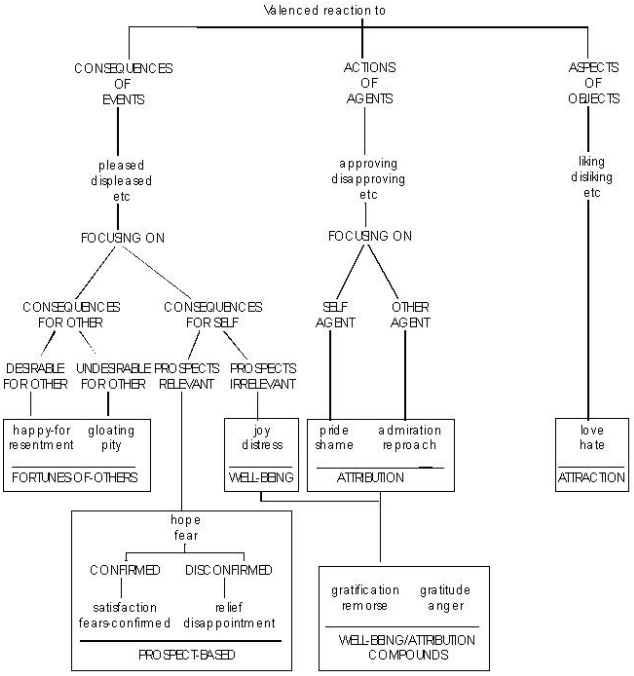

Figure 1. Architecture of OCC

The positive aspect of this model is that it is very close to a computational approach. This model is basic for most of models of emotions thanks to its generic evaluation criterions on emotions. The negative point of this organisation is that it does not define intensity of final emotions to launch.

2) Theory of Lazarus on appraisal and coping proposed in 1991 [16]

According to this theory, there are two processes that allow individual to stabilize his relation with environment: **cognitive evaluation** (*appraisal*) and **adaptation** (*coping*).
Lazarus defined cognitive evaluation as an adaptive process serving to conserve or to modify the relation between agent (its beliefs, its goals) and the world (its constraints, its modifications) in the way to maintain balances. He distinguished two types of evaluation: primary evaluation for the pertinence of an event and the congruence of event or not to goals; secondary evaluation for what could/have to be done in response to event.
For him, when a situation is evaluated as stressful, individual has to adapt: that's the role of the two *copings*:

- *Problem-focused coping* will try to solve the problem (classical approach), but can also deny the problem to minimize the effect.
- *Emotion-focused coping* differs from avoidant strategies as it refers to efforts aimed at regulating the emotional response to the problem. The problem is no longer the problem, but its consequence in the body if a reaction is given.

3) Theory of Scherer [19]

For Scherer five functionally defined subsystems are involved with emotional processes:

- An *information-processing subsystem* evaluates the stimulus through perception, memory, forecast and evaluation of available information.
- A *supporting subsystem* adjusts the internal condition through control of neuroendocrine, somatic and autonomous states.
- A *leading subsystem* plans, prepares actions and selects between competitive motives.
- An *acting subsystem* controls motor expression and visible behavior.
- A *monitor subsystem* finally controls the attention which is assigned to the present states and passes the resulting feedback on to the other subsystems.

Scherer is especially interested in the information-processing subsystem. According to his theory this subsystem is based on appraisals which Scherer calls *stimulus evaluation checks* (SEC). The result of these SECs causes again changes in the other subsystems.
Scherer sees five substantial SECs, four of which possess further subchecks.

- The *novelty check* decides whether external or internal stimuli have changed; its subchecks are suddenness, confidence and predictability.
- The *intrinsic pleasantness check* specifies whether the attraction is pleasant or unpleasant and causes appropriate approximation or avoidance tendencies.
- The *goal significance check* decides whether the event supports or prevents the goals of the person; its subchecks are goal relevance, probability of result, expectation, support character and urgency.
- The *coping potential check* determines to what extent the person believes to have events under control; its subchecks are agent, motive, control, power and adaptability.
- The *compatibility check* finally compares the event with internal and external standards; its subchecks are externality and internality.

Each emotion can, according to Scherer, thus be clearly determined by a combination of the SECs and subchecks. An appropriate table with such allocations can be found in [Scherer, 1988]. A number of empirical studies has supported Scherer's model so far.

B. Models of emotions of computer science

1) Model FLAME proposed en 2000 [1]

El-Nasr et al's FLAME model is a computational model of emotions based on event appraisal. It incorporates some learning components to increase the adaptation in modeling emotions. It also uses an emotion filtering component, which takes into account motivational states, to resolve conflicting emotions. FLAME uses fuzzy logic rules to map assessments of the impact of events on goals into emotional intensities. The agent in FLAME uses a predefined reward value for the user's action's impact on an agent's goal. This model was implemented in a simulation of a pet named PETEEI – a PET with Evolving Emotional Intelligence. However, personality is not mentioned in this model.

2) Model ParleE of Bui et al. (2002) [3]

ParleE is a model of emotions for a conversational agent in a multi-agent environment capable of multimodal communication. ParleE appraises events based on learning and a probabilistic planning algorithm. ParleE also models personality and motivational states and their role in determining the way agent experiences emotion.

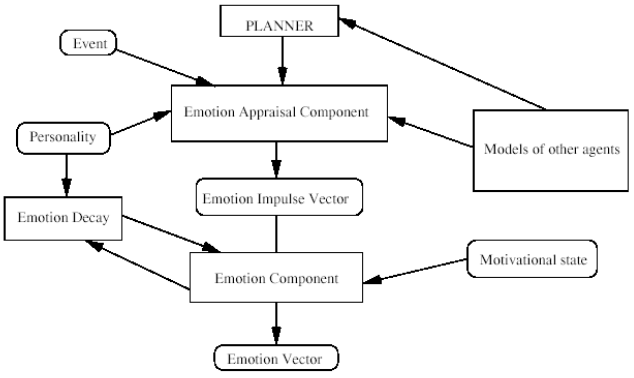

Figure 2. Architecture of ParleE

Personality used in this model is Rousseau's model of personality [4] which is classified according to different processes that an agent can perform: perceiving, reasoning, learning, deciding, acting, interacting, revealing, and feeling emotions. Practically, they have implemented ParleE into

Obie, a conversational agent to illustrate their model. Despite their efforts, the model lacks a specification of exact influence of emotions on the planning process. Moreover, the component *Models of others agents* seems to make the model not as flexible as the authors supposed.

3) Robot Kismet of Breazeal proposed in 2002 [14]

This model tends to establish an interaction between a robot, Kismet and a human inspiring the relation between parents and their child in the premier communication forms.

Cynthia Breazeal situated her approach in agent based architecture: different components of the system work in parallel and mutually influence each other. This model was experimented with 5 base emotions (anger, distaste, fear, sad, happiness) and three additional ones (surprise, interest, and excitation). Since this model inspired the relation between parents and children, the personality was not modeled.

4) Model Greta of Poggi and Pelachaud (2003) [5]

The authors aimed to build a human-computer interface, which is a 3D Conversational Embodied Agent named Greta. Their system includes two tightly interrelated components:

- a *representation of the Agents' Mind* with a dynamic updating mechanism: this includes long and short-term components (personality and emotions), the way they are triggered and they decay over time, the way the Agent decides whether to hide or to manifest them, the way that the `media' to manifest them (gaze, voice, face) is selected. *Dynamic belief networks* with weighting of goals are the formalism employed to this purpose;
- a *translation of the Agent's cognitive state into a face* expression that employs the various available channels (gaze direction, eyebrow shape, head direction and movement etc). This requires solving conflicting situations that arise when computing the final expression: shall the various signals overlap with each other, shall a signal mask another one, and shall a signal be intensified or de-intensified, and so on.

Anyway, a concrete relation between personality and emotion or the influences of emotion on Greta's mind are not really identified.

5) Model EMA proposed in 2004 by Gratch and Marsella [2]

In their research, the authors have been developing a general computational model of human emotion, EMA (EMotion and Adaptation), that attempts to account for both the factors that give rise to emotions as well as the wide-ranging impact emotions have on cognitive and behavioral responses, particularly coping responses. EMA's current mental state is represented with a complex mental structure, called *Causal Interpretation*, designed to unify in one single architecture/structure all the needs of an emotional agent. The *Causal Interpretation* is set up of three causally linked parts: the causal history (the past), the current world (the present) and the task network (the future). This *Causal Interpretation* takes into account many factors affecting emotions like plan, beliefs, desires, intentions, probabilities and utilities of events.

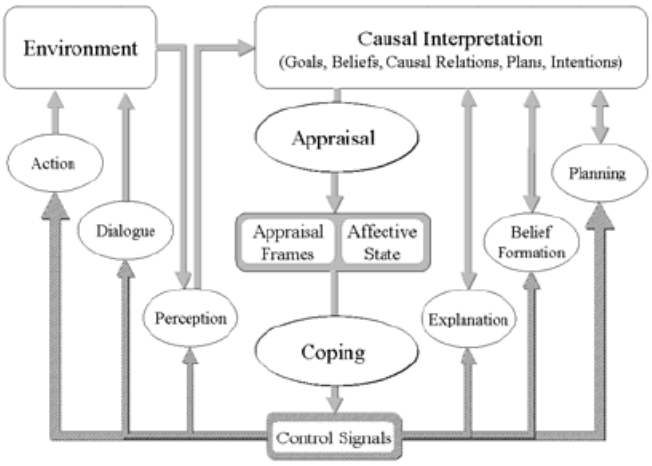

Figure 3. EMA architecture

In modelling EMA, the authors have based on theory of Ortony et al. about *event appraisal*, theory of Lazarus about *appraisal* and *coping*. The model has been implemented and used in virtual human technology applied in training application (e.g. Mission Rehearsal Exercise), health intervention, marketing and entertainment. However, the authors didn't model personality in EMA model.

6) Model GALAAD of Adam et al. (2005) [6]

GALAAD is an emotional conversational agent applied on agents BDI, on dialog games and on speech acts. Based on OCC's theory on *appraisal*, agent GALAAD can produce an emotion. This emotion then influences the rules of dialog game and launches a process of *coping*, which is defined by Lazarus. The strategy of *coping* is in order to maintain agent's balances by decreasing intensity of negative or sensitive emotions that could cause bad effects on its behavior.

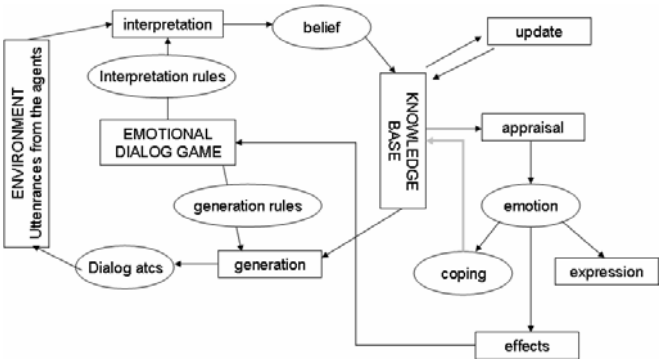

Figure 4. Architecture of GALAAD

Anyway, this model is just an attempt to integrate really *appraisal* and *coping* in conversational agent's architecture in dialog games, it didn't take into account the personality and motivational states in emotion reasoning.

Another model of Carole Adam is the model **PLEIAD** [8] which seemed to be another version of GALAAD. In this model, the author concentrated in the way to update the agent's knowledge base with the introduction of *Logical Prover* and *Activation module*. The perceived stimulus is entered by user in describing its name and effects, the way to express emotions on facial and bodily animation is not handled at all. Like GALAAD, PLEIAD doesn't integrate the notion *personality* for their BDI agent.

TABLE I. COMPARISON OF DIFFERENT MODELS OF EMOTIONS

No	Name of model	appraisal	coping	personality
1	FLAME[1]	Yes	Yes	No
2	ParleE [3]	Yes	Not mentioned	Rousseau's model
3	Robot Kismet [14]	Not mentioned	Not mentioned	No
4	Greta [5]	Not mentioned	Not mentioned	Personality trait
5	EMA[2]	Yes	Yes	No
6	GALAAD[6]	Yes	Yes	no
7	PLEIAD[8]	Yes	Yes	No
8	GRACE	Yes	Yes	MBTI standard

In conclusion, the models that we presented here have most of what we want in a model of emotions. Even so, we find that there is not yet an agreement on emotional process and on personality, neither on the relation between them. From the MBTI standard of personality, it is clear that the personality participate not only in the process of perceiving, reasoning and expressing emotions but also in the way of creating emotions (e.g. *intuition*). In order to take into account all that, we propose here a computational model of emotions that covers not only all existent models but also a more complete notion of personality. We name our model **GRACE – Generic Robotic Architecture to Create Emotions**

IV. GRACE - GENERIC COMPUTATIONAL MODEL OF EMOTIONS

Since there is not a consensus on definition of emotions, we would like to propose one that marks our depart point.

We must specify here that we will use some English words to name some concepts. These words are usually used in real life to cover large notions that can be very different from the sense given here. We have decided to use these words because we consider that it simplifies the presentation.

Definition of emotion: an emotion is the process that characterises the human body's response to an **event.** By *event* we mean: external changes in the environment of the body, absence of external changes in the environment although one expected, and internal body change.

By *human body response* we mean: physiological changes inside the body, external expressions of the body and also … no change.
Notice in this definition that the starting point of the emotion process is an event. The process of reacting to an event takes some time and this time is not constant. So it is possible to have the response to a later event before the anterior one.

Based on this definition we propose the following model in Fig.7:

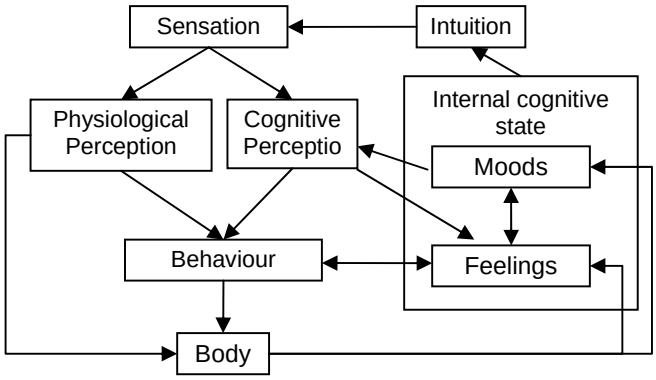

Figure 5. The proposed generic model

Let's look at what we model in our proposal:

Sensation: This part is very difficult to define. It is the place where an emotion will begin. We can consider that the appraisal is always scanning the environment of the body and its internal state. For some reasons a change is detected: a sensation is born. This sensation can come from an event, an action of an agent or an aspect of an object.

Physiological perception: In response to a sensation, the output to the body can be immediate. In this case, we are in the situation where the emotion comes from bodily change (*I see a bear ->I sweat, my heart races -> I feel afraid*).

Cognitive perception: The cognitive perception is a filtering of the sensation. It transforms the sensation at a semantic level. A sense is attached to the sensation. The sense depends on the moods of the person. The mood plays the role of amplifier for some particular features. This is a first part of the interpretation of the sensation. The second part is based on: beliefs, novelty, and concordance with standards, goals connection (cf. Scherer).

Internal cognitive state: The internal cognitive state is the place where two different statements are activated: feelings and moods.

Feelings: is a meta-level in which the cognitive perception, the behaviour and the action on the body is analysed. This level analyses the global situation. It can be: feeling of a situation that has already been experienced, feeling that it is the good direction, feeling uncomfortable because the situation is not

the expected one, feeling happy because everything is under control …
Mood: is the place where a global image of past feelings is kept. It has an influence on cognitive perception. It includes stance (fight, escape, help, love ...), mental states (motivation, interests, extraversion, introversion), physical state (tiredness, anxiety …)

Intuition: This module is used to create sensation while nothing really happens in the environment. This intuition is based on the internal cognitive state. Intuition can be seen as a consequence of the feelings. Feelings analyse the situation and can predict a sensation through acquired knowledge. The intensity of this prediction can generate a real sensation.

Behaviour: This is the response that the body must give to a perception. Here, we find this is very classical in robotics. All the planning, learning, and evolutionary methods can be applied in this case. The difference here from a classical architecture is to create a dependency from the internal cognitive state. In fact, the reaction to a perception is not always the same; two levels can be distinguished:
The first classical one is the idea that when we learn that a response is not adapted to an input, we calculate another response to the situation.
The second one is the consequence of cognitive state dependence. If the cognitive state is aggressive or happy, it will not create the same reaction as someone who is quiet or depressive.

Body: The body is the place in which behaviours are expressed. This expression can be internal through the nervous system. It is responsible for the increase of one's heartbeat and blood pressure, among other physiological changes, along with the sense of excitement one feels due to the increase of adrenaline in the system. The expression can also be external with facial expressions (FAC), voice, stance, sweat …

After defining all components of the model, where will we find out the **role of MBTI**? Here you are:

The first one is the attitude split in **Extraversion** (E) or **Introversion** (I). In the generic model this particular feature is integrated in the Mood and Behaviour modules.
The second perception category of the MBTI is completely covered by the generic architecture. The **Sensing** is constructed with the two perception modules and the **Intuition** by the intuition module.
The third category is decisions **Thinking** (T) or **Feeling** (F). We cover these two approaches by the way that the behaviour module of the generic model is coded.
Lastly, the attitude of MBTI is divided into **Judging** (J) and **Perceiving** (P). This is at the perception level where this feature will be coded. In fact, it is a level of interest for the sensation that will be used. For instance, a sensation directly concerning a person will be more interesting for someone who is Perceiving.

V. CONCLUSION

We have proposed a generic model to build a computational architecture to express emotions and personality. Because these two notions are not consensual, our proposition is open for discussion.
The originality of this work is to include a psychological approach in the software architecture for a robot.
We are currently testing an instance of this architecture in the EmotiRob project.

ACKNOWLEDGMENT

This project is supported by the ANR project Emotirob. All references to people participating in this work can be found in [25].

REFERENCES

[1] Magy Seif El-Nasr, John Yen, and Thomas Ioerger, ***FLAME - A Fuzzy Logic Adaptive Model of Emotions***, Journal of Automous Agents and Multi-agent Systems, vol 3, p. 219-257, 2000
[2] Jonathan Gratch and Stacy Marsella, ***Evaluating a computational model of emotion***, Journal of Autonomous Agents and Multiagent Systems (Special issue on the best of AAMAS 2004), 11(1), pp. 23-43, 2004
[3] The Duy Bui, Dirk Heylen, Mannes Poel, Anton Nijholt: ***ParleE: An Adaptive Plan Based Event Appraisal Model of Emotions***, Proceeding of KI 2002: Advances in Artificial Intelligence, 25th Annual German Conference on AI, p. 129-143, September 16-20, 2002
[4] Rousseau, D. (1996). ***Personality in Computer Characters***. In: Proceedings of the 1996 AAAI Workshop on Entertainment and AI / A-Life, AAAI Press, Portland, Oregon, August 1996, pp. 38–43.
[5] F. de Rosis, C. Pelachaud, I. Poggi, V. Carofiglio, N. De Carolis, ***From Greta's Mind to her Face: Modeling the Dynamics of Affective States in a Conversational Embodied Agent***, Special Issue on "Applications of Affective Computing in Human-Computer Interaction", The International Journal of Human-Computer Studies, vol 59 (1-2), July 2003.
[6] Carole Adam, Fabrice Evrard. ***GALAAD: a conversational emotional agent***. Rapport de recherche, IRIT/2005-24-R, IRIT, 2005.
[7] Carole Adam, Fabrice Evrard. ***Vers un modèle optimal des émotions - revue des modèles existants***. Rapport de recherche, IRIT/2005-15-R, IRIT, juin / june 2005.
[8] Carole Adam, ***Emotions: from psychological theories to logical formalization and implementation in a BDI agent,*** PhD Thesis, 2007
[9] Magda Arnold ***Emotion and personality***, Columbia University Press, New York, 1960
[10]James, William. 1884***. What is an Emotion?*** Mind, 9: 188-205.
[11]Andrew Ortony & Terence J. Turner ***What's Basic About Basic Emotions?*** Phychological review 1990 Vol 97 n°3 315-331
[12]Kleinginna, P.R. and Kleinginna, A.M. (1981) ***A Categorized List of Emotion Definitions with Suggestions for a Consensual Definition***, Motivation and Emotion 5: 345–79.
[13]A. Ortony GL. Clore L.Collins ***The cognitive structure of emotions*** Cambridge University Press, Cambridge 1988
[14]C. Breazeal ***Emotion and sociable humanoid robots***, E. Hudlika (ed), International Journal of Human-Computer Studies, 59, pp.119-155, 2003
[15]Briggs-Meyer Isabel & MacCaulley Mary, ***Manual: a guide to the development and use of the Myers-Briggs Type Indicator***, Consulting Psychologists Press, 1985.
[16]Lazarus R. S., ***Emotion and Adaptation***, Oxford University Press, 1991.
[17]S. Saint-Aimé , B. Le Pévédic , D. Duhaut & T.Shibata ***EmotiRob : Companion Robot Project*** 16th IEEE International Symposium on Robot and Human Interactive Communication August 2007 IEEE RO-MAN 2007.
[18]http://www-valoria.univ-ubs.fr/emotirob/index.html
[19]Klaus R. Scherer, ***What are emotions? And how can they be measured?***, Social Science Information © 2005 Maison des Sciences de l'Homme , SAGE Publications, Vol. 44, No. 4, p. 695-729, 2005