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A generic architecture for emotion and personality

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***Abstract* – In this paper we propose a generic computational model to include emotion and personality in the behaviour of a robot. This model is based on classical hybrid architecture for robot computation and merged with psychological works on emotion and personality.**

***Index Terms* – hybrid architecture, robot programming, emotion, psychology.**

I. INTRODUCTION

Building a companion robot needs to include in its general behaviour some "human characteristics". These human characteristics are the capability to have:

- similar emotions of human being
- a personality

Based on this idea, we looked to the definition of emotion and personality and how to include them in a software architecture. For emotion things are difficult because a lot of different definitions exist depending of the field of interest. For instance philosophers, psychologists, traders, ethnologists do not look to the human emotion by the same way. For personality we found a very popular description that we adopt for this work. Based on this we propose a generic architecture to include emotion and personality in a robot behaviour.

In this paper we present, in section II, the EmotiRob project which aims to build a companion robot. Then, in section III, we look to the definition of emotions and we will propose to keep only 3 mains unsolved questions on emotions: origin, composition and appraisal. Then, in section IV, we look for the MBTI approach to define personality. We retain this approach because it is very famous (more then 10000 MBTI test/day in USA in 1991). We propose, in section V, a generic computational model based on 8 modules to include emotion and personality in the robot control architecture. In section VI we discuss how can be implemented in the modules of the generic architecture all the different features defined for emotion and personality. Lastly we will give some conclusions.

II. EMOTIROB PROJECT

The EmotiRob project consists in designing a robot companion for impaired children or for children having to undergo lengthy hospital stays.

The experiments previously conducted on elderly people staying in pensioners' homes with the Paro [1] seal designed by T. Shibata (AIST, Japan) have clearly shown that robot companions can bring some moral and psychological comfort to fragile people. We used Paro to carry out two experiments with handicapped children. The experiments showed us two main tracks that our research could follow.

The first one is related to mechanical issues: such robots must be very light, easy to grasp and handle (more so than Paro is); what is more, they must be highly autonomous.

The second one deals with man-machine interaction: the kind of psychological comfort that robots can provide depend on the quality of the affective bridge built between them and the children. It seems obvious that the link could be significantly enhanced if robots were to understand human speech and to express emotions in return.

The difficulties therefore consist in adding the constraints of lightness and autonomy to those of understanding and expression. We have already started conducting a study on the expression of emotions; it seems to show that six degrees of freedom (DoF) would be enough for a face to express six fundamental emotions sufficiently well. As for automatic understanding and system adaptation to handicap, they are recurring topics within our laboratory.

Our project, therefore, is to design a robot which would keep Paro's fundamental qualities – stuffed animal pleasant to the touch, use of captors and sensors. 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.

In order to conduct this project, the research program includes building a corpus of child speech within the particular context required by the project, a linguistic study of the corpus with a view to applying the results to natural language processing techniques (particularly in natural language understanding); it

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also includes studies on perception and emotion modelisation, and, last but not least, the actual design and making of a robot.

III. EMOTION STUDY

To introduce the subject we will first present some definitions of emotion.

For Magda Arnold [2]: An emotion … is a felt tendency toward anything intuitively appraised as good (beneficial), or away from anything intuitively appraised as bad (harmful). This attraction or aversion is accompanied by a pattern of physiological changes organized toward approach or withdrawal. The patterns differ for different emotions

For James [3]: My theory ... is that the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur is the emotion."

In Ortony [4] For several contemporary theorists, the idea that there exists a small set of basic emotions is central to their theories

Scherer [5] I want to describe and defend a programmatic statement of a component process definition of emotion.

By the way it is possible to find more then 100 definitions of emotions [6] and 150 theories [7]. The previous set of definitions is interesting because it introduces the basics problems around emotion:

- Is it the emotion coming from a bodily change (*I see a bear ->I sweat, my heart races -> I feel afraid*) or the bodily change is coming by the emotion (*I see a bear-> I feel afraid- I sweat, my heart races*)
- Is there a set of basic emotions. Are emotions based on a combination of elementary emotions.
- Is emotion a consequence of a cognitive appraisal. How is characterised the appraisal.

In the following we will present some models of the organisation of emotions: OCC how an emotion is launched, Plutchik a classification of emotions, Scherer emotion dimensions.

A. *Launching emotion*

The OCC model is proposed by Ortony, Clore Collins [8]. For them 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.

The positive aspect of this model is that it is very near of a computational approach. The negative point of this organisation is that it does not treat intensity on emotion.

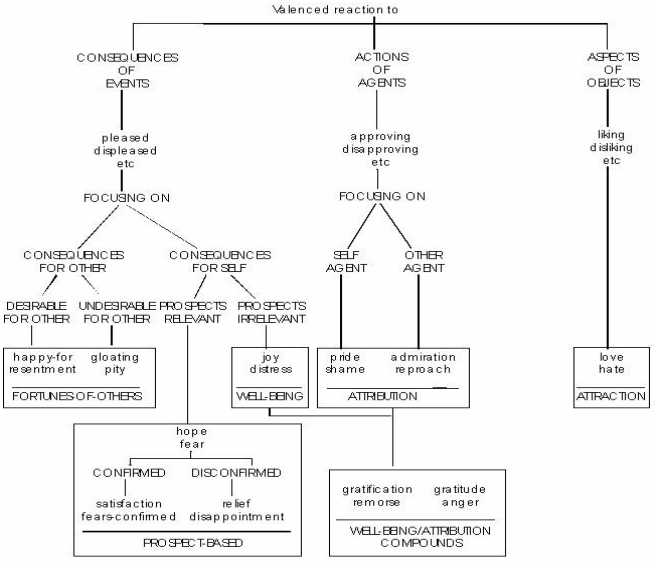

Fig 1 : OCC model of emotion

B. *Emotion organisation*

This classification of emotion defines some intensity sectors. We see here that it defines 8 sectors with for levels of intensity. This approach is interesting to place an emotion in the space of emotions, but does not give an evaluation mode.

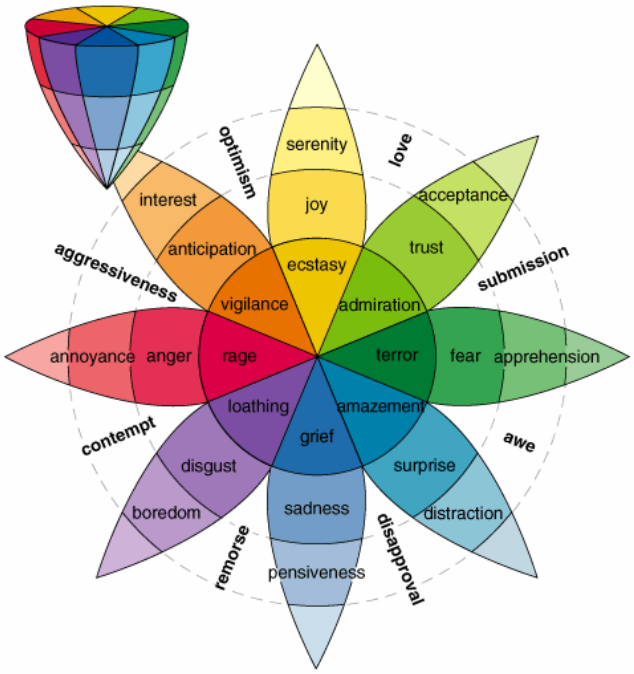

Fig 2 : R.Plutchik [9] emotion wheel

C. *Emotion dimensions*

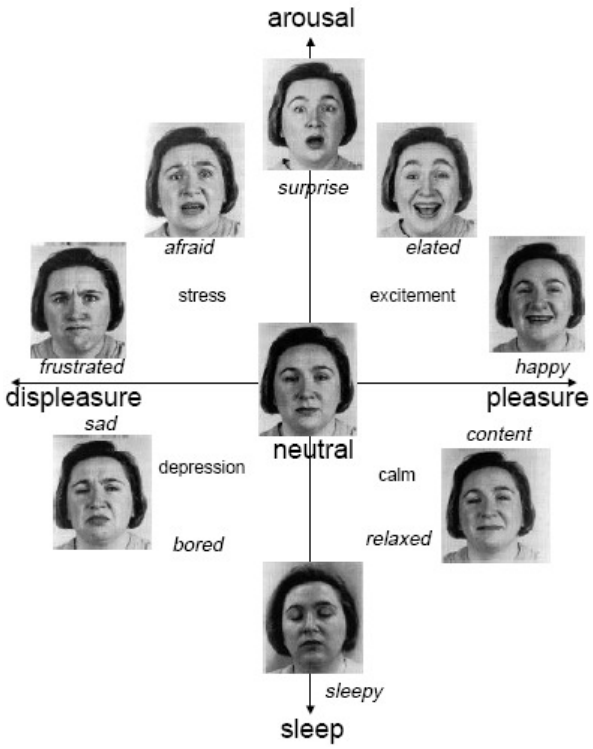

Fig 3 : Emotion dimensions proposed by Breazeal inspired by Russel

This two dimensions (arousal and valence) are proposed here by Breazal [10] are very often used in emotion evaluation because they correspond to physical characteristics that can "easily?" be recognised.

The more achieved model of emotion is proposed by Scherer. In his proposal the approach is based on appraisal. This appraisal gives an evaluation of the external situation: something changes (or did not change) in the environment but the human was waiting for. The appraisal will be based on evaluation of criteria (How suddenly and abruptly did E occur? How familiar was the person with E? How probable is the occurrence of E in general? …). With this decomposition it is proposed a table of influences on basic components of the emotion (not viewed like a composition of basic emotion).

A sequence of treatment is proposed in 5 steps:

- Novelty : suddenness, casualness, foreseeability
- Intrinsic agreement
- Goals connection : pertinence, certainty in effects, expectation, desire, urgency
- Potential control : internal origin, external origin, power, adjustment
- Concordance with standards : legitimacy, fairness, blameworthiness

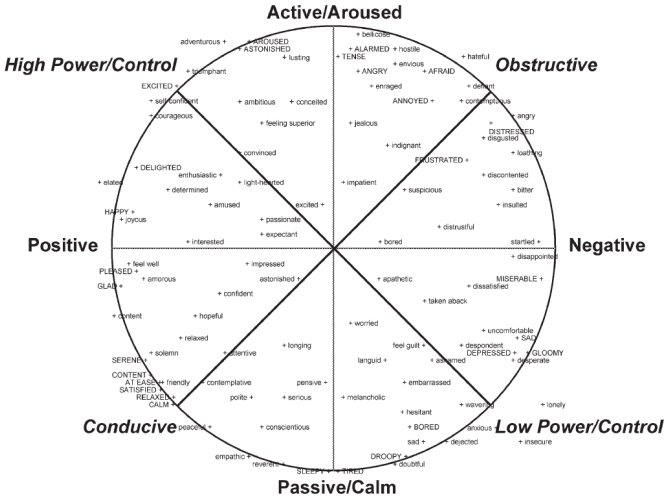

Fig 4 : Emotion dimensions proposed by Scherer

This emotion wheel is proposed by Scherer we can notice how complete it is and that we find the two classical dimensions and two added dimensions.

To summarise this section on emotion we can say that there is no agreement on a single definition and that the number of dimensions or characteristics to take into account change with the model.

IV. PERSONALITY MBTI

The purpose of the Myers-Briggs Type Indicator (MBTI) personality inventory is to make the theory of psychological types described by C. G. Jung understandable and useful in people's lives. A test is defined and based on Carl Jung and Isabel Myers-Briggs typological approach to personality. The theory of psychological type was introduced in the 1920s by Carl G. Jung. The MBTI tool was developed in the 1940s by Isabel Briggs Myers and the original research was done in the 1940s and '50s. The Myers-Briggs Type Indicator [11] is a self-report instrument that helps to identify an individual's strengths and personality preferences.

The test evaluates four categories of basic preferences of each of the four dichotomies specified or implicit in Jung's theory.

A. *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). Extraversion People

who prefer Extraversion tend to relate easily to the outer world of people and things. Introversion People who prefer Introversion tend to relate easily to the inner world of ideas and impressions.

B. *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 who prefer Sensing tend to be interested in what the five senses show them—what exists in the present. Intuition People who prefer Intuition tend to use their imagination to see new possibilities and insights—focusing on the future.

C. Decisions

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

D. Attitude

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 who prefer Judging tend to like to have things decided; life is likely to be planned and orderly. Perceiving People who prefer Perceiving tend to not want to miss anything; life is likely to be spontaneous and flexible.

E. Personality

Your **Personality** Type: 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 is resulting from the interactions among the categories.

V. A GENERIC MODEL TO BUILD PERSONALITY IN A ROBOT

Because there is no consensus of opinion on the definition of emotion, we will first propose here our definition. Then it will be possible to propose a generic model.

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

Definition of emotion: an emotion is the process that characterises the human body response to an event.

By *event* we mean: external changes in the environment of the body, external absence of change in the environment while one was 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 emotion process is an event. The process to react 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 Fig5 the following model:

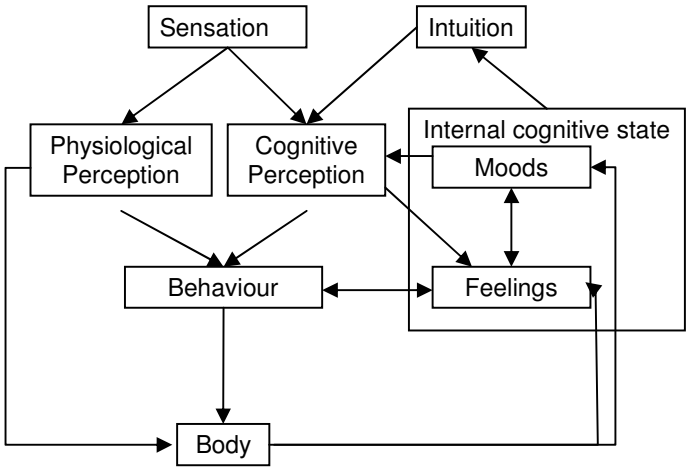

Fig 5: The proposed generic model

In this model *sensation* is the basic starting point. The sensation is generated by an event, something really existing or not, but generating a physiological change in the body or sending objective information on the sensors of the body: touch, hear, see … This sensation will be processed in two levels in parallel.

First, the *physiological* perception will transform this initial signal in a body response directly (the heart races …) and will also alert the *behaviour* level.

The *cognitive* perception will transform a signal received by the body into cognitive information on the environment situation.

The *behaviour* will calculate the response to the information coming for the perceptions based on the internal cognitive

state. This response is sent to the body where the physical reaction will take place.
Let's now have a look to these different levels and to their dependency.

A. *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 is analysed the cognitive perception, the behaviour and the action on the body. This level analyses the global situation. It can be: feeling of already sawn situation, feeling that it is the good direction, feel uncomfortable because the situation is not the expected one, feel happy because everything is under control …

Mood: This is the place where is kept a global image of the past feelings. It has an influence on cognitive perception. It includes stance (fight, escape, help, love ...), personality (motivation, interests, extraversion, introversion …), physical state (tiredness, anxiety …)

B. *Sensation*

This part is very difficult to define. It is the place where an emotion will begin. We can consider (if we follow the idea of Scherer) that the appraisal is always scanning the environment of the body and its internal state. For some reason a change is detected: a sensation is born. This sensation can be (following the idea of OCC model) coming from an event, an action of an agent or an aspect of an object. This sensation is sent to the two perception modules (physiological and cognitive). Each of this module can inhibit this entry is the level is consider to low (we can here make a link with Brooks subsumption architecture[12]).

C. *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 is coming from a bodily change (*I see a bear ->I sweat, my heart races -> I feel afraid*). This part corresponds to the reactive part of robot control architecture [13].
The physiological perception can also be transformed in other information given in entry to the behaviour module.

D. *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 is playing a role of amplifier for some particular feature. 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).

From a computation point of view this level will include learning, world modelling, prediction on the evolution of the world all of this is affected by the mood of the body. We are typical in the cognitive part of an hybrid architecture [13].

E. *Intuition*

This module is used to create sensation while nothing happens really in the environment. This intuition is based on the internal cognitive state. We can see the intuition like a consequence of the feelings. Feelings analyses the situation and can by learning predict a sensation. The intensity of this prediction can generate a real sensation.
From a computation point of view this level will make statistic of sensation already detected in a specific context. A prediction algorithm can then be developed. At a second level intuition can be obtain by matching some sequences of sensation with an homomorphism transformation on past sensations.

F. *Behaviour*

The behaviour is the response that the body must give to a perception. Here we find what is very classical in robotics. All the planning, learning, evolutionary methods can be applied here. 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 we can distinguish two levels:
The first classical one is when we learned that a response is not adapted to an input we calculate another responses to the situation.
The second one is consequence of cognitive state dependence. If the cognitive state is aggressive, happy it will not create a same reaction as someone who is quiet, depressive.
Lazarus [14] proposed the notion of coping to adapt the response to the perception. Iti is decomposed in two: problem focused or emotion focused. The problem focused coping will try to solve the problem (classical approach) but can also denied the problem to minimise 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 not anymore the problem but its consequence in the body if a reaction is given.

G. *Body*

The body is the place here are expressed the behaviours. 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 …

VI. DISCUSSION

A. *On emotion*

The generic model proposed here aims to cover the different approach for modelling emotions. For instance, if we come back to the introduction on emotion definitions then we can see that this model is adapted to an approach based if the emotion coming from a bodily change (*I see a bear ->I sweat, my heart races -> I feel afraid*) in this case the information would follow the path: sensation -> physiological perception ->body -> behaviour -> internal cognitive state -> body again. On another hand if the bodily change is coming by the emotion, the information would follow the path: Sensation -> Cognitive perception -> behaviour -> internal cognitive state -> body.
By the same way, we can notice that assuming that emotions are built over a set of basic emotions can be implemented by coupling the perception & behaviour modules.
Finally a model based on cognitive appraisal is fully covered by definition with the 3 modules: internal cognitive state, cognitive perception , behaviour modules.

B. *On personality*

The MBTI model proposes four categories to build personality.
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. E and I are acting as a filtering in the cognitive perception. An extraversion will take the first sense of a sensation while introversion will search a second sense of sensation. By the same way, in the behaviour module extraversion will find a quick answer while the introversion will search in deep the most appropriated reaction.
The second category perception 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 this two approach by the way that is coded the behaviour module of the generic model. If we make a decision tree with a deep exploration of the solution we will be Thinking but is we code the behaviour by a rule based approach then we will be in the Feeling mode.
Lastly the attitude of MBTI is decomposed in **Judging** (J) or **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 concerning directly the person will have more interest for a Perceving.

Of course this proposed ways to implement a personality is very complex. In the EmotiRob we only implement restriction of the generic model. This work is proposed in another paper [16]. For instance in the cognitive perception module we have two different levels : the first one “emotional experiences selection” which identifies the emotional state of the children and an “emotional experiences generator” which generates the input to the behaviour module in transforming the information acquired on the children on an internal information for the robot.

VII. CONCLUSION

We proposed a generic model to build computation architecture for a robot expressing emotion and personality. Because these two notions are not consensual our proposition is open for discussion.
The originality of this work is to include psychological approach in the software architecture for robot.
We are actually 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 [17].

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