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A way to put empathy in a Robot

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Abstract

A report on the experiments carried out with our robot in the Emotirob project is given in this paper, in which we show how we build emotion and personality in the robot. With children, the results of interaction with the robot are quite satisfactory in a short-term experiment. However, it was noted that during long-term interaction between the children and the robot, the relationship changes as a kind of lassitude sets up. Thus, the question addressed here is, how can we make a robot acceptable for long-term interaction? We propose to explain why empathy is a part of the solution and what the key points are for artificial intelligence to solve this new problem.

1. Introduction

The next generation of the robot will be used to help people in their daily lives. The evolution of technology brings the robot from the factory to home. In this context, the problem to address is the one of long-term interaction between the robot and the human: HRI.

This HRI comes with the fact that the robots will have to perform in a world built for humans, as well as interact with humans. The question then is to know how to design this kind of robot and what problems are to be solved.

We can list a set of classical open problems: sensors for unknown environment, actuators to perform tasks, decision making, planning, models of the tasks, architecture for autonomy, knowledge and learning. All this is very classical and studied, but the fact that the robot must interact for a long time with the human introduces a new challenge: how a machine can be acceptable for long-term interaction. To learn more about this problem, we developed a robot in the Emotirob project for interaction with children. We verified that a machine can become pleasant if the interaction introduces emotions. We believe that, within the context of the ageing process of the population, for old people interacting with a robot at home, sympathy toward the robot is a key point for acceptability. However, it will not be enough to stabilize long-term interaction. Beyond sympathy, we expect the robot to be able to offer empathy to build an affective bridge between the human and the robot.

In this paper we give a summary of the results obtained with Emotirob and present our ideas about what artificial

intelligence must provide to implement empathy in a robot.

Part 2 presents the Emotirob project and shows how emotions and personality are introduced in the robot.

Part 3 gives a state of the art on information technology acceptance. We will discuss the limits of these approaches and explain why sympathy and empathy are necessary in the context of personnel robotics.

Part 4 introduces the major point that artificial intelligence must offer to build empathy.

Finally, we will give some conclusions.

2. The EmotiRob project

The EmotiRob project [1][2] aims at designing a robot companion for impaired children or for children having to undergo lengthy hospital stays. In fact, the experiments previously conducted on elderly people staying in pensioners' homes with the Paro [3] 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 disabled children. The experiments showed that the kind of psychological comfort provided by the robots depends 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 able to understand human behaviour and to react emotionally in return.

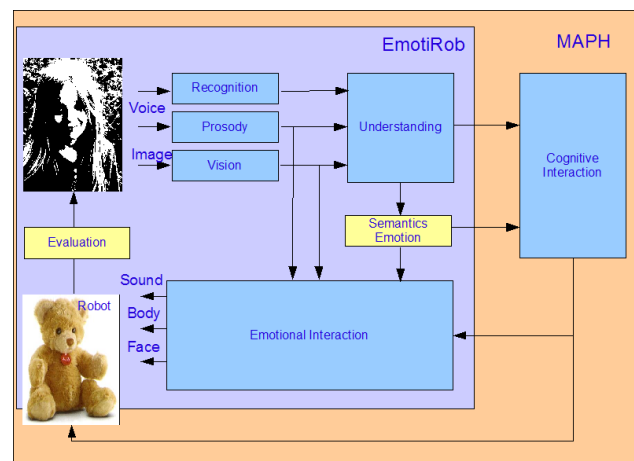


Figure 1: Synopsis of the Emotirob project

As has been shown in the synopsis (see Figure 1), the project is essentially made of three main interdependent parts:

- Recognition and understanding of a child’s spoken language.
- Emotional interaction between the child and the robot.
- Cognitive interaction between the child and the robot.

2.1. Emotion in the robot

We use a model of emotion which takes its background from:

- Ortony, Clore and Collins [4][5], for which 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 theory is that it is very close to a computational approach. This theory is basic for most models of emotions thanks to its generic evaluation criteria on emotions.
- According to Lazarus [6], there are two processes that allow an individual to stabilize his relationship with the environment: cognitive evaluation (appraisal) and adaptation (coping). Lazarus defined cognitive evaluation as an adaptive process which is used to conserve or to modify the relationship between the agent (its beliefs, its goals) and the world (its constraints, its modifications) in such a way so as to maintain balances. For him, when a situation is evaluated as stressful, an individual has to adapt: that is the role of the two types of coping: *Problem-focused coping*, *Emotion-focused coping*.
- Klaus R. Scherer [7] is one of the well-known names in research on emotions. His various publications give different analyses on emotions including the nature of emotion (as a psychological view), the five functional subsystems of emotions (physiological arousal, motor expression, subjective feeling, behaviour preparation, and cognitive processes) and production mechanisms (executing view).

Based on this work we designed a computational abstract model of emotion named Grace [8]. In this model *Sensation* is the basic starting point. The sensation is generated by an event, something which really exists or not, but which generates a physiological change in the body and/or by sending subjective information (from *Intuition*) to the sense organs: touch, hearing, sight ... This sensation will be processed in two ways. First, the

Physiological Interpretation will directly interpret this initial signal into a body reaction (the heart races ...) and will also alert the *Behaviour* module. On the other hand, the *Cognitive Interpretation* will interpret the signals received from *Sensation* into cognitive information about the environment situation.

Behaviour will then calculate the response from the information coming for the perceptions based on the *Internal Cognitive State*. The internal cognitive state is the place where the belief, desire and intention of the robot are implemented.

This response is sent to the *Body* where the physical reaction will take place.

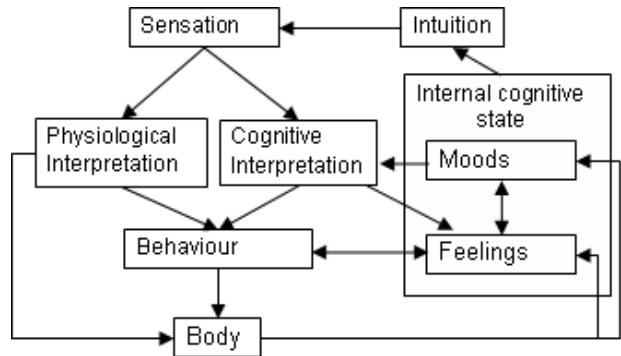


Figure2: GRACE-Generic Architecture to Create Emotions

This generic model has been partially experimented [9] and is the base of the general implementation of iGrace (figure 3). The iGrace model is the instantiation of Grace, which focuses on one-to-one interaction between a child and the EmI robot.

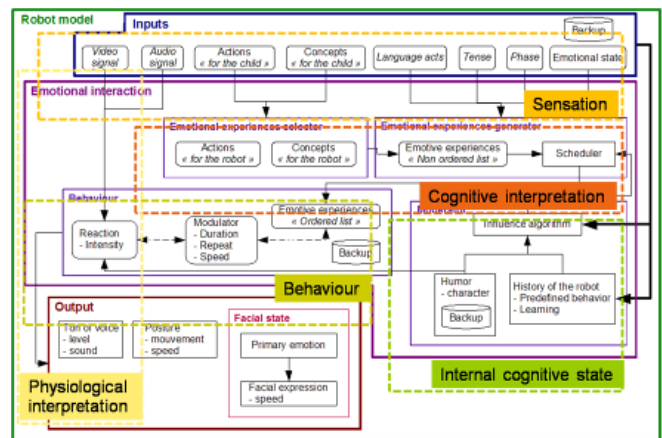


Figure 3: Computational interaction model – iGrace

This model is implemented in the robot and the expressions of emotions are done with 10 degrees of freedom:

- the facial expression of the robot based on 6 degrees of freedom for the face,
- the neck with 2 degrees of freedom (pan-til)
- and 2 others for the body [10]

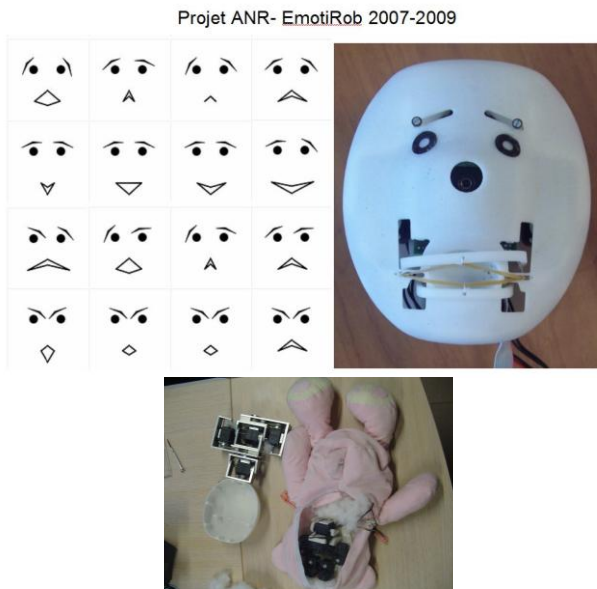


Figure 4: The EmI robot

2.2. Personality in the robot

Introducing personality in the robot is important for acceptability. The personality is the character of the robot.

If we want to express a “cool” robot A or a “nervous” robot B, we need to implement robot movements with different algorithms. Even if the general postures of A & B are the same at the beginning and the end of the movement all the difference will be in the dynamics. For instance, if you slow down for a short time during a displacement it can be perceived by the human as hesitation. The dynamics of the robot is the key point of personality [11].

2.3. Experiment

Experiment with the EmI robot was done in a school with an evaluation grid. The objective of this experiment was to evaluate the recognition of emotions through the simulator, and especially to determine if the response given by the robot to what was said was satisfying or not. As for the rate of appreciation of the behaviour for each speech segment, 54% for at lot of satisfaction and 46% for

a little, we observed that all the users found the simulator’s response coherent, and thereafter admitted that they would be fully satisfied if the robot was as they expected. The fact that testers answered about the expected emotions had an influence on overall satisfaction.



Figure 5: Experiment with EmI in school

For the rate of emotion recognition, 82% in average, the figures were very satisfactory and allowed us to prepare the next evaluation on the classification of facial expressions for each primary emotion. Not all emotions are on the graph because they bore no relation to the sentences chosen. We have also been able to see that even if the results were still rather high, there were some emotions which were recognized although they were not expressed. This confirms the need to classify, and especially the fact that each expression can be a combination of emotions. The next question is to know if the satisfaction rate will be the same with the robot after the integration of the emotional model. The other results were useful for the integration of the model on the robot:

Speed of expressions: normal with 63%

Behaviour length: normal with 63%

Emotional combination: yes with 67%

Natural sequences: yes with 71%

3. The acceptability problem for a long period of time

Usually the problem addressed in research on information technology (IT) acceptance is based on how and why people use a specific technology. Is it easy to use?, do people use it (even if it is easy to use)? are the main problems [12].

The acceptability is then measured according to a theory that privileges [13]:

- Performance expectancy

- Effort expectancy
- Social influence
- Facilitating conditions
- Behavioral intention and use behavior.

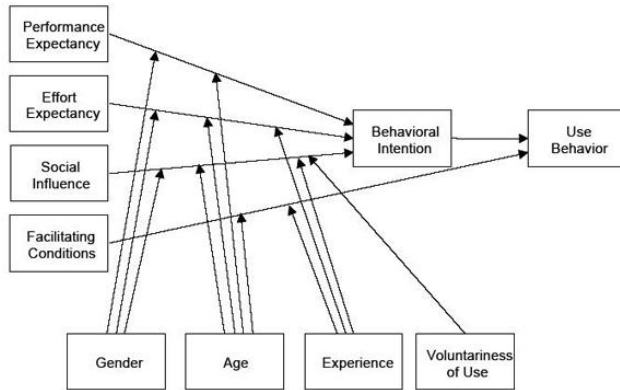


Figure 6: UTAUT unified theory of acceptance and use of technology [13]

This model does not take into account the “prestige” of using something. For instance using an Iphone can be perceived by the user as a machine bringing some prestige to its owner, because it is well designed, nice to see... This prestige is an emotion and the problem of emotional design is addressed by D. Norman [14].

We define “prestige” on two levels:

- Individual or reflection: because we use a nice, rare, expensive, desired object ... then we feel better, higher, stronger, superior, more important...
- Social: in the eyes of the other, because we use an object, we become a member of a group or community, well considered, integrated, desired, care to associate with ...

From the robot point of view, there is another dimension to introduce which is the benefit of the relationship with the robot in daily life. This benefit can be on a first level where the robot is only a machine or object providing functionalities and then the acceptance presented above is applied. On a second level, the robot can be a comforting machine.

A comforting robot if defined on two levels:

- Security: easy to use, reliable, performing actions in a secure way, monitoring your health, preventing accident, supervising the house ...
- Empathy: listening, understanding, acting for the comfort on physical and psychological levels.

This last level is not actually explored in robotics and the reason is that the problem is rather complex because it must be implemented in the robot emotional process. This process of having a strong affective impact is facilitated when people perceive their pets as responding to them on an emotional level (wagging tails in happiness, howling in loneliness, growling in anger, etc.) [15]. But the way that empathy emerges in interaction is when people perceive an objective response as showing that their emotion was understood by the robot. Understanding human emotion needs to merge information from the appearance of a person (posture, state) and from what that person says. Appearance is studied often by a vision system analyzing the face [16].

Understanding speech is still an open problem and here, we would like to present three levels of knowledge that the robot must have to reach this goal.

4. The way to resolve empathy

The emotion coming with speech is very difficult to analyze. Prosody is one possible approach, but does not depend on the associated semantics [17]. This is not enough to build empathy as it is the semantics of speech is fundamental in associating a good reaction of the robot.

We will now show that there are three levels of semantics that must be taken into account if we expect to give the “right” answer.

4.1. First level of understanding

On this first level, the sentence is without any interpretation.

For instance:

“The flowering plant needs water” is something that needs no special interpretation. It is a fact based on common knowledge: plants need water, water is missing then the robot can propose action. In this case, the sentence can be understood as a command coming from the human.

4.2. Second level of understanding

On the second level, reference to specific knowledge is made and interpretation is needed.

For instance:

“The flowering plant looks like Meb Keflezighi”.

To understand this, the robot must find out who Meb Keflezighi is. It will find (on internet) that this man was the winner of the New-York marathon in 2009. With this information, it is possible to infer that after the marathon Meb Keflezighi was tired and thirsty. Then, by

inference on similitude, it will discover that water is missing and then understand that the plant needs water.

We can see here that depending on the image associated to Meb Keflezighi, the sentence can be funny or sad. If the sentence was “The flowering plant looks like Phidippidès”, then the comparison would become a tragedy.

This gives emotional information that can be used to construct the response of the robot.

4.3. Third level of understanding

On the third level, reference to specific knowledge is also made and interpretation is needed, but this information is private to the person.

For instance:

“The flowering plant was given to me the 21st of May, 2007”.

Here, without the information of what happened on the 21st of May, 2007, it is impossible to know what the meaning of the sentence is. The difference with the previous level is that the meaning of the information is linked to a specific period of the life of the person and no data base has recorded this information. Thus, the robot will only be able to understand the sentence if, in its knowledge, it has learned the important events of the person’s life with who it interacts.

These three levels express how human speech must be understood to allow for an implementation of empathy in a robot.

4.4. How to implement

In this part, we want to discuss the possible way for a robot to realize this understanding.

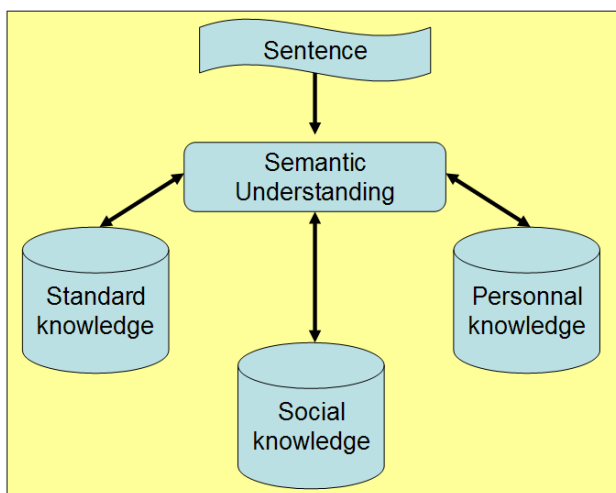


Figure 7: The three levels of knowledge for empathy

The first level is connected to a standard knowledge. This is the first data base to develop and this is currently an active research part. Moreover, this level often generates an action on the environment from the robot. This part of the knowledge is implemented in all the personal robots and is used to understand the meaning of everyday sentences.

The second level requires the robot to search for information to understand the sentence. This means that it must have access to social knowledge and in this case, the internet is a good means for carrying out this type of research. The difficult part here is to filter all the information to obtain what is relevant.

The third level requires that the robot learn the personal history of the human from the human. This is possible only by a dynamic acquisition of information. The sources of this information can be multiple: family, doctor, friend, neighbor. This personal knowledge is the fundamental issue to be in empathy with someone.

5. Conclusion

This paper proposes to introduce the three key points of knowledge to build empathy in a robot, based on the experiment with the EmI robot. Empathy is necessary to solve acceptability in interaction over a long period of time with a robot which is not simply a standard object because it is “alive”.

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