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# Experimentation to evaluate EmotiRob interaction model

Sébastien Saint-Aimé, Brigitte Le-Pévédic and Dominique Duhaut

**Abstract**—This article presents the first experiments conducted on the interaction model of the EmotiRob project. It presents the experimental protocol, the evaluation grid and the results, and a short description of the robot's architecture.

## I. INTRODUCTION

Since a few years, the new challenge is to build systems that will offer behavior enrichment through their interaction with humans. Facial expressions play a major role in the coordination of human conversation [1] and constitute an essential method of human communication.

Robotherapy tries to apply the principles of social robotics with the added goal of improving the psychological and physiological state of those who are sick, secluded, or suffer from physical or mental handicaps. The robots seem to be able to play a part in accompanying and awakening them, and for that purpose should be equipped with a maximum of capacities of communications.

The experiments in this field of robotics - with robots like Paro [25], iCat [26], Cosmobot [27], aibo [29], Kismet [30], Nao [28], etc. - clearly showed that robot companions can give a certain amount of moral and psychological comfort to fragile people.

In this context we began an experiment [9] using the Paro robots to check whether or not the reaction / interaction with the robots was dependent on cultural context. These experiments showed us two principal directions in which it would be interesting to work. The first one deal with mechanical problems: the robot must be very light, easy to take and to handle, easier than Paro; moreover, it must have a great deal of autonomy. The second one leads to changing the man-machine interaction: the psychological comfort that the robot can provide is related to the quality of the emotional tie that the child has with it.

## II. EMOTIROB PROJECT DESCRIPTION

The EmotiRob project [18] aims to design a robot companion for children of 4 to 6 years, with various disabilities, to comfort and accompany them in their daily life. We want to equip this robot with the necessary capacities of perception and comprehension of natural language so that it

can build a formal representation of the emotional state of its interlocutor. Lastly, the project also comprises the design of a model of the emotional states of the robot and their evolution, in order to make its reactions seem as natural as possible. To carry out this project, the research program includes collecting child language recordings and building a corpus allowing for the linguistic studies of child language in context. In turn, it should help with SLU (Spontaneous Language Understanding) issues and, more generally, with NLP- related research the ultimate purpose of which is to model the expression of emotions through speech prior to the actual manufacturing of the robot

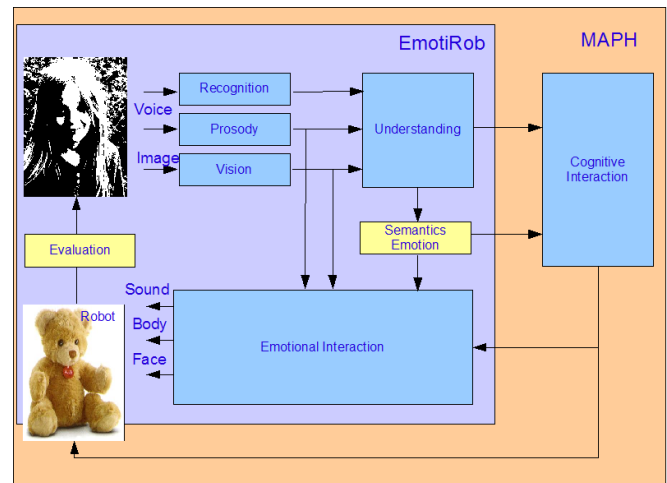


Fig. 1. Project synoptic

The early stages of the project first allowed us to define the necessary degrees of freedom for the robot to express primary emotions, then to define an emotional model for non-verbal and emotional interaction with the interlocutor. We had to take into account the difficulties arising from the understanding of speech, do various manual annotations between emotions, emotional experiences, the words, speech and personality of the robot. The instantiation of the model ended, it is now possible to start the experiments needed to validate it and to check if the acceptance rate of the interaction was acceptable. The great question we were asked was whether the behavior linked to the speech was coherent, if the emotions expressed were recognized, and whether the dynamics of emotions seemed natural. In addition, we had to experience the speed of the expressions and the behavior length in order to include them in the robot. We will try to answer all these questions in our evaluation

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### III. INTERNAL ARCHITECTURE SIMULATION

The emotional model used is entirely based on GRACE [20] and instantiates the different modules for the project. iGrace (see Fig. 2) is divided into 3 distinct, communicating parts: inputs, emotional interaction and outputs. This document describes the information processing and the behavior simulation of the robot.

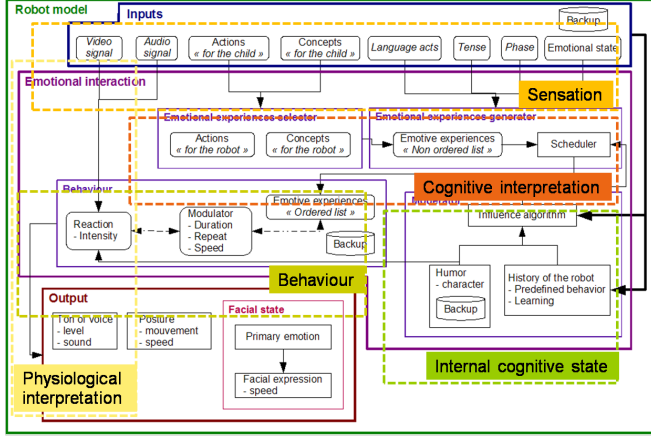


Fig. 2. Computational model iGrace

#### A. Inputs

The inputs we use for our experiments are first fully simulated, but we found many of the elements necessary for a good interaction. For each predefined sentence, the users have to give their emotional state to the speech. They will have the possibility of transmitting incomplete or inconsistent information data. We deliberately excluded from the module input signal sound and video the robot will receive. Indeed, this experiment is primarily designed to focus on the interaction between the robot and its user, based on speeches and related emotional states. Algorithms for image processing and sound are still being developed and will be integrated into the project within 2 months.

#### B. Emotional interaction

The interaction module is like the heart or brain of the system. It receives input information, processes it with different algorithms and determines the robot behavior that must be based on the speech. The algorithms are processed from the following sub-modules:

1) *The Selector:* will weigh an initial list of emotional experiences linked to the words of a speech. Each word, action or concept is associated with a vector of primary emotions (see Table I). We can derive the emotional experiences associated with these emotions (see Table II). We decided not to take into account the emotions with a coefficient greater than 0. This factor will provide a weighting of the list of experiments performed.

TABLE I

EMOTIONAL VECTOR FOR A WORD (ACTION OR CONCEPT).

| Word   | Vector |       |          |         |         |      |
|--------|--------|-------|----------|---------|---------|------|
|        | Joy    | Anger | Surprise | Disgust | Sadness | Fear |
| Daddy  | 1      | -1    | 0        | 0       | -1      | -1   |
| Mummy  | 1      | -1    | 0        | 0       | -1      | -1   |
| Sister | -1     | -1    | 0        | -1      | -1      | 0    |
| Kill   | -1     | 1     | 0        | 0       | -1      | 0    |
| Kiss   | 1      | 0     | 0        | 0       | -1      | 0    |
| Eat    | 1      | 0     | 0        | 0       | -1      | 0    |

Legend for recognition: -1:unknown; 0:none; 1: a little; 2: a lot

TABLE II

ASSOCIATION EXAMPLE BETWEEN EMOTIONAL EXPERIENCES AND EMOTIONS.

| Emotion  | Emotional experiences                       |
|----------|---|
| Joy      | Amusement, bliss, cheerfulness, etc.        |
| Fear     | Anxiety, nervousness, tenseness, etc.       |
| Anger    | Rage, outrage, fury, wrath, hostility, etc. |
| Sadness  | Depression, despair, hopelessness, etc.     |
| Surprise | Amazement, surprise, astonishment, etc.     |
| Disgust  | Disgust, revulsion, contempt, etc.          |

2) *The Moderator:* will weigh a second list of emotional experiences according to the robot's personality and mood. Using definitions of psychological types and MBTI models [22] for the robot, we associate some emotional experiences in the different MBTI dimensions. The weighting of this list is done by increasing the ratio of emotional experiences carrying an affect (positive or negative) similar to the robot's mood.

3) *The emotional experiences generator:* this module performs the most important interaction processing. According to two lists of emotional experiences that we will merge, the mood and life experience of the robot, the emotional state of the child, and the situation for the speech (playing, imagination, real life, etc.), the algorithm will recalculate the weighting of the various lists. There are still some key points to consider. The situation or context of the action is the first element of the list. A child at play tends to be incoherent, and sometimes even violent. We must therefore give him more freedom and not rely on everything he says. In order to participate in his game, it is better to have child like emotional state while retaining our personality. We must also be careful not to be overwhelmed by overly violent words.

The second important concept is the action given by the speaker. The importance of the speech reflects the action that is performed and the object or person on whom the action is performed. That's where we see the need for a context (first item on the list).

To finish with the question of emotional state: the aim of this project is to comfort the child and to make him feel that his companion understands what he feels and shares his emotions - but we must also show that it has something to say. Other parts of speech are not useless; on the contrary, they will provide a weighting of the list more or less on the

choice made with the 3 elements listed above.

4) *Behavior*: once the list of emotional experiences is weighted, we will have to choose how this behavior is to be performed. For the moment, we only have information to simulate experiences, and implicitly emotions related to them. The first thing is to select the best experiences in the list. For this experiment, we limited the number to 3. This will keep behavior cycles from becoming too long and especially allow for dynamic simulations. When the weighting is the same, the history databank makes it possible to filter this list to exclude the experiences that have been used recently, or were already used for this speech. This filtering process avoids behavior repetition.

To increase the interaction and allow the robot to express its emotion better, we need to add for each experience a posture and a sound with a tone. Regarding the sound emitted by the robot, we chose to relate piano notes to emotions [21]. This scientifically validated method was simple to use and very light in terms of information storage. For posture, we associated every emotion to a range of angles: the weighting of the emotional experiences list will play on the angle of the robot's torso.

### C. Outputs

The use of the robot's motors can be summed up by using a graphic panel displaying the emotions of the robot. In the near future, this module will manage all the motors and actuators of the robot in order to synchronize the interaction.

## IV. EXPERIMENTATION

The completed project is designed for children with physical or psychological handicaps. The major difficulty with this population is that we are not able to perform tests as often as we wish. We will travel to various hospitals, in partnership with the EmotiRob project, with our companion robot in its almost final version. To solve this problem, we chose to carry out 3 sets of tests on various audiences:

- 1) The first experiment was performed with a very large audience of all ages to gather as much information as possible on how to improve our interaction. After analyzing the results, some initial improvements were made. For this experiment, only the interface simulation was used.
- 2) The second experiment will be conducted with school children aged from 4 to 6 years and not suffering from disabilities. For these tests, the robot will be used but entries will still be simulated. We will use the Wizard of Oz experiment to capture data before the final integration of the voice recognition system scheduled for late September.
- 3) The third experiment will be conducted in Kerpape rehabilitation center with children with disabilities treated in an educational institute. These tests will be decisive for us and will create test scales. The test conditions will be optimal to have a maximum rate of recognition for our voice and video system.

A valuable aspect of performing experiments with a different audience each time is the analysis of the subsequent perception of emotional interaction between childhood and adulthood. The next stage of development for the EmotiRob project will be its use with elderly.

### A. Protocol

The first step was performed with a wide audience; it was not difficult to find volunteers but we limited sessions to 10 people because as we have already said, this is not the project's target audience, and we didn't wish to modify the interaction on the basis of comments an adult audience can make. The first thing they were asked was to disregard the fact that the interface was the face and behavior of the robot, and all the rest (input mode, ergonomics, etc.) was not evaluated. In addition, in order to obtain valuable feedback, it was necessary for these people to put themselves in the place of the interlocutor.

We had previously defined a list of 4 phrases as basic testers. For each, we associated the following language information:

- Action tense: present.
- Language act: affirmative.
- Context of speech: real life.

This system enabled us to save valuable time each person would use to make his choice. The sentences given were:

- Mummy, to cuddle, daddy.
- Tiger, to attack, grandma.
- Baby, to cry.
- I, to tickle, Sister.

### B. Simulation interface

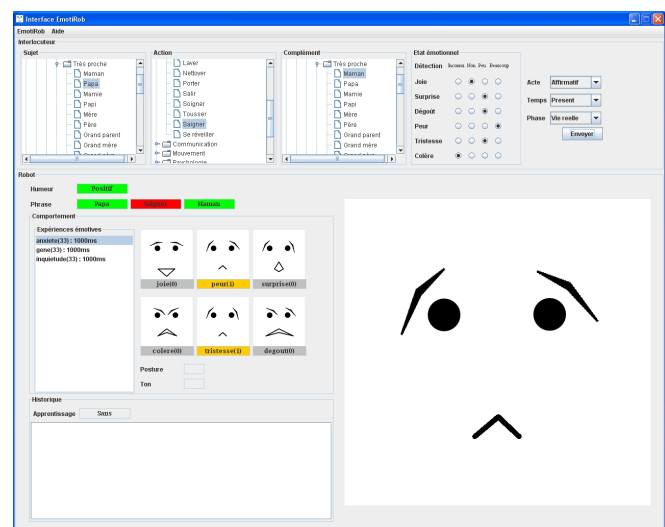


Fig. 3. Interface of simulation

The robot having reached the phase of integration and testing, we had to conduct a test interface (see Fig. 3) to begin the experiments. Not only can this interface enter the necessary information input, but it can also simulate the emotional state and behavior required of the robot according

TABLE III  
EVALUATION GRID

**Sentence**

|         |        |        |        |            |        |
|---------|--------|--------|--------|------------|--------|
| Subject | Affect | Action | Affect | Complement | Affect |
|         |        |        |        |            |        |

|                        |                          |                          |                          |                          |
|------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Emotional state</b> | Certainly not            | A little                 | A lot                    | Don't know               |
| Joy                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Surprise               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sadness                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Anger                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Disgust                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fear                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|                         |                          |                          |                          |                          |
|-------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Expected emotion</b> | Certainly not            | A little                 | A lot                    | Don't know               |
| Joy                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Surprise                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sadness                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Anger                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Disgust                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fear                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**Recognition of emotions expressed**

|                           |                          |                          |                          |                          |
|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Recognized emotion</b> | Certainly not            | A little                 | A lot                    | Don't know               |
| Joy                       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Surprise                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sadness                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Anger                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Disgust                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fear                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|                     |          |      |        |      |          |
|---------------------|----------|------|--------|------|----------|
| Speed of expression | Too slow | Slow | Normal | Fast | Too fast |
|---------------------|----------|------|--------|------|----------|

|                 |          |      |        |      |          |
|-----------------|----------|------|--------|------|----------|
| Behavior length | Too slow | Slow | Normal | Fast | Too fast |
|-----------------|----------|------|--------|------|----------|

|  |     |    |
|--|-----|----|
| Do you feel a combined expression of emotion ? | Yes | No |
|--|-----|----|

|  |     |    |
|--|-----|----|
| The sequence of emotions seems natural ? | Yes | No |
|--|-----|----|

**Satisfaction**

|   |               |          |       |
|---|---------------|----------|-------|
| Are you satisfy with the robot's behavior ? | Certainly not | A little | A lot |
|---|---------------|----------|-------|

to the information it provides. This interface communicates with another application that is the heart of the system, or rather the application that will be mounted on the robot (see Interaction model). It must be stressed that the test interface allows only one simulation input / output and not data processing.

The behavior simulation is a display of the characteristics selected for interaction for each emotional experience. Each experiment is characterized by emotional facial animation, the description of the posture and tone of voice, and a length of simulation. The emotional experience can be a mixture of different emotions; it is not unlikely that there will be a mix of facial expressions to animate the face. Emotions representing emotional experiences are characterized by a coefficient and a color code:

- Gold: emotion displayed
- Silver : emotion not displayed

The interface also shows the robot's mood and the various

affects associated with words of speech through two colors:

- White: neutral
- Green: positive.
- Red: negative.

Finally, in learning mode, the robot displays a history of behavior that it may have for the same speech. This information is not especially designed for the user, but is very useful to us because it allows us verify if the learning takes place properly, and also to check that the behavior of the robot is not always the same. A phenomenon of repetition over time will quickly frustrate the caller, especially if it is a child.

*C. Evaluation grid*

After distribution and explanation of the evaluation grid (see Table III), each person began the simulation in turn.



#### D. Results

The objective of this study is to evaluate the recognition of emotions expressed through the simulator and especially to determine whether the robot's response to the speech was satisfying or not.

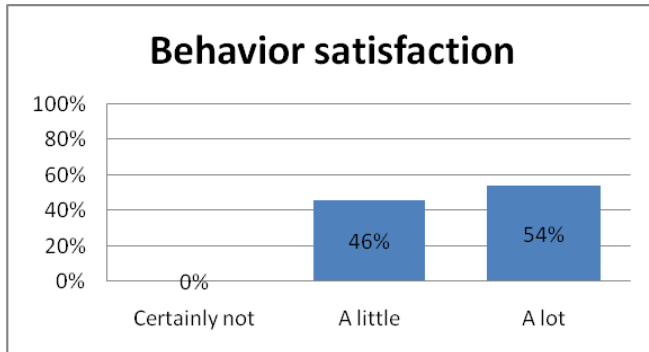


Fig. 4. Emotions satisfaction

As regards the rate of appreciation of the behavior responding to a speech (see Fig. 4) we observed that all the users found the response of the robot coherent, and gave as their opinion that they would be fully satisfied if the simulator response was what they expected. The fact that testers answered about the expected emotions had an influence on overall satisfaction.

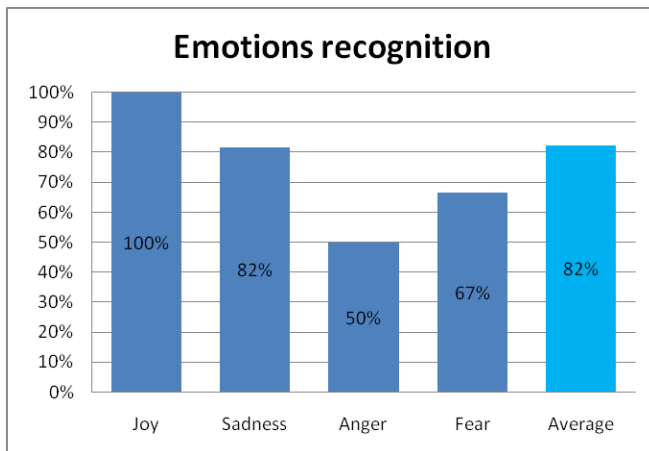


Fig. 5. Emotions recognition

For the rate of emotion recognition (see Fig. 5), the figures are very satisfactory and allow us to prepare better for the next evaluation on the classification of facial expressions for each primary emotion. Not all emotions are on the graph, because they didn't relate to the sentences we had chosen. Even so, we were able to note that even with good results, some emotions 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 other results are not being processed but will be useful for the integration of the model on the robot:

- Speed of expressions: 63% normal
- Behavior length: 63% normal
- Emotions combination: 67% yes
- Natural sequence of emotions: 71% yes

#### V. ROBOTIC CONCEPTION

EmI (see Fig. 6, 7) is still in the construction and integration phase. The robot's mechanics is manufactured by the CRIFF, but not its implementation. We are not currently presenting aspects robotics, but giving a brief description of the work already done. Currently, we have it completely covered with plush but not fully padded. It is equipped with a CMUCAM 3 camera and a fit pc slim. In a short time, all experimentation carried out with the simulation interface could be achieved with a real companion robot.

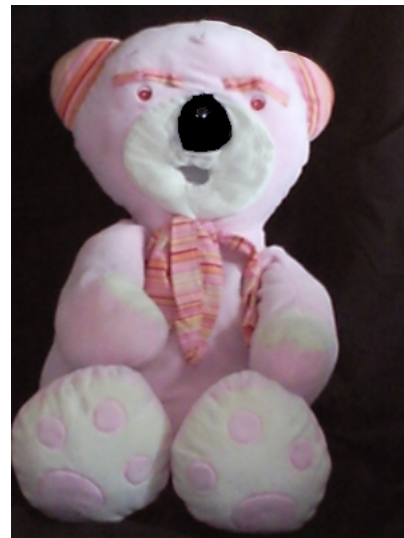


Fig. 6. Entire EmI picture



Fig. 7. EmI architecture conception

## VI. CONCLUSION AND PERSPECTIVES

This experiment enabled us to answer some partially unanswered questions, particularly on the speed of the expressions and on behavior length. But more importantly, we were confirmed in our choices as to information processing and the behavior we associate with the speech of the interlocutor.

However, the rate of emotion recognition, although very acceptable, is still improving. We know the evaluation of the facial expressions we use to be imperative. Furthermore, we have started in-depth work on the dynamics of emotions, in order to increase the fluidity of movement and to make the interaction more natural.

The next experiment will be with the robot, and will enable us to know if his expression recognition will be as high as that of the simulator after integration.

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