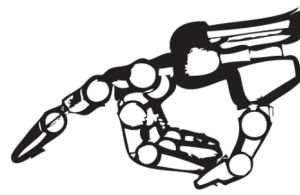


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What Role for Emotions in Cooperating Robots? – The Case of RH3-Y

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Eurobot 2009 – Internat. Conf. on Robotics Research and Education,
La Ferté-Bernard, France, 21-23 May 2009



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What Role for Emotions in Cooperating Robots? – The Case of RH3-Y

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1. Introduction 1 of 2

- **The world keeps changing. What makes humans change, and drives their actions? Emotions! Do we need similar driving forces for robots? And to *communicate* them?**
- **Emotions have started to be systematically explored more than 30 ears ago**
- **More than fifty different kinds of emotions have been identified. Very much expressed on the face.**
- **Multidimensional continua, in spaces of 2 , 3 , or even more dimensions**

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1. Introduction 2 of 2

- **Innovative expressions have been attempted : Kismet ears, Probo trunk, or virtual worlds.**
- **iconic representations are often alternatives to actual human faces**
- **And don't functional behaviors deliver more direct and clearer messages than conventional or cultural attitudes?**
- **Case study, relating to RH3-Y robot**

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2. Models for emotions 1 of 7

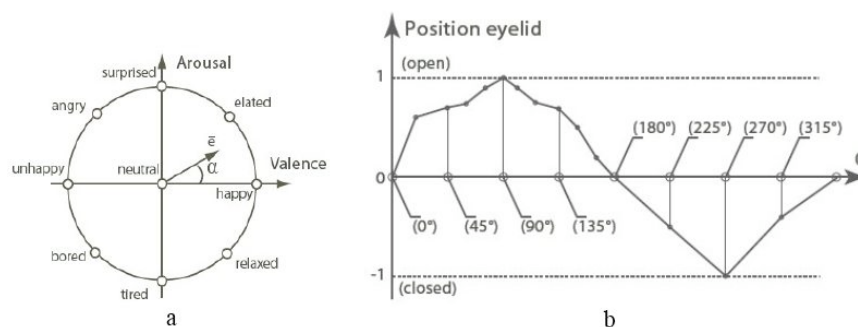
- **Change is general and often very abstract. It could be defined as the inverse of time.**
- **Language often refers to physical analogies : reference to locations and to space dimensions: motion, speed, acceleration, forces, stability, etc.**
- **Def.: “Related to convergence or deviation between status and goals, emotions can be considered as psychological forces that trigger subject activities towards strategic goals”**

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2. Models for emotions 2 of 7



Eight discrete emotions are cyclically represented in 2D, arousal-valence space (a). Corresponding eyelid positions are tabulated for the case of Probo [8], in 10 to 20 values (b).

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Representing emotions as vectors in a 2D or a 3D mathematical space :

- **Arousal.** activity level. Associated aspects : energy, quantity of perceived information, urgency and intensity of desired changes, of planned actions. Arousal is always positive (or zero).
- **Valence.** Valence denotes a happiness degree; it can be either positive or negative. It might be interpreted as the current balance, as subjectively perceived, of overall “benefits” and “costs”
- **Stance.** Taken with less priority into account, stance is an attitude that may vary between “open”, open to dialogue, to empathy or on the contrary “closed”, barring exchanges and cooperation.

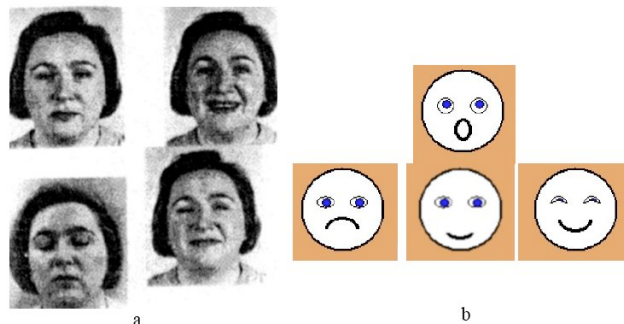
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Facial expression of emotions in positive valence and low arousal quadrant, from Russel [4] (a). And icons in middle to high arousal, negative to positive happiness valence (b)

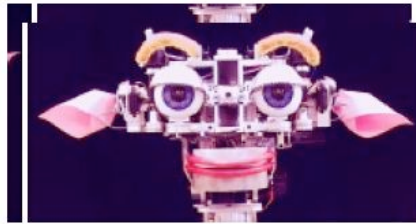
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a



b

With many mobile parts, “Kismet” has been designed for the expression of emotions, for a machine exploring interaction with humans [6] (a); on the right, the robot WE-4RII of Takanishi lab, Waseda University is also a humanoid capable of multiple emotional expressions

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2. Models for emotions

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Emotions apply in human psychology, relying there on physical analogies (forces, motion, etc.).

For machines, analogies may no longer be necessary: resulting from changes in environment, perception and possibly projected consequences, computed in particular from errors between set points and measurements, robot behavioral decisions can be considered as internal commands that trigger actions toward strategic goals.

Emotions cannot be escaped between robots and humans.

Robots and other robots: totally novel approaches can be envisioned, and concept of emotions is not clearly interesting here

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2. Models for emotions

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- **Between humans and robots, emotions are interesting concepts, as they may be communicated (shared, exchanged, in the classical terms of information).**
- **There are many other concepts yet, inspired by biological systems, such as e.g. neurons, genetic algorithms, believes, or intentionality, which, in our opinion, are less important;**
 - **first, the latter are not as obviously apparent in human-robot communication as emotions often are, and**
 - **second (this however is not discussed in this paper), they usually do not ensure better performances as alternatives in classical engineering.**

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3. Images and Icons 1 of 5

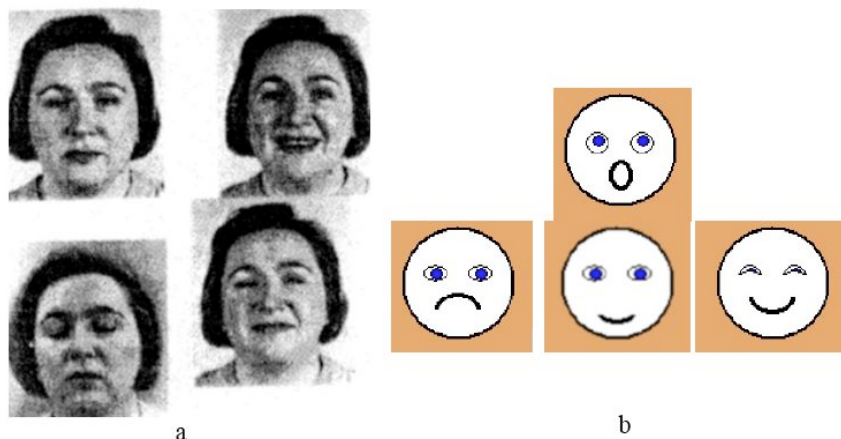
- **In general, the communication of emotions relies primarily on facial expressions.**
- **Although naturally expressed in full (3D) space, most of emotional content can also be perceived on the basis of simple images.**
- **It turns out that yet much simpler representations, such as caricatures or icons, can not only retain essential emotion related messages but also may even be more expressive. Looking at previous images of real people, presented along with a few RH3-Y samples of iconic facial expressions, can easily, qualitatively validate this.**

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3. Images and Icons 2 of 5

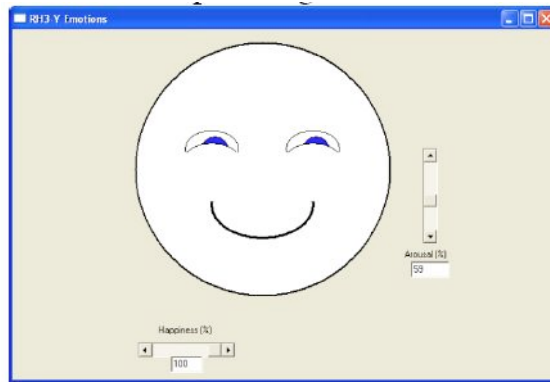


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3. Images and Icons 3 of 5



The expression of emotions can be parameterized and continuously adjusted in terms of mouth shape and eye lid location [12]

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4. Other ways to express emotions

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It has been mentioned that emotions, i.e. internal (“psychological”) forces for behavioral changes, are primarily expressed by specific facial patterns.

- Classically however, robots such as ours can also show their status, processes and intentions, i.e. more or less explicitly rendering their “emotions”, on various control screens, devices and panels

General view of RH4-Y robot



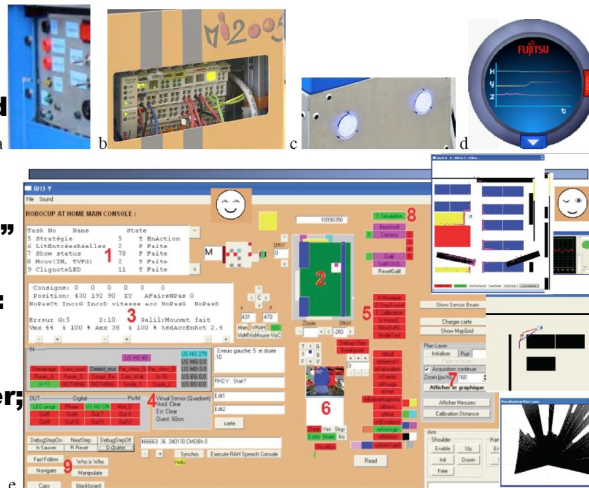
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3. Images and Icons 4 of 5

Expression of status and intentions are classically described by panels, displays and screens (a: Hornuss, b: Dude, c: programmable “eyes” or modulated headlights, RH3-Y; d: 3-D acceleration components on supervising computer; e: set of RH3-Y interactive control screens)



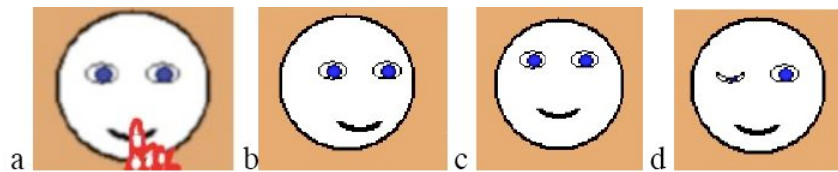
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3. Images and Icons 5 of 5

Expression of machine emotions by real, 3D, dedicated physical structure? Even though some advantages, (e.g. consisting itself as a display medium), the efficiency in terms of communication of emotions is not obvious.



**Extending icons: parameterize expressions to get continuous changes, in particular for smiles or for eye opening.
expression of robot status could evolve towards special adaptations of icons: a: “mute” behavior; b: leftwards intentionality; c: idem upwards; d: acknowledgement of common understanding.**

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4. Other ways to express emotions 2 of 2

- **Now these classical data could be more systematically linked with iconic parameterizations (re. Fig. 6), leading to new head and facial expressions.**
- **RH-Y can express its emotions in many other ways yet: blinking (since 1998, considering previous developments in Eurobot context), speaking, delivering predefined sound waves (re. RH2-Y in Atlanta), or moving its body and its arm in a way quite similar to dancing.**
- **And most naturally, those who know RH3-Y also recognize some of its emotive states, such as when its motors are servoed, or how its right wheel tends to lag behind, when batteries run tired.**

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5. Role of emotions in cooperating robots

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- **Emotions help explaining, in psychology, how humans make their short-term strategic choices. Emotions set a person in motion into a certain direction, towards a certain goal.**
- **Now does referring to emotions make sense for robots? For some purposes it is useful, and for others it is not.**

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5. Role of emotions in cooperating robots

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- **Useful aspects.** The useful aspects of dealing with emotions include experience, legibility and communication:
 - Humans inherit thousands of years of experience, relating to emotions. Attempting to transfer even just part of it to machines could be worth the effort.
 - Describing machine attitudes and behaviors in terms of emotions may get them familiar and immediately understood by humans for design as well as for developmental, operational, and debugging purposes.
 - Improved communication may be the strongest advantage provided by emotional messages: thus in addition or as an alternative to other means, the exchange of information between robots and humans can be conveyed through a channel (emotional expressions) very natural for humans.

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5. Role of emotions in cooperating robots

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- **Limits.** On the other hand, emotion-based approaches have also strong limits due to the nature of robots, of media, and of the domain of emotions itself:
 - Robots are not humans; their differences are far more numerous than potential similarities. Therefore it is now generally considered preferable to let users clearly recognize that they do *not* deal with humans, so as to limit impossible expectations. Furthermore, the same argument of legibility plays here the opposite role for those observers who are more familiar with concrete machine peculiarities, rather than with human affect psychology.
 - Robots feature different media, such as color screens or blinking lights, which allow for novel communication paths.
 - And in fact even for humans, the domain of emotions is *not* so well known today, and therefore transposing classical knowledge of this field to machines means also transferring current uncertainties.

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5. Role of emotions in cooperating robots

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- **Synthesis.** Let's attempt a balanced conclusion, drawing from general considerations as well as from specific Robocup at Home (RAH), and RH3-Y contexts. Here communication is also a key function to consider.
- It is universally true that reality is minimally upon reach. Therefore it is critical here also to set the priority on a goal oriented strategy.
- Our goal relates to robotic help at home. And the latter has been further specified in RAH tests and rulebook.
- Cooperation between humans and robots is often very important.
 - Communication helps in synchronization, e.g. asking for, or providing, mutual help, coordinating intentionality, interest, attention, vergence, possibly threatening.
 - For communication purpose, and more generally successful interaction, expression seems mandatory. Very often however the latter simply result from functionality.
 - E.g. an emotion may induce a backward robot gesture; and for the observer just perceiving that gesture may be sufficient to get aware of the inducing emotion.

5. Role of emotions in cooperating robots

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- Numerous examples for communicating emotions, in the study case of RH3-Y, have been given above. Another interesting one (the latest one implemented and experimented with RH-Y) is the acknowledgement of user commands in switching active or resting modes for the "FastFollow" test: within a fraction of a second, the robot can react with a green or red panel color and diodes to control gestures of human users. This provides a significant improvement with respect to previous situations where dialogue was based on the perception of potential changes in robot motions (thus, reactions now about ten times faster than before).
- Another point relates to the nature of machines, which being different from humans, gains in being granted, beyond classic human emotions, a wealth of variety in terms of internal affect forces and strategic attitudes.

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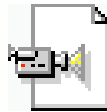
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5. Role of emotions in cooperating robots

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Example

- Our robot RH3-Y in China (Robocup-at-Home 2008, Suzhou)



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6. Conclusion

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- **The presentation has concisely reviewed key aspects of emotions, in the context of cooperating robots, with numerous concrete examples taken from RH-Y robots.**
- **In the past, emotions have first been systematically studied in relations to human expression, and then the shift has come towards machine-based replication.**
- **Emotions appear to result from changes, from convergence or deviation between status and goals, and they trigger appropriate activities. They are commonly represented in 2D or 3D affect space, and made visible by facial expressions.**
- **While specific devices are sometimes created in ad hoc way, emotive expressions seem also to be conveniently rendered by a set of facial images or more simply icons; the latter may possibly be parameterized in a few dimensions, for continuous modulation.**
- **In fact however, internal forces towards activities and changes may be expressed in many ways other than just faces: typically, screens, panels, and operational behaviors may contribute to sharing emotions.**

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6. Conclusion

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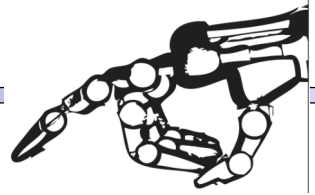
- **Relying on emotions ensures useful aspects, such as experience reuse, legibility or communication. But it also includes limits however, such as due to the nature of robots, of media, and even of the very domain of emotions. For our goal, which is the design of effective and efficient, cooperating robots, in domestic applications, the abilities to communicate and to interact play key roles. Best practices become evident after experimental verification, and tend to point at a variety of strategic attitudes and expression modes, much beyond classic human emotions and facial or iconic images.**
- **In fact our experience shows, after many years of operation with autonomous robots, that communication, while strongly asymmetrical, works rather well between robots and humans. In the direction from humans to robots, communication relies on engineered paths and software based strategies; in the direction from robots to humans, in addition to resources similar to these, the mere functional behavior of robots convey a wealth of effective information to humans, especially when the latter are deeply accustomed to their operation and even involved in their design.**

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Thanks for the attention!

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