Associated Emotion and Its Expression in an Entertainment Robot QRIO

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Associated Emotion and its Expression in an Entertainment Robot QRIO

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Abstract. We human associate and memorize situations with emotional feelings at the time, and these experiences affect our daily behaviors. In this paper, we will present our attempt to design this character in an entertainment robot QRIO aiming for more genuine Human-Robot interaction.

1. Introduction

We consider that entertainment robots have broad potentials for making our life further enjoyable, and have developed several products and applications. After releasing AIBO [1], a pet-type quadruped robot, we also have been started a biped humanoid-type one QRIO [2,3,4] for years increasing its wide range of abilities. Among these manifold directions, we focus our target in this paper to the interaction domain between a human and a robot, especially in topics around emotion [5,6] as we consider it as an important factor realizing entertainment applications for humans. We set three issues: "*Realizing personalized interaction*", "*Experience records dependency*", and "*Clear expression of robotic emotions*". First, to realize personalized interaction between a person and a robot, the latter should be able to recognize the former as an individual, and alter its behavior respectively. QRIO can recognize and identify humans by using its sensory information such as vision and audio [2], and this ability plays an important role here also. Secondly, the interaction process continues through our daily life, and therefore the robot should be able to accumulate experiences in its memories for affecting not only its behaviors but also emotions. This is one central point in this paper. As will be presented in Section 3 and 4, QRIO can associate the variation of its internal value variables with corresponding situation, and update its memories by accumulating many of the experience. This device makes it possible to create such kinds of behavior like *trauma*: just seeing an object scares QRIO, as there were dangerous experiences before about it. Finally, besides these abilities, the robot should be able to exhibit or express its emotions in clear ways. By exploiting its rich motion control system, we implemented above ideas to QRIO with vivid behaviors, which will be described in Section 5.

2. QRIO: a Small Biped Entertainment Robot [2,3,4]

Fig. 1. illustrates the appearance of QRIO. It is a stand-alone autonomous robot interacting with people and the environment with various abilities: walking, running, dancing, singing songs, playing soccer, throwing a ball, making conversation, and so on. Please refer to [2,3,4] for more details about its specification and abilities.

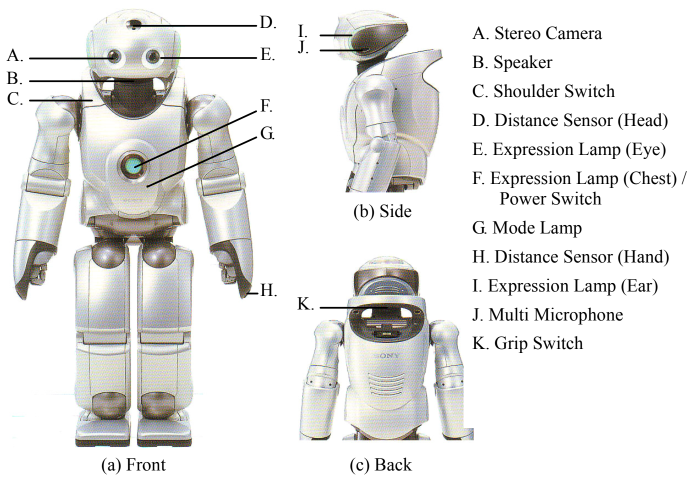

Fig. 1. Appearance of QRIO

3. Software Components in EGO Architecture [7]

In this section, a brief overview of software components inside QRIO is presented (Fig. 2.). As a basic behavior and motion control architecture, we adopt the EGO (Emotionally GrOunded) architecture [7]. The main strategy of it is an ethological model [8,9]. Behavior control is based on homeostasis where a robot selects its behaviors to regulate and maintain its internal state within a certain acceptable range.

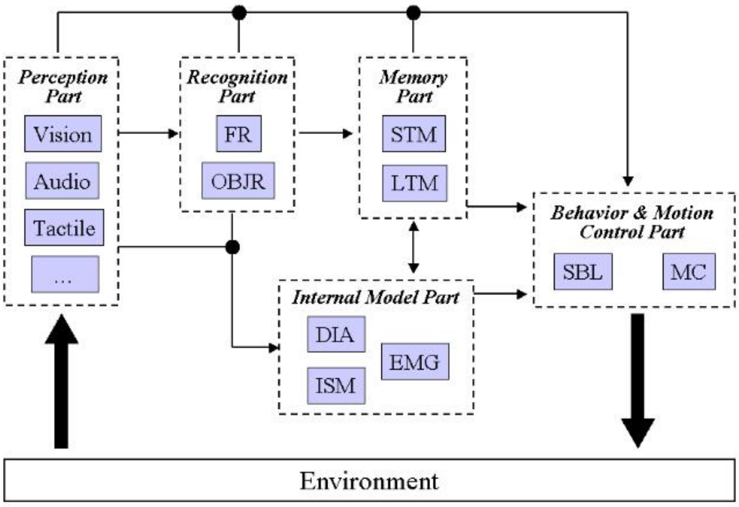

Fig. 2. Overview of the EGO Architecture

Perception part corrects all the input information from outside environment and inside QRIO by using various sensors. Some parts of it are processed by several recognition engines such as face recognition (FR) and general object recognition (OBJR). Memory part consists of the short-term memory (STM) and the long-term memory (LTM). STM integrates the results of perception in many ways. For example, it receives not only speech recognition results but also the sound source direction. LTM and Internal model part (DIA, ISM, and EMG) will be explained in the next section. Behavior and motion control part consists of the situated behavior layer (SBL) and the motion controller (MC). SBL [10] has multiple behavior modules and determines QRIO's actions processed by MC. Details in above are outside scope of this paper, and please refer to other literature [10] for more rich description.

4. Emotion-Grounding in Internal Model Part

Internal model part (Fig. 2, 3.) takes charge of QRIO's internal states and emotions. Internal state model (ISM) maintains the former variables: HUNGER, FULLNESS, PAIN, COMFORT, FATIGUE, and SLEEPINESS [11]. They are varied with the passage of time and external stimuli such as "face detection". Some of the variables relate also to internal information like "battery volume" or "temperature".

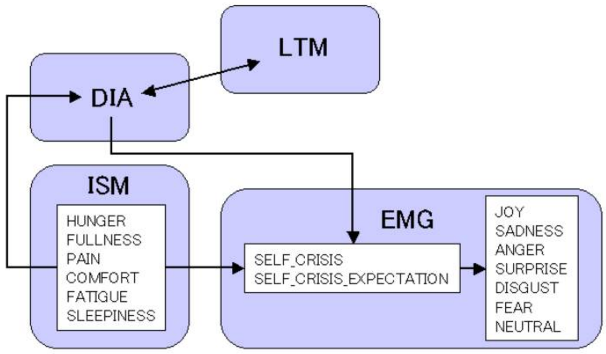

Fig. 3. Overview of the Internal Model Part

Delta-Internal value associator (DIA) associates the variation of the internal state variables with the current situation that is composed of outputs from perception and recognition parts. When a variation (above a threshold) happens in ISM, it sends the variation (of the internal state variables) vector to DIA. Then DIA associates it with current outputs from FR, OBJR (and any other perceptual data). The association can be implemented by any function approximation systems like an artificial neural network or just a simple rule base that is stored at the long-term memory (LTM). After several learning (association) experiences, DIA can remind the variation of the internal state variables just seeing the corresponding person or object or both. Emotion generator (EMG) contains emotion model that is composed of 6+1 emotions: JOY, SADNESS, ANGER, SURPRISE, DISGUST, FEAR and NEUTRAL. Each emotion has an associated value that is determined based on the self-preservation values, SELF_CRISIS and SELF_CRISIS_EXPECTATION that in turn are calculated by values of ISM (and their variation vector from DIA in case there is).

5. Expression of Associated Emotion

We applied above ideas to QRIO interacting with human. The far left in Fig. 4. plots a typical transition of emotion values (only NEUTRAL and FEAR are shown here) with time increases. A person comes and he twisted QRIO's hand (the 2nd picture). Observing his face, the ISM value PAIN stands up, and it leads up to increasing the value of FEAR at t=31. DIA learns the association between the face and the PAIN variation at the same time, updating LTM. After that, the person goes away and the value of FEAR decreases gradually. Then, he comes again in front of QRIO. DIA calculates the associated variation consulting LTM, and the value of FEAR is again stands up even without twisting hands at t=145. This change comes down to the behavior and motion control part, and QRIO expresses the gesture and voice of FEAR (the 3rd picture). We can also test continuous facial change in CG (the far right one).

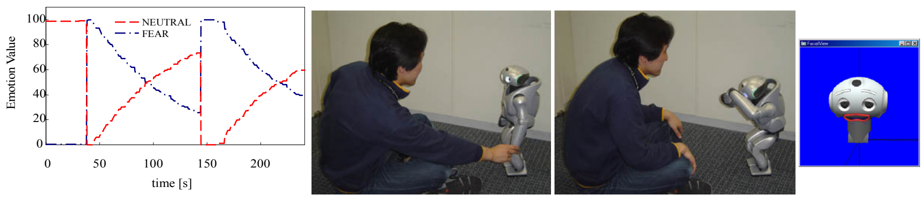

Fig. 4. Association of PAIN and expression of FEAR

Another person comes (the far left in Fig. 5.) stroking QRIO's head with chocolate in his hand. This time, COMFORT value increases (by the stroking) recognizing his face and the chocolate. This association is learned by DIA using a neural network stored at LTM. Thanks to its generalization property, here QRIO can remind the COMFORT variation and express the motion and voice of JOY in case not only showing the face and the chocolate (the 2nd picture) but also just the face (the 3rd one).

Fig. 5. Association of COMFORT and expression of JOY

6. Conclusions

We are trying to develop entertainment robots for human in daily life. To this end, it is important for the robot to be able to identify himself with human, and vice versa. Associated emotion, that is, the one that is associated with the robot's situation at the time can be implemented by using the internal model presented in this paper. Emotion expression is another crucial ability, and we let QRIO do it by exploiting its powerful behavior control system. Regarding face expression [12], we will consider every technology after much debate for realizing further genuine interaction.

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