"Affetto": towards a design of robots who can physically interact with people, which biases the perception of affinity (beyond "uncanny")*

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Abstract— **This article presents the upper-torso design issue of Affeto who can physically interact with humans, which biases the perception of affinity beyond the uncanny valley effect. First, we review the effect and hypothesize that the experience of physical interaction with Affetto decreases the effect. Then, the reality of physical existence is argued with existing platforms. Next, the design concept and a very preliminary experiment are shown. Finally, future issues are given.**

I. The Uncanny Valley revisited

The term "Uncanny" is a translation of Freud's term "Der Unheimliche" and applied to a phenomenon noted by Masahiro Mori who mentioned that the presence of movement steepens the slopes of the uncanny valley (Figure 2 in [1]). Several studies on this effect can be summarised as follows[1].

1) Multimodal impressions such as visual appearance, body motion, sounds (speech and others), and tactile sensation should be congruent to decrease the valley steepness.
2) Antipathetic expressions may exaggerate the valley effect.

The current technologies enable us to minimize the gap caused by mismatch among cross-modal factors. Therefore, the valley effect is expected to be reduced gradually. For example, facial expressions and tactile sensations of Affetto [2] are realistic and congruent due to baby-like face skin mask of urethane elastomer gel (See Figure 1). Generated facial expressions almost conquered the uncanny valley. Further, baby-like facial expressions may contribute to the reduction of the valley effect due to 2).

In addition to these, we suppose that the motor experience of physical interactions with robots biases the perception of affinity as motor experiences biases the perception of movements [3]. To verify this hypothesis, Affetto needs its body which realizes physical interactions naturally. The rest of this article is organized as follows. The next section argues about the reality of physical existence with existing platforms. Then, the design concept and a very preliminary experiment are shown, and the future issues are given.

II. Why Affetto?

Affetto has been created not to study the uncanny valley but as a platform for cognitive developmental robotics [4] which aims to understand the process of children's cognitive development by constructive approaches. Compared to the existing ones with abstract appearance [5], [6], [7], [8], hard shell covering [5], [7], mechanical noise [5], [9], stiff joints [5], [6], bare mechanical parts [7], or reduced number of degrees of freedoms [8], more realistic child robot platforms are needed to realize situations where caregivers naturally interact with child robots such as hand-in-hand rhythmic play or tickling game since caregivers' social interactions seriously affect the developmental process of children, that is, the target of cognitive developmental robotics.

III. Design Concept

The design concept for the upper body of Affetto consists of two kinds issues: 1) realistic impressions in terms of visual, tactile, and auditory ones, and 2) safety owing to flexible body and human-like structure.

1) Visual impression: We follow the design of existing android robots [10] on visual impression: We design Affetto so that each size and movement range of body part are similar to those of children, surface is covered with skin-like material, and its movement looks flexible.

2) Tactile impression: In order to create the realistic tactile sensation when we touch Affetto, we utilize tender skin, bone-shape shell, joint mechanical softness, and similar body mass to the one of real children.

3) human-like DOFs (sense of safety): It is known that prediction difficulty causes our fear. Therefore, we design Affetto so that it has as many degrees of freedoms as possible after those of humans. This point is related to mirror neuron system [11] by which we may easily remind our own

Fig. 1. Examples of the facial expressions [2]

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[1]visit http://en.wikipedia.org/wiki/Uncanny_valley for the references.

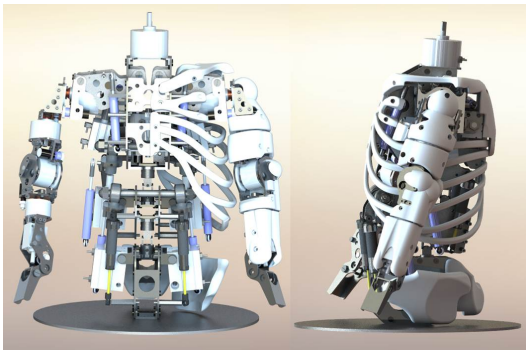

Fig. 2. Overview of the design of the upper body (bone-like shells are attached only on the left side in this figure)

movements by observing the others' movements. This may link to understanding the intention of others' movements.

IV. Preliminary Experiments of Physical Interaction

Fig. 2 shows an overview consisting of bone-shape shell covering the internal structure. This shell is made of a plastic with high elasticity and it supports the skin, protect sensors from external forces, prevent humans body being hurt by the crack of the internal structure.

We selected pneumatic actuation system since it has high power-weight / power-size ratio, high compliance and moves quietly and these features are suitable for the design concept for physical interaction.

We created a prototype to test the feasibility of the design. The motion mechanism of the prototype and the CAD model above are the same though they are slightly different in some features such as locations of the sensors and shape of the shell.

Fig. 3 shows the example of the physical interaction between a human and the robot. In this scene, the robot is trying to keep standing posture and a human take both hands of the robot and shake them. Owing to the mechanical softness, the robot's body parts can follow the humans manipulation rapidly and smoothly without any computation.

V. Future Issues

We have shown our design policy and preliminary experiments of the physical interaction. We are planning the experiments on:

1) generation of various kinds of movements by changing the compliance and their impressions in interaction, and
2) verification of the effect of motor experience of interaction onto the perception of affinity (beyond the "valley" effect): impressions of affinity in cases of:
   a) only observation of Affetto motion
   b) first interaction with Affetto
   c) after many interactions with Affetto

As a long range research issue, we'd like to consider about creativity of any kinds of arts such as improvisations of musical play or dancing with robots. To study it, we will

Fig. 3. Physical interaction between the robot and a human

embed a rhythm generator into Affetto based on a CPG like architecture which may emerge various kinds of rhythmic patterns triggered by external stimuli. Further, mutual entrainment (dynamic coupling) between Affetto and a human player is expected, which may lead so-called improvisations.

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