Affect-Driven Emotional Expression with the Haptic Creature

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ABSTRACT
Touch is an important part of emotional communication, but has been studied far less than visual and auditory expressions of affect. We are using the *Haptic Creature* to investigate fundamentals of affective touch, and demonstrate it here in both an autonomous configuration and with its behavior coupled to a user's sensed affect. This concept has applications ranging from companionship and therapy to gaming and the semi-automated factory floor.

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INTRODUCTION AND OVERVIEW
Affective touch communicates or evokes emotion; it is unique and highly influential among the senses in this regard [4]. The purpose of the Haptic Creature project is to specifically investigate affective *touch* in social interaction between human and robot: to identify physical traits of affective touching, and to support applications in areas such as companionship and therapy. Our immediate goals are to display and recognize this form of touch by both human and machine, trace the interactive dynamics that can develop between them, and develop the possibilities inherent in further driving this dynamic with physiological measures of momentary affective state.

We are leveraging research in human-robot [1] and human-animal interaction with a robotic creature that mimics a small animal, such as a cat or dog, sitting on a person's lap. This platform differs from others (e.g. [3]) through its focus on purely haptic interaction, non-representational form, and richly expressive modes; it avoids confounding factors in human-human social touching like gender, familiarity, social status and culture.

Autonomous Creature: The Creature by itself is a small robot that senses the world solely by being touched, and communicates its "emotional" state via vibrotactile purring, stiffening its ears, modulating its breathing and changing its pulse rate. In this form, we seek to answer questions about pure touch interactivity [6]. For example, what touch gestures do humans naturally use to express specific emotions? What is required to *elicit* (form factor, surface textures, movements) and recognize them? How are physically-expressed animal emotions recognized by humans, and what is mechatronically required to *express* them? Can the robot's intervention alter the emotions that the human user is experiencing?

Affectively Coupled: A domestic pet modifies its behavior according to its awareness of a nearby human's emotion as well as its own personality and mood. To support this kind of interaction, the Creature receives data from a dense array of touch sensors, and when affectively coupled, from the user's physiological sensors; these inform a model of the user's mental state, which in turn drives the *Creature's* behavior (Figure 1). This response model can be defined in myriad ways depending on the purpose. A starting point is to mirror the user's state, as demonstrated here.

SYSTEM DESCRIPTION
We briefly summarize the Creature's current architecture, mechatronics, and our physiological sensing system.

Sensing Human Affective state at Interactive Rates
Physiological monitoring systems have previously been used in both human-computer and human-robot interaction to extract information about a user's reaction to stimuli [5]. Physiological activity serves as a channel for non-

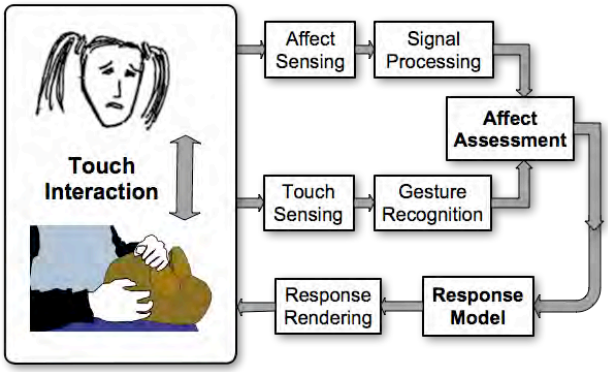

Figure 1: The Haptic Creature physically expresses a response to the user's touch and/or sensed affect.

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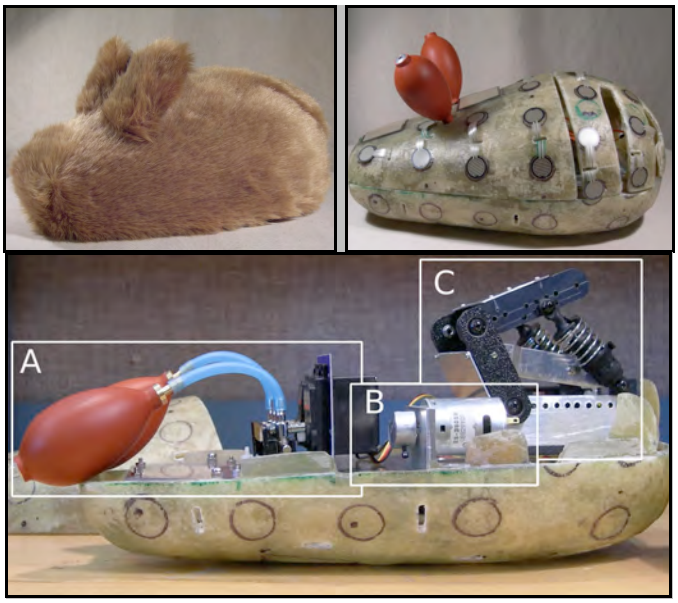

Figure 2: Creature mechatronics. CW from left: (i) with furry skin; (ii) hard fiberglass shell and touch sensors exposed; (iii) ears (A), purring (B) and breathing (C).

conscious affect expression. The user's affective state is modeled via a two-dimensional representation of valence and arousal. Valence measures the degree to which the affect response is positive or negative, and arousal measures the intensity of the response. Heart rate and galvanic skin conductance have been found to provide particularly useful realtime estimates of valence and arousal levels [2], and for our concept study we use individual wired versions of these and other sensors.

Most studies in this area have used post-experiment surveys of users after long term interactions to measure overall affect response [5]. Here we are studying a much more dynamic response to stimuli within a human-robot control-and-response loop that modifies the interaction online [2]. Both fuzzy logic and Hidden Markov Model estimation engines are used to generate online estimates of affective state from the physiological sensors, and update the current model of the user's emotional state.

The Emotionally Expressive Creature Platform

The Creature's mechatronics (Figure 2) are designed to produce organic, coordinated behavior with a minimalist zoomorphism that suggests animal traits while avoiding replication of a single real animal.

Passive elements: The Creature is clothed with faux fur over silicone "flesh" (Fig. 2-i) on a fiberglass shell. *Touch sensing:* 60 force sensing resistors are mounted across the surface of the shell (Fig. 2-ii). *Ears:* The stiffness of two inflation bulbs is individually controlled by out-take valves (Fig 2-iii-A). *Purring:* An offset weight attached to a motor shaft spins under modulated motor control (B). *Breathing:* A servo-actuated scissor jack (Fig. 2-iii, C) displaces the articulated breastplate to simulate breathing.

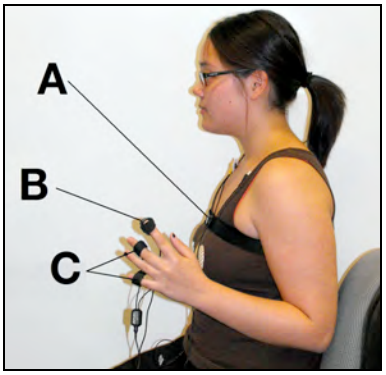

Figure 3: User with biosensors. (A) respiration rate, (B) blood volume pulse and (C) skin conductance.

DEMONSTRATION EXPERIENCE

We will simultaneously demonstrate two mechatronically similar instances of the Creature. An *Autonomous Creature* will respond physically and appropriately to sensed touch gestures – e.g. stroking, poking, ear-pinching, shaking. To experience the *Affect-Driven Creature,* visitors will don unintrusive skin conductance and blood volume pulse biosensors on their fingers and (optionally) a breathing rate sensor around their abdomen (Figure 3) and observe the Creature synchronizing to, and then mirroring, their own breathing and heartrate.

CONCLUSION

We are investigating the basis of affective touch, and exploring applications where touch is influential. We demonstrate a closed-loop platform comprising a touch-sensed robot pet driven by physiological affect, with which we are pursuing these questions and honing the Creatures' response models for various application contexts.

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