CuddleBits: Friendly, Low-cost Furballs that Respond to Touch

Laura Cang
Dept of Computer Science
University of British Columbia
Vancouver, BC
cang@cs.ubc.ca

Paul Bucci
Dept of Computer Science
University of British Columbia
Vancouver, BC
pbucci@cs.ubc.ca

Karon E. MacLean
Dept of Computer Science
University of British Columbia
Vancouver, BC
maclean@cs.ubc.ca

ABSTRACT

We present a real-time touch gesture recognition system using a low-cost fabric pressure sensor mounted on a small zoomorphic robot, affectionately called the 'CuddleBit'. We explore the relationship between gesture recognition and affect through the lens of human-robot interaction. We demonstrate our real-time gesture recognition system, including both software and hardware, and a haptic display that brings the CuddleBit to life.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Haptic I/O

Keywords

HRI, touch-based gestures, flexible touch sensor

Figure 1: Three CuddleBits in various sizes and stages of dress. From Left to Right: (a) Large CuddleBit fitted with a fabric touch sensor; (b) Small CuddleBit skeleton; (c) Medium CuddleBit in a faux fur coat.

1. INTRODUCTION

The CuddleBit is a small 1-DOF zoomorphic robot that adds to a family of robots collectively called the CuddleBots. There are many CuddleBits, each designed to explore robust yet economical solutions to research in affective human-robot interaction. Each is equipped with a custom flexible full-body fabric pressure sensor that supports touch gesture recognition.

CuddleBits are built to resemble small furry animals, often likened to hamsters or guinea pigs (Fig. 1(c)). Recognizing touch gestures is one of the first steps toward automatic prediction of emotional states[3]. With a real-time touch gesture recognition system, we hope to explore the key features of affective touch and develop a robot that can respond to a diverse set of affective contexts.

2. REQUIREMENTS

As a tool for studying affective touch, the CuddleBit is both required to invite touches with emotional content and to encourage continuing interactions through 'believable' responsive behaviours. Our yet-unanswered research questions are:

1. To what extent does touch gesture convey an individual's current affective state?
2. What physical characteristics (e.g., shape, size, fur covering) facilitate a user's sense of appropriate interactivity?
3. What behavioral characteristics (e.g., movements, temporal responsiveness, diversity) facilitate a user's sense of appropriate interactivity?
4. Is a 1-DOF robot platform expressive enough to support exploration of these questions?

In order to elicit naturalistic interactions, a user must imbue the robot with a personality like one might a treasured comfort object. The intent is not to have people believe that the CuddleBit is alive, rather that is a valid receptacle for emotional content. The requirements for this interactive system are two-fold: as an input device, it must be able to recognize touch behaviour; as a display device, it must present appropriate responses to those touches.

3. APPARATUS

To simplify our behaviour design, we intentionally limited our actuation mechanism, following the example of tradi-

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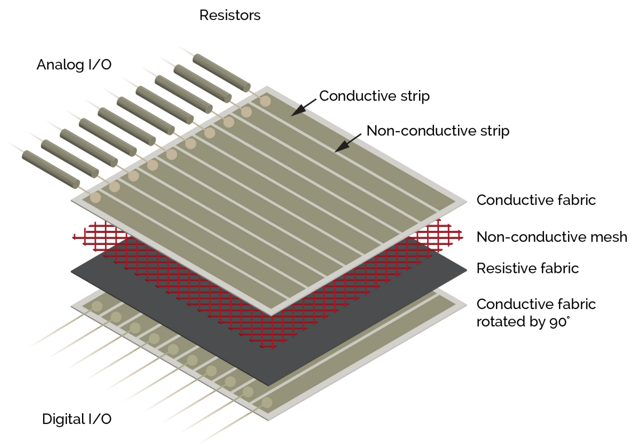

Figure 2: The fabric pressure sensor constructed out of EeonTex conductive fabric (www.eeonyx.com), wired to an Arduino microprocessor.

tional animation techniques[5] and other explorations' attribution of agency to 1-DOF robots[2][4]. The 'skeleton' (Fig. 1(b)) is constructed from flexible plastics to take advantage of the naturalism afforded by deformation and the back-drivability afforded by the material's elasticity. To avoid motor burnout and gear stripping from rough user interactions, the actuation is achieved through a servo motor that drives a pulley.

The touch sensor is constructed from two pieces of conductive piezo-resistive fabric separated by a non-conductive layer and oriented so as to make a 10x10 grid of 1 square-inch taxels (Fig. 2). It is designed to register touches within the range of reasonable social touch, roughly from 50 to 700 grams.

The gesture recognition system works by training a machine learning model on an a series of touch gestures such as 'rub', 'pat', or 'tickle'. Each gesture is recorded continuously and evaluated in 2 second windows. Each window contains roughly one instance of the gesture[1]. The gesture is then classified using a Random Forest model built from training data.

4. APPLICATIONS

A gesture-cognizant, flexible, pressure-sensitive sensor outfitted around a zoomorphic form in motion can be used in a number of scientific applications.

1. As a tool for studying affective touch interaction, the CuddleBit serves as a data collection device for quantitative measurements; with a gesture recognition system, it becomes useful for determining qualitative dimensions of touch semantics. It also serves as a haptic display device to close the interaction loop.

2. As a platform for examining the perceptual range of 1-DOF robot, the CuddleBit allows us to ask:
   (a) which emotions can this robot communicate?
   (b) whether this robot can communicate intention (i.e. does the robot want to be touched?)
   (c) what narratives do people build around the robot?

The above questions will help define the design space of a 1-DOF zoomorphic therapy robot and have direct implications for developing a more complex behavioural system.

5. DEMONSTRATION DESCRIPTION

During a demonstration, visitors will be able to interact with a member of a CuddleBit family as it 'breathes'. We will display the real-time results of the gesture recognition system along with a standalone version of the touch sensor and a touch visualization system. Certain touch gestures will incite behaviours associated with the CuddleBit's personality.

In informal evaluations, we found that supplying a narrative helped users understand how to interact with the CuddleBit. Therefore, our CuddleBit has a 'favourite' touch: it likes to be tickled —but not for too long. If any gesture is recognized consistently over an extended period of time, CuddleBit will shrink away. If it is struck, CuddleBit 'cowers'.

Visitors have an opportunity to experience the CuddleBit as a system where they influence the CuddleBit's behaviour and, hopefully, vice versa. When first approaching the robot, it will be breathing softly. Upon first contact, the CuddleBit will rise to meet the visitor's hand. As the interaction continues, the CuddleBit's body language will convey what the robot wants.

6. DEMONSTRATION REQUIREMENTS

We will require a table accommodating two demonstrators as well as a monitor and accompanying cables to display the visualizations including 2 power strips. One demonstrator will manage the gesture recognition model and the CuddleBits, while the other will manage the standalone sensor. We will bring two laptops, 2–3 touch sensors and CuddleBits.

7. ACKNOWLEDGEMENTS

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