"My Robot Is a Tree-Hugger"
Leveraging Emotive Actuation in Sustainable Interaction Design

John Harris Ehud Sharlin
Interactions Lab, University of Calgary
Calgary, Alberta, Canada
{harrisjj,ehud}@ucalgary.ca

***Abstract*— In this paper, we propose "*eMon*" a robotic interface that uses emotionally meaningful motion, or *emotive actuation*, to affect behavior change in its users, and to create social bonds with them. We explore a design approach where this social connection is applied to a sustainable interaction design (SID) scenario: promoting positive environmental behavior through interaction. The paper outlines our design for *eMon*, and reflects on the potential challenges and biases that arise when creating these types of interfaces. We outline future work that will investigate additional methods of developing long-term emotional bonds with robots, beyond our short term *eMon* design goals.**

Key Words: emotive actuation; social human-robot interaction, sustainable interaction design

I. INTRODUCTION

In [1] we introduced the notion of *emotive actuation*, the ability to actuate a robot in an emotionally meaningful manner, and emphasized its importance in the design of human-robot interfaces. We argued that, from the user's perspective, robots are set apart from computers by their physical manifestation: their fundamentally dynamic physical and spatial qualities. We stated our belief that emotionally expressive motion (gestures, body language, style of locomotion, subtle physical behaviors, etc.) are a primary influence on how people perceive a robot's intelligence, attitude, and purpose. As such, "*emotive actuation"* can be crucial to the design of acceptable and meaningful social robotic interfaces.

In this paper, we explore how the unique physical abilities and dynamic movements of robots taps into our innate human tendency to personify non-living entities (e.g. natural phenomena, animated cartoons, vehicles, robots, androids, etc.) and how we can use *emotive actuation* to leverage this powerful observation to meet specific interface design goals. We intend to demonstrate this through a related research goal: using *emotive actuation* in a human-robot interaction scenario to appeal to commonly held human values and affect behavior change. In particular, we look to apply principals from the domain of Sustainable Interaction Design (SID) to promote environmentally responsible behavioral change.

II. RELATED WORK

Sustainable Interaction Design (SID) is a growing HCI research domain that is challenging interaction designers to make environmental sustainability a fundamental component of their design; this stretches beyond "classical" sustainability concerns such as what types of physical materials are employed, to the ways these systems are used in real-world settings, and to the behavioral attitudes those interactions reinforce. [2][3]

Work by He, Greenberg, and Huang [4] builds upon these concepts and demonstrates how the same methods of promoting sustainable behavior often do not generalize across people with different levels of environmental awareness. For example, the "Power-Aware Chord" concept [5] and similar energy monitoring devices employ a variety of information feedback methods in an attempt to cater to different personal value systems. (e.g. numeric readouts of power consumption in kilowatts, projected economic cost, or even visibly glowing in proportion to energy usage) While these devices may perform as an excellent means of providing relevant energy usage information to those people who are already concerned about their power consumption, these artifacts may still be ill suited to motivate non-interested persons to begin considering how they might improve their own energy usage habits.

We propose a unique perspective on promoting sustainable behavior change by combining SID principals with social human-robot interaction concepts. Our group intends to construct an *emotive actuation* platform that specifically appeals to a person's internal value system and uses this emotional bond to motivate environmentally responsible behavior.

Figure 1 – Artist's rendition of "eMon"

III. DESIGNING "EMON": A LIVING ENERGY MONITOR

To explore how SID can leverage *emotive actuation*, we are designing "*eMon*": a small desktop appliance (much like a clock-radio) that is covered in a cat-like fur material and is

capable of performing a number of emotionally meaningful gestures. (Figure 1)

The body of the device is capable of a simulated "breathing" motion; expanding and contracting in a subtle, natural way so as to provide the outward appearance that it is a "living, breathing entity". The magnitude and frequency of *eMon's* "breathing" is controllable and is used to generate a range of *emotive actuation* expressions. Further, *eMon* is also capable of limited bodily movement such as jittering, shaking, or even small hops. A visual display device is integrated into the robot's body to provide specific forms of information feedback and to serve as an approximation of a physical "head". This head can also be actuated to allow *eMon* to "look around" and perform emotive gestures when interacting with its user.

In terms of function, *eMon's* primary purpose is to monitor the energy usage of a nearby desktop computer as well as whether or not the computer is currently being used. *eMon's* physical behavior is driven by the hypothetical "stress level" it is currently experiencing. That stress level is directly proportional to the current energy efficiency being demonstrated by the human owner of the workstation. As an example, if the computer has been left on and the user has left the workstation for a prolonged period of time, *eMon's* stress level will gradually rise, its breathing motions will transition from a calm, low-frequency "relaxed" state to a rapid, shallow, "high anxiety" state, and it will begin to look around for its owner and shake nervously as a result of the inefficient energy usage of the computer. Conversely, if the computer is shut off when it is not needed, *eMon's* breathing pattern and gestures remain calm, relaxed, and contented. In essence, *eMon* employs *emotive actuation* to simply convey concern and anxiety (or lack thereof) relating to the energy usage behaviors and patterns practiced by the user.

IV. Discussion

While *eMon's* central purpose is the same as any simple energy monitoring device, the method in which the *eMon* robotic interface promotes sustainable behavior is fundamentally different and potentially more potent.

As He, et al. discuss [4], a primary shortcoming of traditional energy feedback devices is that they typically only appeal to those persons who have already made a conscious decision to reduce their energy consumption. These devices only externalize the source of energy information feedback. They do little to motivate behavioral change for those people who lack strong internal motivation to conserve energy.

In contrast, *eMon* uses *emotive actuation* to externalize both the motivating information feedback and physically manifest the social and emotional pressures that drive Blevis' perspective of "global collective fate" [3]. Instead of appealing to concepts of personal material gain (energy savings), or directly to personal environmental concerns (which may be non-existent for a given individual), *eMon* engages the observer's innate human values via the robot's evident psychological distress; distress which is a direct result of the user's behavior.

The primary challenge in designing *eMon* will be in creating a sufficiently engaging and believable robotic entity, both in terms of visual appearance and physical motion capabilities. While it will be necessary for *eMon* to engage people on an instinctual level, it is important that *eMon's* appearance does not become too similar to existing natural morphologies so as to introduce new biases. (e.g. if *eMon* takes on a distinctly feline appearance, dog-lovers may be less likely to be as engaged by *eMon's* motions.) *eMon's* furry, natural appearance and emotionally purposeful motion must be carefully designed to appeal to the widespread and innate human value of promoting quality of life and freedom from suffering. *eMon's* design should not be limited to any one specific user type or demographic. This approach takes advantage of the idea that although some people may not express concerns about global climate change, many people automatically cringe and feel uncomfortable when viewing scenes of human/animal distress.

While *emotive actuation* is the main technique we are exploring with *eMon*, it is also important to recognize that it does not supplant other methods of designing engaging social human-robot interfaces such as visual affordances, expressive facial features, or natural speech interaction. Instead, *emotive actuation* is meant to operate in concert with and enhance these other techniques. We limit the expression of these other interaction modalities in the design of *eMon* so as to better study the impact of *emotive actuation* in relative isolation.

V. Future Work

In theory, it is the emotional bond between *eMon* and the human user that empowers *eMon* to motivate sustainable behavior. Given the level of attachment that has already been demonstrated between some robot owners and their commercial robotic appliances [6], we argue that it is not unreasonable to expect that robots like *eMon*, which are specifically designed to appeal to human emotions, would be even more capable of affecting long-term behavior patterns.

However, while *emotive actuation* plays a central role in developing that bond, we recognize that a variety of other important factors could influence, both positively and negatively, the formation of a long-term emotional attachment with a robot: 1) memory and familiarity, 2) emergent behavior, and 3) unpredictability.

This list of variables is by no means comprehensive. Instead, we see it as detailing some of the challenges that will evolve out of our *eMon* design, and that should be explored as future work.

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