On line - Affective state reporting device: A tool for evaluating affective state inference systems

CONFERENCE PAPER · MARCH 2009

DOI: 10.1145/1514095.1514191 · Source: DBLP

4 AUTHORS, INCLUDING:

Susana Zoghbi

University of Leuven

On Line - Affective State Reporting Device: A Tool for Evaluating Affective State Inference Systems

Susana Zoghbi
Department of Mechanical Engineering
University of British Columbia
6250 Applied Science Lane
Vancouver, BC CANADA V6T 1Z4
1-604-822-3147
szoghbi@interchange.ubc.ca

Dana Kulić
Department of Mechano-Informatics
University of Tokyo
7-3-1 Hongo, Bunkyo-ku,
113-8656 Japan
+81-3-5841-6380
dana@ynl.t.u-tokyo.ac.jp

Elizabeth Croft
Department of Mechanical Engineering
University of British Columbia
6250 Applied Science Lane
Vancouver, BC CANADA V6T 1Z4
1-604-822-3147
ecroft@mech.ubc.ca

Machiel (Mike) Van der Loos
Department of Mechanical Engineering
University of British Columbia
6250 Applied Science Lane
Vancouver, BC CANADA V6T 1Z4
1-604-822-3147
vdl@mech.ubc.ca

ABSTRACT

The monitoring of human affective state is a key part of developing responsive and naturally behaving human-robot interaction systems. However, evaluation and calibration of physiologically monitored affective state data is typically done using offline questionnaires and user reports. In this paper we investigate the use of an online-device for collecting real-time user reports of affective state during interaction with a robot. These reports are compared to both previous survey reports taken after the interaction, and the affective states estimated by an inference system. The aim is to evaluate and characterize the physiological signal-based inference system and determine which factors significantly influence its performance. This analysis will be used in future work, to fine tune the affective estimations by identifying what kind of variations in physiological signals precede or accompany the variations in reported affective states.

General Terms

Measurement, Experimentation, Human Factors

Keywords

Human's Responses to Robots – Affective responses, – physiological signal monitoring, affective state estimation, human-robot interaction

1. INTRODUCTION

Robots have been successfully employed in industrial settings to improve productivity and perform dangerous or monotonous tasks. More recently, attention has turned to the use of robots to aid humans outside the industrial environment. For example, as the population in the developed world ages, robots that can interact with humans in a safe and friendly manner, while performing necessary home-care/daily living tasks, would allow more seniors to maintain their independence.

An important step towards this goal is the acquisition, analysis, and integration of non-explicit user-interaction data within the human-robot control loop, such as user attention and approval. Essentially, the robot should respond to the "body language" of the user. In recent work, the acquired non-explicit control data from the human user has been integrated into the robot control system to provide a safer and more usable modality for human-robot control. Face direction, body location, and physiological cues such as heart rate, skin conductance, etc. are tracked [1]. Previously, these studies have used off-line user reports to calibrate this information in order to form an estimate of human affective state. In fact, throughout the literature, the most common way of recording the reported mood and intensity of a user for calibration of physiological sensors has been through the aid of pre and post activity questionnaires. This "off-line" information is not ideal when attempting to relate changing physiological responses to reported affective state, and is especially problematic in a dynamic human-robot interaction environment where affective responses may vary substantially throughout the interaction.

Real-time reporting of affective state by the user is proposed as a more effective way to calibrate user physiologic responses. In the current work, we investigate the use of a handheld device that allows people to report their affective state, i.e., valence and arousal, continuously during a human-robot interaction trial. We study how well the online data correlates to both previously employed off-line questionnaire and a physiological signal based affective-state inference system. The main purpose is to evaluate and characterize the physiologically-based estimations and determine which factors significantly influence its performance. The users' reported data can be further utilized to fine tune the affective state estimation system by indentifying the variations in physiological signals that precede or accompany the variations in reported affective states.

2. METHODOLOGY

Our study investigates an online method for collection and calibration of physiological signals in an HRI (human-robot interaction) context in order to improve the estimation of the users' affective state response to the interaction. Two instruments were used to collect the data, an in-house developed modified joystick [2] called an Affective State Reporting Device (ASRD) and a questionnaire [3]. This experiment builds on methodology from our previous studies [4] which measured user-affective response to HRI, and then utilized the responses in a closed loop system [5].

A hand-held affective state monitoring device (ASRD) was used to record emotions expressed by each user. Emotions were mapped on a 2-dimensional representation of valence and arousal.

The handheld device has two inputs, as shown in Figure 1 [2]. By using the forward/backward motion, the indication of valence is registered. The forward motion relates to positive mood and the backward motion to negative mood. By squeezing the handle, the level of intensity of this mood is recorded where no squeezing represents low intensity and forceful squeezing represents high intensity. These reports are compared to both a previous safety questionnaire taken after the interaction, and the affective states estimated by a fuzzy inference system.

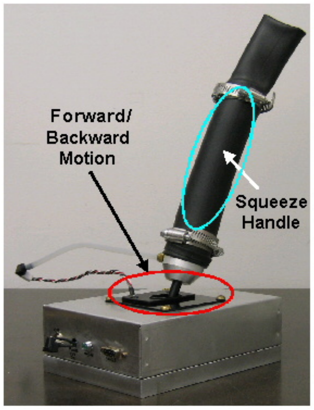

Figure 1. Hand-Held Affective-State Reporting Device

Collecting these data allows us to determine quantitatively the online deviations between the estimations of the affective-state inference system and users' subjective responses. It would also allow us to characterize the inference system and determine under what conditions it is better used. This could not be done before since there was not a mechanism or device to allow the user to report their affective state continuously at the same time as the robot motions occur and physiological data is collected.

In order to characterize the estimated signal, we compare the data collected from the user and the estimations generated by the fuzzy inference engine. We define the Normalized Integrated Mean Square Error as

$$IMSE = \frac{1}{N}\sum_{i=1}^{N}\left(X_i - Y_i\right)^2 , \qquad \textbf{(1)}$$

where X is the estimated affective state calculated by the fuzzy inference engine, Y is the affective state reported by the user and N is the number of measurements for a given trajectory.

3. DISCUSSION AND CONCLUSIONS

In this paper we presented the implementation of a new handheld device that permits the users to report their affective state, i.e. valence and arousal, continuously during a human-robot interaction trial.

The Affective State Reporting Device provides a new source of information that allows us to evaluate and characterize the performance of an affective state inference system., by calculating how much deviation it exists between the estimations and the actual affective state the user experiences at every time step during the motion. By analysing the behaviour of deviations, it is possible to determine under which conditions the inference system can be best used and which factors influence its performance. In particular, we calculated the deviation between the estimated signals from a fuzzy inference engine and the users' reported states, by using the Integrated Mean Square Error over the duration of the motion.

Being able to determine when the participants experience a change in their comfort level and its intensity will help identify what kind of variations in physiological signals -and their extracted features- precede or accompany the variations in reported affective states. This would lead to fine tune the fuzzy inference engine (or analogously, other affective inference systems) so that deviations –i.e. IMSE- from the users' reported signal are minimized.

4. REFERENCES

[1] D. Kulic and E. A. Croft, "Real-time safety for human - robot interaction," presented at Robotics and Autonomous Systems, 2005.

[2] A. Lanz and E. Croft, " On Line- Affective State Monitoring Device Design " presented at the 2007 ASME International Mechanical Engineering Congress and Exposition, Seattle, Washington, USA, 2007.

[3] C. Bartneck, D. Kulic, E. Croft, S. Zoghbi, "Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots". International Journal of Social Robotics, 2009.

[4] Kulic, D. and E. A. Croft. "Affective State Estimation for Human-Robot Interaction." IEEE Transactions on Robotics 23(5): 991-1000., 2007.

[5] Kulic, D. and E. A. Croft (2007). "Pre-Collision Safety Strategies for Human-Robot Interaction." Autonomous Robots 22(2): 149-164.