Using brain-robot interfaces for controlling implicit social patterns

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Introduction

The concept of 'brain-computer interaction' involves one or two-way communication between a human brain, and an external computer device. Our particular interest is in how such a system could be used to subtly influence robot behaviour in less direct, implicit ways. The preliminary research presented in this abstract explores a limited use of brain-computer interaction to control the implicit behaviour patterns of an iRobot Roomba® vacuum cleaner robot. In particular, we used the OCZ NIA™ neural impulse actuator [1], an off-the-shelf, low-cost commercial interface designed for video game use that reads bioelectrical signals via the forehead. We linked this input device to the iRobot Roomba to facilitate behavioural control, where a person's emotional state was crudely inferred based on the brain interface output signal state, and the robot adjusted its behaviour in attempt to fit that person's emotional state. This manuscript is based on an earlier work [2], and highlights our efforts to use the brain interface to influence the robotic behaviour patterns in ways that will be perceived by users as subtle, indirect and implicit.

Preliminary Prototype

The OCZ NIA consists of a headband worn by the person on their forehead (Figure 1). One reviewer of this product [2] suggests that its sensors read skin biopotentials, i.e., small electrical changes on the surface of the skin.

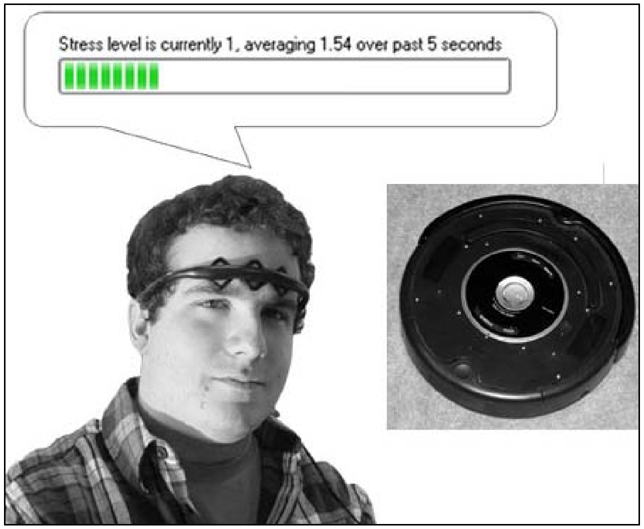

Figure 1. A person wears the NIA™ device. Our software infers the person's stress level from it (also displayed graphically) and uses that to influence Roomba® behaviour.

Our current design is using the OCZ NIA to control the iRobot Roomba. Based on our current experience, the OCZ NIA is quite limited, only allowing muscle tension to be captured reliably. In spite of these shortcomings, we were able to use this input for crudely inferring human emotional states such as stress and relaxation. We used this reading to influence (rather than directly control) aspects of the robot behaviour.

Our control software reinterprets natural muscle tension as a measure of one's stress level: the more muscle tension, the more stress is inferred. We map these onto four stress levels (which are displayed graphically via the prototype's GUI, see Figure 1, top).

Two distinct robotic behaviours corresponding to two extreme emotional states, either relaxed or stressed, are triggered when the stress reading reaches a threshold. Robot actions are then influenced by these stress readings. When a person shows high stress (~levels 3 & 4), the robot enters its cleaning mode but moves away from the user so as not annoy them. When a person is relaxed (~level 1), the robot (if cleaning) approaches the person and then stops, simulating a pet sitting next to its owner. If the reading is in between these two levels, the robot continues operating in its current mode until the stress reading reaches a threshold.

While a simple mapping, this strategy reveals several important properties.

1. A crude emotional level can be inferred from bio-electrical signals. While not an ideal brain interface, it roughly simulates the kinds of input we may be able to capture in the future.
2. Control of a robot is implicit, where the robot reacts to emotions rather than direct control. The person does not have to do anything (except wear the input device).
3. It is the robot's autonomous behaviour – rather than low-level, direct actions– that are altered based on its perception of human emotional state.

4. Appropriate robot behaviour can be designed following a simple, and perhaps anthropomorphic, heuristics.
5. The heuristics can be robust in terms of input errors. That is, in this example none of the actions of the robot are 'bad ones'. At its worst, if the robot incorrectly assumes a relaxed state when the person is in fact stressed, the consequences are small.

Conclusion

While the idea of a brain or bioelectric signal interface is typically marketed as a way to explicitly direct commands to devices, we see promise in a different approach which uses this (often inaccurate) input as a way to mediate the robot's behaviour, adjusting to people's moods in socially appropriate ways. This opens the idea of a brain-robot interaction as an emotional mediator which affects implicit aspects of the robot's synthetic emotional state. Our simple prototype illustrated how the Roomba would work away from stressed people so as not to annoy them. Even if the Roomba were wrong, this would not be considered bad behaviour. Another example could be a social robot that approaches people when they are perceived to be emotionally down. A more holistic view of this approach would be to see the explicit behavioural patterns as an added layer which integrates to more direct robotic interactions. For example, a robot which walks with a human may get slightly closer, or a bit more distant according to the sensed emotional state of the user as perceived through the brain interface.

References

1. OCZ Peripherals. Neural Impulse Actuator. http://www.ocztechnology.com/products/ocz_peripherals/nia-neural_impulse_actuator . Retrieved December, 2008.
2. Saulnier, P., Sharlin, E. and Greenberg, S. (2009) Using Bio-electrical Signals to Influence the Social Behaviours of Domesticated Robots. In Adjunt Proc. Human Robot Interaction (Late Breaking Abstracts) - HRI'09. (San Diego, California), 2 pages, March 11-13. To appear
3. TechRadar.com. OCZ Neural Impulse Actuator Review. Reviewed on July 3rd, (2008) and retrieved December, 2008. http://www.techradar.com/products/computing/peripherals/input-devices/other/ocz-neural-impulse-actuator--269721/review

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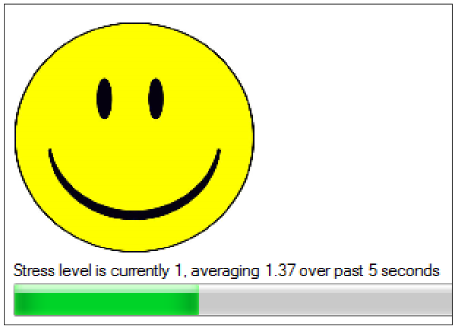
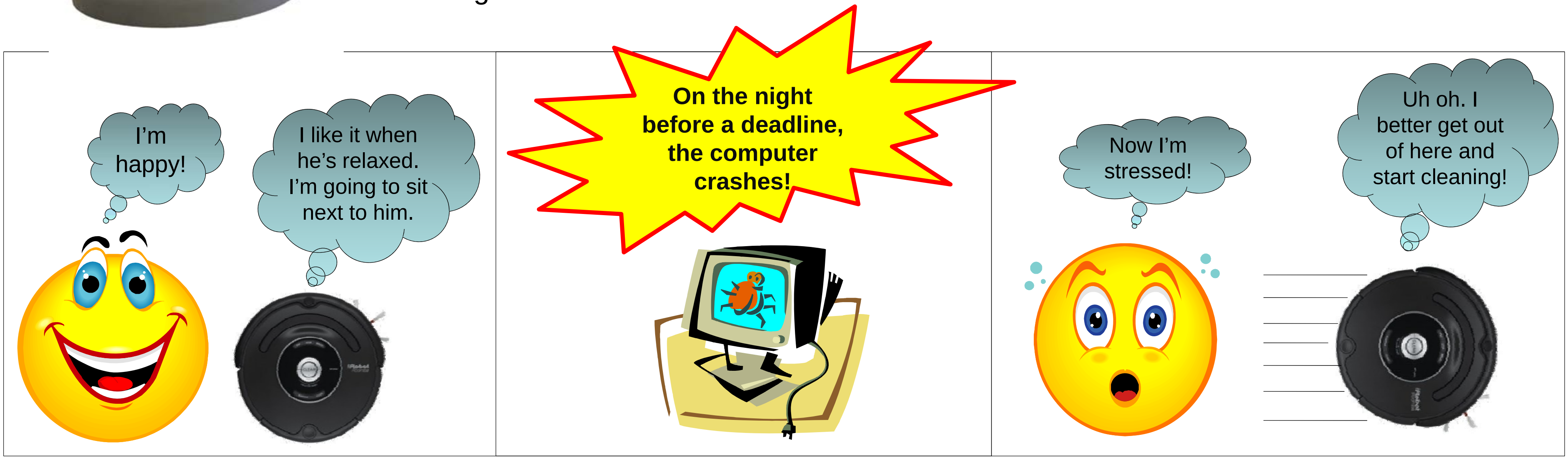
A new way of thinking about HRI
Robot behaviour reacts *implicitly* to human emotions rather than direct *explicit* control.

Example: Reacting to Human Stress
We translate OCZ NIA™ headband signals worn by a person into a crude stress reading. Robot motion and actions are moderated depending on particular stress level readings.



Screenshot of controller software



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