Exploring Cognition and Affect during Human-Cobot Interaction

CAL POLY

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Introduction

A collaborative robot (cobot) is designed to work alongside a human to complete a common task. One challenge in Human-Robot Collaboration (HRC) is the capability for cobots to recognize a human's affective and cognitive states. These essential factors are important in decision making and overall cognitive ability. In this research, we investigate how the affective state of the user can be used to improve Human-Robot Collaboration. Specifically, we center on stress and focus.

Tools

PAD: The PAD Model is a psychological model made of 3 dimensions: Pleasure, Arousal, Dominance. The 3 dimensions are representative of all emotions and measure how intensive, pleasant, or dominant an emotion is.

Emotiv: An EEG headset supported by a Brain-Computer Interface with 5 sensors that capture a user's brainwave activity.

Cobot: A 6 DOF collaborative arm equipped with a Raspberry Pi microprocessor and built in Ubuntu operating system.

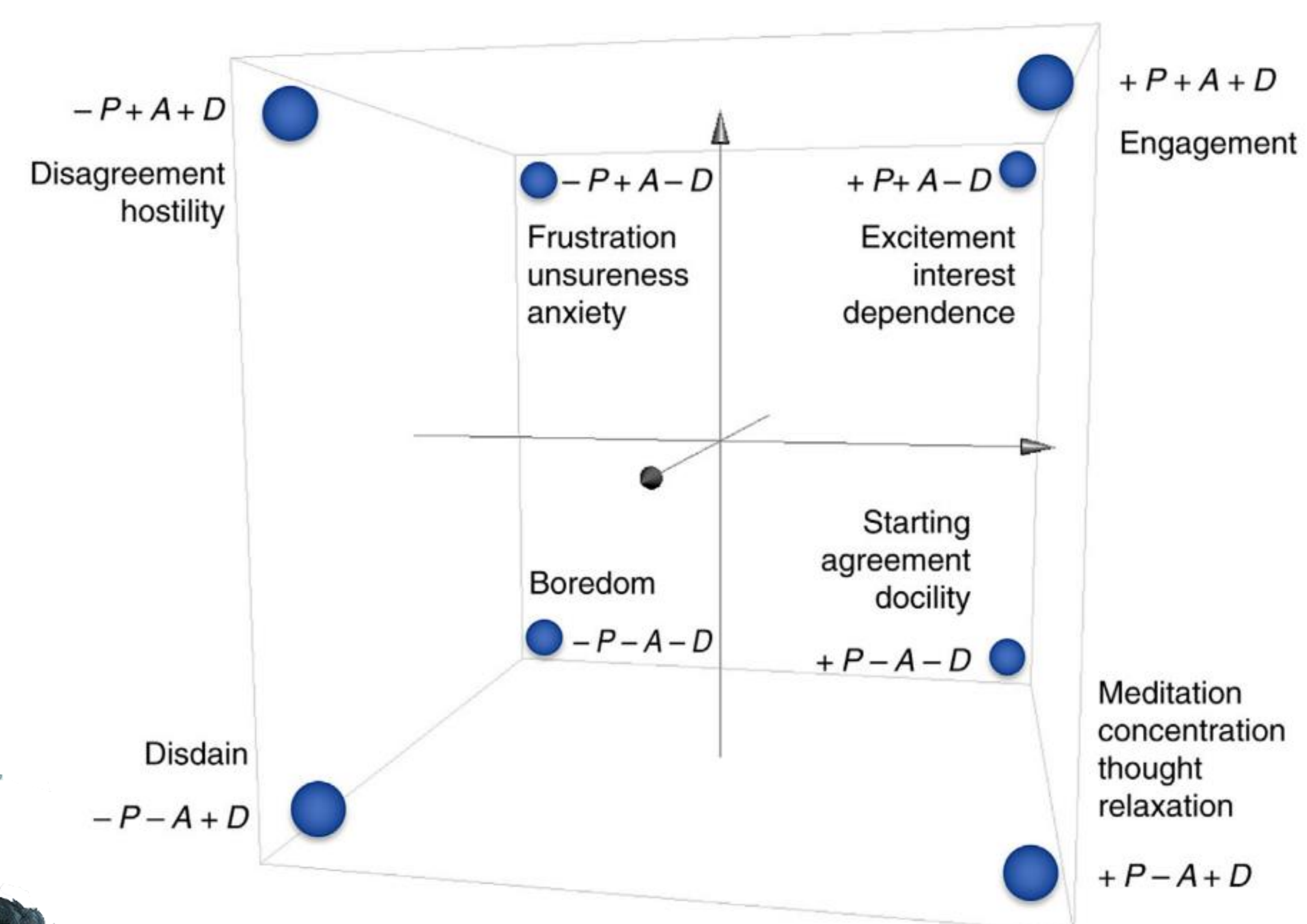
Affective States: We primarily use stress and focus since these are important to employees in a manufacturing operation.

Emotiv Insight
Photo from Emotiv Inc.

Methods

An Emotiv Insight headset sends 6 data points per minute. Two programs organize each data point into vectors, which are then added together. From there, this cumulative value per minute is used to pinpoint what affective state the user is in according to the PAD Model. The WebSocket based communication between a Java server and Python client allows the user's brain activity data to be transferred from the computer to the cobot. From there, the cobot can adjust its behaviors, such as its speed and RGB light, to adapt to the human's affective state.

The Emotiv headset collects real time data from the user and sends that to a computer via USB. A Java server on the computer sends the data to a Python client on a Raspberry Pi installed in the cobot.



***Pleasure-Arousal-Dominance dimensional model**. Source: From Gonzalez Sanchez, J., 2016. Affect-Driven Self-Adaptation: A Manufacturing Vision with a Software Product Line Paradigm. Doctoral dissertation. Arizona State University,*

Testing

To test if the Python client could receive various mental states from the robot, a function named "displayPAD" takes the cumulative value and prints out the inferred affective state of the user. During testing of the headset, a user would watch Internet videos and perform tasks that require intense focus. This allowed us to study if the cobot could receive and display the affective states. Some states, specifically relaxation and interest, were more difficult for the headset to pick up. Hence, we chose to target focus and stress states. Additionally, downloading software on the Raspberry Pi was much slower, which required us to build a Python client server instead to receive data.

Cobot 280
Photo retrieved from Elephant Robotics

Discussion of Results

The cobot was able to receive the affective states from the user and adjust its speed and RGB lighting according to the user's affective state, specifically a focused or stressed state. Utilizing Web-based socket communication between a Java server and Python client allowed us to successfully create a connection between the Emotiv EEG headset to the cobot. Therefore, allowing the cobot to respond and adapt to user's affective state and setting us up for further collaboration between a human operator and robot.

Future Work

This project is the first step in the development of a new method for HRI. Future steps should consider:

1. simulating pick and place in a manufacturing situation
2. add benchmark testing for different collaboration situations
3. implement safety stop features
4. Multiple robots and multiple human users in a production line

References

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