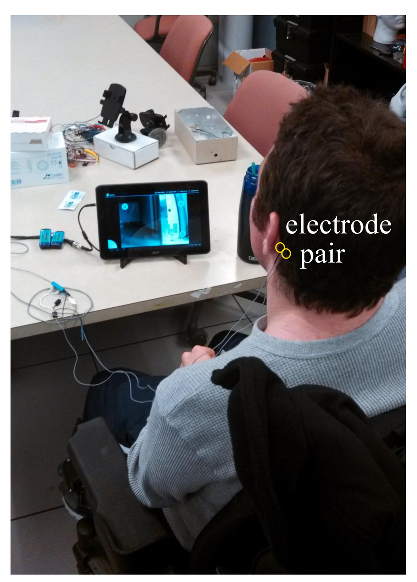
Paralyzed subject controls telepresence mobile robot using novel sEMG brain-computer interface: case study

Kenneth R. Lyons and Sanjay S. Joshi
Department of Mechanical and Aerospace Engineering, University of California, Davis

Introduction

This case study presents the use of a novel surface electromyography (sEMG) brain-computer interface (BCI) for controlling a mobile robot, using only the robot's video feedback to navigate an obstacle course.



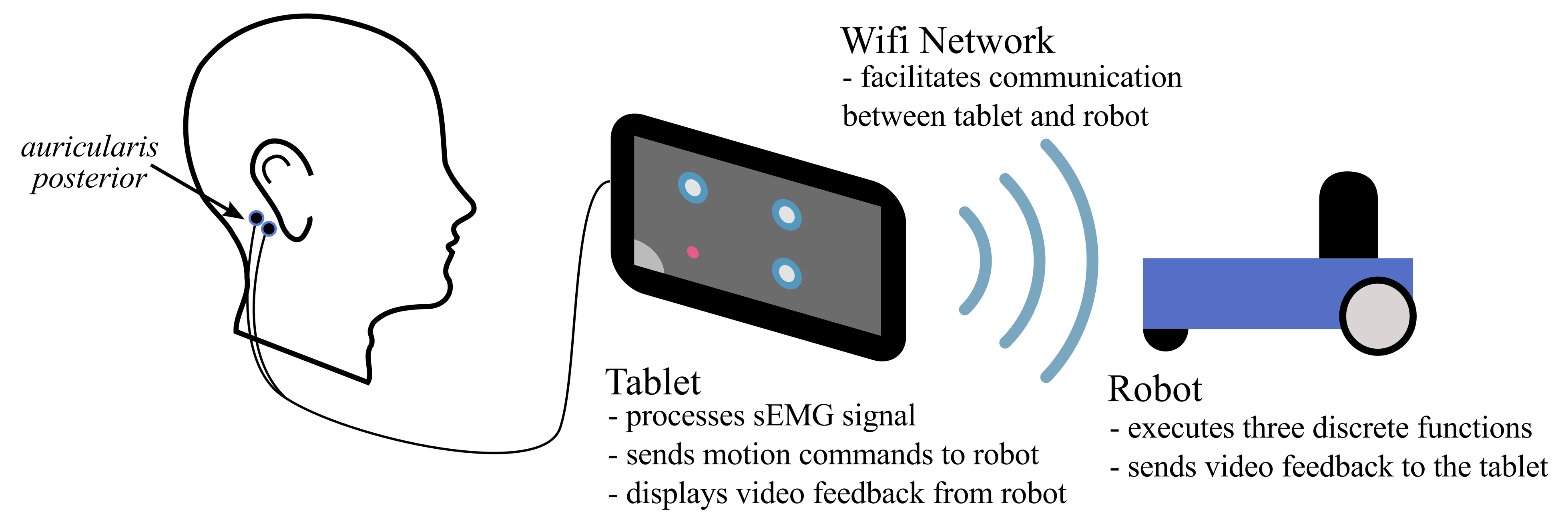
The BCI uses the signal power in two frequency bands of the sEMG spectrum of a **single muscle site** to continuously control a cursor in **two dimensions**. The robot is controlled via discrete commands which are selected by contracting the muscle to move the cursor to targets on the interface screen.

The participant, pictured right, is a 30 year-old C3-C4 spinal cord injury patient who has used the mobile phone version of our BCI [1] in the past. The current study represents his first time controlling the robot. After briefly viewing the course, he moved to a partitioned section of the room and began the trial presented.

System Configuration

A differential pair of electrodes placed on the *auricularis posterior* with an EMG preamplifier bring a single muscle signal to the microphone input hardware of a tablet computer, which processes the signal in order to obtain a cursor position in two dimensions.

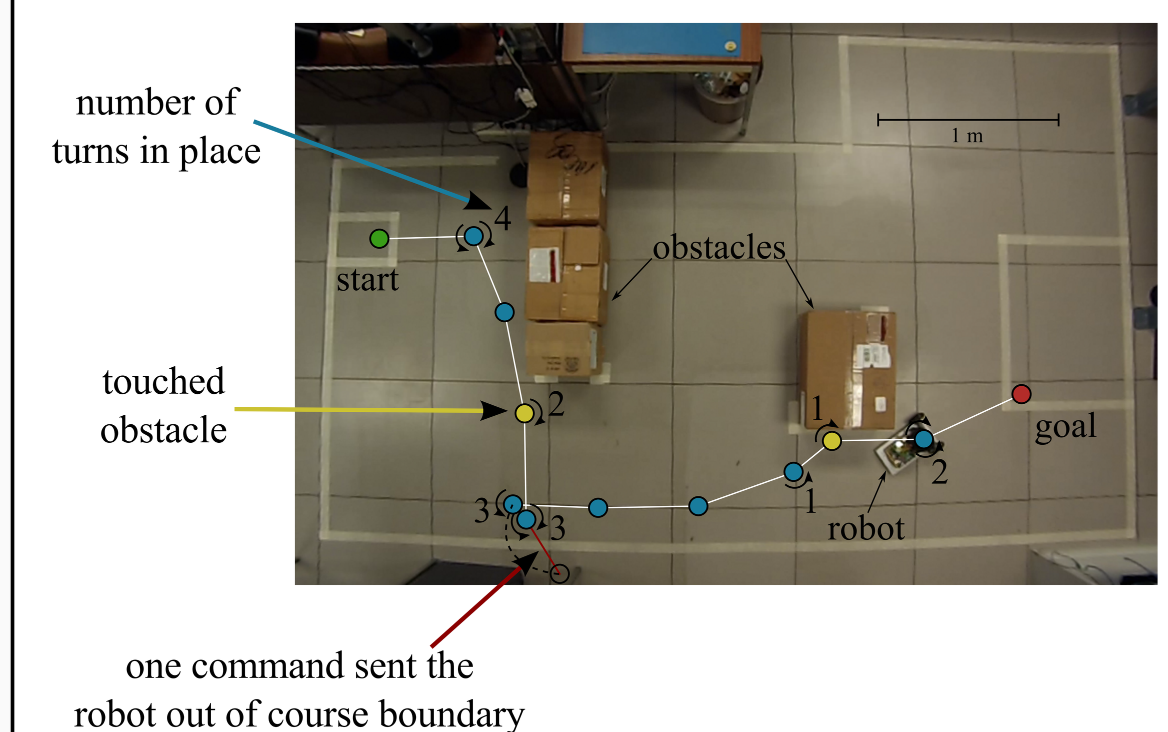
Targets on the screen of the tablet correspond to three mobile robot commands: move forward one meter, turn left 15 degrees, and turn right 15 degrees. Robot motion commands as well as video feedback from the robot are transmitted via Wifi.



Navigation Task

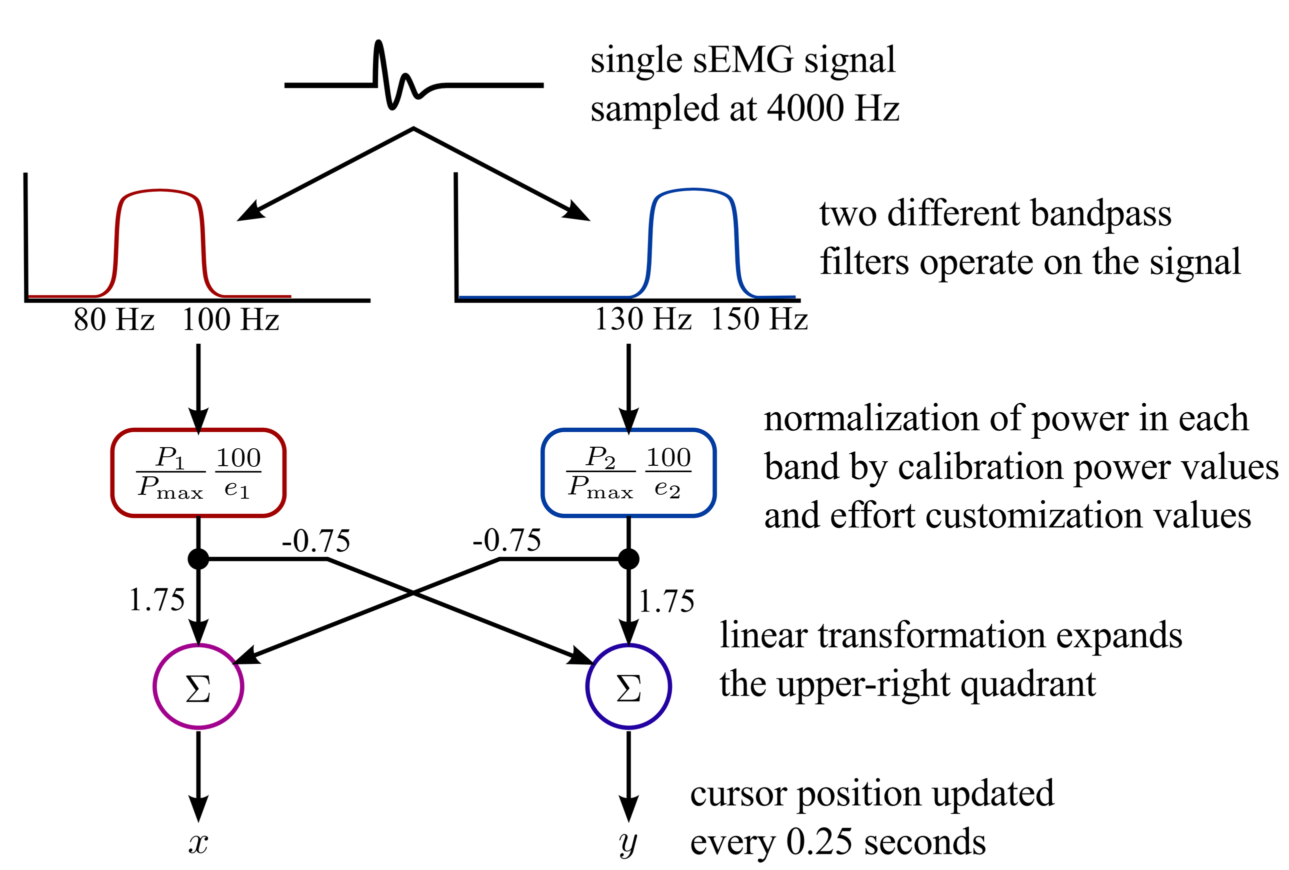
The navigation task involves using the brain-computer interface to send commands to the robot such that it travels from the start location to the goal. The robot has no "intelligence" -- it is completely under the control of the user.

The participant in this study was able to complete the task in **8 minutes and 30 seconds**, using 28 commands (15-20 optimal).



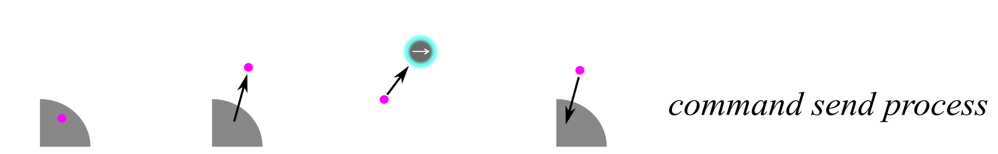
Signal Processing

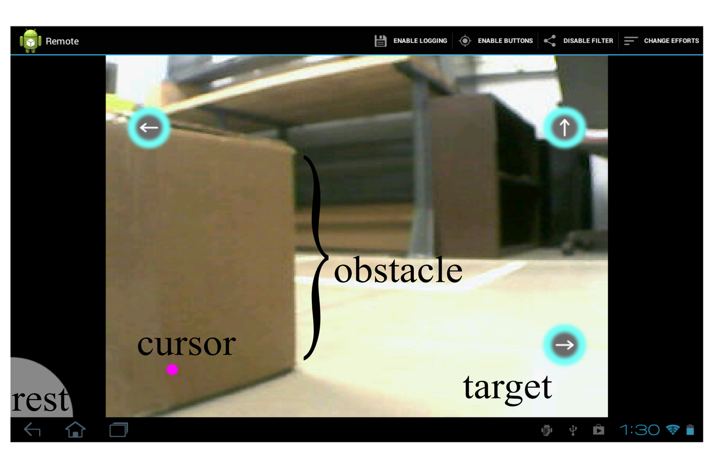
The signal processing is largely derived from our previous work [2]. A single sEMG signal is used to obtain a cursor position in 2D by calculating the signal power in two separate frequency bands.



Brain-Computer Interface and Robot Control

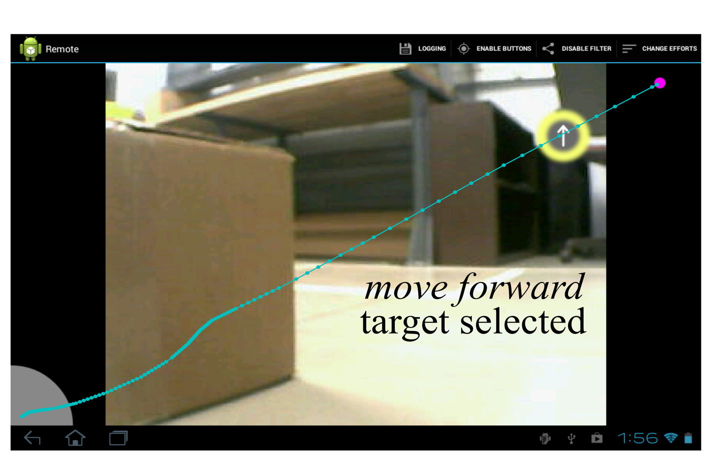
Robot commands are sent by moving the cursor to a target (target selection), then relaxing the muscle to return to rest (target confirmation).





Targets can be deselected by refraining from returning to rest for three seconds. This allows the user to avoid sending undesired commands due to accidentally selecting targets.

Cursor wander occurs when the cursor leaves the rest area and returns without having selected any targets. This accounts for a large portion of the time our participant spent performing the navigation task.



Case Study Data

target selections	47	total time with cursor in rest	2:40
target deselections	19	total time due to deselections	1:23
commands sent	28	total time due to cursor wander	2:44

Discussion

Though the participant in this case study had been previously trained to modulate the signal power in two frequency bands of the sEMG signal of his *auricularis posterior*, he faced several new features of the BCI. All three targets were shown on screen as opposed to one at a time, so this was his first time needing to avoid certain targets. Also, the addition of video feedback in back of the BCI and the navigation task increases the complexity of using the BCI.

The trial was a success, but there are several ways we can attempt to increase the usability of the system while minimizing some of the inefficiencies we noted. Simple obstacle detection would prevent the robot from striking obstacles or boundaries. Also, a method for determining the factors that lead to undesired target selection may help to find ways of avoiding them altogether. A larger subject pool would also allow us to investigate the practical usability of our system for different users. In addition, we are interested in the possibilities of continuous robot control, using the two degrees of freedom our BCI provides to steer the robot continuously.

References

[1] S. Vernon and S. S. Joshi, "Brain-muscle-computer interface: Mobile phone prototype development and testing," *IEEE Trans. Inf. Technol. Biomed.*, vol 15, pp. 531-538, July 2011.
[2] C. Perez-Maldonado, A. S. Wexler, and S. S. Joshi, "Two dimensional cursor-to-target control from single muscle site sEMG signals," *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 18, pp. 203-209, April 2010.

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