Blink Controlled Brain Computer Interface Using EEG

Oguz Yetkin, Kristi Wallace, Fahad Mirza, Roopak Karulkar, Joshua Baptist, Chelsea Mont, Joe Sanford, Dr. Dan O. Popa, Dr. Mario I. Romero
(oguz.yetkin@mavs.uta.edu, lena.wallace@mavs.uta.edu, fahad.mirza34@mavs.uta.edu,
roopak.karulkar@mavs.uta.edu, jbaptist@uta.edu, , chelsea.mont@mavs.uta.edu, joe.sanford@mavs.uta.edu, mromero@uta.edu)
Department of Biomedical Engineering, University of Texas at Arlington, Arlington TX, 76019

Background

A wide variety of disorders (e.g, ALS, MS) can lead to complete paralysis, leaving only the ability to blink intact. These patients can't use traditional computer input devices or robotic manipulators. We describe an electroencephalogram (EEG) based Brain Machine Interface (BMI) which allows the user to move a manipulator by blinking after an LED representing the desired movement direction, and report the feasibility of system operation in healthy subjects. We extend the system to demonstrate control a 4 Degree of Freedom (DOF) arm, and propose using a P300 Event Related Potential (ERP) or Steady State Visually Evoked Potential (SSVEP) based system to allow control of a multi-DOF robotic actuator without any physical input b the user.

Aims

Aim 1: Demonstrate the feasibility of EEG based robot control using a 1 DOF robotic actuator.
Aim 2: Develop and test a fast method of controlling a multi-DOF robotic actuator using a single input, allowing for arbitrary actuator positioning in 3-space.
Aim 3: Replace actuator signal with P300 ERP or Steady State Visually Evoked Potential (SSVEP) based system, allowing for multi-DOF positioning of an actuator in 3D space and creating a true "mind controlled robot"

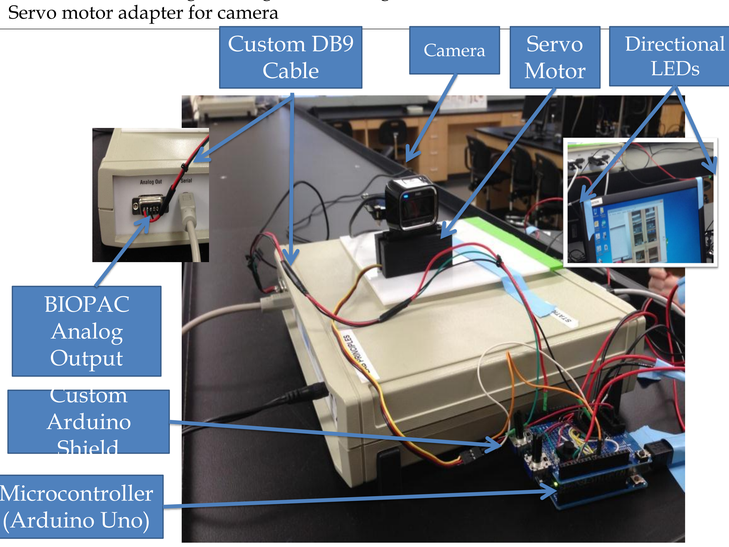
Materials & Methods

Aim 1: The 1-DOF robotic system is comprised of the following existing and custom made components:

BIOPAC MP30 System & Software, Arduino UNO Microcontroller, Camera, Flashing LEDs attached to monitor

Custom made components include:

- DB9 Cable for interfacing with BIOPAC
- "Shield" for Arduino interfacing with all cables and LEDs
- LED with extension cable (2)
- Software for detecting blinking from EEG signals
- Servo motor adapter for camera

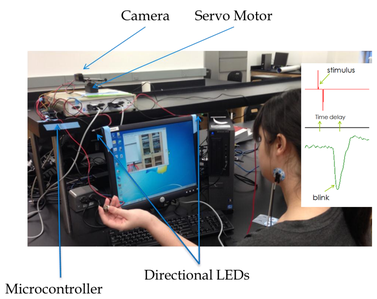


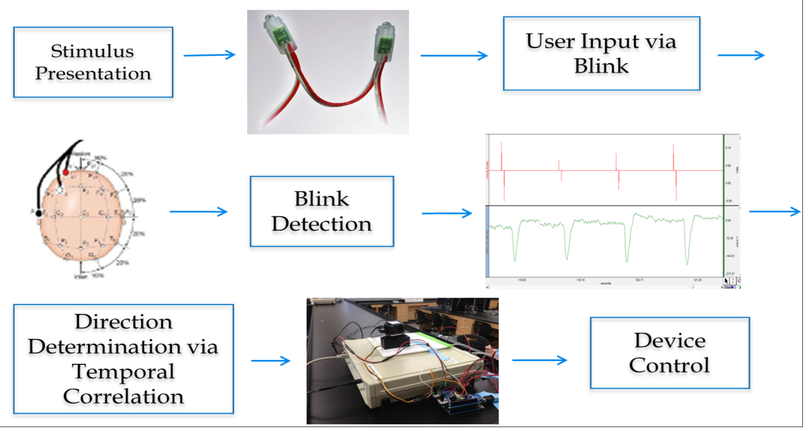
Aim 2: The 5-DOF robotic arm is comprised of the following components:

Arduino Uno Microcontroller with custom shield
Hand-held pushbutton for input
Seven Dynamixel-MX106T Robotic Actuators with associated brackets and hinges
Robotis USB2Dynamixel Adapter
LabView VI to communicate with the Arduino
Three NeoPixel Addressible LED arrays (two rings and one 1/4 ring)
One NeoPixel Addressible LED Strip

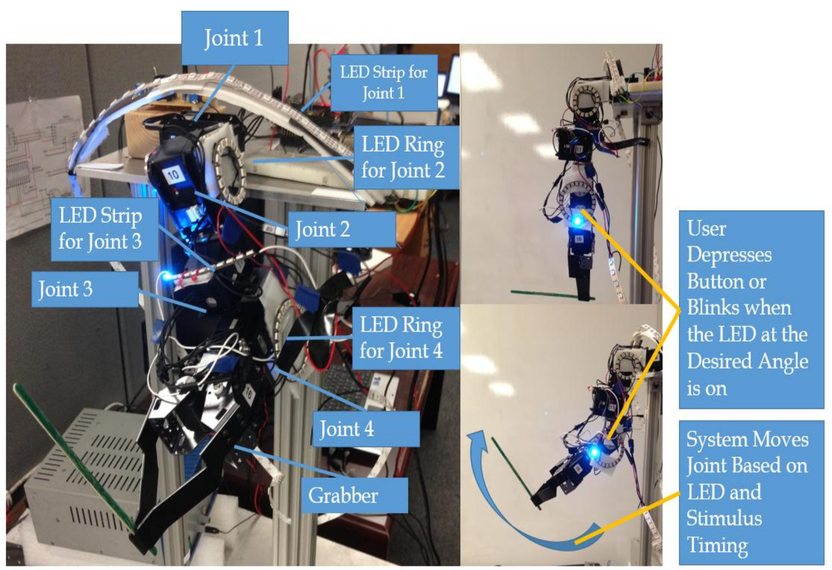
System Operation

Aim 1:
1. System flashes right and left LEDs in succession (1 Hz)
2. User chooses to blink after right or left LED
3. System detects blink via EEG Blink Artifact
4. System moves camera in desired direction





Aim 2:
1. System Flashes the LED on each ring corresponding to a joint
2. User chooses to blink after the LED on the joint representing the desired angle of movement
3. System detects blink via EEG Blink Artifact
4. System moves specified robotic joint in desired direction

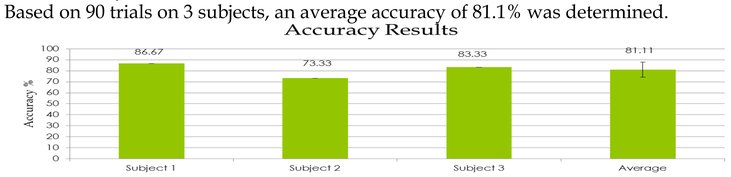


Results

Aim 1
Each subject was trained on the system and given randomly generated instructions of "Right," "Left," and "Don't Move" (3 subjects, 30 instructions per subject). An attempt was counted as positive if:

- Camera moved in instructed direction
- Camera stayed still for "Don't Move" instruction for 5 seconds

Based on 90 trials on 3 subjects, an average accuracy of 81.1% was determined.



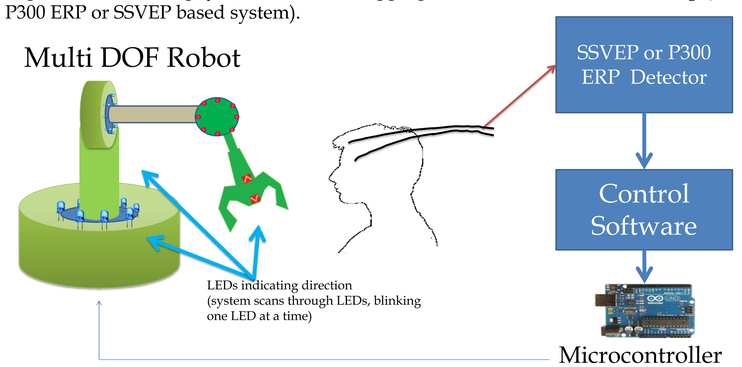
Conclusion

Aim 1: We demonstrate a very simple system for a disabled individual to drive a one degree of freedom servo with an attached camera left and right using EEG input and blinking. The accuracy of the system can be increased by slowing the LED blinking rate.

Aim 2: We have extended the system to control a multiple degree of freedom robot, using LED rings to allow for much faster input

Future Work

We intend to integrate the multi-DOF robot with a compact, wireless EEG sensor and characterize the speed of manipulating objects with the grabber (Completion of Aim 2). We also intend to modify the multi-DOF arm system to use an EEG-based paradigm that only requires the user to pay attention to the appropriate LED rather than blinking (such as a P300 ERP or SSVEP based system).



References

Yuksel, Beste F., et al. "A novel brain-computer interface using a multi-touch surface." *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2010.
Hoffmann, Ulrich, et al. "An efficient P300-based brain–computer interface for disabled subjects." Journal of Neuroscience methods 167.1 (2008): 115-125.
Donchin, Emanuel, Kevin M. Spencer, and Ranjith Wijesinghe. "The mental prosthesis: assessing the speed of a P300-based brain-computer interface."Rehabilitation Engineering, IEEE Transactions on 8.2 (2000): 174-179.
Mak, J. N., et al. "Optimizing the P300-based brain–computer interface: current status, limitations and future directions." Journal of neural engineering 8.2 (2011): 025003.
Palankar, Mayur, et al. "Control of a 9-DoF wheelchair-mounted robotic arm system using a P300 brain computer interface: Initial experiments." Robotics and Biomimetics, 2008. ROBIO 2008. IEEE International Conference on. IEEE, 2009.
Y. Renard, F. Lotte, G. Gibert, M. Congedo, E. Maby, V. Delannoy, O. Bertrand, A. Lécuyer, "OpenViBE: An Open-Source Software Platform to Design, Test and Use Brain-Computer Interfaces in Real and Virtual Environments", Presence : teleoperators and virtual environments, vol. 19, no 1, 2010
Gilja, Vikash, et al. "A high-performance neural prosthesis enabled by control algorithm design." Nature neuroscience (2012).
Muller-Putz, Gernot R., and Gert Pfurtscheller. "Control of an electrical prosthesis with an SSVEP-based BCI." Biomedical Engineering, IEEE Transactions on 55.1 (2008): 361-364.